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

## CONTENTS

## SECTION A. General description of the project

### A.1. Title of the project:

**"Landfill gas capture and utilization at Chernihiv MSW landfill"**

Sectoral scope 13: Waste handling and disposal

PDD Version: 07, dated August 08, 2011

### A.2. Description of the project:

The main goal of the project is reduction of the GHG (methane) emission into the atmosphere by means of collection and utilization of energy potential of the landfill gas (LFG) which is generated due to anaerobic decomposition of organic waste at Chernihiv municipal solid waste (MSW) landfill.

Uncontrolled landfill gas emissions into the environment generate the negative effect both of global and of local character. At the global level, the landfill gas is one of the strongest factors of green-house effect at the planet. At the local level, the LFG is the reason of increased fire and explosion danger at landfills, it presses the vegetation development in the area of its location, has the ability to fill the underground communications and by such a way to create the danger for human life.

Chernihiv city is a regional center of Chernihiv Region in Ukraine, with population of about 300 ths inhabitants, and nearly 30 large and a lot of average and small enterprises. The total amount of waste is delivered and stored at the Chernihiv municipal solid waste landfill, which operates since 1961. The landfill belongs to the category of highly loaded, the way of waste stowage is high-rise.

The landfill owner is Chernihiv community, represented by the Chernihiv District State Administration. According to the Decree of Chernihiv District State Administration № 263 from 30.04.2003, the land of total area 30.18 ha under the MSW landfill and its administrative buildings situated at the territory of Novy Bilous village council is given for permanent use to the Department of Municipal Household of the Chernihiv City Council for waste abolishment (governmental act to the right of permanent use of land series II-ЧН No. 001945 dated 03.10.2003). Chernihiv MSW landfill is operated by PE "Granplast".

The authorities on re-cultivation of the landfill, LFG collection and utilization at the MSW landfill are delegated to the OJSC "Oblteplocomunenergo" by agreement with the Department of Municipal Household of the Chernihiv City Council (No. 616 dated 16.12.2009, with Additional agreement No. 1 dated 19.02.2010), and confirmed by the Decree of Chernihiv District State Administration No. 67 dated 11.03.2010.

The MSW abolishment through their burial at the landfills has been the only country strategy during many years. An anaerobic decomposition of municipal solid waste happens at the landfill with permanent methane emission, which decreases slowly with time without volley or escape emissions. The technology for the LFG capture and utilization of its energy potential is widely used in the world practice, however, it is quite new for Ukraine, and actually there is no experience of its implementation.

The namely landfill area takes 14 ha [1]. Filling of the landfill with waste has been done by the way of local working charts with the operation areas of 1.5 to 3.5 ha. The waste storage was implemented by layers (with the thickness of 2 to 3 meters) with leveling and compression by heavy bulldozer. Such operation method has provided the landfill widening to the lateral directions and its gradual height increasing. In the result of this, the oval-like in plan body was created with the thickness of 6 to 20 m, in the average of 15 m (Figure A.1).

[1] *"Implementation of the system for biogas collection and utilization at Chernihiv MSW landfill". Project. / STC "Biomass", Kyiv, 2010*


*Figure A.1. Chernihiv MSW landfill before rehabilitation start*

At present the area for waste placing at the landfill is practically exhausted, the landfill is already almost fully filled and is subject to be closed in the nearest years, however the project for a new landfill is not ready so far, and exploitation of the old landfill obviously will be continued for some time (in reality at least up to 2012).

The project foresees construction of the landfill gas collection system for the LFG capture. Collected LFG through the local transport system and processing system will be supplied to the boiler-house of OJSC "Oblteplocomunenergo" to the new energy complex (EC) which will consist of four gas-turbine units (GTU) C65-ICHP produced by Capstone corporation (USA) and exhaust gases heat exchanger, with the total electric capacity of 260 kW and total heat capacity of 296 kW, as well as to the existing

boilers for replacement (partly or completely) the natural gas for heat generation in form of hot water for the heating and hot water supply purposes. Electric power generated by this EC will be used for supplying the equipment of the boiler-house, heat energy – for preliminary heating of return network water. The local flaring system HOFGAS-Ready 800 for possible excess and emergency LFG combustion at the landfill site is designed as well.

The monitoring equipment will include flow meter and gas analyzer of LFG content which will register the gas amount, composition and parameters. The enterprise will have the ability for daily monitoring of LFG collection and utilization process.

Project implementation will enable to achieve:

1) Reduction of the GHG methane emission into the atmosphere from Chernihiv MSW landfill and receiving of additional investments to the project from the ERUs selling at least for the first commitment period according to the Kyoto Protocol.
2) Improvement of the fire safety of landfill operation.
3) Improvement of the atmospheric air conditions and general sanitary state at the territories situated around the MSW landfill.
4) Saving of the non-renewable energy sources due to LFG consumption for electricity production by CHP.
5) Saving of the non-renewable energy source - natural gas due to LFG consumption instead of the natural gas for heat production by boiler-house of the Chernihiv heat supply enterprise OJSC "Oblteplocomunenergo", with additional emission reduction.

Saving of the fossil energy sources consumed for the electricity and heat energy production will favour the economical attractiveness of the project implementation as well. Calculated project annual GHG emission reduction will be about 80 ths t $CO_2$e up to the end of the first commitment period as compared to the situation "business-as-usual".

Social impact of the project will be positive due to creation of the new work places.

The environmental impact of the project upon Chernihiv district is expected to be very positive since:

- The potential risk of waste self-firing at the MSW landfill will be reduced and gradually eliminated that contributes to essential reduction of its operation danger;
- The environmental conditions around the landfill will become partially normal due to reduction of organoleptic, sanitary and migratory-air indicators of harmful substances ingress to the atmosphere and ground water;
- Proposed monitoring system will provide the clear measuring of results of the scheduled nature protection activity implementation;
- Contribution will be made to the implementation of the country commitments in accordance with the regulations of Kyoto Protocol to the UNFCCC.

Therefore, construction and operation of the LFG collection and utilization system at the Chernihiv MSW landfill, under conditions of the proper nature protection measures implementation and following the technical regulations, will have the environmental impact within the valid sanitary norms and will improve the living conditions of the population.

Technology of LFG capture and flaring and/or utilization is already widely used throughout the world. However, in Ukraine such technology is not spread due to financial barriers and absence of mandatory regulatory requirements for its implementation at old landfills. Only with the arising of possibility to use the JI mechanism for such projects, the real possibilities for implementation of this technology appeared in Ukraine.

## A.3. Project participants:

| Party involved | Legal entity project participant (as applicable) | Please indicate if the Party involved wishes to be considered as project participant (Yes/No) |
|---|---|---|
| Ukraine (Host Party) | OJSC "Oblteplocomunenergo" | No |
| Estonia | OÜ Biotehnoloogia | No |

- ***OJSC "Oblteplocomunenergo" (Supplier, project owner): –*** organization to which the authority for implementation of project on landfill re-cultivation, LFG collection and utilization at the Chernihiv MSW landfill was delegated by the owner of the last one (Department of Municipal Household of the Chernihiv City Council).

  Since this enterprise has the authority for landfill degassing, and also will consume the LFG, it has the top-priority interest in the implementation of LFG collection and utilization system. OJSC "Oblteplocomunenergo"is the heat supply organization in Chernihiv region. This enterprise operates the heat production and heat distribution equipment, and renders the heat supply services. It has all necessary licenses and permissions for operation, designing and reconstruction of the heat supply equipment in Ukraine.

  OJSC "Oblteplocomunenergo" is responsible for the execution of design, engineering and installation works by its own staff and with help of sub-contractors. It will be the ERUs Supplier, will finance this project and receive the benefits.

Historical details:

The Enterprise "Chernihivteplomerezha" was founded on the basis of Order No. 353 of the Minister of Municipal Housing of UkrSSR and Decision No. 714 of the Executive committee of the City Council of Deputies from December 31st, 1968. It has started its work on January 1st, 1969. Since 1982 the enterprise became the regional production association "Chernihivteplomerezha". On the 27-th of August, 1985, the enterprise was re-named to the Oblast Production Association (OPA) «Chernihivteplocomunenergo». On 25.03.1992 the enterprise became State Municipal Enterprise (SME)"Oblteplocomunenergo".

In 1995 the privatization of enterprise objects was hold. On 31.07.95 the SME "Oblteplocomunenergo" was re-named to the Joint Stock Company "Oblteplocomunenergo"

Today the OJSC "Oblteplocomunenergo" is the powerful heat supply complex. It has 12 boiler-houses and 2 heat points, automobile division, repairing-mechanical division, pre-isolated pipes manufacture division, measuring devices repairing and testing division, metrological lab, etc. The heat energy is also

produced by 107 rented boiler-houses. 18 operation divisions in the region belong to the enterprise. The enterprise supplies heat energy to over 270 thousand of consumers (population, housing and administrative buildings) in 22 settlements in Chernihiv Region. The heating set load is nearly 288 Gcal/hour, hot water supply – nearly 92 Gcal/hour. The part of the housing (populated) heated area is about 81%, of legal persons – 19%.

The stuff of the enterprise consists of about 1.5 ths workers. They provide continuous operation of the heat generating, transporting and distributing equipment.

OJSC "Oblteplocomunenergo" has all the necessary permissions and licenses, issued by the State Inspection on Labor Safety, that allow performing of the following activities:

1. to operate, repair and install the steam and hot-water boilers, steam and hot-water pipelines;
2. to perform building and installation works;
3. to perform designing works;
4. to conduct adjustment and alignment of fuel-using equipment.

## A.4. Technical description of the project:

### A.4.1. Location of the project:

The project is located in Chernihiv Region in the Northern part of Ukraine (Fig. A.2).


*Figure A.2. The map of Ukraine*

#### A.4.1.1. Host Party(ies):

Ukraine is the Eastern European country that ratified the Kyoto Protocol to UNFCCC on February 4, 2004, is listed in the Annex 1, and meets the requirements for participation in the Joint Implementation projects.

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

The project is located in Chernihiv Region.

Chernihiv Region is situated in the Northern part of Ukraine on the left bank of middle current of Dnipro river. The main river is Desna. Chernihiv region borders at the north with Russian Federation (Bryansk region), at the north-west – with Belarus (Homel region), at the east – with Sumy region, at the south – with Poltava region and at the south – west and south-east- with Kyiv region.

The total area is 31.9 ths $km^2$ .

Chernihiv region has a moderate-continental climate with snowy winter and quite rainy summer. The average temperatures are: -7 $^0$C in January, and +19 $^0$C in July. The area belongs to the zone of sufficient humidity. The average annual precipitations are 550-660 mm. The number of days with a stable snow cover is 95-110. The maximum depth of soil frost penetration is 1.4 meters.

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

Chernihiv city is a regional center of Chernihiv Region and an administrative center of Chernihiv district. Population of the city is about 300 ths (as of 2009). There are nearly 30 large and a lot of average and small enterprises at the city's territory that work in the chemical, food, light, woodworking industry fields, as well as building materials manufacturing.

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

Chernihiv MSW landfill is located at the north-western end of Chernihiv city, in 800 meters to the north-west from housing district Masany, in 1 km to the north-east from inhabited locality Novyi Bilous, in 1.5 km to the south of Desnyanka village, between Bilous and Strizhen rivers.

The climate conditions, according to SNiP 2.01.01-82, belong to the II climate area, which is described by temperate-continental climate, with snowy winters and rainy summers.

Location of the Chernihiv MSW landfill is shown at the satellite map by the red oval, and location of the boiler-house where the LFG will be utilized (Instrumentalna str., Chernihiv) – by the red circle; the center of Chernihiv city is marked as well (Fig. A.3).

Details of the physical location[2]:

GPS coordinates of the landfill (of the entrance):
N (northern latitude): 51°32'33'' (51.542904),
E (eastern longitude) 31°12'46'' (31.211761).

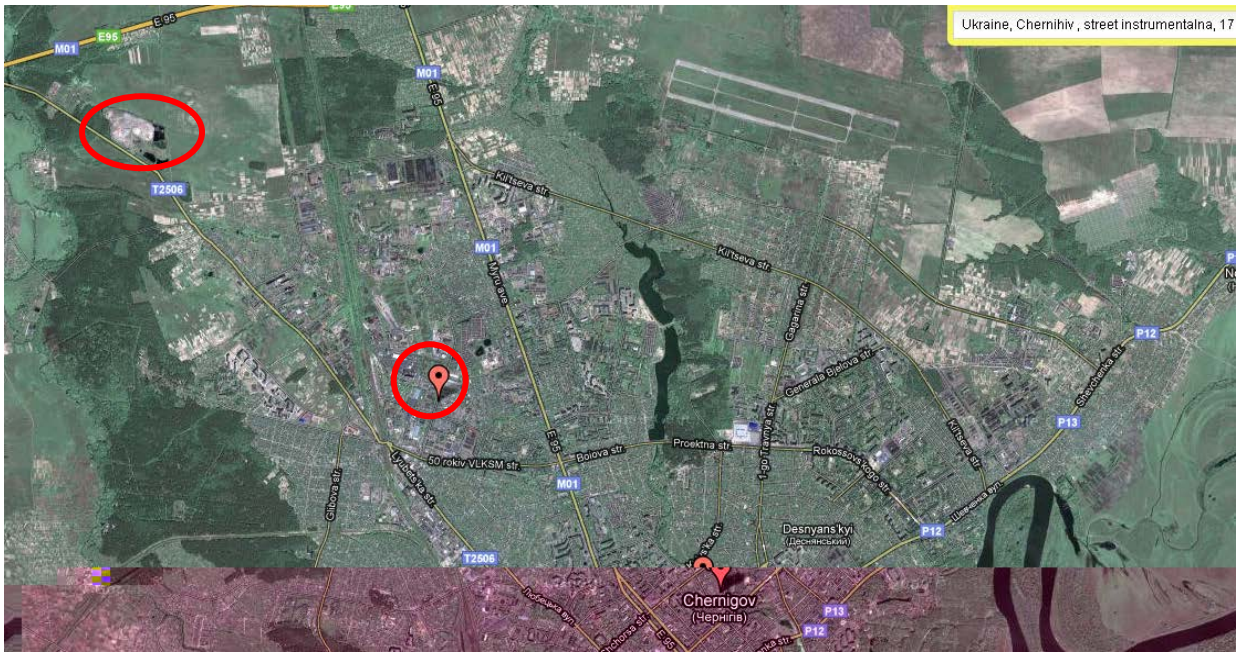


*Figure A.3. Location of the Chernihiv MSW landfill (red oval) and the boiler-house (Instrumentalna str., Chernihiv)(red circle)*

[2] http://maps.google.com.ua/?ie=UTF8&ll=51.542759,31.199541&spn=0.040196,0.056133&t=h&z=14

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

The detailed description of the Chernihiv MSW landfill and its state before project implementation (description, structure, layout, features of morphology of the landfill body, etc) is provided in the Annex 2 "Baseline information".

The project activity foresees construction of the active system for collection of the LFG, its processing and transport to boiler-house for utilization of the energy potential of methane contained in it, as well as flare equipment for possible excess and emergency LFG combustion.

The following activity is foreseen:

- boring and constructive equipping of gas collection boreholes;
- building of discharge pipelines;
- building of gas collection wells;
- building of the trunk pipeline to the technological ground;
- construction of the technological ground;
- installation of the main equipment, which includes:
  - LFG processing unit;
  - LFG registration unit;
  - flaring system for excess and emergency LFG combustion;
  - compression unit;
- building of the trunk pipeline to the boiler-house;
- installation of the CHP units;
- replacing of the boiler's burners and re-equipment of the boiler-house to enable LFG combustion.

The character of location and the number of gas-collecting boreholes in the LFG collection system have been planned with taking into account the morphologic peculiarities of main landfill body and its resource for LFG generation. Design of the LFG collection system is based on the results of the made test boring[3] and is described in the work design made by the SEC "Biomass" to the order PR3-2010 of "Stiks-oil", Ltd.[4].

The main equipment for the LFG collection and transport system includes:

- boreholes with perforated polyethylene pipes for LFG captation;
- horizontal LFG drainage perforated polyethylene pipelines network;
- gas drainage wells;
- interconnecting and trunk pipelines;
- degassing utility with vacuum pumps;
- LFG processing unit (separation of condensed moisture, cleaning, etc.);
- LFG registration unit;
- flaring system for excess and emergency LFG combustion;
- LFG dehumidification unit;
- compression unit for feeding to the trunk transport pipeline.

The scheme of the planned system for LFG collection and utilization is given at Fig. A.4.

[3] *"Technical report on results of test boring at Chernihiv municipal solid waste landfill" / TOV "Stiks-oil", 2010*

[4] *"Implementation of the system for biogas collection and utilization at Chernihiv MSW landfill". Project. / STC "Biomass", Kyiv, 2010*

*Figure A.4. The scheme of system for LFG collection and utilization*

The system for LFG collection, transportation, preparation and utilization will operate as following:

- all boreholes with perforated polyethylene pipes (52 units, approximately evenly covering all existing working charts of the landfill main body) are connected with polyethylene perforated pipelines to 4 gas drainage wells, catenated by the trunk pipeline coming to the technological ground;

- landfill gas from gas-collecting boreholes is drawn through the horizontal drainage pipelines into the gas drainage wells, due to decompression generated by vacuum pumps;

- collected LFG from gas drainage wells through the trunk pipeline is moved to the technological ground.

- at the technological ground the LFG separation from condensed moisture and cleaning happens, as well as its analysis and registration;

- with help of compressor, the LFG is pumped through the monitoring system and next through the trunk pipeline to the boiler-house for utilization of its energy potential;

- implementation of reserve system for possible excess over the technical capacities of the boiler-house and emergency LFG flaring is provided.

***LFG productivity of the Chernihiv MSW landfill:***

According to the results of calculations (see section E.4, and Appendix A), the maximum gas productivity of the Chernihiv MSW landfill will be 21.025 mln $m^3$ in 2012, or 2.400 ths $m^3$/hour. Usually the part of LFG that may be captured and collected is assumed as 50%, that is up to 1 200 $m^3$ LFG/hour.

In case of continuation of operation of the landfill after 2012, the maximum gas productivity of the landfill will increase.

***Characteristic of the LFG collection and transport system:***

The boreholes of 600 mm in diameter are to be drilled with ~30 m interval according to the scheme provided at Fig. A.4. Total number of the boreholes is 56: 52 for discharging perforated polyethylene pipes (Ø 63 mm), and 4 for building of the gas drainage wells with the similar pipes at the bottom. Diameter of wells is 2.5 m, depth is up to 5 m from the surface.

Horizontal perforated polyethylene discharging pipes of 110 mm in diameter are to be built with 30 m interval according to the scheme (Fig. A.4), approximately evenly covering all existing working charts of the landfill main body with exception of 20 m zone from slope along the landfill edges, and connected to the gas drainage wells.

Shut-off and regulating valves, control and measuring instrumentation, sampling instruments for chemical analysis of LFG, systems for condensate removing are placed in the 4 gas drainage wells.

These 4 gas drainage wells are sequentially connected by the trunk pipeline with gradually increasing (200 to 280 mm) diameter (Fig. A.5), through which collected LFG comes to the technological ground.

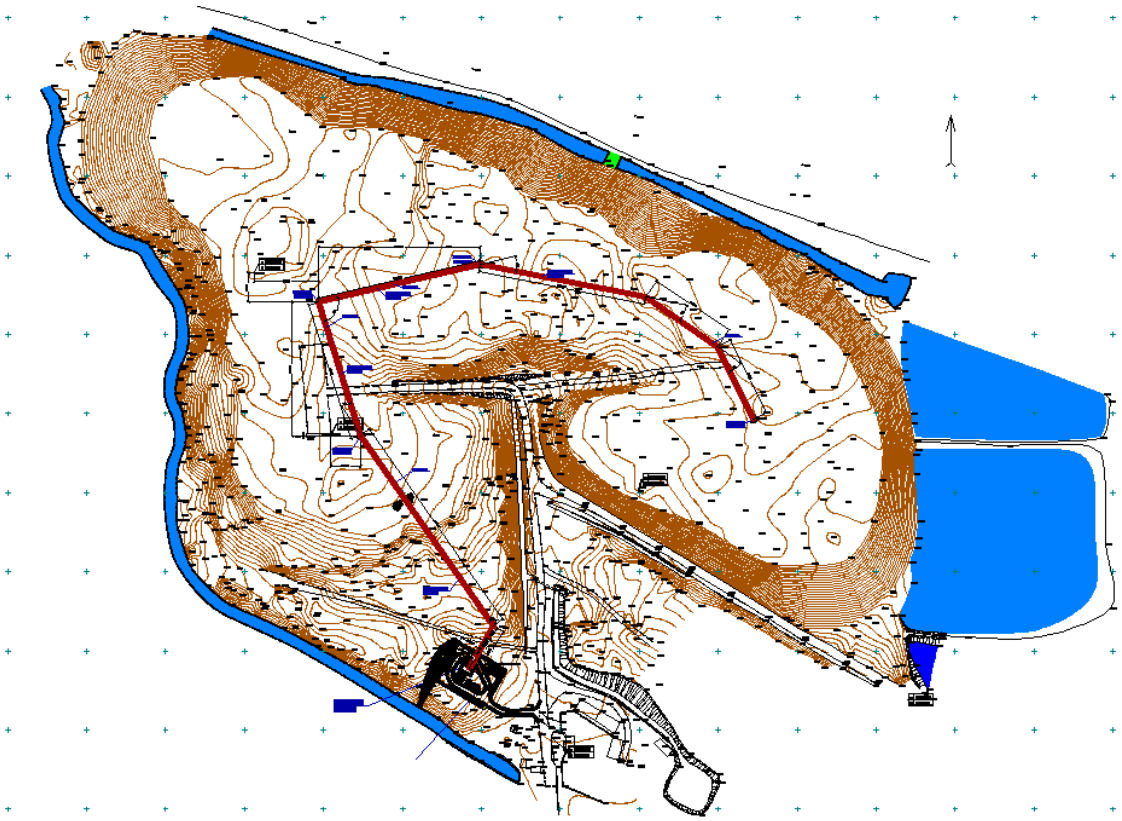

*Figure A.5. The scheme of wells localization and connecting trunk pipeline*

The technological ground of 35x27 m is located in the southern part of the landfill near the main gate.

The following main technological equipment is located on the ground:

- flaring system with gas blower and preliminary cleaning;
- condensate collection well (Ø 1.5 m);
- moisture eliminator;
- compressor unit;
- cooler;
- gas flow registration unit;
- electric power supply unit and control/switchboard panel room;

Installation of the equipment is scheduled in two stages. The first stage includes installation of the electric power supply unit and control/switchboard for flaring system with gas blower and preliminary cleaning, gas flow registration unit and condensate collection well; the second stage – installation of the moisture eliminator, compressor unit and cooler.

The enclosed high temperature flaring system HOFGAS-Ready 800 produced by Hofstetter Umwelttechnik AG (Switzerland) is scheduled to be installed.

Measurement of collected LFG will be provided with the gas meters SVG.M-2500 and SVG.M-1600, including the gas flow meter DRG.M-2500, pressure sensor, temperature sensor and microprocessor controller.

Measurement of consumed electric power will be provided with electronic transformer power meter located in the control/switchboard.

Specification of the main parameters of the landfill on-site equipment for LFG collection and transport is provided in Table A.1.[5]

| ## | Parameter | Unit | Value |
|---|---|---|---|
| 1 | Number of gas drainage wells | pcs. | 4 |
| 2 | Number of gas boreholes | pcs. | 52 |
| 3 | Scheduled flaring unit type | – | HOFGAS- Ready 800 |
| 4 | Flaring unit capacity | kW<br>$nm^3/h$ | 400…4000<br>160…800 |
| 5 | Scheduled type of compressor (2 units) | – | Zephyr C-DLR 400 |
| 6 | Scheduled type of moisture eliminator | – | FriCon-200/750-40-14-2-IB |
| 7 | Scheduled type of cooler | – | FriConAIR-150/750-88-40-0-0 |
| 8 | Installed capacity of equipment | kW | 77.859 |
| 9 | Scheduled building term for the first stage | months | 3 |
| 10 | Scheduled building term for the second stage | months | 5 |
| 11 | Number of maintenance staff | people | 3 |
| 12 | Total area of the technological ground | Ha | 0.094 |
| 13 | Total area covered by the gas drainage system | ha | ≈14 |
| 14 | Length of the gas drainage pipelines | km | 2 |
| 15 | Length of the trunk pipeline to the technological ground | km | 0.6 |
| 16 | Start of building | year | 2010 |

*Table A.1. Specification of the main parameters of LFG collection and utilization (flaring part) system*

[5] *"Implementation of the system for biogas collection and utilization at Chernihiv MSW landfill". Project. / SEC "Biomass", Kyiv, 2010.*

***Landfill gas utilization:***

At the early stage of the project implementation, immediately after construction of the LFG collection system, the local enclosed high temperature flaring system at the landfill site will be used for LFG utilization.

At the next stage, after construction of the LFG processing and transport systems, this local flaring system will be used for possible excess and emergency LFG combustion.

At the second implementation stage collected LFG from the technological ground through the processing system and transport system will be supplied to the boiler-house of OJSC "Oblteplocomunenergo" by the address 17, Instrumentalna Street, Chernihiv city, where it will be completely utilized.

Building of the trunk pipeline to the boiler-house is to be executed along the railway line within right-of-way, with the passage under the embankment near the boiler-house.

Collected LFG will be utilized by the new energy complex (EC) which will consist of four co-generation gas-turbine units (CGTU) C65-ICHP produced by Capstone corporation (USA) and exhaust gases heat exchanger, with the total electric capacity of 260 kW and total heat capacity of 296 kW, as well as by the existing boilers for replacement (partly or completely) the natural gas for heat generation. Electric power generated by this EC will be used for supply the equipment of the boiler-house, heat energy – for preliminary heating of the return network water.

The boilers of DKVR-20/13 (2 units), DE-25/14 (1 unit) and PTVM-30M (1 unit) types are installed in the boiler-house. The boiler-house produces thermal energy for in form of hot water for heating and hot water supply purposes. During the non-heating period the heat load of boiler-house in 2010 was about 4,7 MW, during the heating period – over than 28 MW, respectively.

At present, electricity is supplied to the boiler-house from "Chernihivoblenergo" through transformer substation, which belongs to OJSC "Oblteplocomunenergo"[6].

The current power demand of the boiler-house is:

- 250 kW – in the heating period;
- 55 kW – in the non-heating period.

Landfill gas is to be supplied to the boiler-house at the pipeline tie-point for the feeding to CGTU and to one burner of the DKVR-20/13 st.#2 boiler. Two other burners will be worked on natural gas. Connection is planned to be realized by organizing the branch line from landfill gas pipeline, before gas distribution unit, with the installation of technological meter and electromagnetic cut-off valve.

GTU consists of the following technological equipment:

- Micro turbine C65-ICHP produced by Capstone Turbine Corporation (USA). This high pressure micro turbine has 65 kW 400 V three-phase AC 50Hz output. It is designed for self-sufficient operation and for using landfill gas as a fuel. Reserve and emergency fuel is not envisaged;
- Heat exchanger produced by Capstone Turbine Corporation (USA) of 74 kW unit heat capacity;
- BVG30-6.0 CD compressor with frequency controller (Italy).

Cogeneration complex consists of:

- Two compressors – one operating and the second is reserve;
- Automatic control system for four C65 for self-sufficient operation;

[6] "*Implementation of the biogas collection system at Chernihiv MSW landfill". The energy unit based on gas turbine cogeneration modules C65 for electricity generation by utilizing of Chernihiv MSW landfill gas for boiler-house auxiliaries at the Instrumental str., 17, Chernihiv. - Project. General explanatory note. Book 4. 1/02/04/10/179 - EN. / JSC "STIKS-OIL", 2011.*

- Two circulating pumps produced by Wilo company – one operating and the second is reserve, with maximum capacity of 350 $nm^3/h$.

The turbines operate in automatic mode; they don't require permanent maintenance personnel. Possibility of remote control of turbines from a PC is provided; alarm signal is displayed to a PC located at the boiler-house operator's room.

The modern ultrasonic heat flow meter CVTU-11M-2-RU50 produced by "Sempal" is envisaged to account the heat energy.

The filter with 25 micron filtration degree and with automatic condensate drain is installed at the input of compressor for gas cleaning.

C65-ICHP Microturbine specifications are given in Table. A.2.

| Parameter | Unit | Value |
|---|---|---|
| Electric power | kW | 65 |
| $Efficiency_e$ | % | 29 (±2) |
| Total efficiency (with heat recovery) | % | 80-90 |
| Heat energy output | kW*h | 74 |
| Landfill gas consumption (at NCV of 3850 kcal/$m^3$) | $nm^3$ | 56 |
| LxWxH | m | 2,2x0,76x2,4 |
| Weight | kg | 1121 |
| Interval between maintenance | hours | 8 000 |
| Service life before overhaul | hours | 60 000 |

*Table A.2. C65-ICHP micro turbine specifications*

LFG will be burned in cogeneration complex in 4 GTU, and its surplus will be burned in the boiler-house boilers.

Collected landfill gas will be completely utilized in the boiler-house, and the needs of the latter in non-heating period will be satisfied almost completely, while for covering of the considerably larger boiler-house needs during the heating period, in addition to LFG, the natural gas will be used as well.

For providing the stable combustion of LFG in boilers, replacement of boilers' burning devices is planned. Also, installation of additional unit for LFG account and reconstruction of auxiliary equipment of boiler-house for possibility of the LFG combustion are planned.

Technology of the LFG collection and utilization of its energy potential is widely used in world practice (for example, in Germany more than 400 such systems are installed, in Italy and Sweden – by over 100), however it is yet new for Ukraine, experience for its implementation is practically absent. Consequently, some complications typical for the process of implementation of new technologies and equipment are possible.

The generalized schedule of their implementation will be the following:

| Project phase | Period |
|---|---|
| Construction of the active system for collection of the LFG and flare equipment for possible excess and emergency LFG combustion. | 01/02/2011 – 30/06/2011 |
| Implementation of the transport to boiler-house and the utilization system of the energy potential of methane contained in it | 01/07/2011 – 31/12/2011 |

*Table A.3. Measures to be implemented*

**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:**

Project activity foresees construction of the collection and utilization system for landfill gas that at present is freely discharged into atmosphere. Collected LFG with ~50% of methane will be consumed for electricity and heat energy production at the district heating boiler-house, which will enable also to decrease consumption of the non-renewable fuel sources (TPPs operate on coal, at present the boiler-house is natural gas fired) and correspondingly to decrease additionally the GHG emissions. The system for possible excess and emergency flaring of LFG is also foreseen.

Calculated project annual averaged greenhouse gases emission reductions will be about 80 ths t $CO_2$e (for the nearest 2 years) as compared to the situation "business-as-usual".

Today in Ukraine there is no widespread practice of MSW landfills rehabilitation with construction of the system for landfill gas collection and utilization. Up to 2005 there was no national strict regulations as to MSW landfill designing and LFG collection. From January 1, 2006, the State Construction Standard of Ukraine "Municipal solid waste landfills. Basic designing" (DBN V.2.4-2-2005)[7] has come into effect, that regulates designing of newly building, reconstruction, technical re-equipment and revegetation of the MSW landfills, including entering of recommendations related to expedience of foreseeing of the system for LFG collection and utilization at designing of new MSW landfills. However this DBN does not contain requirements as to collection and utilization of LFG at existing landfills, thus the continuation of present situation at the Chernihiv landfill, that is the free releasing of LFG from MSW body without its collection, does not contradict the normative documents.

For an investor, preparation of the main MSW landfill body for implementation of the system for LFG collection and utilization is quite expensive and highly risky. Project implementation within JI mechanism will give the ability to use the additional money from ERUs selling, and, by such a way, to make the project more financially attractive, through decreasing project risks and increasing financial indicators.

Without the proposed JI project, the landfill will continue to work in usual mode and no emission reduction will occur.

[7] http://www.proxima.com.ua/dbn/pred.php?id=dbn-V.2.4-2-05.DOC

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

In course of project implementation, the following emission reductions will be achieved, at the stages of project implementation:

The First Kyoto Commitment period 2011 – 2012:

| | Years |
|---|---|
| Length of the crediting period | 1.5 |
| Year | Estimate of annual emission reductions in tonnes of $CO_2$ equivalent |
| 2011 | 35 420 |
| 2012 | 89 586 |
| Total estimated emission reductions over the first commitment period (tonnes of $CO_2$ equivalent) | **125 006** |
| Annual average of estimated emission reductions over the first commitment period (tonnes of $CO_2$ equivalent) | **83 337** |

*Table A.4: Estimated emission reductions during the first commitment period*

The Post-first commitment period 2013 – 2027:

| | Years |
|---|---|
| Length of the crediting period | 15 |
| Year | Estimate of annual emission reductions in tonnes of $CO_2$ equivalent |
| 2013 | 80 976 |
| 2014 | 73 202 |
| 2015 | 66 184 |
| 2016 | 59 847 |
| 2017 | 54 126 |
| 2018 | 48 961 |
| 2019 | 44 297 |
| 2020 | 40 087 |
| 2021 | 36 286 |
| 2022 | 32 854 |
| 2023 | 29 755 |
| 2024 | 26 957 |
| 2025 | 24 432 |
| 2026 | 22 151 |
| 2027 | 20 092 |
| Total estimated emission reductions over the post-first commitment period (2013 – 2027) (tonnes of $CO_2$ equivalent) | **660 206** |
| Annual average of estimated emission reductions over the post- first commitment period (tonnes $CO_2$ equivalent) | **44 014** |

*Table A.5: Estimated emission reductions after the first commitment period (2013-2027)*

Total amount of Emission Reductions over the crediting period:

| | Years |
|---|---|
| Length of the crediting period | 16.5 |
| | Estimate of annual emission reductions in tonnes of $CO_2$ equivalent |
| Total estimated emission reductions over the crediting period 2011 – 2027 (tonnes of $CO_2$ equivalent) | **785 212** |
| Annual average of estimated emission reductions over the crediting period (tonnes of $CO_2$ equivalent) | **47 589** |

*Table A.6: Estimated total amount of Emission Reductions over the crediting period*

Thus the estimated amount of emission reductions over the first Kyoto commitment period (2011-2012) is **125 006** tonnes of $CO_2$e, over the whole crediting period – **785 212** tonnes of $CO_2$e.

For more detailed information please see Appendix A (Excel file PDD_LFG_Appendix_A). The values in tables in this section A.4.3.1 correspond to the values in the Excel file, and are rounded to integers.

## A.5. Project approval by the Parties involved:

The project was initiated in 2009.

The main milestones of the project history and approval:

October, 2009 – Agreement was signed between the OJSC "Oblteplocomunenergo" and the Institute of Engineering Ecology on development of the Joint Implementation Project on Green House Gas Emissions Reduction from Chernihiv MSW landfill (No. 668 dated 14.10.2009). Accepted as the project starting date.

December, 2009 – Agreement was signed between the OJSC "Oblteplocomunenergo" and the Department of Municipal Household of the Chernihiv City Council for services, by which the OJSC "Oblteplocomunenergo" has undertook the recultivation of the Chernihiv MSW landfill (No. 616 dated 16.12.2009).

March, 2010 – the National Environmental Investment Agency of Ukraine has issued the Letter of Endorsement for the JI Project "Landfill gas capture and utilization at Chernihiv MSW landfill" (No. 181/23/7 dated 03.03.2010).

According to the adopted procedure, the LoAs by Parties involved are expected to be issued after the project determination.

## SECTION B. Baseline

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

According to the paragraph 9(b) of the «*Guidance on criteria for baseline setting and monitoring*» *(version 02)*[8], the approved CDM methodologies may be used in the process of PDD development for JI projects.

For the baseline scenario development of the proposed project, the approved consolidated baseline methodology ACM0001 *"Consolidated baseline and monitoring methodology for landfill gas project activities" (version 11, May 2009)*[9] and *"Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" (version 05.1.0, June 2011)*[10] were used.

**Justification of the baseline methodology chosen:**

The approved consolidated baseline methodology ACM0001 is applicable to landfill gas capture project activities, where the baseline scenario is the partial or total atmospheric release of the landfill 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), including where the LFG displaces use of fossil fuel either in a boiler or in an air heater; and/or

(c) The captured gas is used to supply consumers through natural gas distribution network.

In the proposed project:

- the baseline scenario is the continuation of total uncontrolled atmospheric release of the landfill gas;
- the project scenario foresees collection and utilization of the landfill gas for thermal energy production in the boiler-house, with replacing the corresponding amount of natural gas;
- in excess and emergency cases the LFG will be flared.

Therefore, the project meets the applicability criteria of consolidated baseline methodology ACM0001.

Detailed description of formulae used to calculate the baseline and emission reductions is provided in Section D.1.2.2, calculations are provided in Appendix A.

The key information and data used to establish the baseline are presented in tabular form below.

[8] http://ji.unfccc.int/Ref/Documents/Baseline_setting_and_monitoring.pdf

[9] http://cdm.unfccc.int/UserManagement/FileStorage/UJBDVFYLQKSEWCM73XG14Z692TRHO0

[10] *http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v5.1.0.pdf*

**Data and parameters not monitored**

These data and parameters are to be determined once before start of the project activity.

| **Data / Parameter** | ***Regulatory requirements relating to landfill gas*** |
|---|---|
| Data unit | n/a |
| Description | Regulatory requirements relating to landfill gas in Ukraine |
| Time of determination/monitoring | Once before start of the project activity |
| Source of data (to be) used | Publicly available information of the Ukrainian regulatory requirements relating to landfill gas |
| Value of data applied (for ex ante calculations/determinations) | n/a |
| Justification of the choice of data or description of measurement methods and procedures (to be) applied | n/a |
| QA/QC procedures (to be) applied | n/a |
| Any comment | The information though recorded annually, is used for changes to the adjustment factor (AF) or directly $\boldsymbol{MD_{BL,y}}$ at renewal of the credit period. Relevant regulations for LFG project activities shall be updated at renewal of each credit period. Changes to regulation should be converted to the amount of methane that would have been destroyed/combusted during the year in the absence of the project activity ($\boldsymbol{MD_{BL,y}}$). Project participants should explain how regulations are translated into that amount of gas |

| **Data / Parameter** | $\boldsymbol{GWP_{CH4}}$ |
|---|---|
| Data unit | t $CO_2$e/ t $CH_4$ |
| Description | Global warming potential of $CH_4$ |
| Time of determination/monitoring | Once before start of the project activity |
| Source of data (to be) used | 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2 |
| Value of data applied (for ex ante calculations/determinations) | 21 for the first commitment period. Shall be updated according to any future COP/MOP decision |
| Justification of the choice of data or description of measurement methods and procedures (to be) applied | n/a |
| QA/QC procedures (to be) applied | n/a |
| Any comment | n/a |

| Data / Parameter | $D_{CH4}$ |
|---|---|
| Data unit | t $CH_4$/ths. $m^3CH_4$ |
| Description | Methane Density |
| Time of determination/monitoring | Once before start of the project activity |
| Source of data (to be) used | ACM0001 "Consolidated baseline and monitoring methodology for landfill gas project activities" (version 11) |
| Value of data applied (for ex ante calculations/determinations) | 0.7168 |
| Justification of the choice of data or description of measurement methods and procedures (to be) applied | n/a |
| QA/QC procedures (to be) applied | n/a |
| Any comment | At standard temperature and pressure (0 degree Celsius and 1,013 bar) |

| Data / Parameter | $BE_{CH4,SWDS,y}$ |
|---|---|
| Data unit | t $CO_2e$ |
| Description | Methane generation from the landfill in the absence of the project activity in year *y* |
| Time of determination/monitoring | Once before start of the project activity |
| Source of data (to be) used | "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" (version 05.1.0) |
| Value of data applied (for ex ante calculations/determinations) | Estimated using the actual amount of waste disposed in the landfill as per the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" (version 05.1.0) |
| Justification of the choice of data or description of measurement methods and procedures (to be) applied | n/a |
| QA/QC procedures (to be) applied | n/a |
| Any comment | Used for *ex ante* estimation of the amount of methane that would have been destroyed/combusted during the year *y* |

| **Data / Parameter** | $\varphi$ |
|---|---|
| Data unit | - |
| Description | Model correction factor to account for model uncertainties |
| Time of determination/monitoring | Once before start of the project activity |
| Source of data (to be) used | "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" (version 05.1.0) |
| Value of data applied (for ex ante calculations/determinations) | 0.9 |
| Justification of the choice of data or description of measurement methods and procedures (to be) applied | n/a |
| QA/QC procedures (to be) applied | n/a |
| Any comment | Given the uncertainties associated with the model and in order to estimate emission reductions in a conservative manner, a discount of 10% is applied to the model results. |

| **Data / Parameter** | ***OX*** |
|---|---|
| Data unit | - |
| Description | Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste) |
| Time of determination/monitoring | Once before start of the project activity |
| Source of data (to be) used | 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5 |
| Value of data applied (for ex ante calculations/determinations) | 0 |
| Justification of the choice of data or description of measurement methods and procedures (to be) applied | n/a |
| QA/QC procedures (to be) applied | n/a |
| Any comment | 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. |

| **Data / Parameter** | ***f*** |
|---|---|
| Data unit | - |
| Description | Fraction of methane captured at the SWDS and flared, combusted or used in another manner |
| Time of determination/monitoring | Once before start of the project activity |
| Source of data (to be) used | Landfill management |
| Value of data applied (for ex ante calculations/determinations) | 0 |
| Justification of the choice of data or description of measurement methods and procedures (to be) applied | n/a |
| QA/QC procedures (to be) applied | n/a |
| Any comment | Before project start no LFG is captured and utilized at the landfill, thus f=0 |

| **Data / Parameter** | ***F*** |
|---|---|
| Data unit | - |
| Description | Fraction of methane in the LFG (volume fraction) |
| Time of determination/monitoring | Once before start of the project activity |
| Source of data (to be) used | 1996 IPCC Guidelines for National Greenhouse Gas Inventories |
| Value of data applied (for ex ante calculations/determinations) | 0.5 |
| Justification of the choice of data or description of measurement methods and procedures (to be) applied | n/a |
| QA/QC procedures (to be) applied | n/a |
| Any comment | 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 value of 0.5 is recommended by IPCC. |

| **Data / Parameter** | $DOC_f$ |
|---|---|
| Data unit | - |
| Description | Fraction of degradable organic carbon (DOC) that can decompose |
| Time of determination/monitoring | Once before start of the project activity |
| Source of data (to be) used | 1996 IPCC Guidelines for National Greenhouse Gas Inventories |
| Value of data applied (for ex ante calculations/determinations) | 0.5 |
| Justification of the choice of data or description of measurement methods and procedures (to be) applied | n/a |
| QA/QC procedures (to be) applied | n/a |
| Any comment | n/a |

| **Data / Parameter** | ***MCF*** |
|---|---|
| Data unit | - |
| Description | Methane correction factor |
| Time of determination/monitoring | Once before start of the project activity |
| Source of data (to be) used | 1996 IPCC Guidelines for National Greenhouse Gas Inventories, volume 5 |
| Value of data applied (for ex ante calculations/determinations) | 0.8 |
| Justification of the choice of data or description of measurement methods and procedures (to be) applied | The following values for MCF should be used:<br>• 1.0 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;<br>• 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 pondage; and (iv) gas ventilation system;<br>• 0.8 for **unmanaged solid waste disposal sites . deep and/or with high water table**. This comprises all SWDS not meeting the criteria 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;<br>• 0.4 for **unmanaged-shallow solid waste disposal sites.** This comprises all SWDS not meeting the criteria of managed SWDS and which have depths of less than 5 meters. |
| QA/QC procedures (to be) applied | n/a |
| Any comment | Methane correction factor 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** | $DOC_j$ |
|---|---|
| Data unit | - |
| Description | Fraction of degradable organic carbon (by weight) in the waste type *j* |
| Time of determination/monitoring | Once before start of the project activity |
| Source of data (to be) used | 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5 |
| Value of data applied (for ex ante calculations/determinations) | The following values for the different waste types *j* should be applied: |

| Waste type *j* | $DOC_j$ (% wet waste) |
|---|---|
| Wood and wood products | 43 |
| Pulp, paper and cardboard (other than sludge) | 40 |

| | | |
|---|---|---|
| | Food, food waste, beverages and tobacco (other than sludge) | 15 |
| | Textiles | 24 |
| | Garden, yard and park waste | 20 |
| | Rubber and Leather | 39 |
| | Glass, plastic, metal, other inert waste | 0 |
| Justification of the choice of data or description of measurement methods and procedures (to be) applied | n/a | |
| QA/QC procedures (to be) applied | n/a | |
| Any comment | n/a | |

| **Data / Parameter** | $k_j$ | | |
|---|---|---|---|
| Data unit | - | | |
| Description | Decay rate for the waste type *j* | | |
| Time of determination/monitoring | Once before start of the project activity | | |
| Source of data (to be) used | 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5 | | |
| Value of data applied (for ex ante calculations/determinations) | Waste type (j) | | Boreal and Temperate (MAT≤20°C) Wet (MAP/PET >1) |
| | Slowly degrading | Pulp, paper and cardboard (other than sludge), textiles | 0.06 |
| | | Wood, wood products and straw | 0.03 |
| | Moderately degrading | Other (non-food) organic putrescible garden and park waste | 0.10 |
| | Rapidly degrading | Food, food waste, sewage sludge, beverages and tobacco | 0.185 |
| | MAT – mean annual temperature, MAP –mean annual precipitation, PET – potential evapotranspiration. MAP/PET is the ratio between the mean annual precipitation and the potential evapotranspiration | | |
| Justification of the choice of data or description of measurement methods and procedures (to be) applied | n/a | | |
| QA/QC procedures (to be) applied | n/a | | |
| Any comment | MAT = 6,7°C, MAP = 599 mm, PET = 540 mm; MAP/PET = 1.1 | | |

| Data / Parameter | $FC_x$ |
|---|---|
| Data unit | ths $m^3$ |
| Description | Amount of the natural gas consumed by the boiler-house during the previous year before the start of project activity |
| Time of determination/monitoring | Once before start of the project activity |
| Source of data (to be) used | Boiler-house management |
| Value of data applied (for ex ante calculations/determinations) | 5 839.568 |
| Justification of the choice of data or description of measurement methods and procedures (to be) applied | Measurements are taken by gas meters at the boiler-house |
| QA/QC procedures (to be) applied | Equipment is inspected and calibrated according to the State Standard of Ukraine No.2708:2006 "Metrology. Calibration of measuring equipment. The organization and procedure"[11]. |
| Any comment | n/a |

| Data / Parameter | $NCV_x$ |
|---|---|
| Data unit | GJ / ths $m^3$ |
| Description | Net calorific value of the natural gas consumed by the boiler-house during the previous year before the start of project activity |
| Time of determination/monitoring | Once before start of the project activity |
| Source of data (to be) used | Boiler-house management |
| Value of data applied (for ex ante calculations/determinations) | 34.72 |
| Justification of the choice of data or description of measurement methods and procedures (to be) applied | Fuel Supplier's Report |
| QA/QC procedures (to be) applied | n/a |
| Any comment | n/a |

[11] http://oscill.com/files/27082006.pdf

**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:**

Under the scenario "business-as-usual", emissions of the LFG containing methane from the landfill to the atmosphere will take place continuously. For changing of this situation there are no financial or judicial reasons.

By the project scenario the methane in the content of LFG will be collected and utilized by means of combustion in boiler-house in GTUs and in boilers with production of electrical and heat energy, as described in the Section A.2.

Green-house gas emission reduction from Chernihiv landfill will be essentially reduced in comparison with that which would be in case of absence of this project.

The approved consolidated baseline methodology ACM0001 *"Consolidated baseline and monitoring methodology for landfill gas project activities" (version 11)*[12] is used for the proposed project.

**Additionality of the project**

According to ACM0001, project additionality is demonstrated and assessed with using the «*Tool for the demonstration and assessment of additionality» (version 5.2)*[13] (Fig. B.1).

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

***Sub-step 1a: Define alternatives to the project activity:***

There are 3 alternatives to the project activity:

Alternative (1): Continuation of the current situation (no project activity or other alternatives undertaken); LFG is released into atmosphere, no LFG capture. Thermal energy is produced by existing natural gas fired boiler-house, and electric energy for boiler-house needs is completely supplied from the power grid.

The local administrations in Ukraine have not enough financial resources for investing in recultivation of the MSW landfills, as well as technical experience for implementation of LFG capture and utilization. The tariffs of companies which are engaged in transporting and burial of wastes at the MSW landfills do not provide profits sufficient for investing in the system of the LFG collection. This scenario reflects the common practice in Ukraine, meets the present situation ("business-as-usual") and does not need any additional investments. This is the most probable scenario, and it is considered to the baseline scenario for the project.

Alternative (2): Extraction of LFG from the MSW landfill and its flaring with the purpose of methane emission reduction (without JI mechanism). Utilization of the LFG for electricity and thermal energy production is absent, electricity is taken from grid, thermal energy is produced by existing natural gas fired boiler-house.

This alternative scenario fully meets valid legal and ecological standards. But it requires considerable additional non-recoupmentable investments for the reconstruction of landfill, installation of the system for LFG catching and flaring. Such project activity does not give any refinancing - for implementation of the alternative scenario (2) there are investment barriers. Very low probable scenario.

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[12] http://cdm.unfccc.int/UserManagement/FileStorage/UJBDVFYLQKSEWCM73XG14Z692TRHO0
[13] http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html

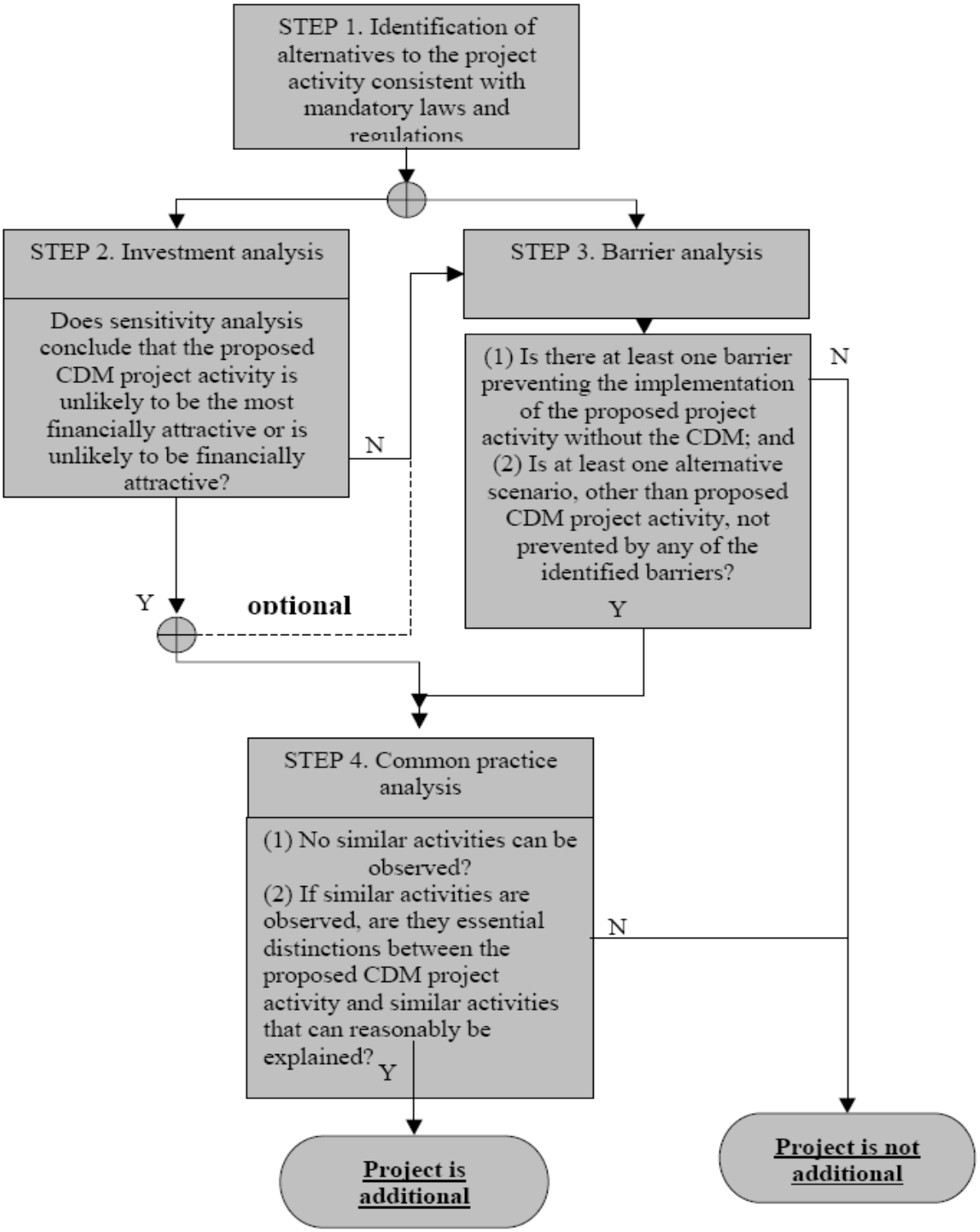


*Figure B.1. Steps for demonstration of additionality*

Alternative (3): Extraction and collection of LFG from the MSW landfill and its utilization in the Energy Complex for production of electricity and heat energy, and in existing boiler-house for production of heat energy and hot water-supply (the proposed project activity without JI mechanism). There is substitution of fossil fuel (natural gas) by a renewable energy source – LFG, and substituting for electricity, that a boiler house consumes and electricity production to the grid.

Needs very high investments for the reconstruction of landfill, installation of the systems for LFG catching, emergency flaring, transporting from the MSW landfill to the boiler-house, and implementation of EK for the LFG combustion. This scenario is characterized by the high risks through the necessity of attracting of large investments with long-term recoupment, that it is especially problematic in the conditions of financial crisis. In addition, the organizational barriers exist, as the technology of the LFG combustion in a boiler is new for Ukraine. The necessity for training of personnel arises. For implementation of the alternative scenario (3) there are investment and organizational barriers. Very low probable scenario.

**Outcome of Step 1a:** Three realistic and credible alternative scenarios to the project activity, which can be taken into account at determination of baseline scenario, are identified.

***Sub-step 1b: Consistency with mandatory laws and regulations:***

All three alternative baseline scenarios are in compliance with mandatory applicable legal and regulatory requirements of Ukraine in this field, including the Law of Ukraine "On the local self-administration in Ukraine"[14] (article 30), the Law of Ukraine "On the wastes"[15] and the State Building Norm DBN V.2.4-2-2005 "Municipal solid waste landfills. Basic provisions for designing"[16]. It should be noted that DBN V.2.4-2-2005 contains the requirements on collection and flaring/utilization of LFG after closing of a MSW landfill, but covers designing of the new building, reconstruction, technical re-equipment and recultivation of MSW landfills, and contains mainly recommendations on designing of the new landfills, and also in particular requirements on building of the degassing system at the technical stage of recultivation of ground after closing of the landfill. Valid Ukrainian legislation does not require the obligatory degassing of existing operating MSW landfills.

Besides, even valid legal requirements as to the proper exploitation of the MSW landfills are not satisfied during long period through existence of financial barriers; thus non-sticking of these requirements is wide-spread in Ukraine.

**Outcome of Step 1b:** According to the valid Ukrainian laws and regulations, all 3 defined alternative scenarios to the project activity are in compliance with mandatory legislation and regulations, and may be considered as possible scenarios.

**Step 2. Investments analysis**

According to the "Tool for the demonstration and assessment of additionality" (version 5.2)[17], one of the following analysis methods should be applied: (I) simple cost analysis (in case of no financial or economic benefits other than JI related income), otherwise (II) investment comparison analysis (if there are project alternatives) or (III) benchmark analysis.

***Sub-step 2a: Determine appropriate analysis method***

As the proposed JI project creates other benefits, except for an income from realization of the JI mechanism, the simple cost analysis (option I) is not used here. The investment comparison analysis (option II) also is not appropriate, as the baseline scenario does not foresee investments. Thus, the project developers have chosen the benchmark analysis (option III).

[14] http://zakon1.rada.gov.ua/cgi-bin/laws/main.cgi?nreg=280%2F97-%E2%F0

[15] http://search.ligazakon.ua/l_doc2.nsf/link1/Z980187.html

[16] http://www.proxima.com.ua/dbn/pred.php?id=dbn-V.2.4-2-05.DOC

[17] http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html

***Sub-step 2b: Option I. Apply simple cost analysis***

Not applicable.

***Sub-step 2b: Option II. Apply investment comparison analysis***

Not applicable.

***Sub-step 2b: Option III. Apply benchmark analysis***

Economical attractiveness of the project alternative 3 was estimated based on calculation of the Net Present Value (NPV) and the Internal Rate of Return (IRR). Attractiveness of this variant, as an alternative to the current situation (alternative 1: LFG capture and utilization are absent), is assessed by comparison of the corresponding IRR with the typical integral interest rate of the Ukrainian banks (as control point). According to the reports of the National bank of Ukraine, the integral interest rate in foreign currency in September, 2009, was 10.2 %[18,].

The long term financial model requires adjustment for inflation, which may be done by deriving the real IRR benchmark from the above nominal rate with taking into account an average inflation index for EuroZone (since financial calculations are made in Euros).

IRRr = (IRRn+1)/(I+1)-1,

where IRRr- is real IRR, IRRn – nominal IRR, I – inflation rate.

The average inflation index for EuroZone for the 12 year period preceding project start (1997-2008) is 2.1 %[19].

Thus the final benchmark value (IRRr) is:

IRRr = 1.102 / 1.021 - 1 = 0.079 = 7.9 %.

This value of 7.9 % is considered as the benchmark value for the benchmark analysis of this project.

The financial indicators Net Present Value (NPV) and Internal Rate of Return (IRR) were calculated for the project and alternative baseline scenarios, results are provided in Appendix B. (file Excel PDD_LFG_ Appendix_B).

***Sub-step 2c: Calculation and comparison of financial indicators (only applicable to Options II and III):***

The total capital investments into the systems for collection and flaring of the LFG (alternative scenario 2) are estimated as 3 640.92 thousand Euro. This sum includes design development, construction, field tests, implementation of the system for collection and local transporting of the LFG, installation of the flaring system.

The alternative scenario 2 does not foresee any profit which can cover investment costs, therefore the NPV for this scenario is constantly negative. Thus, without an income from selling of emission reduction units this scenario is not economically beneficial.

For the alternative scenario 3, total investments are estimated as 5 035.05 thousand Euro. This sum includes the costs for alternative scenario 2, plus installation of the gas processing equipment, building of the trunk pipeline to boiler-house, installation of the EC and re-equipment of the boiler-house for combustion of the LFG.

NPV: – 2 464.4 thousand euro,
IRR: – 3.1 %.

[18] *http://bank.gov.ua/Fin_ryn/Pot_tend/2009.zip*

[19] *http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&language=en&pcode=tsieb060&tableSelection=1&footnotes=yes&labeling=labels&plugin=1*

That certifies financial unattractiveness of this scenario.

Thus, reconstruction of landfill with utilization of LFG in a boiler-house without the additional external financing (grants, subsidies, subventions, etc) is practically impossible. Ukrainian landfill operators can not obtain credits from the Ukrainian banks, where the rate of annual return through the high risks usually is up to 25% in UAH, up to 15% in USD and up to 14% in euro[20]. In present situation practically only the state financing can be used for such purposes. But the Ukrainian government does not have enough funds for this.

NPV and IRR for the project scenario with the JI mechanisms at the ERU price of 10 euro/ t $CO_2$eq will be:

NPV: 2 243.7 thousand euro,
IRR: 17.0 %.

In this case project becomes investment attractive, as IRR becomes higher then the benchmark value above.

Thus, utilization of the JI mechanism substantially increases attractiveness of the project, and in result makes its implementation financially more attractive than placing of funds to a deposit.

**Outcome of Step 2c:** The IRR values for analyzed scenarios are substantially lower than the typical deposit rates of the Ukrainian banks. Project activity without JI mechanism is not financially attractive, however using of the JI mechanism substantially improves the attractiveness of project, and in result makes its implementation financially attractive.

***Sub-step 2d: Sensitivity analysis*** (only applicable to Options II and III):

The financial analysis was made after two sensitivity parameters: change of price of the consumed at present energy sources: fuel – natural gas, and electricity.

Values of the NPV and IRR for the proposed project in dependence on the three variants of natural gas and electricity prices is represented in Table B.1.

| Range of variation | 100% | 125% | 150% |
|---|---|---|---|
| NPV, ths EUR | -2464.4 | -1938,0 | -1411.5 |
| IRR, % | -3.1 | -0.4 | 2.1 |

*Table B.1. The NPV and IRR calculation for different prices for natural gas and electricity*

As it is seen from Table B.1, the project NPV without JI financing, even for the prognosis prices of natural gas and electricity in the range of by +50 % comparing to the prices by which the OJSC "Oblteplocomunenergo" buys natural gas and electricity at present, has negative values until the end of the project lifetime, and the corresponding project IRR values does not approach the control point.

Results of the IRR calculations confirm the reliability of the financial analysis above.

[20] http://news.finance.ua/ru/~/4/0/all/2010/07/01/199189

**Outcome of Step 2d:** Sensitivity analysis has shown that the project financial indexes are sensible to the price of fuel and electricity that are used at the boiler-house. The basic conclusion is that the higher fuel and electricity prices make project more beneficial.

**Outcome of Step 2:** Investment and sensitivity analysis has shown that the project is not financially attractive and beneficial without JI mechanism. The use of the JI mechanism substantially improves the attractiveness of project, and makes it financially attractive with income from ERU sale.

**Step 3. Barrier analysis**

***Sub-step 3a: Identifying barriers that would prevent the implementation of the proposed JI project activity:***

***Investment barriers***

For the investor the project of such kind is very expensive and has high risks. In spite of that OJSC "Oblteplocomunenergo" is a quite successful company, the company re-invests the majority of its funds in its direct activities. Thus the deficit of the own funds exists that the enterprise can spend to realization of the project.

No similar activities have been implemented in Ukraine, there are only 3 JI project PDDs published for planning similar activities, and even the test borings at three landfills in Ukraine were made only with using grants.

***Technological barriers***

Today in Ukraine there is no widespread practice on MSW landfills rehabilitation with construction of the system for LFG collection and utilization. Proposed technologies for LFG collection are not yet widely approved. The qualification of operational personal is not always high enough for operate and maintain the new technologies.

***Organizational barriers***

The proposed project is one of the first projects of such kind in Ukraine. This will be the new practice for Ukraine, at least during some time. The work experience on implementation of landfill gas collection and utilization system is absent.

**Outcome of Step 3a:** There are serious barriers identified that may prevent one or more alternative scenarios to occur.

***Sub-step 3b: Show that the identified barriers would not prevent the implementation of at least one of the alternatives (except the proposed project activity):***

The investment analysis and above mentioned barriers obviously demonstrate, that continuation of the existing situation is the cheapest and most probable scenario without any barriers.

**Outcome of Step 3b:** Identified barriers would not prevent the implementation of at least one alternative scenario - continuation of the "business-as-usual" activity.

**Outcome of Step 3.** There is one alternative scenario, except for the proposed JI project, application of which would not be prevented by any of the identified barriers. The investment barrier is absent in the

alternative scenario (1) which is continuation of the usual activity of landfill. This scenario farther will be considered as the baseline scenario for the proposed project.

**Step 4: Common practice analysis**

***Sub-step 4a: Analyze other activities similar to the proposed project activity:***

Without regard to the entry into force in 2006 of the State building norms DBN V.2.4-2-2005 "Municipal solid waste landfills. Basic provisions for designing"[21], placing of wastes in Ukraine in most cases is continued to be at dumps, which were not even designed as landfills, covering of their surfaces with soil is absent, thus uncontrolled emissions of LFG into atmosphere as well as formation of filtrate take place.

No information on the implemented systems for collection and utilization of LFG (beyond the frames of the JI/CDM projects, see ***Sub-step 4b)***, except for the demonstration project of 3 wells and flaring at the Luhansk MSW landfill, all the more on recultivated landfills with LFG utilization, was available upon the date of the PDD development.

***Sub-step 4b: Discuss any similar Options that are occurring:***

The real possibilities for installation of the systems for collection and utilization of landfill gas at the MSW landfills in Ukraine appeared only with the arising of possibility to use the JI mechanism for such projects.

At present time several similar JI projects in Ukraine are already known (for example, projects on LFG collection at landfills in Lviv, Mariupol and Yalta and Alushta cities), which are at different stages of development from identification of project idea (PIN) till development of project design document (PDD) of the JI project and working documents of technical project and starting of implementation.

However according to the «*Tool for the demonstration and assessment of additionality» (version 5.2)*[22], the "other JI/CDM projects activities are not to be included in this analysis".

**Outcome of Step 4:** Since there are no implemented similar projects in Ukraine, there is no necessity and possibility to conduct the analysis of similar project activity.

**Conclusion**

Since all steps of additionality test are satisfied, it is possible to make conclusion that the project activity is additional.

[21] http://www.proxima.com.ua/dbn/pred.php?id=dbn-V.2.4-2-05.DOC
[22] http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-01-v5.2.pdf/history_view

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

Greenhouse Gas Sources and Project Boundaries in current (baseline) and project scenarios are shown at the Figures B.2 and B.3:

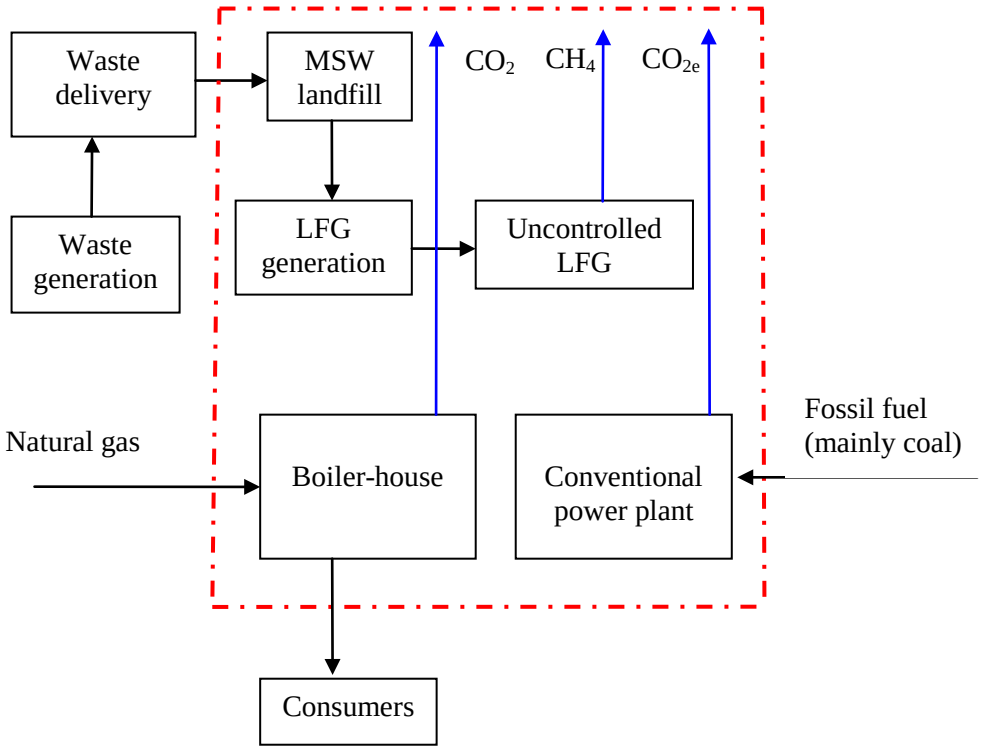


*Fig. B.2. Project Boundaries for the current (baseline) scenario.*

The project boundary is outlined by the red dotted line. The project boundary includes all sources and emissions which are under influence or control by the project.

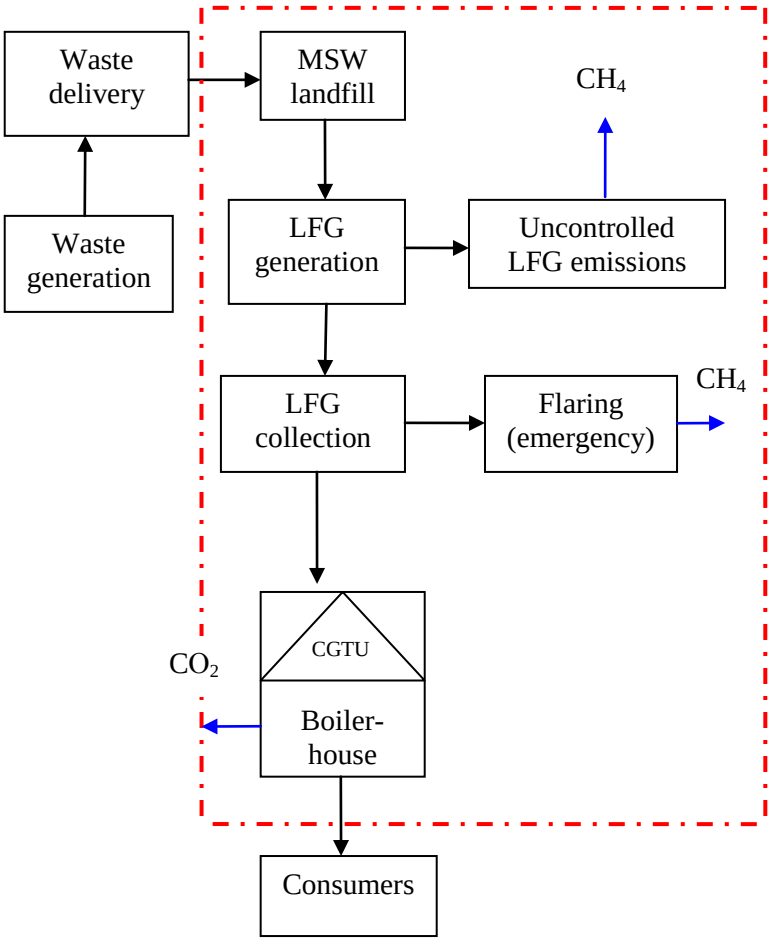


*Fig.B.3. Project Boundaries for the Project scenario*

According to the ACM0001, the summary of GHG and their potential sources in the project boundary and justification/explanation where gases and sources are included or not included is listed in Table B.2.

| | Source | Gas | Included? | Justification / Explanation |
|---|---|---|---|---|
| Baseline | Emissions from decomposition of waste at the landfill site | $CH_4$ | Yes | The major source of emissions |
| | | $N_2O$ | 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 thermal energy generation at boiler-house | $CO_2$ | Yes | Thermal energy generation is included in the project activity |
| | | $CH_4$ | No | Excluded for simplification. This is conservative |
| | | $N_2O$ | No | Excluded for simplification. This is conservative |
| | Emissions from electricity production to power grid | $CO_2$ | Yes | $CO_2e$ emissions from production to power grid of the consumed electricity which will be replaced by electricity produced from LFG in project scenario |
| | | $CH_4$ | No | Excluded for simplification. This is conservative |
| | | $N_2O$ | No | Excluded for simplification. This is conservative |
| Project activity | LFG flaring | $CO_2$ | No | $CO_2$ emissions from LFG flaring are not accounted |
| | | $CH_4$ | Yes | Emissions from methane not combusted in the flare (default value of 10%) |
| | | $N_2O$ | No | Excluded for simplification. This emission source is assumed to be very small |
| | Emissions from thermal energy generation at boiler-house | $CO_2$ | Yes | On-site fossil fuel consumption may be present for heat energy production |
| | | $CH_4$ | 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 electricity use | $CO_2$ | Yes | May be 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. |

*Table B.2: Summary of gases and sources included in the project boundary and justification / explanation where gases and sources are not included*

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

The baseline study was started in 2009 and completed on 14/04/2011.

The baseline is determined by the Institute of Engineering Ecology (IEE), project developer (is not the project participant), and OJSC "Oblteplocomunenergo", project supplier (is the project participant).

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## SECTION C. Duration of the project / crediting period

### C.1. Starting date of the project:

Starting date of the project: 14/10/2009.

This is the data when the Agreement was signed between the OJSC "Oblteplocomunenergo" and the Institute of Engineering Ecology on development of the Joint Implementation Project on Green House Gas Emissions Reduction from Chernihiv MSW landfill (No. 668 dated 14.10.2009).

### C.2. Expected operational lifetime of the project:

According to the commonly adopted estimation, the minimum duration of the considerable LFG generation after closing of a landfill is 15 years. Since closing of the Chernihiv MSW landfill is planned for 2012, the expected duration of operational lifetime of the project makes at least 16 years 6 months (198 months): from 01.07.2011 till 31.12.2027.

### C.3. Length of the crediting period:

Generation of the ERUs corresponds to the first commitment period of the Kyoto Protocol and is scheduled for 1.5 years (18 months): from 01.07.2011 till 31.12.2012.

The crediting period during the Post-first commitment period is 15 years (180 months): from 01.01.2013 till 31.12.2027.

The total length of the crediting period is 16.5 years (198 months): from 01.07.2011 till 31.12.2027.

## SECTION D. Monitoring plan

### D.1. Description of monitoring plan chosen:

Monitoring methodology of the project in accordance with approved consolidated baseline methodology ACM0001 "Consolidated baseline methodology for the projects activity from landfill gas" (version 11)[23] is based on the direct measurement of the amount of captured and destroyed landfill gas.

The main variables that need to be determined in context of this project are the quantity of methane actually captured, quantity of methane used to generate thermal energy, and quantity of methane flared.

Monitoring plan foresees the permanent measuring of the amount and quality of landfill gas, which is being collected and is supplied to the boiler-house for combustion in boilers and EK (GTU with cogeneration). Measurements are to be carried out with the use of flow meters and gas analyzers. Temperature and pressure of the landfill gas will also be measured with the gas analyzers.

In case when for the excess and emergency LFG combustion the enclosed flare will be used, its efficiency will be determined according to the "Tool to determine project emissions from flaring gases containing methane" (Version 01, 15 Dec 2006)[24].. This tool provides for continuous monitoring of the methane destruction efficiency of the flare (flare efficiency), or using a 90% default value provided that flare parameters (temperature and flow rate of residual gas) are in compliance with manufacturer's specification (otherwise a 50% default value for the flare efficiency should be used for the calculations for the specific hour).

Continuous measuring of the electricity taken from grid for operation of the methane collection and processing system will be provided as well.

The detailed data management system was developed for the control and archiving of all necessary information. The control system for information saving includes electronic and paper records, which are made by the operator of landfill, as well as employees of the production-technical department and accounting department of the OJSC "Oblteplocomunenergo".

Monitoring of the gas stream intensity, pressure and temperature, methane content is to be executed by the control system with the measuring equipment.

See Annex 3 "Monitoring plan" for details.

[23] http://cdm.unfccc.int/UserManagement/FileStorage/UJBDVFYLQKSEWCM73XG14Z692TRHO0

[24] http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-06-v1.pdf

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

| 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 |
| | | | | | | | | |

This Table is left blank on purpose, since Option 2 is chosen.

| 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 |
| | | | | | | | | |

This Table is left blank on purpose, since Option 2 is chosen.

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

This sub-section is left blank on purpose, since Option 2 is chosen.

**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 *(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 |
| 1.$\boldsymbol{LFG_{total,y}}$ | Total amount of landfill gas captured, at normal temperature and pressure, in year *y* | Landfill management | $m^3$ | (m) | Continuous | 100% | Electronic | Measurements will be executed with the flow meter. Data will be aggregated monthly and annually |
| 2.$\boldsymbol{LFG_{flared,y}}$ | Amount of landfill gas flared, at normal temperature and pressure, in year *y* | Landfill management | $m^3$ | (m) | Continuous | 100% | Electronic | Measurements will be executed with the flow meter. Data will be aggregated monthly and annually |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 3.$LFG_{electricity,y}$ | Amount of landfill gas combusted in CGTU, at normal temperature and pressure, in year *y* | Landfill / CGTU management | $m^3$ | (m) | Continuous | 100% | Electronic | Measurements will be executed with the flow meter. Data will be aggregated monthly and annually |
| 4.$LFG_{thermal,y}$ | Amount of landfill gas combusted in boiler, at normal temperature and pressure, in year *y* | Landfill / boiler-house management | $m^3$ | (m) | Continuous | 100% | Electronic | Measurements will be executed with the flow meter. Data will be aggregated monthly and annually |
| 5.$PE_{flare,y}$ | Project emissions from flaring of the residual gas stream in year *y* | PDD management | $tCO_2e$ | (m/c) | See comments | n/a | Electronic | Will be monitored according to the "Tool to determine project emissions from flaring gases containing methane"[25] |
| 6.$w_{CH4,y}$ | Methane fraction in the LFG in year *y* | Landfill management | $m^3$ $CH_4$ / $m^3$ LFG | (m) | Continuous | 100% | Electronic | Will be measured by qualitative gas analyzer |
| 7.$T$ | LFG temperature | Landfill management | °C | (m) | Continuous | 100% | Electronic | Measured to determine the density of methane $D_{CH4}$ |

[25] http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-06-v1.pdf/history_view

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 8.$P$ | LFG pressure | Landfill management | Pa | (m) | Continuous | 100% | Electronic | Measured to determine the density of methane $D_{CH4}$ |
| 9.$EL_{LFG,y}$ | Total amount of electricity generated using LFG | CGTU management | MWh | (m) | Continuous | 100% | Electronic | Will be measured with electric power meter |
| 10. $EC_y$ | Total amount of electricity consumption by the project activity during the year *y* | Landfill / boiler-house management | MWh | (m) | Continuous | 100% | Electronic | Will be measured with electric power meter |
| 11.$EL_{EX,LFGy}$ | Total amount of electricity output to the grid during the year *y* | CGTU management | MWh | (m) | Continuous | 100% | Electronic | Will be measured with electric power meter |
| 12..$ET_{LFG,y}$ | Total amount of heat generated using LFG | CGTU management | GJ | (m) | Continuous | 100% | Electronic | The temperature, pressure and mass flow rate will be measured |
| 13.$FC_y$ | Amount of the natural gas consumed by boilers, in year *y* | Boiler-house management | $m^3$ | (m) | Continuous | 100% | Electronic | Will be measured with the flow meter. The data will be aggregated monthly and annually |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 14. $CEF_{CO2,ELEC\ c}$ | Carbon emission factor for electricity consumption | Order of the National Environmental Investment Agency of Ukraine No. 75 dated 12.05.2011[26] | t $CO_2e$ / MWh | Normative | Annually | 100% | Electronic | In course of preparation of the Monitoring reports, the actual values for that period should be used |
| 15. $CEF_{CO2,ELEC,\ g}$ | Carbon emission factor for electricity generation | Order of the National Environmental Investment Agency of Ukraine No. 75 dated 12.05.2011[25] | t $CO_2e$ / MWh | Normative | Annually | 100% | Electronic | In course of preparation of the Monitoring reports, the actual values for that period should be used |
| 16. $EF_{CO2,NG}$ | Carbon Emission Factor for natural gas | 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2[27] | t $CO_2$/GJ | Normative | Annually | 100% | Electronic | In course of preparation of the Monitoring reports, the actual values for that period should be used |
| 17. $NCV_y$ | Net Calorific Value of the natural gas used in the boiler-house | Fuel Supplier's Report or Chem. Lab Analysis Report | $MJ/m^3$ | (m, c) | Once per month | 100% | Electronic | |
| 18. $\varepsilon_{boiler,BL}$ | Efficiency of the baseline boiler | Boiler-house management | % | (m, c) | Annually | 100% | Electronic | |
| 19. $\varepsilon_{boiler,y}$ | Efficiency of boiler in year *y* | Boiler-house management | % | (m, c) | Annually | 100% | Electronic | |

[26] http://www.neia.gov.ua/nature/doccatalog/document?id=127498

[27] http://www.ipcc-nggip.iges.or.jp/public/gl/pdfiles/rusch1-1.pdf

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 20. $\tau_{GTU}$ | Operation time of the CGTU equipment | CGTU management | h | (m) | Annually | 100% | Electronic | Is monitored to ensure methane destruction is claimed for methane used in CGTUs when they are in operation |
| 21. $\tau_{boiler}$ | Operation time of the boiler equipment with using LFG | Boiler-house management | h | (m) | Annually | 100% | Electronic | Is monitored to ensure methane destruction is claimed for methane used in boiler when it is in operation |
| 22. $PE_{EC,y}$ | Project emissions from generation of electricity consumed by the project activity in year *y* | Project management | $tCO_2e$ | (m/c) | See comments | n/a | Electronic | Will be monitored according to the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"[28] |
| 23. $PE_{FC,y}$ | Project emissions from consumption of heat from fossil fuel combustion in the project activity in year *y* | Project management | $tCO_2e$ | (m/c) | See comments | n/a | Electronic | Will be monitored according to the "Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion". [29] |

[28] http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-05-v1.pdf

[29] http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-03-v2.pdf

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 24. $MG_{PR,y}$ | Amount of methane generated during year *y* | Landfill management | $tCH_4$ | (e) | Annually | 100% | Electronic | Will be 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"[30] |

**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 methodology ACM0001"*Consolidated baseline and monitoring methodology for landfill gas project activities" (version 11)*[31], emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y \quad \text{(D.1)}$$

where:

$ER_y$ = Emission reductions in year *y*, tCO2e;
$BE_y$ = Baseline emissions in year *y*, tCO2e;
$PE_y$ = Project emissions in year *y,* tCO2e.

[30] http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v5.1.0.pdf

[31] http://cdm.unfccc.int/UserManagement/FileStorage/UJBDVFYLQKSEWCM73XG14Z692TRHO0

$$BE_y = (MD_{project,y} - MD_{BL,y}) * GWP_{CH4} + EL_{LFG,y} * CEF_{elec,BL,,y} + ET_{LFG,y} * CEF_{thermal,BL,y} \quad y \qquad \text{(D.2)}$$

where:
$BE_y$ = baseline emissions in year *y,* tCO2e;
$MD_{project,y}$ = amount of methane that would have been destroyed/combusted during the year *y*, in project scenario, tCH4;
$MD_{BL,y}$ = amount of methane that would have been destroyed/combusted during the year *y* in the absence of the project activity due to regulatory and/or contractual requirements, tCH4;
$GWP_{CH4}$ = Global Warming Potential value for methane, for the first commitment period is 21 tCO2e/tCH4;
$EL_{LFG,y}$ = 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*, MWh;
$CEF_{elec,BL,y}$ = Carbon emission factor of the baseline source of electricity displaced in Ukraine, tCO2e/MWh;
$ET_{LFG,y}$ = quantity of thermal energy produced utilizing the landfill gas, which in the absence of the project activity would have been produced from the fossil fuel fired boiler, during the year *y,* GJ;
$CEF_{ther,BL,y}$ = $CO_2$ emissions intensity of the fuel used by boiler to produce thermal energy which is displaced by LFG based thermal energy production, tCO2e/GJ.

$$MD_{BL,y} = MD_{project,y} * AF \qquad \text{(D.3)}$$

According to the baseline chosen, in the absence of the project activity no destroying / combustion of methane will take place, thus Adjustment Factor $AF$ = 0, and $MD_{BL,y}$ = 0.

$MD_{project,y}$ will be determined *ex post* by metering the actual quantity of methane captured and combusted to produce electricity and thermal energy once the project activity is operational.

According to the project, the whole captured methane will be completely combusted at the boiler-house to produce electricity and thermal energy, with emergency flaring.

$$MD_{project,y} = MD_{flared,y} + MD_{electricity,y} + MD_{thermal,y} + MD_{PL,y} \qquad \text{(D.4)}$$

where:
$MD_{project,y}$ = quantity of methane captured and destroyed during the year *y*, $tCH_4$;
$MD_{flared,y}$ = quantity of methane destroyed by flaring during the year *y*, $tCH_4$;
$MD_{electricity,y}$ = quantity of methane destroyed for the generation of electricity during the year *y*, $tCH_4$;

$MD_{thermal,y}$ = quantity of methane destroyed for the production of thermal energy during the year *y*, $tCH_4$.
$MD_{PL,y\,y}$ = quantity of methane sent to the pipeline for feeding to the natural gas distribution network during the year *y*, $tCH_4$.

$$MD_{flared,y} = (LFG_{flared,y} \times w_{CH4,y} \times D_{CH4}) - (PE_{flare,y} / GWP_{CH4}) \quad \text{(D.5)}$$

where:
$MD_{flared,y}$ = quantity of methane destroyed by flaring during the year *y*, $tCH_4$;
$LFG_{flared,y}$ = quantity of landfill gas fed to the flare during the year *y*, ($m^3$;
$w_{CH4,y}$ = average methane fraction of the landfill gas as measured during the year and expressed as a fraction, $m^3$ $CH_4/m^3$ LFG;
$D_{CH4}$ = methane density expressed in tonnes of methane per cubic meter of methane, $tCH_4/m^3CH_4$, at standard temperature and pressure (0 degree Celsius and 1.013 bar) the density of methane is 0.0007168 $tCH_4/m^3CH_4$);
$PE_{flare,y}$ = 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";*
$GWP_{CH4}$ = Global Warming Potential value for methane, valid for the relevant commitment period (for the first commitment period is 21 $tCO_2e/tCH_4$).

$$MD_{electricity,y} = LFG_{electricity,y} \times w_{CH4,y} \times D_{CH4} \quad \text{(D.6)}$$

$MD_{electricity,y}$ = quantity of methane destroyed by generation of electricity during the year *y*, $tCH_4$;
$LFG_{electricity,y}$ = quantity of landfill gas fed to electricity generator (CGTU) during the year *y*, $m^3$;
$w_{CH4,y}$ = average methane fraction of the landfill gas as measured during the year and expressed as a fraction, $m^3$ $CH_4/m^3$ LFG;
$D_{CH4}$ = methane density expressed in tonnes of methane per cubic meter of methane, $tCH_4/m^3CH_4$, at standard temperature and pressure (0 degree Celsius and 1.013 bar) the density of methane is 0.0007168 $tCH_4/m^3CH_4$);

$$MD_{thermal,y} = LFG_{thermal,y} \times w_{CH4,y} \times D_{CH4} \quad \text{(D.7)}$$

where:
$MD_{thermal,y}$ = quantity of methane destroyed for the production of thermal energy during the year *y*, tCH4;
$LFG_{thermal,y}$ = quantity of landfill gas fed into the boiler for the production of thermal energy during the year *y*, $m^3$;
$w_{CH4,y}$ = average methane fraction of the landfill gas as measured during the year and expressed as a fraction, $m^3$ CH4/$m^3$ LFG;
$D_{CH4}$ = methane density expressed in tonnes of methane per cubic meter of methane, $tCH_4/m^3CH_4$, at standard temperature and pressure (0 degree Celsius and 1.013 bar) the density of methane is 0.0007168 $tCH_4/m^3CH_4$).

$$CEF_{thermal,BL,y} = EF_{fuel,BL} / (\varepsilon_{boiler} * NCV_{fuel,BL}) \quad (D.8)$$

$CEF_{thermal,BL}$ = $CO_2$ emissions intensity of the fuel used by boiler to produce thermal energy which is displaced by LFG based thermal energy production, tCO2e/GJ;
$EF_{fuel,BL}$ = emission factor of the fuel used in the boiler to produce thermal energy in the absence of the project activity, $tCO_2$ /ths. $m^3$;
$\varepsilon_{boiler\ r}$ = efficiency of the boiler used to produce thermal energy in the absence of the project activity;
$NCV_{fuel,BL}$ = net calorific value of fuel used in the boiler to produce thermal energy in the absence of the project activity (GJ / ths.$m^3$).

$$MD_{PL,y} = 0$$

The *ex ante* estimation of the amount of methane that would have been destroyed/combusted during the year, in tonnes of methane ($MD_{project,y}$), is done with the approved "*Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" (version 05.1.0)*[32], considering the following additional equation:

$$MD_{project,y} = BE_{CH4,SWDS,y} / GWP_{CH4} \quad (D.9)$$

$$BE_{CH4,SWDS,y} = \varphi \cdot (1-f) \cdot GWP_{CH4} \cdot (1-OX) \cdot 16/12 \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1} \sum_{j} W_{j,x} \cdot DOC_j \cdot (e^{-k(y-x)} \cdot (1-e^{-k}_j) \quad (D.10)$$

where:

$BE_{CH4,SWDS,y}$ = methane emissions avoided during the year *y* from waste disposal at the landfill (SWDS) during the period from the start of the project activity to the end of the year *y*, $tCO_2e$;
$\varphi$ = model correction factor to account for model uncertainties, 0.9;
$f$ = fraction of methane captured at the landfill and flared, combusted or used in another manner (in our case 0);
$GWP_{CH4}$ = Global Warming Potential for methane, valid for the relevant commitment period (for the first commitment period is 21 $tCO_2e/tCH_4$);
$OX$ = oxidation factor (reflecting the amount of methane from landfill that is oxidized in the soil or other material covering the waste (in our case 0);
$F$ = fraction of methane in the landfill gas (volume fraction), 0.5;

[32] http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v5.1.0.pdf

$DOC_f$ = fraction of degradable organic carbon (DOC) that can decompose, 0.5;
$MCF$ = methane correction factor (in our case 0.8);
$W_{j,x}$ = amount of organic waste type *j* disposed at the landfill in the year *x*, tons;
$DOC_j$ = fraction of degradable organic carbon (by weight) in the waste type *j;*
$k_j$ = decay rate for the waste type *j;*
$j$ = waste type category (index);
$x$ = year during the crediting period: $x$ runs from the first year of the first crediting period ($x$ = 1) to the year $y$ for which avoided emissions are calculated ($x$ = $y$);
$y$ = year for which methane emissions are calculated.

$MD_{project,y}$ will be determined ex-post by measuring the actual amount of the methane (LFG) captured and utilized in result of the project activity.

According to the project, the whole captured methane will be completely combusted at the boiler-house to produce electricity and thermal energy.

Project emissions will be calculated as:

$$PE_y = PE_{EC,y} + PE_{FC,J,y} \quad \text{(D.11)}$$

where

$PE_{EC,y}$ = emissions from power consumption in the project scenario;

$PE_{FCj,y}$ = emissions from heat energy consumption produced from fossil fuel, in the project scenario;

Consumption of the heat energy produced from fossil fuel, in not included into the project boundaries, thus $PE_{EC,y} = 0$.

According to the project scenario, emissions are taking place from:

- combustion of LFG in the closed flare at the first stage of project execution, flaring efficiency is to be determined according to the "Tool to determine project emissions from flaring gases containing methane" (version 1)[33]. This Tool provides, in absence of continuous monitoring of the LFG flaring efficiency, using of 90% value, which is used in calculations;

- combustion of the natural gas in the boiler-house.

[33] http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-06-v1.pdf

Thus, project emissions are calculated as:

$$PE_{FC,J,y} = PE_{FC,f,y} + PE_{FC,b,y} \quad \text{(D.12)}$$

where:

$PE_{FCf,y}$ = emissions from LFG flaring in the project scenario;
$PE_{FC,b,y}$ = emissions from natural gas combustion in the boiler-house in the project scenario.

For the preliminary estimation, project emissions $PE_y$ are considered as equal to 0.

In case of consumption of electric power produced with the use of fossil fuel in project activity, the project emissions will include the emissions of $CO_2e$ from production of this power. It will be taken into account during monitoring.

The emission reduction in the project will be controlled by means of direct measuring of the amount of methane actually captured and destroyed.

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

**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 *(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 |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |

This Table is left blank on purpose.
According to the methodology ACM0001, no leakage effects need to be accounted under this methodology.

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

According to the methodology ACM0001, no leakage effects need to be accounted 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):**

Formulae used to estimate emission reductions for the project are described in details in sub-section D.1.2.2.

**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:**

Collection and archiving of information on the environmental impacts of a project, in accordance with Ukrainian regulations, has to meet the requirements of the Law of Ukraine «On ecological expertise»[34] and the State Building Norms of Ukraine DBN A.2.2-1-2003 "Composition and content of the Environmental Impact Assessment (EIA) materials at designing and construction of enterprises, buildings and premises"[35]

[34] http://zakon1.rada.gov.ua/cgi-bin/laws/main.cgi?nreg=45%2F95-%E2%F0

[35] http://www.budinfo.com.ua/dbn/8.htm

| 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. |
| Table D.1.2.1. 1. $LFG_{total,y}$ | Low | Measuring instruments are to be calibrated according to the Ukrainian national regulations |
| Table D.1.2.1. 2. $LFG_{flared,y}$ | Low | Measuring instruments are to be calibrated according to the Ukrainian national regulations |
| Table D.1.2.1. 3. $LFG_{electricity,y}$ | Low | Measuring instruments are to be calibrated according to the Ukrainian national regulations |
| Table D.1.2.1. 4. $LFG_{thermal,y}$ | Low | Measuring instruments are to be calibrated according to the Ukrainian national regulations |
| Table D.1.2.1. 5. $PE_{flare,y}$ | Low | ACM0001 "Consolidated baseline and monitoring methodology for landfill gas project activities" (version 11)[36] |
| Table D.1.2.1. 6. $w_{CH4,y}$ | Medium | Measuring instruments are to be calibrated according to the Ukrainian national regulations |
| Table D.1.2.1. 7. $T$ | Low | Measuring instruments are to be calibrated according to the Ukrainian national regulations |
| Table D.1.2.1. 8. $P$ | Low | Measuring instruments are to be calibrated according to the Ukrainian national regulations |
| Table D.1.2.1. 9. $EL_{LFG,y}$ | Low | Measuring instruments are to be calibrated according to the Ukrainian national regulations |
| Table D.1.2.1. 10. $EC_y$ | Low | Measuring instruments are to be calibrated according to the Ukrainian national regulations |
| Table D.1.2.1. 11.$EL_{EX,LFGy}$ | Low | Measuring instruments are to be calibrated according to the Ukrainian national regulations |
| Table D.1.2.1. 12. $ET_{LFG,y}$ | Low | Measuring instruments are to be calibrated according to the Ukrainian national regulations |

[36] http://cdm.unfccc.int/UserManagement/FileStorage/UJBDVFYLQKSEWCM73XG14Z692TRHO0

| | | |
|---|---|---|
| Table D.1.2.1.<br>12. $FC_y$ | Low | Measuring instruments are to be calibrated according to the Ukrainian national regulations |
| Table D.1.2.1.<br>14. $CEF_{CO2,ELEC\ c}$ | Low | Data for emission factors will be used from official document[37] |
| Table D.1.2.1.<br>15. $CEF_{CO2,ELEC,\ q}$ | Low | Data for emission factors will be used from official document[37] |
| Table D.1.2.1.<br>16. $EF_{CO2,NG}$ | Low | Data for emission factors will be used from official document [38] |
| Table D.1.2.1.<br>17. $NCV_y$ | Low | Measuring instruments are to be calibrated according to the Ukrainian national regulations |
| Table D.1.2.1.<br>18. $\varepsilon_{boiler,BL}$ | Low | Measuring instruments are to be calibrated according to the Ukrainian national regulations |
| Table D.1.2.1.<br>19. $\varepsilon_{boiler,y}$ | Low | Measuring instruments are to be calibrated according to the Ukrainian national regulations |
| Table D.1.2.1.<br>20. $\tau_{GTU}$ | Low | Measuring instruments are to be calibrated according to the Ukrainian national regulations |
| Table D.1.2.1.<br>21. $\tau_{boiler}$ | Low | Measuring instruments are to be calibrated according to the Ukrainian national regulations |
| Table D.1.2.1.<br>22. $PE_{EC,y}$ | Low | ACM0001 "Consolidated baseline and monitoring methodology for landfill gas project activities" (version 11, May 2009)[39] |
| Table D.1.2.1.<br>23. $PE_{FC,yy}$ | Low | ACM0001 "Consolidated baseline and monitoring methodology for landfill gas project activities" (version 11, May 2009)[39] |
| Table D.1.2.1.<br>24. $MG_{PR,y}$ | Low | ACM0001 "Consolidated baseline and monitoring methodology for landfill gas project activities" (version 11, May 2009)[39] |

[37] http://www.neia.gov.ua/nature/doccatalog/document?id=127498

[38] http://www.ipcc-nggip.iges.or.jp/public/gl/pdfiles/rusch1-1.pdf

[39] http://cdm.unfccc.int/UserManagement/FileStorage/UJBDVFYLQKSEWCM73XG14Z692TRHO0

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

The management structure will include management departments of Supplier (OJSC "Oblteplocomunenergo").

The operational structure will include operational departments of the Supplier, operation personnel of landfill and boiler-house, as well as the specialists of the project developer (Institute of Engineering Ecology).

All information obtained during monitoring the above parameters (LFG collection and combustion, $CH_4$ content, etc.) will be kept electronically, with possibility of processing and printing of the collected information with the above regularity.

After implementation of the system for collection and utilization of the LFG, training of personnel will be conducted on the management of the system and process control, as well as on safety engineering (management under emergency and extraordinary situations).

Also training will be conducted on the system for monitoring of GHG emission reductions: on processing and archiving of data and registration documentation, calibration and maintenance of the measuring equipment. The operation personnel will be provided with instructions for exploitations of the measuring equipment.

The structure of responsibility for monitoring of emission reductions is provided in Table D.1.

| Task | Landfill operator | Boiler-house operator | OJSC "Oblteplocomunenergo" (Supplier) | Institute of Engineering Ecology (Project developer ) |
|---|---|---|---|---|
| Data collection | + | + | | |
| Data input into the calculation spreadsheets | + | + | | + |
| Preparation of monthly reports | + | + | | |
| Preparation of annual reports | + | + | + | + |
| Data and reports storage | + | + | + | |
| Calibration, service, maintenance of equipment | + | + | + | |

*Table D.1. Structure of responsibility for monitoring of emission reductions*

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

The monitoring plan is determined by the Institute of Engineering Ecology (IEE), project developer (is not the project participant), and OJSC "Oblteplocomunenergo", project supplier (is the project participant).

Date of completion: 06.06.2011.

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## SECTION E. Estimation of greenhouse gas emission reductions

### E.1. Estimated project emissions:

According to the approved consolidated baseline methodology ACM0001 *"Consolidated baseline and monitoring methodology for landfill gas project activities"* (version 11)[40],, the direct monitoring of the methane emission reduction in the project will be carried out (see sub-section D.1.2.2).

The ex-ante calculation of project GHG emission reduction in the PDD is to be used for general information only.

| Year | Emissions from LFG flaring in the project scenario, tonnes of $CO_2e$ | GHG emissions from natural gas combustion in the boiler-house in project scenario, tonnes of $CO_2e$ | Total GHG emissions in the project scenario, tonnes of $CO_2e$ |
|---|---|---|---|
| 2011 | 3 838 | 5 687 | 9 526 |
| 2012 | | 2 656 | 2 656 |
| **2011-2012** | **3 838** | **8 343** | **12 181** |
| 2013 | | 3 579 | 3 579 |
| 2014 | | 4 413 | 4 413 |
| 2015 | | 5 166 | 5 166 |
| 2016 | | 5 846 | 5 846 |
| 2017 | | 6 459 | 6 459 |
| 2018 | | 7 014 | 7 014 |
| 2019 | | 7 514 | 7 514 |
| 2020 | | 7 965 | 7 965 |
| 2021 | | 8 373 | 8 373 |
| 2022 | | 8 741 | 8 741 |
| 2023 | | 9 074 | 9 074 |
| 2024 | | 9 374 | 9 374 |
| 2025 | | 9 645 | 9 645 |
| 2026 | | 9 889 | 9 889 |
| 2027 | | 10 110 | 10 110 |
| **2013-2027** | | **113 162** | **113 162** |
| | | | |
| **2011-2027** | **3 838** | **121 505** | **125 343** |

*Table E.1. Project emissions*

[40] http://cdm.unfccc.int/UserManagement/FileStorage/UJBDVFYLQKSEWCM73XG14Z692TRHO0

## E.2. Estimated leakage:

No leakages need to be accounted under methodology ACM0001.

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

Project Emissions + Leakages = Project Emissions + 0 = Project Emissions

## E.4. Estimated baseline emissions:

Estimation of the baseline emissions was made according to the approved consolidated baseline methodology ACM0001 *"Consolidated baseline and monitoring methodology for landfill gas project activities" (version 11)*[41] with using the data on annual number of inhabitants in Chernihiv city during 1960 – 2009[42], the data on specific norms of MSW accumulation per capita in Ukraine from the National Cadastre of the antropogeneous emissions from sources and absorption by absorbers of GHG in Ukraine for 1990 – 2008[43], as well as available information on the real delivery of wastes to the Chernihiv landfill and on the morphological composition of the wastes.

Calculations were made with assumption that the landfill will be closed in 2012. In case if the landfill will continue operation after 2012, the additional amount of the LFG will be generated and captured, respectively.

The total emissions in the baseline scenario consist of uncontrolled LFG emissions from the landfill in total amount, emissions from electricity generation to the state grid in amount that is consumed according to the baseline and that will be generated by the CGTU in excess to own needs, and emissions from the boiler-house in the amount which is the result of the natural gas combustion in amount that will be substituted by landfill gas.

For calculations the uncontrolled LFG emissions from the landfill only in amount that will be captured and utilized at the boiler-house (and occasionally by flaring) are taken into account.

Estimation of the baseline emission which will be destroyed according to the project:

[41] http://cdm.unfccc.int/UserManagement/FileStorage/UJBDVFYLQKSEWCM73XG14Z692TRHO0

[42] http://ru.wikipedia.org/wiki/%D0%A7%D0%B5%D1%80%D0%BD%D0%B8%D0%B3%D0%BE%D0%B2#cite_note-1#cite_note-1

[43] http://unfccc.int/national_reports/initial_reports_under_the_kyoto_protocol/items/3765.php

| Year | Estimated uncontrolled LFG methane emissions by the basic scenario, t $CO_2e$ | Emissions from boiler-house from the natural gas combustion, t $CO_2e$ | Emissions from electricity generation to the state grid in amount that is consumed according to the baseline, t $CO_2e$ | Emissions from electricity generation to the state grid in amount that will be generated by the CGTU in excess to own needs, t $CO_2e$ | Total emissions in baseline scenario, t $CO_2e$ |
|---|---|---|---|---|---|
| 2011 | 38 385 | 5 687 | 829 | 45 | 44 945 |
| 2012 | 79 120 | 11 374 | 1 658 | 89 | 92 242 |
| Subtotal 2011-2012 | **117 505** | **17 061** | **2 487** | **134** | **137 187** |
| 2013 | 71 434 | 11 374 | 1 658 | 89 | 84 555 |
| 2014 | 64 494 | 11 374 | 1 658 | 89 | 77 615 |
| 2015 | 58 228 | 11 374 | 1 658 | 89 | 71 350 |
| 2016 | 52 571 | 11 374 | 1 658 | 89 | 65 693 |
| 2017 | 47 464 | 11 374 | 1 658 | 89 | 60 585 |
| 2018 | 42 853 | 11 374 | 1 658 | 89 | 55 974 |
| 2019 | 38 690 | 11 374 | 1 658 | 89 | 51 811 |
| 2020 | 34 931 | 11 374 | 1 658 | 89 | 48 052 |
| 2021 | 31 537 | 11 374 | 1 658 | 89 | 44 659 |
| 2022 | 28 473 | 11 374 | 1 658 | 89 | 41 595 |
| 2023 | 25 707 | 11 374 | 1 658 | 89 | 38 829 |
| 2024 | 23 210 | 11 374 | 1 658 | 89 | 36 331 |
| 2025 | 20 955 | 11 374 | 1 658 | 89 | 34 076 |
| 2026 | 18 919 | 11 374 | 1 658 | 89 | 32 041 |
| 2027 | 17 081 | 11 374 | 1 658 | 89 | 30 203 |
| Subtotal 2013-2027 | **576 546** | **170 614** | **24 869** | **1 339** | **773 369** |
| | | | | | |
| Total 2011-2027 | **694 051** | **187 675** | **27 356** | **1 473** | **910 556** |

*Table E.2. Baseline emissions that will be destroyed according to the project*

The detailed calculations of the annual baseline emissions are provided in **Appendix A.** (file Excel PDD_LFG_Appendix_A).

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

Project emissions reduction = Baseline emissions – Project emissions.

Emission reductions of the project are represented in the Table E.3 (section E.6) below.

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

| Year | Estimated project emissions (tonnes of $CO_2$ equivalent) | Estimated leakage (tonnes of $CO_2$ equivalent) | Estimated baseline emissions (tonnes of $CO_2$ equivalent) | Estimated emission reductions (tonnes of $CO_2$ equivalent) |
|---|---|---|---|---|
| 2011 | 9 526 | 0 | 44 945 | 35 420 |
| 2012 | 2 656 | 0 | 92 242 | 89 586 |
| Total 2011-2012 (tonnes of $CO_2$ equivalent) | **12 181** | **0** | **137 187** | **125 006** |

*Table E.3. Table containing results of emission reductions estimation during the first commitment period*

| Year | Estimated project emissions (tonnes of $CO_2$ equivalent) | Estimated leakage (tonnes of $CO_2$ equivalent) | Estimated baseline emissions (tonnes of $CO_2$ equivalent) | Estimated emission reductions (tonnes of $CO_2$ equivalent) |
|---|---|---|---|---|
| 2013 | 3 579 | 0 | 84 555 | 80 976 |
| 2014 | 4 413 | 0 | 77 615 | 73 202 |
| 2015 | 5 166 | 0 | 71 350 | 66 184 |
| 2016 | 5 846 | 0 | 65 693 | 59 847 |
| 2017 | 6 459 | 0 | 60 585 | 54 126 |
| 2018 | 7 014 | 0 | 55 974 | 48 961 |
| 2019 | 7 514 | 0 | 51 811 | 44 297 |
| 2020 | 7 965 | 0 | 48 052 | 40 087 |
| 2021 | 8 373 | 0 | 44 659 | 36 286 |
| 2022 | 8 741 | 0 | 41 595 | 32 854 |
| 2023 | 9 074 | 0 | 38 829 | 29 755 |
| 2024 | 9 374 | 0 | 36 331 | 26 957 |
| 2025 | 9 645 | 0 | 34 076 | 24 432 |
| 2026 | 9 889 | 0 | 32 041 | 22 151 |
| 2027 | 10 110 | 0 | 30 203 | 20 092 |
| Total 2013-2027 (tonnes of $CO_2$ equivalent) | **113 162** | 0 | **773 369** | **660 206** |

*Table E.4. Table containing results of emission reductions estimation after the first commitment period*

| Year | Estimated project emissions (tonnes of $CO_2$ equivalent) | Estimated leakage (tonnes of $CO_2$ equivalent) | Estimated baseline emissions (tonnes of $CO_2$ equivalent) | Estimated emissions reductions (tonnes of $CO_2$ equivalent) |
|---|---|---|---|---|
| Total 2011-2027 (tonnes of $CO_2$ equivalent) | **121 505** | **0** | **910 556** | **785 212** |

*Table E.5. Total estimated project emission reductions*

## 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:

In Ukraine the basic mechanisms directed on the account of ecological consequences of the planned activity at acceptance of decisions is the state ecological expertise (EE) and Environmental Impact Assessment (EIA).

Environmental Impact Assessment is directed on determination of scales and levels of the project activity impact on an environment, on development of measures for prevention or reduction of this impact, on estimation of acceptability of project decisions from the ecological point of view. The EIA is inalienable part of project documentation of any economical activity, but does not influence on the process of economic decisions acceptance. The EIA is conducted under the strict requirements.

The legislative requirements to EIA materials content are enshrined in the Article 36 of the Law of Ukraine «On ecological expertise»»[44]. Requirements to the structure, composition and content of the EIA sections are enshrined in the state building norms of Ukraine DBN A.2.2-1-2003 "Composition and content of the Environmental Impact Assessment (EIA) materials at designing and construction of enterprises, buildings and premises"[45]. Requirements to the content of documents being applied for the state ecological expertise are provided in Instruction on implementation of the state ecological expertise. Requirements to the content of ecological expertise conclusions are provided in the Article 43 of the Law of Ukraine «On ecological expertise»[43].

By the order of the OJSC "Oblteplocomunenergo" that implements this project "Landfill gas capture and utilization at Chernihiv MSW landfill", the company "Stics-Oil", Ltd. has performed the Environmental Impact Assessment (EIA) [46] of this project activity in accordance with Ukrainian regulations.

Atmospheric air conditions under operation of the projected object will be influenced by: nitrogen dioxide, carbon oxide, nitrogen dioxide, carbon dioxide, sulphureted hydrogen, methane. The maximal expected contamination levels of atmospheric air at the adjoining to the building object territory will be within the established Allowed Concentration Limits with taking into account the background concentrations. On the basis of the executed calculations and estimation of the projected activity impact on the components of environment, under condition of observance of valid normative acts and technological process, the level of impact of the object under building is determined as insignificant. The affected zone of the projected object will not spread to inhabited building.

As to estimation of risk of the environmental impact of the planned activity:

General level of risk: Acceptable

Risk of development of carcinogenic effects: The risk of origin of harmful effects to the population is considered as depreciatingly small.

Carcinogenic risk of the combined action: absent

Level of social risk: Acceptable

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[44] http://zakon1.rada.gov.ua/cgi-bin/laws/main.cgi?nreg=45%2F95-%E2%F0

[45] http://www.budinfo.com.ua/dbn/8.htm

[46] *Environmental Impact Assessment of the project "Landfill gas capture and utilization at Chernihiv MSW landfill" ПР3-2010/02-11-ОВНС. "STICS-OIL", Ltd., Kyiv, 2010. – 117 p.*

DBN A.2.2-1-2003 does not contain the requirement as to the obligatory analysis of the transboundary impact, and in accordance with this the EIA for this project, prepared by the "STICS-OIL" Ltd. (ПР3-2010/02-11-ОВНС) does not contain such special analysis. However, taking into account the insignificant emissions even in the most unfavorable case of project activity, transboundary impact is not foreseen, the emissions are localized not far away from the source.

Administration of the OJSC "Oblteplocomunenergo" is obligated to provide meeting of the ecological safety requirements and legislation of Ukraine on the questions of environmental protection in course of construction and operation of the projected object.

**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:**

Possible environmental impact of the projected activity is considered as insignificant. Moreover, in general the project "Landfill gas capture and utilization at Chernihiv MSW landfill" is expected to have a positive environmental impact. The following points will give the detailed information on environmental impacts.

**Impact on the climate and microclimate**

As a result of construction and operation of the projected object, no changes of climate and microclimate are expected (emissions of rare gases, a plenty of warmth and moisture are absent). Any possibility of growth of intensity of environmental impacts is absent.

**Impact on the ambient air**

The project implementation will have a positive effect on the ambient atmosphere.

The negative effect of the MSW landfill on the atmosphere will be essentially reduced under the efficient following the regime of wastes layer stowage with interspersing by the isolating material, periodic watering of working charts during hot weather for avoiding of fires. Active pumping of LFG out from the landfill will reduce its uncontrolled emissions as well as emissions of the toxic non-methane organic compounds.

The risk of occurrence of local fires, explosions and poisoning of local population and landfill workers by the highly toxic combustion materials will be reduced.

Under condition of implementation of environmental protection measures and observance of technological regulation at construction and operation of the system for collection and utilization of LFG at the Chernihiv MSW landfill, the maximal expected contamination levels of atmospheric air at the boundaries of sanitary protection area and inhabited buildings will not exceed the established Allowed Concentration Limits for inhabited places with taking into account the background concentrations, the level of concentrations of contaminating matters in the ground layer of atmosphere is also provided within the limits of operating sanitary norms and the terms of residence of population do not get worse. Measures on reduction of formation and removing of contaminating matters are not foreseen.

**Impact on the water environment**

The system of collection and cleaning of LFG is placed at existing territory of the landfill, does not increase the volume of filtrate formation and does not affect the hydrological conditions of district of its

placing. Waste water is taken out into the sewage system with concentrations within the established Allowed Concentration Limits. Therefore the special measures for the rational use of water resources, water protection are not foreseen by the project.

**Impact on the land use**

The MSW landfill is placed on the industrial purpose ground. Fertile layer in the places of building is absent. Chemical, biological and radioactive contaminations, origin of dangerous engineering-geological processes and phenomena which would negatively affect the round conditions, are absent. Impact on the land use within the frameworks of the project activity is insignificant and controlled. Contamination of bowels of the earth from construction and operation of the system for LFG collection and utilization is not foreseen.

**Impact on the biodiversity**

In the affected zone of activity of the system of LFG collection and utilization, any negative influence on flora and fauna is not foreseen.

**Waste generation, treatment and disposal**

In the process of project implementation, formation of wastes is not foreseen, except for the worked luminescent lamps (1 ps per year). Utilization of the worked luminescent lamps is foreseen by the agreement with PE «Don-Bas». The worked luminescent lamps (wastes of the 1 class of danger) will be kept untill the moment of their transference in the air-tight container in the specially purposed place at the OJSC “Oblteplocomunenergo”.

**Conclusion**

The project activity will have no local or region negative environmental impact, the project will have general positive effect on an environment.

## SECTION G. Stakeholders' comments

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

Briefing of acting vice-chairman of the Chernihiv regional state administration Olexander Belsky on the subject "Participation of the Chernihiv region in the process of landfill gases discharge into the atmosphere reduction within the frames of Kyoto protocol" was held on 19.06.2007, at which journalists and all participants were informed about ecological projects, that will improve the Chernihiv region ecological situation and also make profits to the region, in particular about the project on landfill gas collection at the Chernihiv MSW landfill and utilization of this gas for the thermal energy production for heating and hot water-supply of Chernihiv population.

*Source: «Chernihiv monitor»*[47]

The JI project "Landfill gas capture and utilization at Chernihiv MSW landfill" was represented at International conferences "Problems of ecology and exploitation of energy objects", XVII (Yalta, June 5-9, 2007) and XVIII (Yalta, June 10-14, 2008), where it was comprehensively discussed by the participants of conference.

**The report about intention** was published in newspaper «Desnianska pravda» dated 11.01.2011 №2 (28116). Department of municipal economy of Chernihiv city council as well as other executive branches of the city council as to 15.02.2011 did not received any remarks or objections from the public in relation to intentions of implementation of the project "Landfill gas capture and utilization at Chernihiv MSW landfill",

Since the project activity does not foresee any negative environmental impact and any negative social effect, there were no special consultations with stakeholders.

[47] http://monitor.chernigov.net/arhiv-novin/u-planah-znachne-pokraschennya-ekologichnogo-stanu-ta-otrimannya-vid-tsogo-do-2.html

Annex 1

## CONTACT INFORMATION ON PROJECT PARTICIPANTS

| | |
|---|---|
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| State/Region: | Chernihiv Region (Oblast) |
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| Represented by: | |
| Title: | Head of the Board |
| Salutation: | Mr. |
| Last name: | Barbarov |
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Annex 2

## BASELINE INFORMATION

### Background state of the Chernihiv MSW landfill

Chernihiv MSW landfill belongs to the typical dump-like landfills of the big cities in Ukraine. Within the landfill boundaries the primary sorting and separate waste storage is absent. General statistics shows that the amount of organic biological substances which are the main material for anaerobic decomposition and the source of LFG generation on the landfill, makes 30 to 50 %. Therefore, the amount of LFG generation is determined, first of all, by the quantity and content of solid waste which is transported to the landfill.

According to the information from the Department of Municipal Household of the Chernihiv City Council, the MSW landfill in Chernihiv operates since 1961. The total area is 30.18 ha, namely landfill takes 14 ha[48], the depth of the foundation pit is 10 m, the soil is a sandy loam with 10-30 % content of the clay particles. The pit walls are made of clay soil. The landfill was founded on the slightly sloping flat territory with absolute marks 139 - 142 meters. The general slope of relief is a south-west.

The waste storage has been done by layers (with thickness of 2 - 3 m) with floating and compacting by heavy bulldozer, in recent years – with sprinkling with the layer of soil. As a result, the oval-like in plan plate body was created with the thickness of 6 to 20 m, in the average of 15 m (Fig. An2-1).

The eastern part of the landfill (with the total area up to 5 ha) is assigned for the filtrate collectors. Today more than 150 ths $m^3$ of filtrate is located in four collectors with total area nearly 6.0 ha. The filling of collectors occurs from drain trenches, which are laid along the perimeter of the main landfill body. The trench width is 3.0-3.5 m, and its total length is near 1.5 km.

The filtrate collector, which is located in the northern-east corner of the landfill, is additionally used as the pond-evaporator for localization of the oil mud volume, which is storied in within its borders.

Historically after 1990 the large volume part of polymer products began to get to the landfill (tape, packages, packing, polyethylene bottles, etc.). As a result the top layers of landfill body have mainly the fragile structure, high porosity and are practically dehydrated. Below there are domestic wastes of the mixed composition and physical state. These are the fragments of polymeric origin and glass, which are unevenly dispersed in dry and semidry (weakly moist) grey and darkly grey mass. The processes of anaerobic fermentation at these depths (3 - 5 m from the surface of the landfill body) are in developmental stage. The lower layers of accumulated wastes are turned by the processes of decomposition into homogeneous black mass of high humidity.

Above-mentioned elements of the internal structure of the landfill body are typical for all its territory, some differences consist only in time of MSW accumulation.

The landfill belongs to the category of highly loaded. Today the area for waste storage is practically used up, that is why the area on which the waste loading station was planned to be built (near the road Chernihiv - Lubech) is used. The requirements of sanitary regulations on isolation of waste layers by the soil are met insufficiently. There are no careers for taking out the soil and using it for a waste compaction near the MSW landfill. Building wastes, street garbage are used for isolation. The network of observational boreholes for the control of ground water quality is placed near the landfill.

[48] *"Implementation of the system for biogas collection and utilization at Chernihiv MSW landfill". Project. / STC "Biomass", Kyiv, 2010*

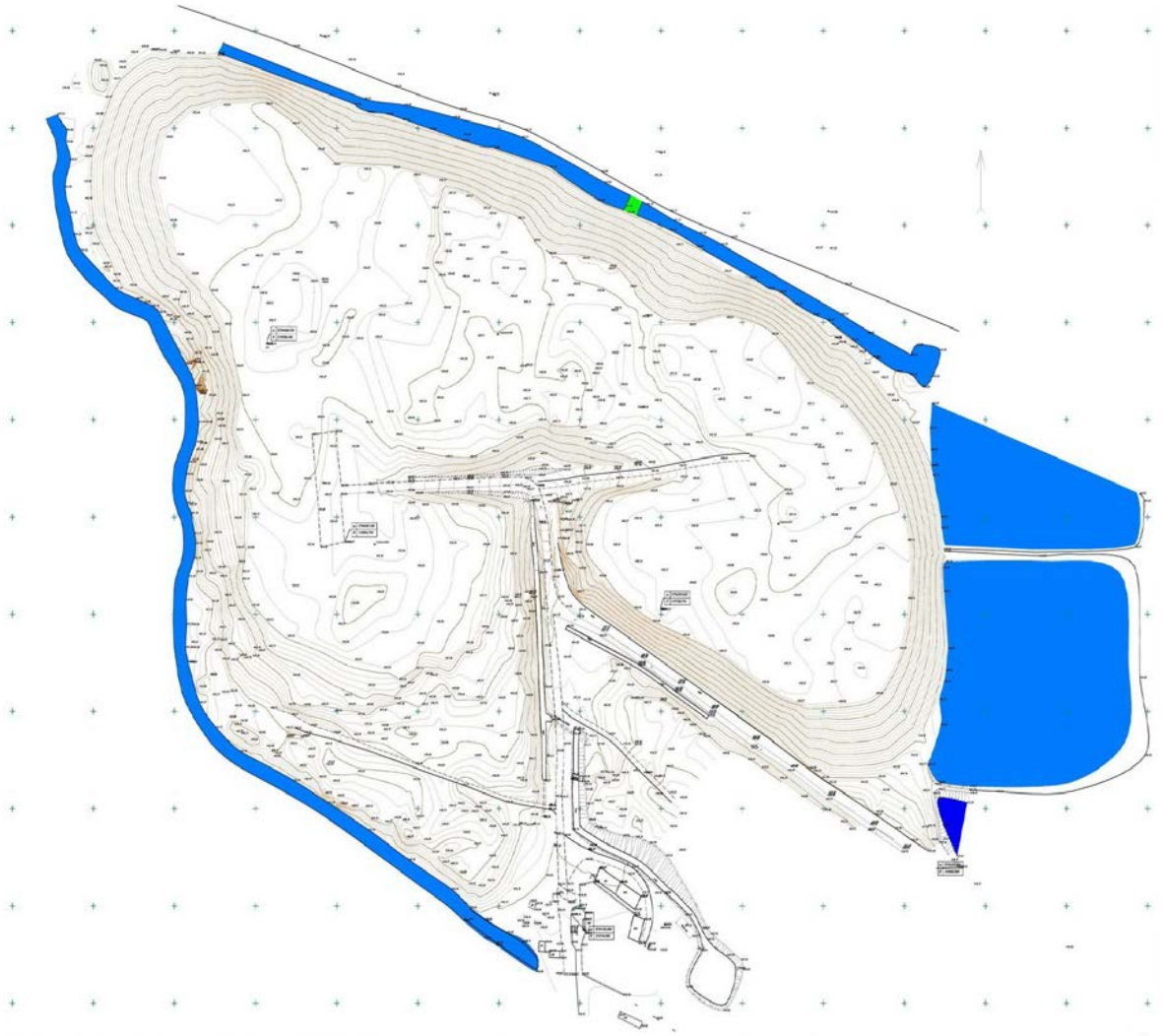

*Figure An2-1. The scheme of existing landfill*

| Year | Amount of MSW delivered, ths t |
|---|---|
| 2003 | 108 |
| 2004 | 109 |
| 2005 | 122 |
| 2006 | 164 |
| 2007 | 183 |
| 2008 | 185 |
| 2009 | 148 |

*Table An2-1. Amount of MSW delivered to the landfill during 2003 - 2009*

At present the area for waste placing at the landfill is practically exhausted, the landfill is already almost fully filled and is subject to be closed in the nearest years, however the project for a new landfill is not ready so far, and thus exploitation of the old landfill obviously will be continued for some time (really at least up to 2012).

This circumstance predetermines the obvious complications for implementation of the system for LFG collection at the landfill, in particular necessity of laying pipelines in deep trenches in those places where elimination of possibility of their damage by a machinery passing above is required, necessity of stage-by-stage realization of covering the landfill body by screening soil layer, etc.

**Estimation of amount of landfill gas emissions**

Estimation of amount of landfill gas emissions from the landfill was made according to the approved consolidated baseline methodology ACM0001 "*Consolidated baseline and monitoring methodology for landfill gas project activities" (version 11)*[49] with using the data on annual number of inhabitants in Chernihiv city during 1960 – 2009[50], the data on specific norms of MSW accumulation per capita in Ukraine from the National Cadastre of the antropogeneous emissions from sources and absorption by absorbers of GHG in Ukraine for 1990 – 2008[51], as well as available information on the real delivery of wastes to the Chernihiv landfill and on the morphological composition of the wastes.

Calculations were made with assumption that the landfill will be closed after 2012.
The detailed calculations are provided as the Excel electronic tables in the **Appendix A** (file Excel PDD_LFG_Appendix_A).

Utilization of the captured LFG will be made by supplying it to the boiler-house of the OJSC "Oblteplocomunenergo" system by the address: Chernihiv, 17, Instrumentalna street, for production of the electricity by CGTUs and of the thermal energy as a steam (for technological needs) and hot water for the needs of heating and hot water-supply by boilers.

The DKVR_20/13 (2 units), DE-25/14 (1 unit) and PTVM-30M (1 unit) boilers are installed in the boiler-house.

During the non-heating season the heat load of the boiler-house is about 4.7 MW, during the heating season – over than 28 MW.

[49] http://cdm.unfccc.int/UserManagement/FileStorage/UJBDVFYLQKSEWCM73XG14Z692TRHO0

[50] http://ru.wikipedia.org/wiki/%D0%A7%D0%B5%D1%80%D0%BD%D0%B8%D0%B3%D0%BE%D0%B2#cite_note-1#cite_note-1

[51] http://unfccc.int/national_reports/initial_reports_under_the_kyoto_protocol/items/3765.php

Annex 3

## MONITORING PLAN

According to the approved consolidated baseline methodology ACM0001 "Consolidated baseline and monitoring methodology for landfill gas project activities" (version 11)[52], monitoring of the GHG emissions after project implementation is based on direct measurement of the amount of captured and destroyed landfill gas.

The typical monitoring scheme is shown in Fig. An3-1.

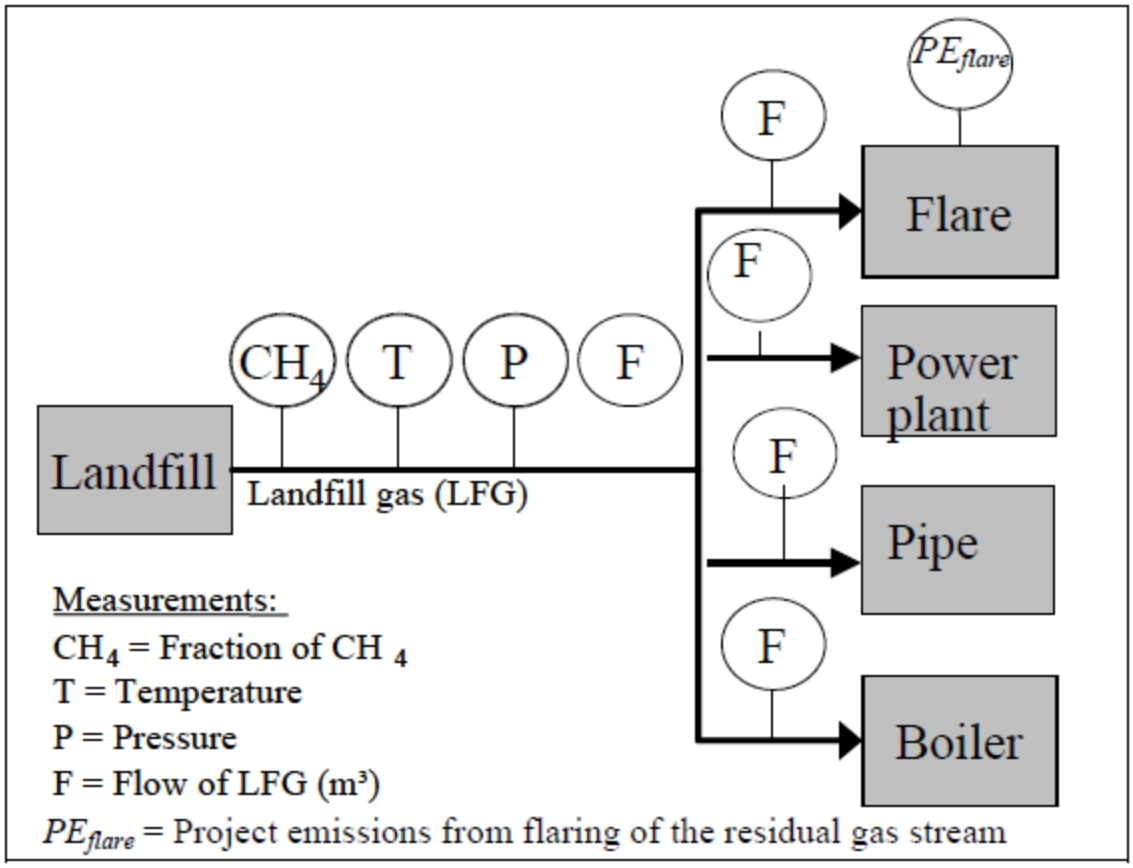


*Figure An3-1. Monitoring plan*

Concerning this project, the main variables that need to be determined are the quantity of methane actually captured ($MD_{project,y}$), quantity of methane flared ($MD_{flared,y}$), quantity of methane used to generate electricity ($MD_{electricity,y}$) and the quantity of methane used to produce thermal energy ($MD_{thermal,y}$). The methodology also foresees measuring the energy generated by use of LFG ($EL_{LFG,y}$, $ET_{LFG,y}$), and energy consumed by the project activity that is produced using fossil fuels. In case if flaring will be used for methane destroying, the monitoring plan provides for continuous measurement of the quantity and quality of LFG flared.

[52] http://cdm.unfccc.int/UserManagement/FileStorage/UJBDVFYLQKSEWCM73XG14Z692TRHO0

To determine these variables, the following parameters have to be monitored:
• The amount of landfill gas captured ($LFG_{project,y}$) and fed to the flare ($LFG_{flare,y}$) (if any), to the power generating units ($LFG_{electricity,y}$) and to the boiler equipment ($LFG_{thermal,y}$) should be measured continuously with flow meters.
• The fraction of methane in the landfill gas ($w_{CH4,y}$) should be measured with a continuous analyzer. In all cases, methane fraction of the landfill gas and LFG flow have to be measured on same basis (either wet or dry).
• Temperature ($T$) and pressure ($p$) of the landfill gas are required to determine the density of methane in the landfill gas, with gas analyzer or special devices – thermometer and manometer;
• The quantity of electricity consumed in the project activity from external sources (grid) (for pumping equipment for the collection and transport system, etc), if any will be consumed, should be measured with power meter;
• Relevant regulations for LFG project activities shall be monitored and updated at renewal of each credit period. Changes to regulation, if any, should be converted to the amount of methane that would have been destroyed/combusted during the year in the absence of the project activity ($MD_{BL,y}$).
Project participants should explain how regulations are translated into that amount of gas;
• The operating hours of the boilers, and the amount of thermal energy produced.

In case when for the excess and emergency LFG combustion the enclosed flare will be used, its efficiency will be determined according to the "Tool to determine project emissions from flaring gases containing methane" (Version 01)[53].. This tool provides for continuous monitoring of the methane destruction efficiency of the flare (flare efficiency), or otherwise using a 90% default value provided that flare parameters (temperature and flow rate of residual gas) are in compliance with manufacturer's specification (otherwise a 50% default value for the flare efficiency should be used for the calculations for the specific hour).

**Data and parameters monitored**

| **Data / Parameter:** | $LFG_{total,y}$ |
|---|---|
| Data unit: | ths.$m^3$ |
| Description: | Total amount of landfill gas captured at Normal Temperature and Pressure |
| Source of data: | Project participants |
| Measurement procedures (if any): | Measured by a flow meter. Data to be aggregated monthly and yearly |
| Monitoring frequency: | Continuous (average value in a time interval not greater than an hour shall be used in the calculations of emission reductions) |
| QA/QC procedures: | Flow meters should be subject to a regular maintenance and calibration in accordance to national standard |
| Any comment: | n/a |

| **Data / Parameter:** | $LFG_{flare,y}$ |
|---|---|
| Data unit: | ths.$m^3$ |
| Description: | Amount of landfill gas flared, at Normal Temperature and Pressure |
| Source of data: | Project participants |
| Measurement procedures (if any): | Measured by a flow meter. Data to be aggregated monthly and yearly |

[53] http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-06-v1.pdf

| | |
|---|---|
| Monitoring frequency: | Continuous (average value in a time interval not greater than an hour shall be used in the calculations of emission reductions) |
| QA/QC procedures: | Flow meters should be subject to a regular maintenance and calibration in accordance to national standard |
| Any comment: | n/a |

| **Data / Parameter:** | $LFG_{electricity,y}$ |
|---|---|
| Data unit: | ths.$m^3$ |
| Description: | Amount of landfill gas combusted in CGTU, at Normal Temperature and Pressure |
| Source of data: | Project participants |
| Measurement procedures (if any): | Measured by a flow meter. Data to be aggregated monthly and yearly |
| Monitoring frequency: | Continuous (average value in a time interval not greater than an hour shall be used in the calculations of emission reductions) |
| QA/QC procedures: | Flow meters should be subject to a regular maintenance and calibration in accordance to national standard |
| Any comment: | n/a |

| **Data / Parameter:** | $LFG_{thermal,y}$ |
|---|---|
| Data unit: | ths.$m^3$ |
| Description: | Amount of landfill gas combusted in boiler, at Normal Temperature and Pressure |
| Source of data: | Project participants |
| Measurement procedures (if any): | Measured by a flow meter. Data to be aggregated monthly and yearly |
| Monitoring frequency: | Continuous (average value in a time interval not greater than an hour shall be used in the calculations of emission reductions) |
| QA/QC procedures: | Flow meters should be subject to a regular maintenance and calibration in accordance to national standard |
| Any comment: | n/a |

| **Data / Parameter:** | $PE_{flare,y}$ |
|---|---|
| Data unit: | tCO2e |
| Description: | Project emissions from flaring of the residual gas stream in year *y* |
| Source of data: | Calculated as per the "Tool to determine project emissions from flaring gases containing methane"[54] |
| Measurement procedures (if any): | As per the "Tool to determine project emissions from flaring gases containing methane" |
| Monitoring frequency: | As per the "Tool to determine project emissions from flaring gases containing methane" |
| QA/QC procedures: | As per the "Tool to determine project emissions from flaring gases containing methane" |
| Any comment: | n/a |

[54] http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-06-v1.pdf

| **Data / Parameter:** | $W_{CH4}$ |
|---|---|
| Data unit: | m³ CH4/m³ LFG |
| Description: | Methane fraction in the landfill gas |
| Source of data: | Project participants |
| Measurement procedures (if any): | Shall be measured using equipment that can directly measure methane content in the landfill gas (continuous gas quality analyzer) |
| Monitoring frequency: | Continuous (average value in a time interval not greater than an hour shall be used in the calculations of emission reductions) |
| QA/QC procedures: | The gas analyzer should be subject to a regular maintenance and calibration in accordance to national standard |
| Any comment: | n/a |

| **Data / Parameter:** | $T$ |
|---|---|
| Data unit: | °C |
| Description: | Temperature of the landfill gas |
| Source of data: | Project participants |
| Measurement procedures (if any): | No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters |
| Monitoring frequency: | Continuous |
| QA/QC procedures: | Measuring instruments should be subject to a regular maintenance and calibration in accordance to national standards |
| Any comment: | n/a |

| **Data / Parameter:** | $P$ |
|---|---|
| Data unit: | Pa |
| Description: | Pressure of the landfill gas |
| Source of data: | Project participants |
| Measurement procedures (if any): | No separate monitoring of pressure is necessary when using flow meters that automatically measure temperature and pressure, expressing LFG volumes in normalized cubic meters |
| Monitoring frequency: | Continuous |
| QA/QC procedures: | Measuring instruments should be subject to a regular maintenance and calibration in accordance to national standards |
| Any comment: | n/a |

| **Data / Parameter:** | $EL_{LFG}$ |
|---|---|
| Data unit: | MWh |
| Description: | Total amount of electricity generated for grid using LFG |
| Source of data: | Project participants |
| Measurement procedures (if any): | Electric power meter |
| Monitoring frequency: | Continuous |
| QA/QC procedures: | The meter shall be subject to regular maintenance and calibration in accordance to national standards |
| Any comment: | Required to estimate the emission reductions from electricity generation from LFG |

| **Data / Parameter:** | $EC_y$ |
|---|---|
| Data unit: | MWh |
| Description: | Total amount of electricity generated using LFG, consumption by the boiler-house equipment during the year *y* |
| Source of data: | Project participants |
| Measurement procedures (if any): | Electric power meter |
| Monitoring frequency: | Continuous |
| QA/QC procedures: | The meter shall be subject to regular maintenance and calibration in accordance to national standards |
| Any comment: | Required to correct the emission reductions |

| Data / Parameter: | $ET_{LFG}$ |
|---|---|
| Data unit: | GJ |
| Description: | Total amount of thermal energy generated using LFG |
| Source of data: | Project participants |
| Measurement procedures (if any): | Electric power meter<br>(the temperature, pressure and mass flow rate will be measured) |
| Monitoring frequency: | Continuous |
| QA/QC procedures: | The meter shall be subject to regular maintenance and calibration in accordance to national standards |
| Any comment: | Required to correct the emission reductions |

| **Data / Parameter:** | $CEF_{elec,c,y}$ |
|---|---|
| Data unit: | t $CO_2$e / MWh |
| Description: | Carbon emission factor for JI projects on decreasing electricity consumption in Ukraine |
| Source of data: | For electricity the $CO_2$ emission factors from the Order of the National Environmental Investment Agency of Ukraine No. 75 dated 12.05.2011[55].are used |
| Measurement procedures (if any): | n/a |
| Monitoring frequency: | Annually |
| QA/QC procedures: | n/a |
| Any comment: | In course of preparation of the Monitoring reports, the actual values for that period should be used |

| **Data / Parameter:** | $CEF_{elec,g,y}$ |
|---|---|
| Data unit: | t $CO_2$e / MWh |
| Description: | Carbon emission factor for electricity generation in Ukraine |
| Source of data: | For electricity the $CO_2$ emission factors from the Order of the National Environmental Investment Agency of Ukraine No. 75 dated 12.05.2011[56].are used |
| Measurement | n/a |

[55] http://www.neia.gov.ua/nature/doccatalog/document?id=127498
[56] http://www.neia.gov.ua/nature/doccatalog/document?id=127498

| | |
|---|---|
| procedures (if any): | |
| Monitoring frequency: | Annually |
| QA/QC procedures: | n/a |
| Any comment: | In course of preparation of the Monitoring reports, the actual values for that period should be used |

| **Data / Parameter:** | $EF_{CO2,ng}$ |
|---|---|
| Data unit: | t $CO_2$ /GJ |
| Description: | Carbon emission factor for natural gas |
| Source of data: | For natural gas the $CO_2$ emission factors from the data table provided in 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2[57] are used |
| Measurement procedures (if any): | n/a |
| Monitoring frequency: | Annually |
| QA/QC procedures: | n/a |
| Any comment: | In course of preparation of the Monitoring reports, the actual values for that period should be used |

| **Data / Parameter:** | $FC_y$ |
|---|---|
| Data unit: | |
| Description: | Amount of the natural gas consumed by boilers, in year *y* |
| Source of data: | Boiler-house management |
| Measurement procedures (if any): | Gas flow meter |
| Monitoring frequency: | Continuous |
| QA/QC procedures: | The meter shall be subject to regular maintenance and calibration in accordance to national standards |
| Any comment: | Fossil fuel that would have been used for thermal energy generation, in year *y* |

| **Data / Parameter:** | $NCV_{ng,y}$ |
|---|---|
| Data unit: | GJ/ths.$m^3$ |
| Description: | The averaged Net Calorific Value of the natural gas used in the boiler-house |
| Source of data: | Boiler-house management |
| Measurement procedures (if any): | Calculated as weighted average |
| Monitoring frequency: | Annually |
| QA/QC procedures: | n/a |
| Any comment: | For fossil fuel that would have been used in the baseline for heat energy generation |

[57] http://www.ipcc-nggip.iges.or.jp/public/gl/pdfiles/rusch1-1.pdf

| **Data / Parameter:** | $\varepsilon_{boiler,y}$ |
|---|---|
| Data unit: | - |
| Description: | Efficiency of the baseline boiler for producing heat energy |
| Source of data: | Boiler-house management |
| Measurement procedures (if any): | Option A<br>Use the highest value among the following three values as a conservative approach:<br>1. Measured efficiency prior to project implementation;<br>2. Measured efficiency during monitoring;<br>3. Manufacturer's information on the boiler efficiency. |
| Monitoring frequency: | Annually |
| QA/QC procedures: | n/a |
| Any comment: | n/a |

| **Data / Parameter:** | $\tau_{CGTU}$ |
|---|---|
| Data unit: | Hours |
| Description: | Operation time of the CGTU equipment for electricity generation with using LFG |
| Source of data: | Project participants |
| Measurement procedures (if any): | Measured with clock |
| Monitoring frequency: | Annually |
| QA/QC procedures: | n/a |
| Any comment: | This is monitored to ensure methane destruction is claimed for methane used in CGTU when it is operational |

| **Data / Parameter:** | $\tau_{boiler}$ |
|---|---|
| Data unit: | Hours |
| Description: | Operation time of the boiler equipment for thermal energy generation with using LFG |
| Source of data: | Boiler-house management |
| Measurement procedures (if any): | Measured with clock |
| Monitoring frequency: | Annually |
| QA/QC procedures: | n/a |
| Any comment: | This is monitored to ensure methane destruction is claimed for methane used in boiler when it is operational |

| **Data / Parameter:** | $PE_{EC,y}$ |
|---|---|
| Data unit: | $tCO_2e$ |
| Description: | Project emissions from electricity consumption by the project activity during the year *y* |
| Source of data: | Calculated as per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"[58] |

[58] http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-05-v1.pdf/history_view

| | |
|---|---|
| Measurement procedures (if any): | As per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" |
| Monitoring frequency: | As per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" |
| QA/QC procedures: | As per the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" |
| Any comment: | n/a |

| **Data / Parameter:** | $PE_{FC,j,y}$ |
|---|---|
| Data unit: | $tCO_2e$ |
| Description: | Project emissions from fossil fuel combustion in process *j* during the year *y* |
| Source of data: | Calculated as per the "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion" [59] |
| Measurement procedures (if any): | As per the "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion" |
| Monitoring frequency: | As per the "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion" |
| QA/QC procedures: | As per the "Tool to calculate project or leakage CO2 emissions from fossil fuel combustion" |
| Any comment: | n/a |

| **Data / Parameter:** | $MG_{PR,y}$ |
|---|---|
| Data unit: | t $CH_4$ |
| Description: | Amount of methane generated during year *y* of the project activity |
| Source of data: | Project participants |
| Measurement procedures (if any): | Estimated using the actual amount of waste disposed in the landfill as per the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" (the latest version 05.1.0)[60] |
| Monitoring frequency: | Annually |
| QA/QC procedures: | As per the latest version of the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" |
| Any comment: | n/a |

Scheme of data collection for Monitoring Report

Scheme of data collection for Monitoring Report is shown at the Fig. An3-1.

Data monitored and required for emission reductions calculation and verification, according to paragraph 37 of the JI guidelines, are to be kept for two years after the last transfer of ERUs for the project.

[59] http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-03-v2.pdf

[60] http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v5.1.0.pdf

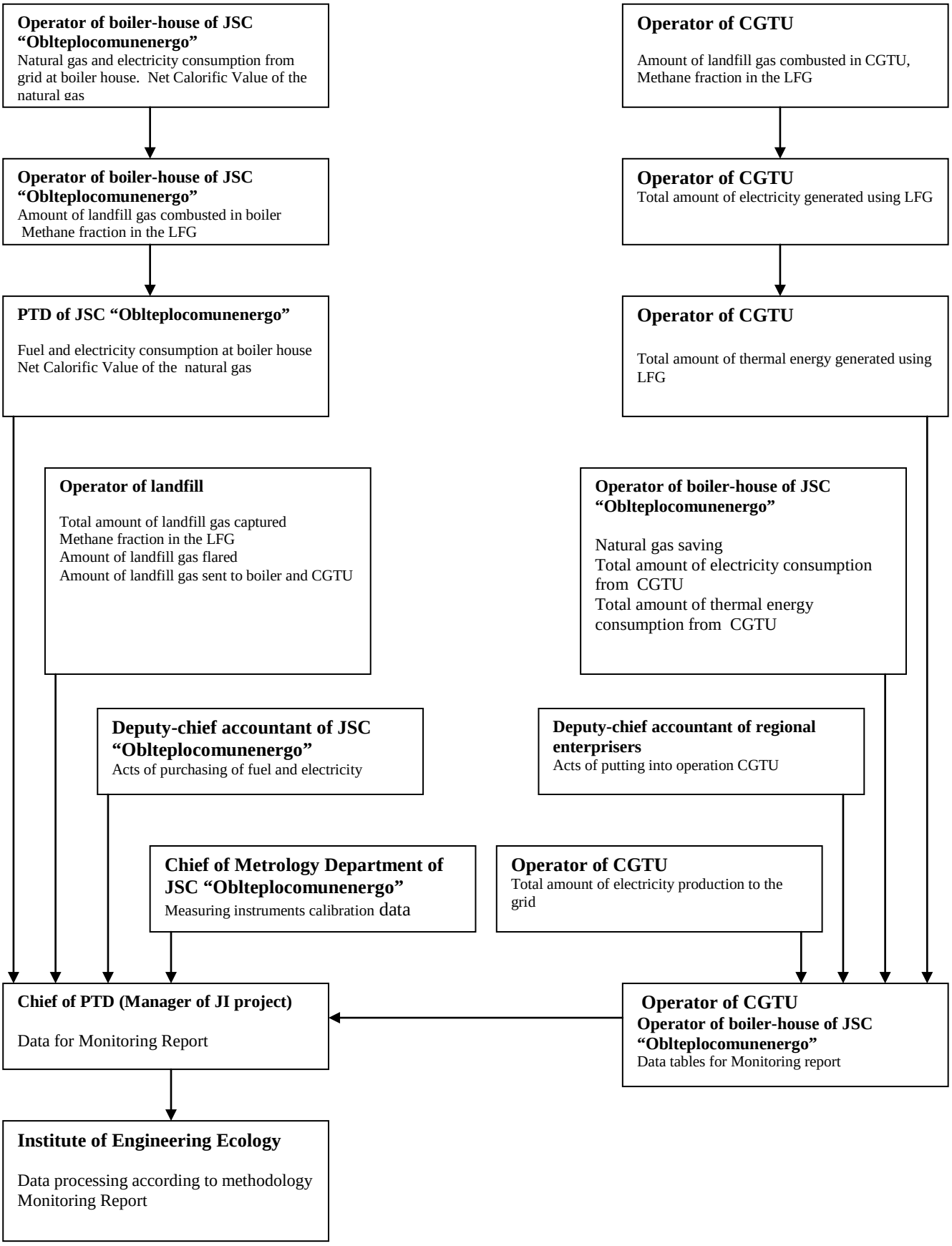


*Figure An3-2. Scheme of data collection for Monitoring Report*

Trainings

JSC “Oblteplocomunenergo” provides personnel retraining according to protection of labour norms. The enterprise has the Labour protection department, which is responsible for raising the level of personnel skills and trainings.

In the case of establishing a new (this previously was not maintained at the plant equipment, such as: CGTU, etc.), equipment, manufacturer of the equipment shall conduct training for personnel.

The special training is scheduled to be held before the development of the first Monitoring report.