Monitoring report form for CDM project activity

(Version 06.0)

MONITORING REPORT		
Title of the project activity	Djebel Chekir Landfill Gas Recovery and Flaring Project – Tunisia	
UNFCCC reference number of the project activity	0487	
Version number of the PDD applicable to this monitoring report	3	
Version number of this monitoring report	1	
Completion date of this monitoring report	02/10/2017	
Monitoring period number	4	
Duration of this monitoring period	01/04/2014- 30/06/2017	
Monitoring report number for this monitoring report	Not applicable	
Project participants	Agence Nationale de Gestion des Déchets (ANGED) International Bank for Reconstruction and Development (IBRD) as the Trustee of the Italian Carbon Fund (ICF) Italy - Ministry for the Environment, Land and Sea Cementerie Aldo Barbetti S.p.A E.ON Produzione S.p.A. Enel Trade S.p.A. ERG S.p.A. Italcementi S.p.A. Iren Mercato S.p.A	
Host Party	Tunisia	
Sectoral scopes	Sectoral scope 13 – Waste handling and disposal	
Applied methodologies and standardized baselines	ACM0001 “Consolidated baseline and monitoring methodology for landfill gas project activities” - Version 2	
Amount of GHG emission reductions or net anthropogenic GHG removals achieved by the project activity in this monitoring period	Amount achieved before 1 January 2013	Amount achieved from 1 January 2013
	-	203,586 t CO_2e
Amount of GHG emission reductions or net anthropogenic GHG removals estimated ex ante for this monitoring period in the PDD	835,334 t CO_2e	

SECTION A. Description of project activity

A.1. General description of project activity

The National Waste Management Agency (ANGed) is the government agency in charge of the waste management sector in Tunisia (project developer). ANGed is currently implementing a CDM project at the Djebel Chekir landfill in Tunisia, which seeks to reduce greenhouse gas (GHG) emissions reductions through the capture and flaring of landfill gas (LFG).

During the considered monitoring period, LFG is extracted and collected from the landfill using gas wells on closed cells (i.e. cells 1, 2, 3 and 4). The main equipment at the site consists of two enclosed flares that are operated alternately.

A blower creates a negative pressure in the gas collection system and extracts the LFG. The gas is fed to one of the two flares manufactured by LES, model ES 375C ICH. Each flare has a maximum capacity of 3,750 Nm^3/h. GHG emission reductions are obtained through the destruction of the methane contained in the gas captured from the landfill.

The two flares were installed on 20/06/2008. The project was commissioned on 13/11/2008. The project activity has been continuously operating since then.

The total GHG emissions reductions (ERs) achieved during this monitoring period, **from 01/04/2014 to 30/06/2017, are 203,586 tCO_2e.**

A.2. Location of project activity

The project activity is located in Djebel Chekir, Greater Tunis, Tunisia.
GPS coordinates are: 36.745066, 10.067157 (or 36º 44' 42.236669" N 10º 04' 1.763928" E).

A.3. Parties and project participants

Parties involved	Project participants	Indicate if the Party involved wishes to be considered as project participant (Yes/No)
Tunisia (host)	Public entity: Agence Nationale de Gestion des Déchets (ANGED)	No
Italy	Public entity: International Bank for Reconstruction and Development (IBRD) as the Trustee of the Italian Carbon Fund (ICF) Public entity: Italy - Ministry for the Environment, Land and Sea Private entity: Cementerie Aldo Barbetti S.p.A Private entity: E.ON Produzione S.p.A. Private entity: Enel Trade S.p.A. Private entity: ERG S.p.A. Private entity: Italcementi S.p.A. Private entity: Iren Mercato S.p.A.	Yes

A.4. Reference to applied methodologies and standardized baselines

ACM0001 "Consolidated baseline and monitoring methodology for landfill gas project activities" Version 2.0.
UNFCCC CDM website reference:
http://cdm.unfccc.int/filestorage/C/D/M/CDMWF_AM_JIVCJD2PTI9976ZOV4A8KRO8T9QUWW/EB21_repan9_ACM0001_Revision_clean.pdf?t=Q298b25ndGRrfDAeHvgdnY4yxPJlxyM6B0Dk

"Tool for demonstration and assessment of additionality" Version 2. *Not used for monitoring*.

A.5. Crediting period type and duration

The crediting period is 10 years fixed, from 13/11/2008 until 12/11/2018.

SECTION B. Implementation of project activity

B.1. Description of implemented project activity

Implementation status of the project:
The starting date of operation of the project activity on the Djebel Chekir landfill is 13/11/2008. Since then, the project has been continuously operating.

Description of the installed technology, technical process and equipment:
The capture and flaring of LFG requires three main components:

1. LFG vertical extraction wells
   - At present, LFG extraction wells were drilled on cells 1 (30 wells drilled), 2 (26 wells), 3 (33 wells) and 4 (52 wells). In each well, a high-density polyethylene (HDPE) perforated pipe is installed in order to collect and transfer the LFG to the network laid on the surface.
   - All wells are equipped with wellheads to allow control of the quantity and quality of the landfill gas (for cross-checking purposes only), and with valves to allow for an appropriate adjustment of the vacuum power in each well.

2. Intermediary piping system to convey the LFG from the wells, to the primary collection pipes
A high-density polyethylene collection piping system is buried in trenches, and allows the transfer of LFG from the wells to the primary collection pipes.
The LFG is vacuumed by a blower into the flaring station (blower manufactured by Continental Industrie).

3. Flaring equipment
A flaring station is equipped with a blower, de-condensation equipment, two enclosed flares, and instruments for measurement and monitoring. Currently the two flares are operated alternately given the low volume of gas extracted. According to initial CH_4 flow estimates, the maximum flaring capacity of the landfill (for cells 1 to 5) was expected to reach 7,000 Nm^3/hour.

The flare technical specifications are as follow:

Manufacturer	LES
Type	Landfill gas; enclosed flare
Serial number	Flare 1: 8041 / Flare 2: 8042
Mixture	50% CH_4 50% CO_2, air, inert gases
Flow rate	300-3,750 Nm^3/h (min-max)
Operational temperature	500ºC-1200ºC
Retention time	0.344 second

B.2. Post-registration changes

B.2.1. Temporary deviations from the registered monitoring plan, applied methodologies or standardized baselines

Not applicable.

B.2.2. Corrections

Not applicable.

B.2.3. Changes to the start date of the crediting period

The starting date of the crediting period was changed from 01/01/2007 to 13/11/2008.

B.2.4. Inclusion of monitoring plan

Not applicable.

B.2.5. Permanent changes to the registered monitoring plan, or permanent deviation of monitoring from the applied methodologies, standardized baselines, or other applied standards or tools

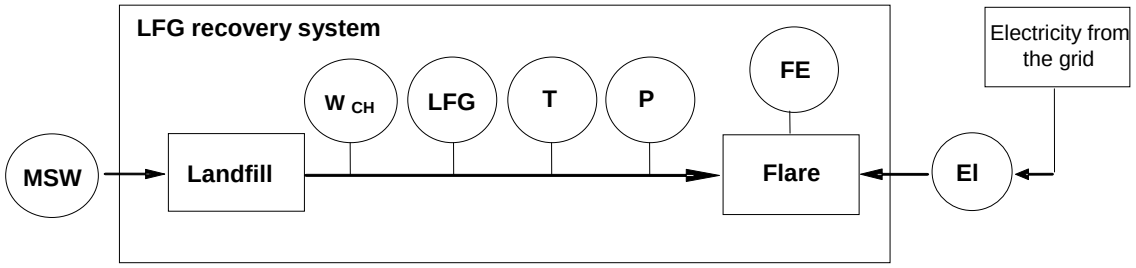
Not applicable.

B.2.6. Changes to project design

Not applicable.

SECTION C. Description of monitoring system

The monitoring system for the project was developed according to version 2.0 of methodology ACM0001. It is based on direct measurement of the amount of landfill gas captured and destroyed at the flare and the electricity consumed for the project as shown in the figure below.



Measurements:

$MSW_{total,y}$ = total quantity of waste landfilled in year y (t)
w_{CH4} = methane fraction in the LFG (%)
LFG_{total} = LFG_{flare} = total amount of landfill gas flared (Nm^3)
T, P = temperature (ºC) and pressure (Pa/mbar) of LFG
FE = flare efficiency, determined by the operating hours and methane content in exhaust gas
EL_y = electricity consumption (MWh)

SECTION D. Data and parameters

D.1. Data and parameters fixed ex ante

Data/Parameter	GWP_{CH4}
Unit	tCO_2/tCH_4

Description	Global warming potential of CH_4
Source of data	IPCC
Value(s) applied	25
Choice of data or measurement methods and procedures	
Purpose of data/parameter	Baseline emissions calculations
Additional comments	Value shall be updated according to any future COP/MOP decisions.

Data/Parameter	**D_{CH4}**
Unit	tCH_4/m^3CH_4
Description	Methane density
Source of data	IPCC
Value(s) applied	0.0007168
Choice of data or measurement methods and procedures	
Purpose of data/parameter	Baseline emissions calculations
Additional comments	At standard T and P (0ºC and 1.013 bar), the density of methane is 0.0007168 tCH_4/m^3CH_4

Data/Parameter	**EF_{grid}**
Unit	tCO_2e/MWh
Description	Grid emission factor for Tunisia
Source of data	PDD
Value(s) applied	0.627
Choice of data or measurement methods and procedures	
Purpose of data/parameter	Project emission calculation
Additional comments	Fixed ex ante for the crediting period

D.2. Data and parameters monitored

Data/Parameter	**$MSW_{total,y}$**
Unit	Metric tonnes
Description	Total quantity of waste disposed in year *y*
Measured/calculated/ default	Measured
Source of data	Measured at weight bridge
Value(s) of monitored parameter	Not applicable: Waste disposed in the landfill during the monitoring period was not deposited in the area covered by the project activity, since the project is implemented on closed cells (i.e. cells 1, 2, 3 and 4)
Monitoring equipment	Weighing scale
Measuring/reading/recording frequency	Measured continuously; recorded continuously (i.e., each truck entering the site)
Calculation method (if applicable)	Aggregated monthly and annually
QA/QC procedures	Calibration is performed by a third-party entity according to a schedule established as per the manufacturer specifications.

Purpose of data/parameter	Baseline emission calculations for ex ante estimation in PDD. Not used for monitoring.
Additional comments	-

Data/Parameter	**$LFG_{total,y} = LFG_{flare,y}$**
Unit	Nm^3
Description	Total amount of landfill gas captured and flared
Measured/calculated/ default	Measured by flow meter (m^3) that compute readings using measured temperature and pressure of LFG to provide normalized flow (Nm^3)
Source of data	Flow meter
Value(s) of monitored parameter	Refer to electronic spreadsheets for exhaustive hourly measures during the entire monitoring period.
Monitoring equipment	See nested table below
Measuring/reading/recording frequency	Measured continuously; recorded on hourly basis.
Calculation method (if applicable)	Not calculated. Flow meter records LFG volumes in normalized cubic meters.
QA/QC procedures	Calibration is performed according to a schedule established as per the manufacturer specifications. The validity of the calibration of the monitoring equipment covered the whole monitoring period except from 21/03/2017 to 31/03/2017. Values recorded during these 10 days have been discounted by 3.2%, corresponding to the result of the delayed calibration.
Purpose of data/parameter	Baseline emission calculations.
Additional comments	-

Monitoring equipment	Manufacturer Type Accuracy	Serial number	Calibration frequency	Date of last calibration	Validity
Differential pressure flow meter	Fuji Electric/ Platon Torbar QRT/FKCP11V4 AKDYYCA Accuracy: +/- 1%	A8C8656F/ 0QC6236	3 years as per the manufacturer specifications	21/03/2014 31/03/2017	calibration not valid from 21/03/2017 to 31/03/2017

Data/Parameter	**$w_{CH4,y}$**
Unit	% (m^3CH_4/m^3LFG)
Description	Methane fraction in the landfill gas
Measured/calculated/ default	Measured
Source of data	Gas analyzer
Value(s) of monitored parameter	Refer to electronic spreadsheets for exhaustive hourly measures during the entire monitoring period.

<table>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><th>Monitoring equipment</th><th>Manufacturer
Type
Accuracy</th><th>Serial number</th><th>Calibration frequency</th><th>Date of last calibrations</th><th>Validity</th></tr>
<tr><td>Gas analyzer</td><td>FUJI electric

ZRJF4D25-BURYR-YYYVYAY-A

Accuracy +/- 2%</td><td>A8C7246T</td><td>6 months (as per the manufac-turer)</td><td>02/01/2014
07/07/2014
31/12/2014
24/02/2016
14/10/2016
24/02/2017</td><td>Not valid from 02/07/2014 to 07/07/2014 and from 24/08/2016 to 14/10/2016</td></tr>
</table>

From 04/04/2015 to 03/02/2016, the main gas analyser was not working properly due to a failure of the sample pump. During this period, manual measurements were taken every hour using a portable gas analyser (refer to parameter FE below, Geotech Biogas Check BM11071 for calibration information).</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>Measured continuously; recorded on hourly basis.</td></tr>
<tr><td>Calculation method
(if applicable)</td><td>Not calculated.</td></tr>
<tr><td>QA/QC procedures</td><td>Calibration is performed by a third-party entity according to a schedule established as per the manufacturer specifications.</td></tr>
<tr><td>Purpose of data/parameter</td><td>Baseline emission calculations</td></tr>
<tr><td>Additional comments</td><td>The delays have been addressed by deviating the measured values of $w_{CH4,y}$ by the maximum permissible error of the gas analyzer (2%) since the results of the delayed calibrations were lower than the accuracy of the instrument.</td></tr>
</table>

<table>
<tr><td>Data/Parameter</td><td>FE</td></tr>
<tr><td>Unit</td><td>%</td></tr>
<tr><td>Description</td><td>Flare combustion efficiency</td></tr>
<tr><td>Measured/calculated/
default</td><td>Measured/Calculated</td></tr>
<tr><td>Source of data</td><td>Measured by a gas quality analyzer (methane content in exhaust gas) taking into account the operating hours of the flare</td></tr>
<tr><td>Value(s) of monitored parameter</td><td>Refer to electronic spreadsheets for exhaustive monthly measures during the entire monitoring period.</td></tr>
<tr><td>Monitoring equipment</td><td>
<table>
<tr><th>Monitoring equipment</th><th>Manufacturer
Type
Accuracy</th><th>Serial number</th><th>Calibration frequency</th><th>Date of last calibration</th><th>Validity</th></tr>
<tr><td rowspan="3">Gas analyzer</td><td rowspan="2">Geotech Biogas Check ±0.5%</td><td>BM11071
Used in 04/2014 and from 09/2014 to 09/2016</td><td rowspan="3">1 year
(As per the manufac-turer)</td><td>02/01/2014
31/12/2014
30/12/2015</td><td rowspan="3">Calibrations valid during the entire monitoring period</td></tr>
<tr><td>BM11259
Used from 05/2014 to 08/2014</td><td>02/01/2014</td></tr>
<tr><td>Geotech Biogas 5000</td><td>G504112
Used from 10/2016 to 12/2016</td><td>06/09/2016</td></tr>
</table>
</td></tr>
<tr><td>Measuring/reading/recording frequency</td><td>Combustion efficiency: measured monthly
Operating hours: measured continuously; recorded on hourly basis.</td></tr>
<tr><td>Calculation method
(if applicable)</td><td>Flare/combustion efficiency is determined by the operation hours and the methane content in the exhaust gas. The operating hours of the flare are taken into consideration in the ER calculations only for the hours when the flare combustion temperature is above 500°C and below 1200°C. The flare combustion temperature is measured continuously by a thermocouple type K and automatically recorded.</td></tr>
<tr><td>QA/QC procedures</td><td>Calibration is performed by a third-party entity according to a schedule established as per the manufacturer specifications.</td></tr>
</table>

Purpose of data/parameter	Baseline emission calculations
Additional comments	During the entire monitoring period, the measured value of methane in the exhaust gas analysis was 0%. Though a flare efficiency of 100% could be claimed, to be conservative it has been considered that the minimum value to be taken into account should be based on the detection limit of the instrument, i.e. 0.5%, for the value of CH_4 in the exhaust gas. Then, the flare efficiency is calculated as 1 – (%CH_4 in the exhaust gas / %CH_4 in the LFG). The resulting flare efficiency has been calculated every month and applied to final values of MD_{flare} on a monthly basis.

Data/Parameter	**T**
Unit	°C
Description	Temperature of the landfill gas
Measured/calculated/ default	Measured
Source of data	Temperature sensor
Value(s) of monitored parameter	Refer to electronic spreadsheets for exhaustive hourly measures during the entire monitoring period.
Monitoring equipment	

Monitoring equipment	Manufacturer Type Accuracy	Serial number	Calibration frequency	Date of last calibration	Validity
Temperature transmitter	Jumo Pt100 0.10°C	918197/ 134177	3 years (as per the manufacturer)	21/03/2014 10/04/2015	calibrations valid during the entire monitoring period

Measuring/reading/recording frequency	Measured continuously; recorded on hourly basis.
Calculation method (if applicable)	This parameter is measured to calculate the LFG volumes in normalized cubic meters.
QA/QC procedures	As per the manufacturer specifications the transmitter should be calibrated every 3 years
Purpose of data/parameter	Baseline emissions calculations
Additional comments	-

Data/Parameter	**P**
Unit	mbar
Description	Pressure of the landfill gas
Measured/calculated/ default	Measured
Source of data	Pressure sensor
Value(s) of monitored parameter	Refer to electronic spreadsheets for exhaustive hourly measures during the entire monitoring period.
Monitoring equipment	

Monitoring equipment	Manufacturer Type Accuracy	Serial number	Calibration frequency	Date of last calibration	Validity
Pressure transmitter	FUJI ELECTRIC FCX-AII ±0.07%	A8C8697F/ FK97907	3 years as per the manufacturer	21/03/2014 31/03/2017	Calibration not valid from 21/03/2017 to 31/03/2017

Measuring/reading/recording frequency	Continuous measurement and at least hourly recording.
Calculation method (if applicable)	This parameter is measured to calculate the LFG volumes in normalized cubic meters.

QA/QC procedures	Calibration is performed by a third party entity at a frequency recommended by the manufacturer. The validity of the calibration of the monitoring equipment covered the whole monitoring period except from 21/03/2017 to 31/03/2017. Values recorded during these 10 days have been discounted by 0.07%, as the result of the delayed calibration showed an error with the acceptable range of the instrument.
Purpose of data/parameter	Baseline emissions calculations
Additional comments	-

Data/Parameter	**EI_y**
Unit	KWh
Description	Electricity consumption
Measured/calculated/ default	Measured
Source of data	Electricity meter
Value(s) of monitored parameter	58.2 MWh for the entire monitoring period
Monitoring equipment	<table><tr><th>Monitoring equipment</th><th>Manufacturer Type Accuracy</th><th>Serial number</th><th>Calibration frequency</th><th>Date of last calibration</th><th>Validity</th></tr><tr><td>Electricity meter</td><td>SIAME T34B Triphase Class 2</td><td>0110041</td><td>5 years as per the manufacturer</td><td>18/08/2011 17/08/2016</td><td>calibrations valid during the entire monitoring period</td></tr></table>
Measuring/reading/recording frequency	Measured continuously, recorded manually daily.
Calculation method (if applicable)	Aggregated monthly and annually.
QA/QC procedures	According to the manufacturer's technical specifications, electricity meters are tested and calibrated and then sealed. Their use in optimal conditions does not alter the uncertainty rate.
Purpose of data/parameter	Project emissions calculations
Additional comments	-

Data/Parameter	Regulatory requirements related to landfill gas projects
Unit	n/a
Description	Required for any changes to the adjustment Factor (AF) or directly $MD_{reg,y}$
Measured/calculated/ default	N/A
Source of data	National regulations
Value(s) of monitored parameter	N/A
Monitoring equipment	N/A
Measuring/reading/recording frequency	N/A
Calculation method (if applicable)	Annually
QA/QC procedures	n/a. Regulation has not changed during monitoring period.
Purpose of data/parameter	Baseline emissions calculations
Additional comments	-

D.3. Implementation of sampling plan

Not applicable.

SECTION E. Calculation of emission reductions or net anthropogenic removals

E.1. Calculation of baseline emissions or baseline net removals

According to the baseline methodology ACM0001 - Version 2, emission reductions are calculated as follows:

$ER_y = BE_y - PE_y$
$BE_y = (MD_{project,y} - MD_{reg,y}) * GWP_{CH4}$
$PE_y = EI_y * 0.627$

Where
$MD_{project,y}$ = amount of methane actually destroyed/combusted during the period
$MD_{reg,y}$ = amount of methane that would have been destroyed/combusted during the period in the absence of the project activity ($MD_{reg,y} = 0$ in absence of regulation)
GWP_{CH4} = global warming potential of methane
EI_y = net quantity of electricity consumed during year y, in megawatt hours (MWh)

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

Where
$MD_{flare,y}$ = the quantity of methane destroyed by flaring,
$MD_{flare,y} = LFG_{flare,y} * W_{CH4,y} * D_{CH4} * FE$

Where
$LFG_{flare,y}$ = Total amount of landfill gas flared
w_{CH4} = Methane fraction in the landfill gas
D_{CH4} = Density of methane derived from measurement of LFG (0.0007168 tCH_4/m^3CH_4)
FE = Flare/combustion efficiency (values provided in spreadsheets)

Thus, baseline emissions are calculated as follows:
$BE_y = LFG_{flare,y} * w_{CH4,y} * D_{CH4} * FE$
Baseline emissions for the period are calculated as BE_y = 203,623 tCO_2e.

Therefore, emission reductions are calculated as follows:
$ER_y = LFG_{flare,y} * w_{CH4,y} * D_{CH4} * FE * GWP_{CH4} - (EI_y * 0.627)$

This equation is equivalent to the one presented in the registered PDD:

$ER_y = (ER\_CH4_y * CF * GWP\_CH4) – (EI_y * 0.627)$
$ER\_CH4_y = CH4_{project,y} – CH4_{baselne,y}$

Where:
- ER_CH4_y is the methane emission reduction in m^3; ***equivalent to $LFG_{flare,y} * W_{CH4,y} * FE$***
- CF is the conversion factors from m^3 CH_4 to t CH_4 (0.0007168) at standard temperature and pressure; ***equivalent to D_{CH4}***
- GWP_CH4 is the global warming potential for CH_4; ***equivalent GWP_{CH4}***
- EI_y is the annual electricity consumption of the LFG system
- 0.627 is the emission indicator for electricity from the grid in Tunisia expressed in tCO_2e/MWh

E.2. Calculation of project emissions or actual net removals

Project emissions are calculated as follows:

$PE_y = EI_y * 0.627$

Where
El_y = net quantity of electricity consumed during year y, in megawatt hours (MWh).
El_y is measured as 36.49 MWh for the entire monitoring period.

Project emissions for the period are calculated as PE_y = 37 tCO_2e

E.3. Calculation of leakage emissions

No leakage will be considered for the project activity.

E.4. Calculation of emission reductions or net anthropogenic removals

	Baseline GHG emissions or baseline net GHG removals (t CO_2e)	Project GHG emissions or actual net GHG removals (t CO_2e)	Leakage GHG emissions (t CO_2e)	GHG emission reductions or net anthropogenic GHG removals (t CO_2e)		
				Before 01/01/2013	From 01/01/2013	Total amount
Total	203,623	37	-	-	203,586	203,586

E.5. Comparison of emission reductions or net anthropogenic removals achieved with estimates in the registered PDD

Amount achieved during this monitoring period (t CO_2e)	Amount estimated ex ante (t CO_2e)
203,586 tCO_2e	835,334[1] tCO_2e

E.6. Remarks on increase in achieved emission reductions

There is no increase in the actual GHG emission reductions achieved during this monitoring period as compared to values estimated ex-ante in the registered PDD.

The low amount of reductions achieved is due to following reasons:
- High leachate level in the landfill.
- Gas extraction system in cell 4 has started only in September 2016 due to procurement issues.

The PDD had an overestimation in the average methane concentration used for calculations (50%) and an optimistic biogas recovery rate of 70%.

[1] The value is calculated as the sum of the ERs reported in the registered PDD for 9 months of 2014 (337,765 / 12 x 9 = 253,324 tCO_2), the year 2015 (305,571 tCO_2) and the year 2016 (276,439 tCO_2). The PDD did not show any value for year 2017.