CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
Version 02 - in effect as of: 1 July 2004)

CONTENTS

Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

- Landfill Gas Recovery and Flaring for 9 bundled landfills in Tunisia
- Version number of the document: 04
- Date of the document: 10 August 2006

A.2. Description of the project activity:

The National Waste Management Agency of Tunisia (ANGED) is launching a project aimed at installing a Gas Recovery and Flaring Project at 9 new Landfills to be put into operation beginning from 2007 as a part of the National Waste Management Programme.

The nine landfills are disseminated over the Tunisian Territory and close to the following cities: Bizerte, Sfax, Kairouan, Djerba, Gabes, Monastir, Sousse, Nabeul and Medenine. Apart from Tunis Capital, these represent the major urban agglomerations of Tunisia.

The nine landfills have an aggregated nominal capacity of 3,300 tons of waste per day; i.e. 1.2 million tons of waste/year.

The project activity will install a gas recovery and flaring system in each of the nine landfills, in order to reduce CH_4 emissions, and thus generate CERs, while ensuring safety at the Landfill sites, serving sustainable development purposes, and providing additional resources to environment protection in Tunisia.

The Nine Landfills are being put into operation between 2006 and 2008, following competitive bids, which are being progressively launched to select the landfill operators. Sfax and Kairoun will be bundled and awarded to a single operator. That will also be the case for Djerba and Gabes. Each of the other 5 landfills will be awarded separately.

Table 1, shown below, presents the physical characteristics of the 9 landfills, and the expected date of operation.

While respective infrastructures of the nine landfills are almost completed, only the first receiving Cell has been managed to receive wastes. Originally, none of the nine landfills was designed to be equipped with LFG management system. The bids being launched to select landfills operators have specified that LFG management system will be developed and implemented under CDM framework.

The future contracts with landfill operators will encompasses the usual responsibilities of landfill management, including technical activities (waste control before reception, waste reception, landfilling according to a defined protocol, data monitoring including environmental data, monitoring of the leachate and draining system, etc.), Personnel, and the management and maintenance of stationary and mobile equipments, which are properties of ANGED. The costs of all these activities are to be covered by the landfill operators.

In relation with LFG system, the landfill operator will be simply requested to make the sub-cells available, as soon as they are fully filled with wastes, to allow for a separate LFG operator to install and operate the LFG management system.

The LFG recovery and flaring systems will be financed by the National Waste Management Agency (ANGED), and operated by private contractors. Separate competitive bids will be issued in order to recruit specialized companies for the purpose of designing, building and operating the LFG component of each of the nine landfills. In order to avoid a threat to the proper operation of the landfills the LFG, operation will be based on performance-based contracts

This system is considered as a CDM project under a partnership with Carbon Finance Business of the World Bank.

Table 1: Background information on the 9 targeted landfills

Nbr	**City**	Expected date of operation	Nominal capacity (1000 tons of wastes/yr)	Shares of the nominal capacity (%)	Size of Cell 1 (hectares)
1	Bizerte	July 2006	100 000	8,4%	6
2	Sfax	January 2007	180 000	15,1%	6
3	Kairouan	July 2006	60 000	5,0%	5,5
4	Djerba	July 2006	50 000	4,2%	3,5
5	Gabès	July 2006	90 000	7,6%	5
6	Monastir	October 2006	160 000	13,4%	5
7	Sousse	January 2007	220 000	18,5%	6
8	Nabeul	October 2008	240 000	20,2%	7
9	Medenine	July 2007	90 000	7,6%	5
	TOTAL		**1 190 000**	**100%**	**49**

The project will have a significant contribution to sustainable development:

The project will demonstrate the application of a World Standard methane capture system in Tunisia, and will allow for replicating such experience in the country.

Socio-economic potential benefits will include the development of endogenous capacities to better manage Landfilling operations, the development of a number of employment opportunities in the different infrastructure works involved: Wells building, Piping network, management and monitoring of the system, etc.

By recovering LFG, it will also contribute to mitigate pollution, and thus limit landfill impacts by preserving air quality, within the neighboring human establishments of the targeted regions.

The project will ensure appropriate leachate management practices. In doing so, the project will reduce the impact of the Landfills on the soils and on ground water resources, and thus preserve the environment.

The project will contribute to the National Solid Waste Management Programme, by allocating 25% of the CERs revenues to rehabilitate a number of existing dumps. By preventing these dumps continuously impacting soils, groundwater resources, air quality and public health, the financial resources provided by the project will therefore restore the ecological equilibrium in the targeted areas and encourage human economic and social activities in the surrounding areas, all of which will effectively contribute to Sustainable Development.

The project will also provide for new foreign currency resources for Tunisia and thus improve the profitably of the waste sector. This will ensure high standard practices in waste management in Tunisia, and thus contribute to Sustainable Development.

Bizerte Landfill – Front Entrance

Bizerte Landfill – Cell 1 during construction phase

Figures 1: The nine landfills before their launching

Sfax Landfill – Cell 1 during construction phase

Sfax Landfill – Cell 1 during construction phase

Figure 1: The nine landfills before their launching (continued)

Kairouan Landfill – Cell 1 during construction phase

Gabès Landfill – Front Entrance

Figure 1: The nine landfills before their launching (continued)

Djerba Landfill - Cell 1 during construction phase

Djerba Landfill -Entrance Area

Figure 1: The nine landfills before their launching (continued)

A.3. Project participants:

Name of Party involved (*):	Private and/or public entity(ies) Project Participants(*)	Does the Party involved wish to be considered as project participant?
Tunisia (Host Party)	Agence Nationale de Gestion des Déchets (ANGED-Tunisia-Host Party) – Project Proponent-Public	No
Government of Italy	International Bank for Reconstruction and Development (IBRD) as the Trustee of Italian Carbon Fund (ICF)	Yes

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

A.4.1.1. Host Party(ies):

Tunisia

A.4.1.2. Region/State/Province :

Nine landfills disseminated over the territory of Tunisia

A.4.1.3. City/Town/Community:

Bizerte, Sfax, Kairouan, Djerba, Gabes, Monastir, Sousse, Nabeul, Medenine

A.4.1.4. Detail of physical location, including information allowing the unique identification of this project activity

The nine landfills are disseminated over the territory of Tunisia, from North to South, mainly in coastal zones where is located the highest proportion of the population and of economic and industrial activities.

The nine landfills are being implemented as to replace the existing dumps located in the same regions. These dumps will also be rehabilitated and closed subsequently to the opening of the new landfills.

The nine Landfills are located close to the 9 main cities of Tunisia (see location map in figure 1). More detailed description of the respective locations of each landfill is shown is table 2 below.

Aggregated size of the nine landfills is approximately 320 hectares. The Landfills will be implemented sequentially, following the end of the upstream works involved (e.g. transfer centers) in relation with landfills.

Aggregated size of cells n°1 of the nine landfills, which will be targeted by the project activity, is 49 hectares. At the closure dates of Cells 1, the nine Landfills would have landfilled a total of 7.6 Million tons of Wastes.

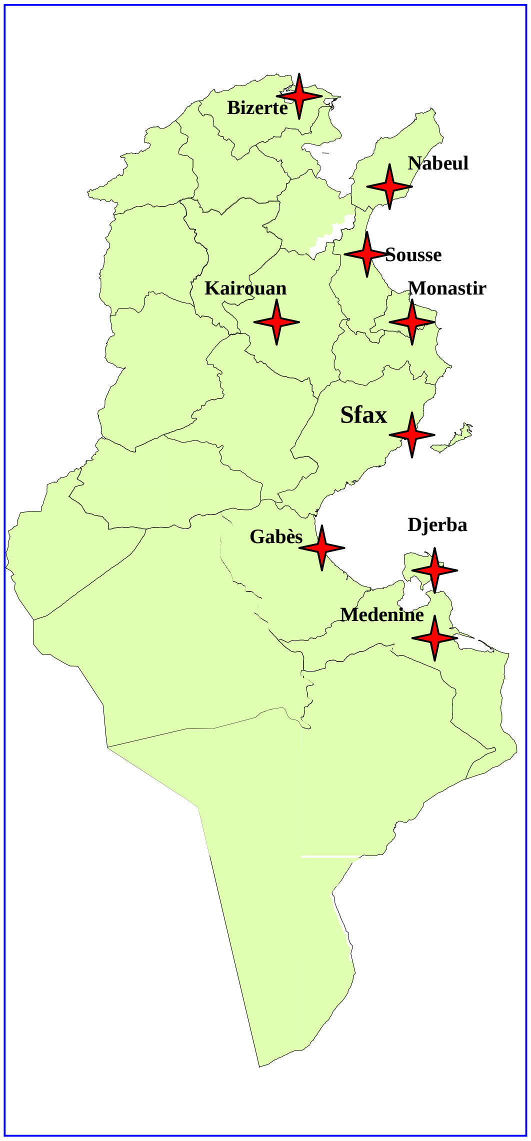

Figure 2: Geographical location of the nine landfills

Table 2: Detailed locations of the 9 targeted landfills

City	Location
Bizerte	10 km, West to the City of Bizerte, South-East side of Jebel Abdallah
Sfax	21 km-East to Sfax city, through RN14, at around 4 km from Agareb
Kairouan	12 km, West to the urban area of Kairouan, at around 2 km from El Baten
Djerba	18 km from centre of Houmt Essouk, close to Guallala at 4 km-South from the road RV942
Gabès	East of Mezra Ghannouch, between Oued El Demna (North) and Oued Ettine (South)
Monastir	North-West of Monastir, in Masjed Issa, in Menzel Harb region
Sousse	At 17 km fro Sousse, close to Bir sidi El Oussaief
Nabeul	The Landfill site is located on the edge of the regional road RR43-PK26, linking Menzel Bouzelfa and Menzel Temime Communes, East of Errahma village
Medenine	South-East of Medenine city, on the road RR118 linking Medenine to Zarzis

A.4.2. Category(ies) of project activity:

Project activity: 13- Waste handling and disposal

A.4.3. Technology to be employed by the project activity:

The purpose of the project is to implement efficient gas recovery and flaring systems in nine controlled landfills, as to generate Certified Emission Reductions. The project activity will only involve Cell 1 of each landfill.

The LFG System

The extraction, collection and destruction of LFG would require three main components:

LFG vertical extraction wells

- Prepare the places and infrastructure of the LFG extraction wells (4 wells per ha, 50 meter distance between well centerlines) in Cell 1 of each landfill.
- Complete the drilling and building of the wells as soon as the alveolus are full of wastes (nominal well diameter of 600 mm)
- In each well, install a high density polyethylene perforated pipe (minimum of 150 – 160 mm in diameter) to receive and transmit the LFG to the surface.
- Fill the space surrounding the perforated pipe with clean crushed stones or gravel of 19 – 80 mm size.
- All wells will be equipped with wellheads to enable monitoring of quantity and quality of the LFG, and with valves to allow for an appropriate adjustment of the vacuum of each well.

Intermediary piping system to convey the LFG from the wells, to the primary collection pipes

- Dig trenches and bury high density polyethylene collection piping system, to convey the LFG from the wells to primary collection pipes.
- Install a high density polyethylene collection piping system, to convey the collected LFG to the blower/flaring Station.

Flaring Equipment

- Design and install the relevant flares (blower, de-condensation equipment, flare, and all monitoring and measuring soft and hardware). The flares will be designed according to the CH_4 flow estimates. The total flare capacity could be installed from the beginning, but it might be decided to install a small capacity at the beginning, and to upgrade it progressively.
- The maximum flaring capacities of the nine landfills are shown below:

Table 3: Maximum flaring capacity needs of the nine landfills

Nbr	**City**	Nominal capacity (1000 tons of wastes/yr)	Maximum capacity of flares (m^3/hour)	Maximum capacity of flares reached in year:
1	Bizerte	100	548	2011
2	Sfax	180	1 016	2012
3	Kairouan	60	587	2015
4	Djerba	50	332	2013
5	Gabès	90	420	2011
6	Monastir	160	949	2012
7	Sousse	220	2 272	2016
8	Nabeul	240	1 909	2016
9	Medenine	90	446	2012
TOTAL		**1 190**		

Activities to be launched by the project

To allow for an appropriate LFG extraction and flaring, starting from year 2007, the project should undertake the following activities, targeting the projected Cell 1 in each landfill:

- Design and Implement an appropriate LFG collection and piping network system. Implementation of the LFG systems should be synchronized with the usual landfilling operations.
- Install a primary LFG collection and a full LFG flaring system in the nine landfills.
- Put in place a formal Operational Guide to enable for the optimization of the LFG extraction and flaring.
- Undertake a training program targeting ANGED staff involved in monitoring and supervising the project.
- Design and implement an appropriate monitoring and measuring system of the LFG for cell 1 in the nine landfills.

A.4.4. Brief explanation of how the anthropogenic emissions of anthropogenic greenhouse gas (GHGs) by sources are to be reduced by the proposed CDM project activity, including why the emission reductions would not occur in the absence of the proposed project activity, taking into account national and/or sectoral policies and circumstances

Waste management regulations in Tunisia do not require recovery and destruction of CH4 in Landfills. There are currently 5 controlled Landfills in Tunisia, Djebel Chekir and four other small landfills, none of them being equipped with LFG systems.

One exception relates to the closed Henchir Lihoudia, formerly one of the largest open dumpsites in Greater Tunis. Several years after the closure this dump, it was decided to rehabilitate it as to exploit it for various social and recreational activities (public park, museum), for the benefit of the surrounding poor communities.

During the rehabilitation activities, site investigations have been conducted and the conclusions were the existence of two minor gas pockets that might affect the safety use of the site. Therefore, decision was taken to install limited gas wells with the necessary flaring equipment. In fact, several months after the implementation of the flaring equipment, actual data of flared gas reveals minor quantities of CH4 still remaining in the dump, which suggest major part of methane was partly burned due self ignition and burning of waste practices and partly emitted into the atmosphere during the operational life of the dump.

Another exception relates to Djebel Chekir, where previous contractual arrangements with SOMAGED the landfill operator have included clauses for LFG recovery and destruction as a unique site safety purposes that is not required by Law. However, for various reasons, these clauses have never been applied, and the wells were damaged and simply abandoned due to inappropriate maintenance. Therefore, all generated CH4 was finally emitted into the atmosphere.

Although some rough technical description concerning the installation method of the wells, the contract neither described characteristics of the LFG collection system and flaring equipment, nor did it mention how it would be operated and who would be bearing the cost of all the equipments.

Due to such unclear specifications and also inappropriate overall operating conditions of the landfill partly resulting from ANPE not being able to meet its own contractual commitments, the LFG collection, and evacuation and flaring were never implemented as it should have been. The only LFG wells installed at Djebel Chekir site were then 20 wells installed in Cell 1. But these wells were apparently too small in diameter, were blanked off and were not interconnected by the collection piping. It was also reported that the wells were drilled right to the bottom of the waste bed and that the perforated inner tube was 100 mm in diameter, which are not appropriate for any LFG extraction.

Due to this unsuccessful experience, no LFG recovery system was installed in cells 2 and 3 of Dejebel Chekir. Overall, there was an evident technical, financial and operational lack of capacity to operate such LFG safety system in Tunisia.

The new contractual clauses for Djebel Chekir or the other nine landfills do not request the new landfill operator to install any LFG recovery system.

It is unlikely that economic, technical, regulatory or other types of measures would be adopted in the foreseeable future that could significantly change the current practices. Taking national circumstances into account, there are no serious macroeconomic or microeconomic incentives or rationale, for Tunisia, to invest in or to promote LFG extraction and destruction systems. More logically, the limited resources should be allocated to priority needs such as replacing dumps with managed landfills, and closing and rehabilitating existing dumps as well as surrounding areas.

Therefore, significant quantities of CH4 would have been emitted into the atmosphere over the whole "active" period of the landfills, in the absence of the CDM project activity.

Moreover, there are already some difficulties to attract private sector to simply operate landfills in Tunisia due to the lack of skills and interest to the waste sector.

The implementation of an appropriate LFG extraction system will therefore allow LFG recovery and flaring to CO2, which would contribute to dramatically reduce GHG emissions into the atmosphere, as compared to the baseline situation.

A.4.4.1 Estimated amount of emission reductions over the chosen crediting period:

Years	Annual estimation of emission reductions in tonnes of CO_2 e
2007	16 075
2008	94 225
2009	176 870
2010	272 382
2011	358 019
2012	420 038
2013	440 310
2014	455 728
2015	471 653
2016	473 792
Total estimated reductions (tonnes of CO_2 e)	**3 179 092**
Total number of crediting years	**10**
Annual average over the crediting period of estimated reductions (tonnes of CO_2 e)	**317 909**

A.4.5. Public funding of the project activity:

None

SECTION B. Application of a baseline methodology

B.1. Title and reference of the approved baseline methodology applied to the project activity:

"Consolidated baseline methodology for landfill gas project activities – ACM0001/Version3, dated 19 May 2006 "

B.1.1. Justification of the choice of the methodology and why it is applicable to the project activity:

Project activity meets applicability criteria of the chosen methodology. This methodology is adopted in relation with the selected approach for Baseline taken from paragraph 48 of the CDM modalities and procedures: "(b) Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment".

The baseline scenario in the nine landfills does not consider any LFG system, and leads to a total atmospheric release of the landfill gas. The project activity includes the situation where the LFG is captured and flared, assuming a realistic collection and destruction efficiency.

B.2. Description of how the methodology is applied in the context of the project activity:

According to the Consolidated Baseline Methodology ACM0001, the greenhouse gas emission reduction achieved by the project activity during a given year "y" (ER_y) is the difference between the amount of methane actually destroyed/combusted during the year ($MD_{project,y}$) and the amount of methane that would have been destroyed/combusted during the year in the absence of the project activity ($MD_{reg,y}$), times the approved Global Warming Potential value for methane (GWP_{CH4}), plus the net quantity of electricity displaced during the year (EG_y) multiplied by the CO2 emissions intensity of the electricity displaced ($CEF_{electricity,y}$), plus the quantity of thermal energy displaced during the year (ET_y) multiplied by the CO2 emissions intensity of the thermal energy displaced ($CEF_{thermal,y}$).

In the case of the nine landfills of this bundling project, no Electricity generation will be considered. Therefore, the emission reduction will be calculated as follows:

$$ER_y = (MD_{project,y} – MD_{reg,y})*GWP_{CH4}$$

There is no regulation requesting recovery and flaring of any LFG portion in the landfills in Tunisia. Moreover, in the case of Djebel Chekir, there was no CH4 recovery and flaring, and the new bids for operating the landfills do not commit the landfill contractor to recover and flare LFG. Therefore, the baseline will not consider any destruction of methane (MDreg = 0), and all the CH4 potential of the nine landfills will be emitted into the atmosphere, based on the IPCC methodology for estimating these emissions.

Estimation of Methane to be Generated by the Landfills

The first step in applying the methodology is to estimate the volume of methane that is expected to be generated from the landfills during the project lifetime. This estimated quantity of methane is based on the projected quantities of wastes to be disposed of in Cells 1 of the nine respective landfills according to the quantities specified in the coming contract between ANGED and the new contractors.

The first order decay model[1] as described in the Revised 1996 IPCCC Methodology was used to estimate methane emissions from the landfill. The model is as follows:

$$CH4_{Projected,\ y} = k * L_o * \sum_{t=0,y} WASTE_{contract,\ t} * e^{-k(t-y)}$$

Where:

- **$CH4_{projected,y}$** : the quantity of methane projected to be generated (m^3)
- **k** : the methane generation rate constant (1/yr) relates to the time taken for the Degradable Organic Carbon (DOC) in waste to decay to half its initial mass.
- **L_o** : the methane generation potential (t CH4 / t Waste)
- **$Waste_{contract,y}$** : the waste input at year y
- **y** : the year where the waste was input to the landfill
- **t** : the year where methane emission is estimated for the waste deposited in year y

♦ ***Assumption of k***

According to IPCC guidelines, the value of the methane generation rate constant may range from 0.005 to 0.4 per year. The estimation of methane generated form the landfill is highly sensitive to the assumption of the value of k.

k value depends on the moisture content in the landfills, temperature in the anaerobic zone, pH, and nutrient availability.

Relatively rapid rates (e.g. k = 0.2 or a half life of about 3 years) are associated with high moisture conditions and rapidly degradable material such as food waste. Lower decay rates (k = 0.03 or a half life of about 23 years) are associated with dry conditions and slowly degradable waste such as wood or paper. Tunisian conditions are quite favorable to biodegradation kinetic because of the high temperature, moisture content and humidity conditions and the high composition in rapidly degradable materials such as food waste (60%). Despite these favorable conditions, a conservative k value of 0.1 is adopted (or a half life of about 7 years).

♦ ***Estimation of Methane Generation Potential (Lo)***

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[1] See USEPA Manual "Turning a Liability into an asset: A landfill gas to energy Handbook for Landfill Owners and Operators" (December 1994).

According to IPCC guidelines, methane generation potential (t CH4 / t Waste) is estimated using the following equation:

$L_o = MCF*DOC*DOC_f*F*(16/12)$

Where:

MCF: the methane correction factor

DOC: the degradable organic carbon in the waste (fraction)

DOC_f : the fraction of organic carbon dissimilated (fraction)

F : the fraction by volume of CH4 in the landfill gas (fraction)

16/12 : Conversion from C to CH4

Estimating MCF

According to IPCC, MCF is assumed according to the types of sites shown in Table 1.

Table 4: Methane Correction Factor (MCF)

Type of Site	Methane Correction Factor (MCF)
Managed Landfill	1
Unmanaged – deep (≥ 5m waste)	0.8
Unmanaged – shallow (< 5m waste)	0.4
Default value – uncategorized SWDSs	0.6

MCF was assumed to have a value of 1 since the nine landfills will be a well managed and controlled. According to IPCC guidelines, well managed landfills should have controlled placement of waste and a degree of control of scavenging activities and control of fires should be in place. The nine landfills will be able to satisfy these criteria based on the following reasons:

- Placement of waste will be well planned in previously designed cells.
- The bottom of the landfills is made of deep non-porous clay.
- After the placement of each 2 m-layer of waste, the waste layer is cover by a 30 cm sand layer which help better compaction and leveling of the waste and prevents any human interference with waste as well as possible self ignition..
- The landfills will be protected with a fence that surrounds them from all sides and no scavenging activities will be allowed inside the landfill.

Estimating DOC

Degradable organic fraction is based on the composition of the waste. DOC is estimated from a weighted average of the carbon content of various components of the waste stream. Table 6-3 of the Revised 1996 IPCC guidelines gives default values for the carbon content for various waste types. These values are presented in Table 5, shown below.

Table 5: Degradable Organic Carbon For Major Waste Streams

Waste Stream	Percent DOC by Weight
A. Paper and textiles	40%
B. Garden and park waste, and other (non-food) organic putrescibles	17%
C. Food wastes	15%
D. Wood and straw waste	30%

In case the percentage of each type of waste in the total waste stream is known, the weighted average of the degradable organic carbon can be estimated as follows:[2]

% DOC (by weight) = 0.4(A) + 0.17(B) + 0.15(C) + 0.3(D)

Where:

A: Percent paper and textiles in the waste

B: Percent garden and park waste, and other non-food organics

C: Percent food waste

D: Percent wood and straw waste

Table 6, shown below, presents the composition of waste in Tunisia. This composition was used to estimate the degradable organic fraction of the Tunisian waste. In addition, relevant correction factors were used for lignin when calculating DOC (Lignin proportion subtracted).

Table 6: Organic Materials subject to decomposition that are contained in the Tunisian Waste

	Waste composition
Paper and Textiles	11.0%
Garden and park waste and other (non food) organic putrescibles	5.63%
Food Waste	60.26%
Wood and Straw Waste	0.04%
Total	**76,9%**

The calculated DOC for the nine landfills would be the following:

% DOC = 0.4 x (0.11) + 0.17 x (0.0563) + 0.15 x (0.6026) + 0.3 x (0.04) = 0.14

[2] Equation 2 of the Revised 1996 IPCC guidelines, p. 6.9.

Estimating DOC_f

Fraction dissimilated DOC is the portion of the degradable organic carbon that is converted to landfill gas. IPCC guidelines present the following equation to estimate DOC_f:

$$DOC_f = 0.014T + 0.28$$

T, the temperature in the anaerobic zone was assumed at 35 ^oC. Therefore, the DOC_f was estimated as follows:

$$DOC_f = 0.014(35) + 0.28 = 0.77$$

According to the IPCC Good Practice Guidance, this default factor of DOC_f should be used only if the lignin C is excluded from the DOC Value. Since this has been applied for the current DOC calculation, 0.77 is an appropriate number for the nine landfills.

Estimating F

The default value for the fraction of methane in landfill gas is 0.5 as recommended by IPCC.

Estimating L_o

Based on the estimation of different parameters calculated above, methane generation potential was estimated as follows:

$$Lo = MCF*DOC*DOC_f*F*(16/12)$$

Lo = 1*0.14*0.77*0.5*(16/12) = 0.072 T CH4 / t Waste (approximately 100 m3 CH4 / Mg Waste)

IPCC guidelines states that the value of L_o may range from less than 100 to over 200 m3 CH4 / t Waste (i.e. 0.072 to 0.143 t of CH4/ton of wastes using a standard density of 0.72). This shows that the estimated value to be used for the nine landfills is equal to the lowest value of the range.

♦ ***Estimation of Waste Quantities***

Waste streams that are considered are based on the nominal capacities that Cell 1 of each landfill has been designed for, as well as the projected lifetime of this Cell 1. The lifetime was defined by ANGED according to the projected quantities of wastes to be generated by each municipal area.

It is assumed here that at the opening period, each landfill will be receiving smaller quantities wastes than its nominal capacity. In general, it is assumed that the targeted landfills will be receiving the equivalent of their nominal capacities only:

- four years after their opening date: Kairouan, Djerba, Gabès, Nabeul and Medenine;
- five years after their opening date: Sfax, Monastir, Sousse;
- Six years after their opening date: Bizerte.

Taking these assumptions into account, the quantities of wastes to be received by each landfill from the opening date until the closing year or the last year of the project (2016) were estimated according to the official projections of ANGED, which have been estimated for each landfill on the basis of the population growth and the assumed growth of the daily waste generation per capita.

In addition, the quantities of wastes to be landfilled during the first year period of each landfill were estimated proportionally to the number of effective operational months in the projected opening year.

Taking all these assumptions into consideration, Cell 1 of the nine landfills will be receiving an aggregated amount of around 7.6 million tons of wastes over their total lifetime. This corresponds to the whole quantity of waste that will be involved in CH4 generation, and which recovery will be considered by the project for the period 2007-2016.

♦ ***Total Quantity of Methane Generated***

Applying the IPCC model and using the estimated parameters, the total quantity of methane generated in the baseline situation by the nine landfills can be estimated. Figure 3, shown below, presents in tonnes, the total quantities of methane that are expected to be generated from Cell 1 of the nine landfills, during the period 2007 to 2037 which is the almost whole "active" period of these Cell 1 in terms of CH4 generation.

Figure 4 shows quantities of methane to be generated in baseline situation expressed in tCO2 equivalent, for the period 2007 -2016.

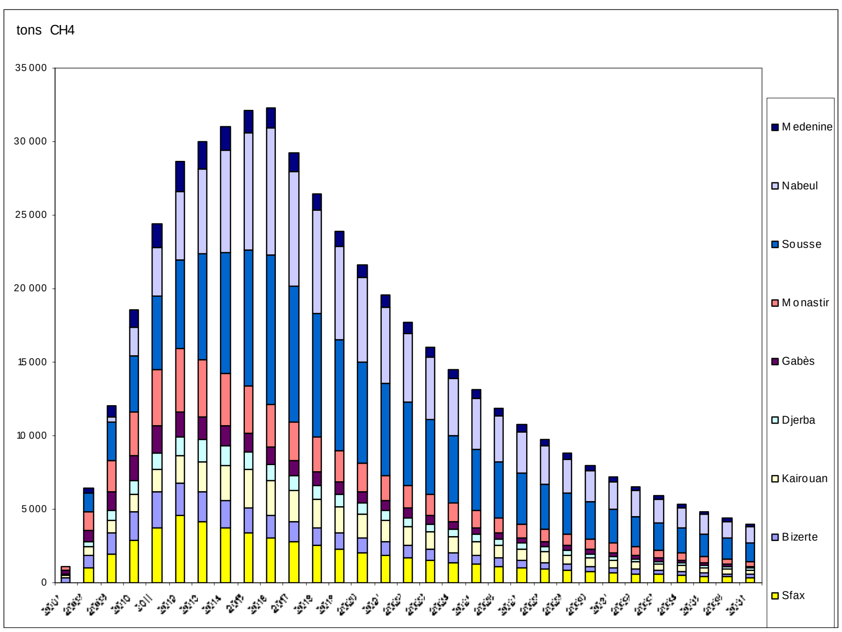

Figure 3: Projected Methane Generation from the Cells 1 of the nine landfills (t CH4) in the baseline situation for the period 2007-2037

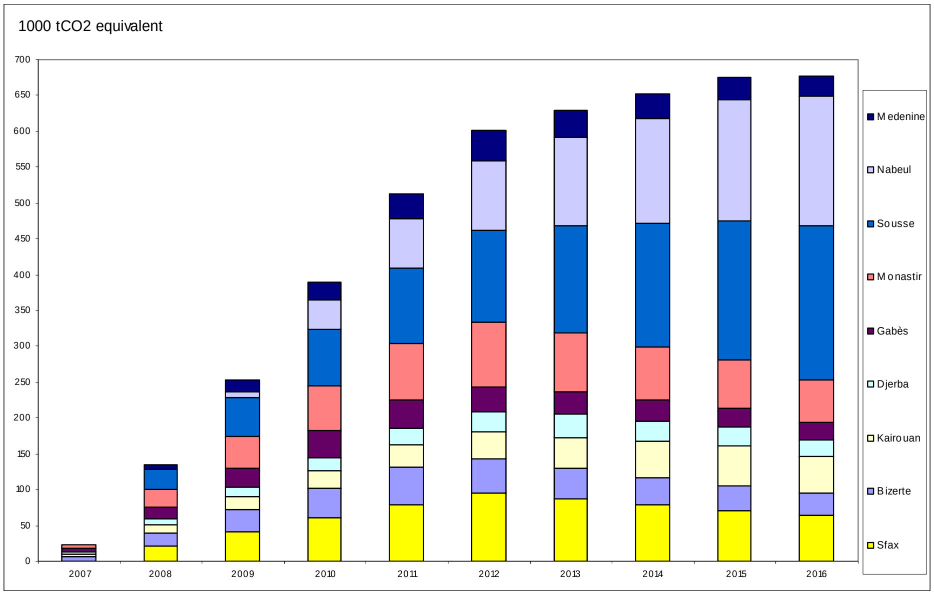

Figure 4: Projected Methane Generated by Cells 1 of the nine landfills (1000 tCO2 equivalent) in the baseline situation for the project period (2007-2016)

♦ ***Estimation of Baseline Emissions***

As stated in the consolidated baseline methodology ACM0001, baseline emissions should be calculated from the above estimates, while applying the mandated regulatory or contractual fraction to be flared if any.

According to the contract arrangements to be made for the nine landfills, baseline situation does not consider any proportion of the LFG to be flared.

Overall, the estimated baseline emissions will amount to **4,547,992** tonnes of CO2e over the 10 years of the prescribed crediting period.

B.3. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity:

This section describes how the anthropogenic emissions of greenhouse gases by the source (the landfill) are reduced below those that would have occurred in the absence of the registered CDM project activity. The determination of the landfill gas capture project scenario additionality for the nine landfills is done using the CDM consolidated "Tool for the demonstration and assessment of additionality", which follows five steps. The purpose of the consolidated tools for the demonstration of additionality is to check that the claim of additionality is justified and to ensure that baseline activities do not receive CERs.

Demonstration of additionality

The additionality tool is used in conjunction with the consolidated methodology ACM0001.

The following steps from the "tool for the demonstration and assessment of additionality" will be applied:

Step 0 - Preliminary screening based on the starting date of the project activity

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

Step 2 - Investment Analysis

Step 3 – Barrier analysis

Step 4 - Common Practice Analysis

Step 5 - Impact of CDM Registration

Step 0 - Preliminary screening based on the starting date of the project activity

The project will start by July 2006, so the registration will occur before the start of the first crediting period.

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

- ***Definition of alternatives to the project activity:***

In order to estimate the attractiveness of the project activity, two other credible and realistic alternatives that provide outputs or services comparable with the proposed CDM project activity are considered.

Alternative 1: Continuation of current practice which means the waste will continue to be disposed off in a controlled landfill without collecting and flaring landfill gas.

Alternative 2: The proposed project activity (LFG collection and flaring) is implemented for security purposes but not considered as a CDM project activity.

An additional **Alternative**: "LFG from the nine landfills is recovered and used for electricity generation" might also be considered. However, besides its higher emission reductions and safety this alternative provides a significantly different service i.e. the power to be exported to the grid. It also implies a much higher level of investments.

- ***Enforcement of applicable laws and regulations:***

As mentioned below, there is no mandatory law or regulation, or any contractual arrangement that force Landfill operators to collect and flare methane or to use it for electricity generation. Therefore, the three alternatives considered above are in compliance with all applicable legal and regulatory requirements.

In addition, in the foreseeable future, it is unlikely that new regulations or laws that may bring one of these projects to non-compliance would be issued. Moreover, and according to the monitoring plan ACM0001, relevant regulations for LFG extraction or combustion (even if these laws and regulations have objectives other than GHG reductions) will be monitored yearly, and any implication on emissions will be taken into account when calculating actual emissions of the project activity.

Step 2 - Investment Analysis

Sub-step 2a: Determine appropriate analysis method:

According to the methodology for determination of additionality, if the CDM project activity generates no financial or economic benefits other than CDM related income, then Option I must be used. As this is the case for the project, option I is applied here.

Sub-step 2b: Option I. Application of simple cost analysis

Alternative 1 doesn't imply any investment and it the most workable option for Tunisia.

Total investment of the LFG collection and flaring system in the nine landfills is estimated at 6.7 MUS$, which will be mobilized through a World Bank Loan. The LFG system will also imply various other expenses over the whole project period to operate, maintain the equipments, and cover other project activity-related expenses (including administrative expenses and interest rate-related expenses). Considering alternative 2, i.e. an LFG project without CDM, the project would not have been adopted by Tunisia as it wouldn't generate any revenue, and its Net Present Value would be substantially negative (MUS$ -9.1), with an IRR also negative.

The total investment to equip the nine landfills with LFG collection and Power generator will require much higher investment amounts. Assuming an aggregated power generating capacity of 10 MW, the Investment cost for such project would be 16-18 MUS$ including LFG collection and possibly a portion of the need to enhance the electrical lines to export electricity to the grid. Thus, it implies about 2.5 times higher investment cost than the selected project activity. The size of the project would be much higher, and this is beyond the financial Tunisian capacity for such project.

Moreover, taking into account the current price selling price of electricity (US$3.7/100), and the complex regulatory circumstances for power generation the feasibility of electricity generation could not be considered as a baseline.

Given that, the only remaining plausible baseline scenario is Alternative1. Therefore, there is no economic rationale, for Tunisia, to invest in any LFG collecting and flaring systems or in electricity generation, as limited resources available should be allocated to priority needs such as replacing dumps with managed landfills, and rehabilitating these dumps and the affected surrounding areas.

Step 3 - Barrier Analysis

Step 2 is completed, this Step is therefore skipped.

Step 4 - Common Practice Analysis

Djebel Chekir was the first controlled Landfill of its kind in Tunisia. However, four other small controlled landfills have been established since 1999 (Beja, Jendouba, Siliana and Medjez El Bab). None of these landfills were equipped with LFG and flaring systems.

Moreover, for the nine landfills, the contracts that are being issued for the future landfill contractors are not considering any LFG management mandates. Common Practice for Controlled landfills in Tunisia will not consider CH4 extraction and flaring, and it is unlikely that LFG systems would be prevalent in the future without the CDM contribution.

The only case where a LFG system was seriously considered relates to the previously closed dump of Henchir Lihoudia which is being equipped with LFG wells and flaring equipment, i.e. a years after its closure. The dumpsite has been closed since 1999 and being used as an urban park for recreational purposes. Recently, some specific parts of the site have been identified with potential safety risks and thus limited CH4 extraction and flaring activities are underway for safety of the site.

The other case relates to Djebel Chekir Landfill, which tentative implementation of LFG system is discussed in Section A.4.4.

Step 5 - Impact of CDM Registration

The project activity will generate significant economic benefits through the sale of ERs that will justify contracting a loan to cover the investment expenses and to make project implementation possible.

Description of the baseline scenario: When applying common practice, which assumes a continuation of current practice with wastes being disposed off in a controlled landfill without collecting and flaring LFG, a total release of 4.5 MtCO2e would occur into the atmosphere, over the whole project period (2007-2016).

Description of the project activity scenario: In the project activity situation, wastes will be disposed off in the same controlled landfills but will consider the implementation of full collection and flaring systems. Assuming a conservative **70%** recovery-destruction rate, emissions within the project activity would only totalize **1.37** MtCO2e including induced emissions due to electricity consumption from the grid to operate the whole LFG systems, and thus would avoid **3.18** MtCO2e from being emitted into the atmosphere.

Reason why emissions in the project activity are lower than those generate in the baseline scenario: In the project activity situation, CH4 is fully oxidized as it is, involving the use of a 21 GWP. The project activity will allow to flare the CH4, and thus to generate CO2 instead, which GWP is equal 1. In addition, CO2 emissions are not accounted for in the emission balance, due to the biogenic origin of this CO2.

B.4. Description of how the definition of the project boundary related to the baseline methodology selected is applied to the project activity:

Emissions calculated in the baseline are methane emissions from the Cells 1 of the nine landfills within the same boundaries.

The project boundaries related to the baseline are the respective physical boundaries of the Cells 1 of the nine landfills, including the flaring sites. Emissions calculated in the baseline are methane emissions form the nine landfills within their boundaries. In principal, emissions in the nine landfills during project activity occur within the same boundaries as the one related to the baseline. However the LFG collection and flaring system will also imply a consumption of some quantities of electricity from the grid.

Such emissions are not that significant, but for completeness purposes they have been estimated and reflected in the emissions related to project activity.

Electrical consumption for LFG system is based on an aggregated 100 KW nominal capacity for flaring, which meet the aggregated peek flow of LFG in the nine landfills, taking the requirement of existing technologies into account, plus a 30% overestimation of capacity which will reflect some conservativeness expressed in terms of m^3/hr. A full time functioning; e.g. 8760 hours are also assumed, which is overestimated.

In estimating emissions, the last five-year's emission average at Power Company STEG (Ref. Emission report for energy sector for the period 1990-2003 in Tunisia, under publication) in terms of tCO2e per MWh has been considered, with the transport and distribution losses (12%) added to this average emission indicator. Thus, emission factor for electricity in Tunisia is 0.627 tCO2e/MWh delivered, knowing that electricity generation is mainly based on natural gas in Tunisia.

B.5. Details of baseline information, including the date of completion of the baseline study and the name of person (s)/entity (ies) determining the baseline:

Date of Completion: 20/11/2005
Name of Person Determining Baseline: Dr Samir Amous. He is not a project participant.
Email: amous.apex@gnet.tn

SECTION C. Duration of the project activity / Crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

The starting date of the project activity is expected to be 1st January 2007.

C.1.2. Expected operational lifetime of the project activity:

11 years.

C.2 Choice of the crediting period and related information:

C.2.1. Renewable crediting period

N/A

C.2.1.1. Starting date of the first crediting period:

N/A

C.2.1.2. Length of the first crediting period:

N/A

C.2.2. Fixed crediting period:

A ten-year fixed crediting period will be used for this project.

C.2.2.1. Starting date:

01/01/2007

C.2.2.2. Length:

10 years

SECTION D. Application of a monitoring methodology and plan

D.1. Name and reference of approved monitoring methodology applied to the project activity:

"Consolidated Monitoring methodology for Landfill Gas Project activities – ACM0001 – Version 03, dated 19 May 2006 ".

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

In conjunction with the consolidated baseline Methodology, this consolidated monitoring methodology is applicable for the bundled nine-landfill project activity since the project reduces greenhouse gas emissions through landfill gas capture and flaring where the baseline is established by public concession contracts.

The Monitoring Plan will involve two components:

- individual Monitoring at the level of each landfill;
- Monitoring at the aggregated level of the nine-bundled landfills.

Individual Monitoring

The Monitoring Methodology is based on direct measurement of the amount of landfill gas captured and destroyed at the flare platform of each of the nine landfills. The Monitoring plan provides for continuous measurement of the quantity and quality of LFG flared. The main variables that need to be determined are:

- the quantity of methane actually captured ($MD_{project,y}$)
- the quantity of methane flared ($MD_{flared,y}$)

To determine these variables, the following parameters are to be monitored at the level of each landfill (illustrated for example for landfill 1):

- Continuous monitoring of the quantities of wastes received and landfilled in each landfill.
- The amount of landfill gas generated (in m^3, using a continuous flow meter), where the total quantity ($LFG_{total\ landfill1,y}$) as well as the quantities fed to the flare ($LFG_{flare\ landfill1,y}$) are measured continuously.
- The fraction of methane in the landfill gas ($w_{CH4,\ landfill1,y}$) will be measured with a continuous analyzer.
- The flare efficiency ($FE_{landfill1}$), measured as the fraction of time in which the gas is combusted in the flare multiplied by the efficiency of the flaring process. For this purpose, the methane content of the flare emissions will be analyzed monthly, to determine the fraction of methane destroyed within the flare.
- Temperature ($T_{landfill1}$) and pressure ($p_{landfill1}$) of the landfill gas.
- The electrical consumption (El) of the LFG equipment will also be made on continuous basis, using electrical meters.

Measurement equipment for gas quantity and quality (humidity, particulate, composition, etc.) will be subject to high QA/QC standards and to an appropriate calibration process. Calibration procedures and schedule will be defined by the technology provider according to EU standards.

Aggregated Monitoring

All variables recorded and monitored in each of the nine landfills will be aggregated at the global level of the project.

- Aggregated quantities of wastes received and landfilled in the nine landfills: $MSW_{Project}$
- Aggregated amount of landfill gas generated: $LFG_{total,Project,y}$ as well as the quantities fed to the flare ($LFG_{flare,Project,y}$).
- Aggregated fraction of methane in the landfill gas ($w_{CH4,Project,y}$).
- Aggregated average flare efficiency ($FE_{Project}$).
- Aggregated Quantities of electricity or any other fuels required to operate the bundled landfill gas project.
- Synthesis table of the Temperatures ($T_{landfill1}$) and pressure ($p_{landfill1}$) of the landfill gas in the nine landfills.
- Relevant regulations for LFG project activities will be monitored. Changes to regulation will be converted to the amount of methane that would have been destroyed/combusted during the year in the absence of the project activity ($MD_{reg,y}$). The monitoring report will explain how regulations are translated into that amount of gas if any.

ANGed will establish a monitoring team that will ensure appropriate operation of the LFG systems in the nine landfills. Monitoring of data provided by electronic equipments can be made through remote connection (direct telephone or Internet connection) and through field visits to be undertaken by ANGed LFG Monitoring Unit. ANGed can also mandate external experts as a part of its Auditing and Verification procedures.

D.2. 1. Option 1: Monitoring of the emissions in the project scenario and the baseline scenario

>> Option 1 is not applicable. Option 2: *Direct monitoring of emission reductions from the project activity* is applied.

D.2.1.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:

ID number *(Please use numbers to ease cross-referencing to D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

D.2.1.2. Description of formulae used to estimate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

D.2.1.3. Relevant data necessary for determining the baseline of anthropogenic emissions by sources of GHGs within the project boundary and how such data will be collected and archived :

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

D.2.1.4. Description of formulae used to estimate baseline emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

>>

D. 2.2. Option 2: Direct monitoring of emission reductions from the project activity (values should be consistent with those in section E).

The following tables (2.2.1) will be prepared/replicated at the level of each landfill. The tables will be monthly transmitted to the headquarters of the project at ANGED which will centralize and maintain all the nine landfill-specific data. In addition, the project will prepare aggregated tables as shown in table D.2.2.2

LANDFILLS N°1								
D.2.2.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:								
ID number	Data variable	Data unit	Measured (m), calculated (c), estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is archived data kept	Comment
1 $MSW_{total,y}$	Total Quantiy of Waste Landfilled in year y	metric tonnes	m	Daily	100%	Monthly (e and p) and Annually	During the crediting period and two years after	Measured at weigh bridge Copies of the bills issued by the Landfill operating company to ANGED Data to be aggregated monthly and yearly
2 $LFG_{total,y}$	Total amount of landfill gas captured	m^3	m	Continuous	100%	Daily: e Monthly: p	During the crediting period and two years after	Measured by a flow meter. Data to be aggregated monthly and yearly
3 $LFG_{flare,y}$	Total amount of landfill gas flared	m^3	m	Continuous	100%	Daily: e Monthly: p	During the crediting period and two years after	Measured by a flow meter. Data to be aggregated monthly and yearly
4 $w_{CH4,y}$	Methane fraction in the landfill gas	m^3 CH4/ m^3 LFG	m	Continuous	100%	Monthly: e & p	During the crediting period and two years after	Measured by a continuous gas quality analyzer Data to be aggregated monthly and yearly

5 FE	Flare/combustion efficiency, determined by the operation hours(1) and the methane content in the exhaust gas (2)	%	m/c	(1) Continuously (2) Monthly	n/a	(1) Daily: e (2) Monthly: p	During the crediting period and two years after	(1) Monthly measurement of methane content of flare exhaust gas (2) Continuous measurement of operation time of flare Data to be aggregated monthly and yearly
6 T	Temperature of the landfill gas	°C	m	Continuous	100%	Monthly: e & p	During the crediting period and two years after	Measured to determine the density of the methane D_{CH4} Data to be aggregated monthly and yearly
7 p	Pressure of the landfill gas	Pa (in bars)	m	Continuous	100%	Monthly: e & p	During the crediting period and two years after	Measured to determine the density of the methane D_{CH4} Data to be aggregated monthly and yearly
8 El	Electricity consumption	El (in kWh)	m	continuous	100%	Electronic and Paper	During the crediting period	Measured to determine off-site emissions due to electricity consumption of the project activity from the grid

D.2.2.1.a	***MONTHLY AGGREGATED DATA FOR THE PROJECT***							
ID number	Data variable	Data unit	Measured (m), calculated (c), estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	For how long is archived data kept	Comment
1 $MSW_{total,y}$	Total Quantiy of Waste Landfilled in the nine landfills in year y	metric tonnes	m		100%	Monthly and Annually (e and p)	During the crediting period and two years after	Data to be aggregated monthly and yearly
2 $LFG_{total,y}$	Total amount of landfill gas captured in the nine landfills	m^3	m		100%	Monthly and Annually (e and p)	During the crediting period and two years after	Data to be aggregated monthly and yearly
3 $LFG_{flare,y}$	Total amount of landfill gas flared in the nine landfills	m^3	m		100%	Monthly and Annually (e and p)	During the crediting period and two years after	Measured by a flow meter. Data to be aggregated monthly and yearly
4 $w_{CH4,y}$	Methane fraction in the landfill gas	m^3 CH4/ m^3 LFG	m		100%	Monthly and Annually (e and p)	During the crediting period and two years after	Data to be aggregated monthly and yearly
5 FE	Flare/combustion efficiency in the nine landfills	%	m/c		n/a	Monthly and Annually (e and p)	During the crediting period and two years after	Data to be aggregated monthly and yearly
6 T	Temperature of the landfill gas in the nine landfills	°C	m		100%	Monthly and Annually (e and p)	During the crediting period and two years after	Data to be aggregated monthly and yearly
7 p	Pressure of the landfill gas in the nine landfills	Pa (in bars)	m		100%	Monthly and Annually (e and p)	During the crediting period and two years after	Data to be aggregated monthly and yearly
8 El	Electricity consumption	El (in kWh)	m	Continuou s	100%	Electronic and Paper	During the crediting period	Data to be aggregated Bi-monthly and yearly

9	Regulatory requirements related to landfill gas projects	Test	-	Annually	100%	Annually (e and p)	During the crediting period and two years after	Required for any changes to the adjustment Factor (AF) or directly $MD_{reg,y}$

D.2.2.2. Description of formulae used to calculate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

>> **N/A**

D. 2.3 Treatment of leakage in the monitoring plan

Not Applicable.

>> **N/A**

D.2.3.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project activity

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

D.2.3.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO2 equ.)

N/A

D.2.4. Description of formulae used to estimate emission reductions for the project activity (for each gas, source, formulae/algorithm, emissions units of CO2 equ.)

Emission reduction in each of the nine landfills should be calculated from the following equations:

$$ER_y = (ER\_CH4_y * CF * GWP\_CH4) – (El_y * 0.627)$$

$$ER\_CH4_y = CH4_{project,y} - CH4_{baseline,y}$$

Where:

ER_y is the GHG reduction in t $CO2_e$

ER_CH4_y is the methane emission reduction in m^3

CF is a conversion factor from m^3 CH4 to t CH4 (0.0007168) at standard temperature and pressure (0 degree Celsius and 1.013 bar)

GWP_CH4 is the global warming potential for CH4 (21)

$El_{y:}$ Is the annual electricity consumption of the LFG system
0.627 is the emission indicator for electricity from the grid in Tunisia expressed in tCO2e/MWh.

$CH4_{project,y}$ is the monitored quantity of methane actually flared in the project in m^3

$CH4_{baseline,y}$ is the methane as calculated in section B adjusted by actual waste and actual % CH4 in LFG

D.3. Quality control (QC) and quality assurance (QA) procedures are being undertaken for data monitored

Data	Uncertainty level of data (High/Medium/Low)	Are QA/QC procedures planned for these data ?	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
2. $LFG_{total,y}$	Low	Yes	Flow meter will be subject to a quarterly maintenance and testing regime to ensure accuracy
3 $LFG_{flare,y}$	Low	Yes	Flow meter will be subject to a quarterly maintenance and testing regime to ensure accuracy
4. FE	Medium	Yes	Regular maintenance will ensure optimal operation of flares. Flare efficiency will be checked quarterly, with monthly checks if the efficiency shows significant deviations from previous values
5 $w_{CH4,y}$	Low	Yes	The gas analyser will be subject to a quarterly maintenance and testing regime to ensure accuracy

D.4 Please describe the operational and management structure that the project operator will implement in order to monitor emission reductions and any leakage effects, generated by the project activity

The project will follow the monitoring plan as described in annex 4.

D.5 Name of person/entity determining the monitoring methodology:

Dr. Samir Amous, APEX Conseil – amous.apex@gnet.tn . He is not a project participant.

SECTION E. Estimation of GHG emissions by sources

E.1. Estimate of GHG emissions of the project activity by sources:

Destruction of methane in flares will lead to an almost complete conversion of the generated CH_4 into CO_2. The source of methane, which generates CO_2 emissions when flared, is of biogenic origin, therefore, as stated by IPCC Good Practice Guidance, it is part of the natural organic CO_2 cycle, and the generated CO_2 should not be counted as net contributor to climate change.

There are only two potential sources of project emissions identified within the system boundary: the part of CH_4 potential in the landfill that the project is assuming not to be able to collect and burn, and that might be considered as fugitive methane emissions from the landfill, and the off-site emissions due to the electricity consumption of the project activity. It has been assumed that the LFG systems installed in the nine landfills will only be able to recover and flare a conservative rate of 70% of the whole CH_4 landfill potential. Therefore 30% will have the potential to escape as fugitive emissions, and thus are considered as the reference point project activity emissions. In addition, off-site emissions due to electricity consumption of the LFG system will be accounted as a part of the project activity emissions.

The actual LFG recovery rate based on international experience can range from as low as 50 – 60% to as high as 85%. For the well-designed nine landfills 70% is considered a conservative estimate based on the characteristics of the waste deposited, the proper compaction of the waste deposited, the depth of the waste body, and the proper covering of the waste body during and after completion of waste disposal.

The direct emission source within the project boundary is the methane escaping capture and flaring plus some minor amounts of emissions due to electricity consumption of the LFG system. There are no other significant source of site emissions .

Overall, the directly estimated reference point emission within the project activity is calculated by multiplying baseline emissions by 30% plus emissions due to electricity consumption, and these will amount to 1,368,899 tonnes of CO_2e over 10 years.

Estimated yearly amounts of fugitive gas potential, which reflect the reference point emission of the project activity, are shown in Section E.6.

E.2. Estimated leakage:

No Leakage effects need to be accounted under the consolidated methodology.

E.3. The sum of E.1 and E.2 representing the project activity emissions:

Estimated emissions due to the project activity will amount to **1,368,899** tonnes of CO_2e over 10 years, in which 4,502 tCO_2e are due to electricity consumption of the LFG systems and **1,364,397** tCO2e are emitted within the landfills as a result of incomplete collection and destruction (30%) of the LFG potential in the landfills.

E.4. Estimated anthropogenic emissions by sources of greenhouse gases of the baseline:

Estimated emissions due to the baseline will amount to **4,547,991** tonnes of CO2e over 10 years as shown in section E.6.

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

During operations, actual emission reductions will be calculated from the accurately measured CH4 being flared minus emissions due to electricity consumption of the LFG equipment. Project emissions can only be estimated by assuming the efficiency of collection of the LFG. Conservative efficiency of the collection and flaring systems for the nine landfills is assumed to be 70%.

Estimated emissions reductions due to the project activity will amount to **3,179,092** tonnes of CO2e over 10 years.

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

Years	Estimation of project activity emissions (tonnes of CO_2 e)	Estimation of baseline emissions (tonnes of CO_2 e)	Estimation of leakage (tonnes of CO_2 e)	Estimation of emission reductions (tonnes of CO_2 e)
2007	7 124	23 199	0	16 075
2008	40 774	134 999	0	94 225
2009	76 272	253 142	0	176 870
2010	117 363	389 745	0	272 382
2011	154 221	512 240	0	358 019
2012	180 800	600 838	0	420 038
2013	189 488	629 798	0	440 310
2014	196 097	651 825	0	455 728
2015	202 922	674 575	0	471 653
2016	203 838	677 630	0	473 792
Total (tonnes of CO_2 e)	**1 368 899**	**4 547 991**	**0**	**3 179 092**

Figure 5 depicts the CO2 equivalent emissions in the baseline situation and within the project activity.

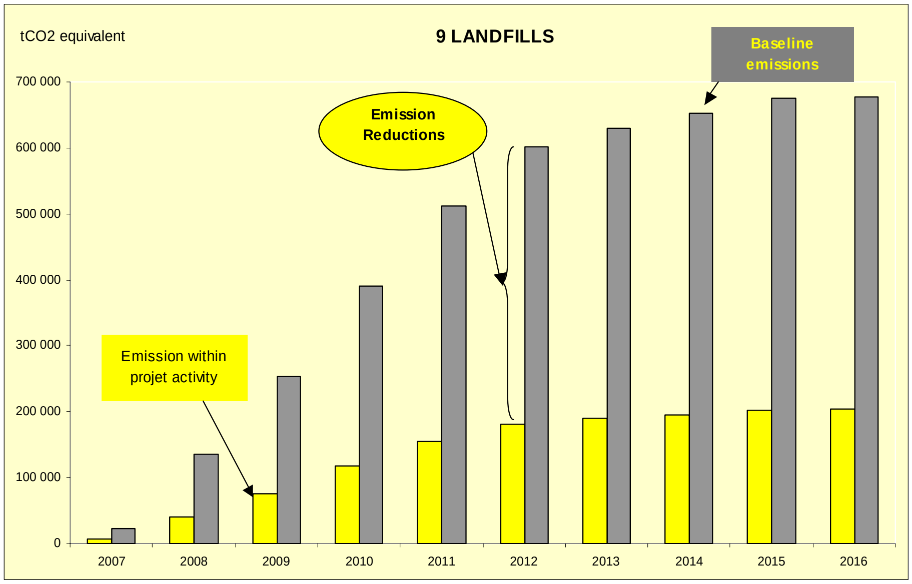

Figure 5: Estimated Carbon Dioxide Equivalent Emissions in the nine landfills (baseline and project activity) (tCO2e)

SECTION F. Environmental impacts

F.1. Documentation on the analysis of the environmental impacts, including transboundary impacts:

The nine landfills have been constructed and being launched after meeting all regulatory requirements, including Environmental Impact Assessment as per Tunisian Regulations.

As regards to the CDM project, it should be noted that it is a part of a larger programme aimed at improving the overall waste management in Tunisia. The World Bank will provide to the government of Tunisia with a loan to partially finance a Solid Waste Management Project to support the implementation of this programme. According to the World Bank rules regarding the Environmental Impact Assessment, it has been requested to update the Environmental Impact Assessment as to better reflect the new landfill components (implementation of a LFG system)

In the baseline situation, Landfill gas is generated as a result of decomposition of municipal waste under anaerobic conditions. It is mainly composed of carbon dioxide and methane. Carbon dioxide and methane are greenhouse gases, which do not cause harmful effects to the local environment, but rather affects global warming and economic value of the area where the landfills are implemented.

In the baseline situation, methane emissions from the landfill are associated with the following negative impacts:

- Undesirable odour especially for the human establishments surrounding the Landfill area.
- Safety and health risks to landfills staff due to generation of methane concentration above safe limits as well as explosions and fires at the landfill site.

A very small percentage of volatile organic compounds (VOCs) are also found in the landfill gas, contributing to the undesirable odour. VOCs emissions are photochemically reactive, and result in the formation of tropospheric ozone. The latter might cause adverse effects to the respiratory system such as breathing difficulty and aggravated Asthma, and damages to crops and plants. VOCs are also known for their toxicity and carcinogenic effect from chronic exposure. However, since volatile organic compounds comprise very small percentage of the landfill gas, impact on air quality is expected to be minimal.

Overall, **the project activity** leads to positive environmental impacts which contribute to the sustainable development of the area and no significant negative impacts are expected.

Risks from collection, pumping and treatment of landfill gas can be properly controlled. Controls from such operations include equipment safety precautions (such as alarms, safety valves, and automatic shutdown), daily inspection, and fire fighting extinguishers.

In the project activity, flaring of the collected biogas will destroy methane and thus will mitigate the above mentioned negative impacts.

Methane is a greenhouse gas, known for its contribution to global warming. The proposed project main activity is combusting the landfill gas to convert methane to carbon dioxide. Therefore, the project will result in positive environmental impacts where it will lead to decrease the amount of greenhouse gases released to the atmosphere.

While the LFG system will minimize explosion risks from methane emissions within the whole landfill sites, there are obviously some risks associated with the operation of the flare, similar to any other industrial risks involving a source of fire. Conservative actions aimed at mitigating the risks are mentioned in section F.2 below.

The LFG system might also lead to some minor CO, NOx and VOCs emissions. However, thanks to the sophisticated combustion and to the high burning temperature (over 1000°C), it will ensure an almost total destruction of the gases. In that way, emission of CO, NOx and VOCs and other compounds present in the biogas such as ammonia will be minimal, and much lower anyway to what it would have been occurred in the absence of eh project activity.

Overall, the minimum required 10 m-height stack will ensure for all emitted gases to be properly evacuated and dissolved into the atmosphere, with very limited impacts in the surrounding local environment and population.

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

An update of the environmental impact assessment of the nine landfills has been carried out. It shows not significant negative impacts from the project activities.

Locally, the capture and destruction of the major part of the LFG generated in the nine landfills through the proposed CDM project will help improve the ambient air quality in the project vicinity areas. It will also help reduce impacts on water and environmental resources through an enhanced and environmentally acceptable leachate management system. Meanwhile, flaring the captured gas will not only destroy methane, but will also destroy compounds in the LFG such as volatile organic compounds and ammonia. The project will also mitigate number of risks associated with LFG gas at uncontrolled landfills such as: risk explosion, risk of fire, odours nuisances, potential local air quality deterioration, etc.

As confirmed by the Environmental Impact Assessment update, the quantities of CO, NOx and VOCs are insignificant, and far to be so important than the CH4 emissions in the baseline case. Therefore, no significant negative impacts are expected from the project.

There are minor risks from collecting, pumping and treatment of landfill gas. Moreover, they can be drastically controlled and mitigated. The mitigation of these minor risks lies on the types and standards of the technologies that will be selected to operate the whole LFG systems, and particularly the flares.

To mitigate risks of fires and explosion, the proposed flares will be made of stainless steel furnaces with internal fireproof concrete protection. Internal flare tubes will be made also of stainless steel protected by ceramic fibbers equipped with a tube flange for exhaust sample analysis. The proposed flares will be equipped with flare and temperature control equipments. The temperature will be regulated by air intake control equipments. Also in terms of minimizing the explosion risks, the proposed flares will be equipped with fully automatic controllers, automatic emergency switches and alarms. The flares will also be equipped with the following: • Manual and automatic on/off switch; • Lightening arrestor; • Flame temperature alarm; • Landfill gas temperature alarm; • Gas flow and temperature regulators; • External emergency switch; • UV radiation detection cells for flame control.

At global level, Greenhouse gas emission reductions will result from the efficient combustion of the recovered methane contained in the landfill gas. It is estimated that this project will generate 3.18 million of Emission reductions within 10-year period (2007-2016).

Capturing and destroying this methane is an efficient and significant contribution to mitigate Climate Change.

SECTION G. Stakeholders' comments

G.1. Brief description how comments by local stakeholders have been invited and compiled:

A public consultation meeting was held on 15 Feb 2006 in Tunis addressing the new CDM project of Djebel Chekir and the 9 other landfills.

A meeting report (Procès-Verbal) will be made available both at the ANGed and World Bank web sites. List of participants will be annexed to this meeting report.

The meeting was introduced by the Minister of Environment and Sustainable Development of Tunisia. The presentations covered various topics in relation with the two CDM projects

- The Kyoto Protocol and CDM, their operating approaches and their contribution to financing Sustainable Development.
- Presentation of the two CDM projects of Djebel Chekir and the 9 landfills.
- Update of the Environment Impact Assessment of Djebel Chekir and the 9 landfills.
- Environmental management of Kairouan, Bizerte, !Djerba, Gabes and Sousse landfills.

About 115 persons have attended this meeting. Participants include the major Stakeholders and Institutions directly involved in Waste Management and Environment Protection:

- Representatives from the Ministry of Environment and Sustainable Development (MEDD)
- Representatives from the Ministry of Interior
- Representatives from the Ministry of Development and International Cooperation
- Representatives from the Ministry of Health
- Representatives from the Ministry of Agriculture
- Representatives from the Ministry of Education
- Representatives from the National Waste Management Agency (ANGed).
- Representatives from the National Environment Protection Agency (ANPE).
- Representatives from NGOs involved in national and regional activities.
- Representatives from academic institutions.
- Representatives from Governorates (Ben Arous, Bizerte, Kairouan, Ariana, Medenine, Midoun Jerba, Monastir, Sfax, Sousse, Tunis),
- Representatives from Municipalities and Communes (Sousse, Medenine, Ariana, Bizerte, Hammamet, Sfax, Nabeul)
- Representatives from Cooperation Institutions and Donors (The World Bank, GTZ-Germany, African Development Bank, JICA-Japan, KfW-Germany)

- Representatives from national and international private operators in waste sector
- Representatives from national and international consulting enterprises in waste sector and Environment
- Representatives from Media and Press operators (National Radio-TV, Newspapers: Le Renouveau, etc.

Articles related to this meeting were also published in various newspapers in arabic and in french: El Sahafa, El Sabah, El Horreya, Le Renouveau, Le Temps, and La Presse. For illustration, article releases in "Le Temps" (15 February 2006) and in "Le Renouveau" (15 February 2006) are annexed to this document.

Another National Conference is also being organized for 6-7 April 2006. This conference will involve the major stakeholders of the waste sector in Tunisia, as well as national and international experts and various donor institutions. The Conference will address various issues related to the "Integrated Waste Management" in Tunisia. The two CDM projects will also be presented in one of the sessions of the conference entitled "Waste and Economy".

G.2. Summary of the comments received:

The main issues addressed by the attending persons related to technical matters involved in landfill management in Tunisia. Four major questions were raised:

- Management and compacting practices issues in controlled landfills and their implication in terms of space use in the landfill sites.
- Issues related to the availability of data interfering with CH4 generation (waste composition, Moisture content, landfilling methods and operations, temperature inside the landfill, etc.) and the extent to which existing data or default factors might affect the project calculations.
- Direct environmental impacts of the LFG flaring.
- The reason behind the choice of the LFG flaring instead of Electricity Generation, which is thought to be more relevant given the international energy circumstances and perspectives.

G.3. Report on how due account was taken of any comments received:

The questions raised by the participants did not show any disagreement with the concept, approaches or operating conditions of the CDM project. Most of them try to stress on the difficulties to address new issues involved in higher standard waste management and landfilling, where knowledge is not perfectly mastered in Tunisia. Some others just needed additional clarification in this emerging CDM topic in Tunisia.

Regarding **management and compacting practices** problems experienced in Djebel Chekir, lack of experience in landfill management both from the Landfill operator side in managing the landfill and from ANGED side in monitoring and supervising the operating practices, should be considered as quite normal as the new management practices for wastes are still in their "teething" phase. However, overall the management of the landfill was considerably improved in the recent years, although there are still rooms for additional improvements. All these improvements will be reflected in the new landfills to be operated in the future in Tunisia.

The update of the Environmental Impact Assessment was one of the actions, among others, taken by the project to better identify the potential impacts of the landfills and to mitigate these impacts, while providing for the best conditions to maximize the quantity of CH_4 to be collected for the benefit of the project.

Regarding the **data issues**, it was recalled that CH_4 calculations were made using IPPC methodology and IPCC God Practice Guidance. These methodological tools are recommended by the Conference of Parties as they represent the best available knowledge on the landfills for the time being. The calculations in the PDD have fully applied the recommendations to use national data in priority, and if not available, to use default factors recommended by IPCC. To the best possible, Tunisia data were utilized. In fact, although acknowledging the uncertainties associated with these data, they better reflect Tunisian circumstances. On the other hand, where necessary, conservative assumptions were considered to estimate emissions and emission reductions. In the end, the monitoring of emission reductions during the project execution will determine the final amounts of CERs to be marketed.

Regarding direct **environmental impacts of the LFG flaring**, it should be recalled that in the baseline situation, the major potential impact of the nine landfills relates to the important quantities of CH_4 generated from the landfill, resulting in undesirable odour especially for the human establishments surrounding the Landfill sites. There is also a small percentage of volatile organic compounds (VOCs), contributing to the undesirable odour.

Overall, no significant negative impacts are expected from the project activity. Flaring the collected biogas will destroy methane and thus will mitigate the above mentioned negative impacts, besides its contribution to mitigate Climate Change. Other emissions of SO_x, NO_x, CO and VOCs might be emitted, in insignificant quantities though. The sophisticated combustion process of the flare and the high burning temperature (over 1000°C), will ensure an almost total destruction of the exhaust gases. Moreover, the minimum required 10 m-height stack will ensure for all emitted gases to be properly evacuated and dissolved into the atmosphere.

Other risks associated with the operation of the flare will be subject to the conservative actions mentioned in section F. Other potential risks from collecting, pumping and treatment of landfill gas will be properly controlled through the safety precautions also mentioned in section F.

The project will anyway comply with the prescribed tolerance limits of the environmental regulations in Tunisia.

The rationale behind the **choice of LFG flaring instead of Electricity Generation**, lies with the much higher investment volume required for such alternative, which would totalize a minimum of 16-18 MUS$ for the nine landfills. This is much beyond the Tunisian investment capacities. So, there is a major investment barrier to this alternative. Supposing this barrier can be removed, it will take some time before a financial arrangement could be prepared and made effective for such investment.

In addition, the analysis shows that the feasibility of this project is highly dependant on the extent to which Power operators would optimize CH4 flow and suction according to the Generator characteristics and requirements. As Power generator at MSW is a delicate a, and complicated process and given the lack of experience in managing such utility in Tunisia, the technical and, thus, financial risks related to the installation of a power generator are very high at this moment.

Moreover, taking into account the low fixed selling tariff of electricity to the national Power company STEG (around US$ 3.7/100), and the complex regulatory circumstances for private power generation it is unlikely that power generators, under a possible CDM project, would be operated before mid-2009 to the best. Opportunities to reduce significant quantities of CH4 would then be definitely lost until an power generators would be operational.

Annex 1

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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

No public funding is involved in the project.

Annex 3

BASELINE INFORMATION

The project follows the "Consolidated baseline methodology for landfill Gas Project activities –ACM0001/ version03, dated 19 May 2006"

Project activity meets applicability criteria of the chosen methodology. This methodology is adopted in relation with the selected approach for Baseline taken from paragraph 48 of the CDM modalities and procedures: "(b) Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment".

The suggested methodology uses the Internal Rate of Return (IRR) calculations to assess the financial attractiveness of the investment project.

The following tables show the key data and assumptions used in the case of the nine landfills.

Waste streams in the nine landfills for the period 2006-2016 (1000 tonnes)

Year	1 Bizerte	2 Sfax	3 Kairouan	4 Djerba	5 Gabès	6 Monastir	7 Sousse	8 Nabeul	9 Medenine	TOTAL
2006	46	0	27	21	40	37	0			170
2007	93	157	56	42	83	152	205	0	45	833
2008	99	162	59	44	87	157	214	59	77	957
2009	102	168	62	45	92	163	224	239	79	1 174
2010	106	175	65	46	48	168	233	244	81	1 166
2011		181	68	48		131	244	249	83	1 004
2012			71	49			255	254		629
2013			74				265	260		599
2014			77				277	265		619
2015							288	203		491
2016										0
TOTAL	446	843	559	294	350	807	2 205	1 774	365	7 642

BASELINE EMISSIONS

CH4 emissions in the baseline situation in the nine landfills over the whole crediting period of the project (tonnes)

CH4 (tons)	Bizerte	Sfax	Kairouan	Djerba	Gabès	Monastir	Sousse	Nabeul	Medenine	**Total**
2007	300	0	176	134	257	238	0	0	0	**1 105**
2008	877	1 023	524	395	774	1 206	1 336	0	293	**6 429**
2009	1 439	1 982	859	641	1 267	2 114	2 604	382	767	**12 054**
2010	1 967	2 888	1 181	873	1 746	2 975	3 816	1 904	1 209	**18 559**
2011	2 471	3 754	1 492	1 090	1 893	3 787	4 971	3 313	1 622	**24 392**
2012	2 235	4 576	1 794	1 299	1 713	4 277	6 088	4 620	2 009	**28 611**
2013	2 023	4 141	2 086	1 495	1 550	3 870	7 171	5 839	1 817	**29 990**
2014	1 830	3 747	2 369	1 352	1 402	3 502	8 216	6 976	1 644	**31 039**
2015	1 656	3 390	2 646	1 224	1 269	3 169	9 239	8 042	1 488	**32 123**
2016	1 498	3 067	2 394	1 107	1 148	2 867	10 237	8 603	1 346	**32 268**
TOTAL	**16 297**	**28 568**	**15 521**	**9 608**	**13 019**	**28 006**	**53 677**	**39 679**	**12 196**	**216 571**

BASELINE EMISSIONS

CH4 emissions in the baseline situation in the nine landfills over the whole crediting period of the project (1000 tCO2 equivalent)

CH4 (1000 tCO2 equivalent)	Bizerte	Sfax	Kairouan	Djerba	Gabès	Monastir	Sousse	Nabeul	Medenine	Total
2007	6	0	4	3	5	5	0	0	0	**23**
2008	18	21	11	8	16	25	28	0	6	**135**
2009	30	42	18	13	27	44	55	8	16	**253**
2010	41	61	25	18	37	62	80	40	25	**390**
2011	52	79	31	23	40	80	104	70	34	**512**
2012	47	96	38	27	36	90	128	97	42	**601**
2013	42	87	44	31	33	81	151	123	38	**630**
2014	38	79	50	28	29	74	173	147	35	**652**
2015	35	71	56	26	27	67	194	169	31	**675**
2016	31	64	50	23	24	60	215	181	28	**678**
TOTAL	**342**	**600**	**326**	**202**	**273**	**588**	**1 127**	**833**	**256**	**4 548**

CH4 EMISSIONS OF THE PROJECT ACTIVITY

CH4 emissions due to LFG in the nine landfills in the context of the project activity over the whole crediting period of the project (tonnes)

CH4 (tons)	Bizerte	Sfax	Kairouan	Djerba	Gabès	Monastir	Sousse	Nabeul	Medenine	Total
2007	90	0	53	40	77	71	0	0	0	**331**
2008	263	307	157	118	232	362	401	0	88	**1 929**
2009	432	594	258	192	380	634	781	115	230	**3 616**
2010	590	866	354	262	524	893	1 145	571	363	**5 568**
2011	741	1 126	448	327	568	1 136	1 491	994	487	**7 318**
2012	671	1 373	538	390	514	1 283	1 827	1 386	603	**8 583**
2013	607	1 242	626	448	465	1 161	2 151	1 752	545	**8 997**
2014	549	1 124	711	406	421	1 051	2 465	2 093	493	**9 312**
2015	497	1 017	794	367	381	951	2 772	2 413	446	**9 637**
2016	450	920	718	332	344	860	3 071	2 581	404	**9 680**
TOTAL	**4 889**	**8 570**	**4 656**	**2 882**	**3 906**	**8 402**	**16 103**	**11 904**	**3 659**	**64 971**

CH4 EMISSIONS OF THE PROJECT ACTIVITY

CH4 emissions due to LFG in the nine landfills in the context of the project activity (WITHOUT CONSIDERING EMISSIONS DUE TO POWER CONSUMPTION TO OPERATE LFG SYSTEMS) over the whole crediting period of the project (1000 tCO2 equivalent)

CH4 (1000 tCO2 equivalent)	Bizerte	Sfax	Kairouan	Djerba	Gabès	Monastir	Sousse	Nabeul	Medenine	Total
2007	2	0	1	1	2	1	0	0	0	**7**
2008	6	6	3	2	5	8	8	0	2	**40**
2009	9	12	5	4	8	13	16	2	5	**76**
2010	12	18	7	5	11	19	24	12	8	**117**
2011	16	24	9	7	12	24	31	21	10	**154**
2012	14	29	11	8	11	27	38	29	13	**180**
2013	13	26	13	9	10	24	45	37	11	**189**
2014	12	24	15	9	9	22	52	44	10	**196**
2015	10	21	17	8	8	20	58	51	9	**202**
2016	9	19	15	7	7	18	64	54	8	**203**
TOTAL	**103**	**180**	**98**	**61**	**82**	**176**	**338**	**250**	**77**	**1 364**

TOTAL EMISSIONS OF THE PROJECT ACTIVITY

Net CO2 emissions due to the nine landfills (including emissions due to power consumption to operate LFG systems) in the context of the project activity over the whole crediting period of the project (1000 tCO2 equivalent)

1000 tCO2 equivalent (considering emissions to operate LFG systems)	Bizerte	Sfax	Kairouan	Djerba	Gabès	Monastir	Sousse	Nabeul	Medenine	Total
2007	2	0	1	1	2	2	0	0	0	**7**
2008	6	6	3	3	5	8	8	0	2	**41**
2009	9	13	5	4	8	13	16	2	5	**76**
2010	12	18	7	6	11	19	24	12	8	**117**
2011	16	24	9	7	12	24	31	21	10	**154**
2012	14	29	11	8	11	27	38	29	13	**181**
2013	13	26	13	9	10	24	45	37	11	**189**
2014	12	24	15	9	9	22	52	44	10	**196**
2015	10	21	17	8	8	20	58	51	9	**203**
2016	9	19	15	7	7	18	65	54	9	**204**
TOTAL	**103**	**181**	**98**	**61**	**82**	**177**	**339**	**251**	**77**	**1 369**

CH4 REDUCTIONS

CH4 reductions from the collected LFG generated by the project activity in the nine landfills over the whole crediting period of the project (tonnes)

CH4 (tons)	Bizerte	Sfax	Kairouan	Djerba	Gabès	Monastir	Sousse	Nabeul	Medenine	Total
2007	210	0	123	94	180	167	0	0	0	**773**
2008	614	716	367	276	542	844	935	0	205	**4 500**
2009	1 007	1 387	601	448	887	1 480	1 823	267	537	**8 438**
2010	1 377	2 022	827	611	1 222	2 083	2 671	1 333	846	**12 992**
2011	1 729	2 628	1 045	763	1 325	2 651	3 480	2 319	1 135	**17 075**
2012	1 565	3 203	1 255	909	1 199	2 994	4 262	3 234	1 406	**20 028**
2013	1 416	2 898	1 460	1 046	1 085	2 709	5 020	4 087	1 272	**20 993**
2014	1 281	2 623	1 659	947	982	2 451	5 751	4 883	1 151	**21 728**
2015	1 159	2 373	1 852	857	888	2 218	6 467	5 630	1 042	**22 486**
2016	1 049	2 147	1 676	775	804	2 007	7 166	6 022	942	**22 588**
TOTAL	**11 408**	**19 997**	**10 865**	**6 725**	**9 114**	**19 604**	**37 574**	**27 775**	**8 537**	**151 600**

CH4 REDUCTIONS

CH4 reductions from the collected LFG generated by the project in the nine landfills over the whole crediting period of the project (1000 tCO2 equivalent)

CH4 (1000 tCO2 equivalent)	Bizerte	Sfax	Kairouan	Djerba	Gabès	Monastir	Sousse	Nabeul	Medenine	**Total**
2007	4	0	3	2	4	3	0	0	0	**16**
2008	13	15	8	6	11	18	20	0	4	**94**
2009	21	29	13	9	19	31	38	6	11	**177**
2010	29	42	17	13	26	44	56	28	18	**273**
2011	36	55	22	16	28	56	73	49	24	**359**
2012	33	67	26	19	25	63	89	68	30	**421**
2013	30	61	31	22	23	57	105	86	27	**441**
2014	27	55	35	20	21	51	121	103	24	**456**
2015	24	50	39	18	19	47	136	118	22	**472**
2016	22	45	35	16	17	42	150	126	20	**474**
TOTAL	**240**	**420**	**228**	**141**	**191**	**412**	**789**	**583**	**179**	**3 184**

NET EMISSIONS REDUCTIONS

Net Emission reductions generated by the project in the nine landfills over the whole crediting period of the project (1000 tCO2 equivalent)

1000 tCO2 equivalent (considering emissions to operate LFG systems)	Bizerte	Sfax	Kairouan	Djerba	Gabès	Monastir	Sousse	Nabeul	Medenine	**Total**
2007	4	0	3	2	4	3	0	0	0	**16**
2008	13	15	8	6	11	18	20	0	4	**94**
2009	21	29	13	9	19	31	38	6	11	**177**
2010	29	42	17	13	26	44	56	28	18	**272**
2011	36	55	22	16	28	56	73	49	24	**358**
2012	33	67	26	19	25	63	89	68	29	**420**
2013	30	61	31	22	23	57	105	86	27	**440**
2014	27	55	35	20	21	51	121	102	24	**456**
2015	24	50	39	18	19	47	136	118	22	**472**
2016	22	45	35	16	17	42	150	126	20	**474**
TOTAL	**239**	**419**	**228**	**141**	**191**	**411**	**788**	**583**	**179**	**3 179**

INPUTS

Nine Landfills (Bizerte, Sfax, Kairouan, Djerba, Gabes, Monastir, Sousse, Nabeul, Medenine)	
Period of the nine lanfill implementation	2006-2008
Period of closure of Cell 1 of the nine landfills	2011-2015
Waste in place at the project starting (tonnes)	0
Waste to be landfilled after project starting (tonnes)	7 642 205
Total landfilled Waste at the closure of Cell 1 of the nine landfills (tonnes)	7 642 205
GWP for CH4	21

Baseline Data	
CH4 content of Landfill	0,5
L_0 (m3 CH4/t MSW)	100
k	0,10
Proportion of flared CH4	0%

Project Activity	
Projet starting date	January 2007
Methane Collection/Destruction efficiency	70%
Unrecovered CH4	30%

RESULTS

	10 years
Total CH4 generated in the Baseline (tonnes)	216 571

Emission (t CO2 e)	Emissions Baseline	Emissions Project	Emission Reductions
7 years	2 543 961	766 043	1 777 918
10 years	4 547 992	1 368 900	3 179 093
14 years	6 672 168	2 008 348	4 663 820
21 years	8 846 401	2 664 461	6 181 940

Annex 4

MONITORING PLAN

The management structures that will be implemented in the context of the nine-bundled project are as follows:

Personnel:

- ANGED will establish a unit that will be responsible of monitoring the LFG exploitation in the nine landfills and centralizing all the relevant data.
- Each LFG operators will commit at least one site staff for daily data monitoring and storage. This will be the direct counterpart of the ANGED representative for the monitoring component of the project.

Daily Monitoring Records: in each landfill, the site staff will record all data related to the landfill (see Section D.2.2.1) in relevant hardcopy and electronic files. Transmission of these data to ANGED unit is to be made on Weekly basis. ANGED will check for any anomalies before storing the data.

Gas Field Monitoring Records: in each landfill, the Site Staff checks the gas wells on weekly basis, taking readings at each gas well and recording these on a form. These readings are then checked for any anomalies before being filed at landfill site, and transmitted to ANGED. Gas field inspections will also observe occurrence of any unintended releases of landfill gas. In case unintended releases are observed, appropriate corrective action will be taken immediately.

Flaring Monitoring Records: in each landfill, the Site Staff checks, the Site Staff checks the flaring equipment on weekly basis, taking readings and recording these on a form. These readings are then checked for any anomalies before being filed at landfill site, and transmitted to ANGED. Flare inspections will also observe occurrence of any unintended fugitive emissions of landfill gas. In case unintended releases are observed, appropriate corrective action will be taken immediately.

Routine Reminders for Site Technicians: in each landfill, the Site Staff checks, all Site Technicians are issued with a reminder list to guide them through their daily, weekly and monthly routine. Apart from frequent telephone contacts with site staff, the Landfill Engineering Manager and ANGED representative go through this routine during site visits to ensure all aspects of the role are being performed. In addition data archived are to be checked to ensure they are appropriately maintained. This includes all data to be monitored (see D.2.2.1), as well as Wells and flares monitoring records, meter readings, etc. In addition to ensuring the site routines are being performed any additional training needs are assessed and an audit is taken of any outstanding task on site.

Outstanding Work Notice: Following the Site Audit a ‘Plant Outstanding Works Notice’ is issued to each landfill Site Technician listing all the jobs that the management team consider necessary to be undertaken. This is checked on subsequent site audits to ensure these jobs have been carried out.

Permit to Work Scheme: The form is completed before any work is carried out in the LFG Gas Field or in the flares. This is forwarded to head office and attached to the service records for each component of the LFG system. The same form is used for any works associated with the gas field or flares.

Service Sheets: Service sheets are completed for each service to ensure all aspects of the service are completed and recorded. Based on these services operators will ensure an optimum exploitation of the LFG system.

Calibration of measurement equipment: Calibration of measurement equipment will be defined and scheduled by the technology provider according to EU standards and performed by accredited Agencies.

Corrective Actions: The quality assurance measures include procedures to handle and correct nonconformities in the implementation of the Project or this Monitoring Plan. In case such nonconformities are observed:

- An analysis of the nonconformity and its causes will be carried out immediately by each of the nine landfills staff.
- Each of the nine landfills management will make a decision, in consultation with the ANGED, on appropriate corrective actions to eliminate the non-conformity and its causes
- Corrective actions are implemented and reported back to ANGED. All the information about monitoring plant and quality assurance measures described above will be included in the Operational Manual, which would have been edited by each of the nine landfill operators and validated by ANGED prior to the signature of the LFG exploitation contract. The Operational Manual will include procedures for training, capacity building, proper handling and maintenance of equipment, emergency plans. ANGED will also ensure that each of the nine landfills site staff will receive appropriate training on the implementation of this Monitoring Plan and of the project.