CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-SSC-PDD)
Version 03 - in effect as of: 22 December 2006

CONTENTS

Annexes

Revision history of this document

Version Number	Date	Description and reason of revision
01	21 January 2003	Initial adoption
02	8 July 2005	• The Board agreed to revise the CDM SSC PDD to reflect guidance and clarifications provided by the Board since version 01 of this document. • As a consequence, the guidelines for completing CDM SSC PDD have been revised accordingly to version 2. The latest version can be found at <http://cdm.unfccc.int/Reference/Documents>.
03	22 December 2006	• The Board agreed to revise the CDM project design document for small-scale activities (CDM-SSC-PDD), taking into account CDM-PDD and CDM-NM.

SECTION A. General description of small-scale project activity

A.1 Title of the small-scale project activity:

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Power generation from biogas in Windhoek, Namibia
Version: 01
Date: 14/03/2012

A.2. Description of the small-scale project activity:

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The purpose of the project activity is to generate power from biogas generated at Gammams Water Care Works (hence forth referred to as Gammams – the municipal waste water treatment works in Windhoek, Namibia). Gammams is owned by the City of Windhoek (CoW) and the plant currently processes around 37 Ml of sewerage per day which is collected from within the City's municipal boundaries.

The proposed project activity will seal off the anaerobic biodigesters at Gammans. The biogas will be captured and fed to internal combustion engines to generate electricity for captive use. Two new gas engines will be installed, and the existing Jenbacher gas engine (which is not operational) will be refurbished. The captured biogas will also be used for thermal application in a boiler. The project activity forms part of a larger refurbishment of the primary sludge treatment system at Gammams.

The proposed project makes a positive contribution to sustainable development. This contribution is discussed below in terms of three categories: economic, environmental, and social.

Economic

The project will contribute to foreign reserve earnings for Namibia via the carbon credit sales revenue. Since the technology to generate electricity from biogas (from wastewater treatment plants) is new to Namibia, it's the aim of this project to promote this type of technology in the region The generation of renewable electricity from biogas will also reduce the pressure on Namibia's energy infrastructure.

Environmental

Methane recovery:	The bio-digesters will be sealed off to capture the biogas, thus reducing the quantity of methane emitted to the atmosphere. This will result in a reduction of greenhouse gas emissions as methane has a global warming potential of 21 times that of carbon dioxide.
Electricity generation:	The captured biogas will be combusted in gas engines to generate renewable electricity. The renewable electricity will be fed to the water treatment plant, thus replacing the electricity that is currently sourced from the national grid. The Southern African regional grid is predominantly coal-fired, and therefore emissions intensive. The production of electricity from renewable resources will result in a reduction of greenhouse gas emissions associated with coal-based power generation. It will also reduce some of the negative impacts of coal mining. These impacts include: the utilisation of scarce water resources; SO_2 emissions; and the impacts associated with the disposal of coal ash.

Social

The proposed project activity will create local jobs in both the construction and operational phases of the project. As far as possible, the materials needed for this project will be purchased in Namibia and some portions of the project (civil and mechanical works) will be handled by local contractors.

A.3. Project participants:

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Name of Party involved ((host) indicates a host Party)	Private and/or public entity(ies) project participants (as applicable)	Party considered as project participant (Yes/No)
South Africa	Nedbank Group Limited (Private Entity)	No
	Cape Advanced Engineering (Pty) Ltd (Private Entity)	No
Namibia (host)	City of Windhoek (Public Entity)	No

A.4. Technical description of the small-scale project activity:

A.4.1. Location of the small-scale project activity:

A.4.1.1. Host Party (ies):

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Namibia

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

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Khomas Region

A.4.1.3. City/Town/Community etc:

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Windhoek

A.4.1.4. Details of physical location, including information allowing the unique identification of this small-scale project activity:

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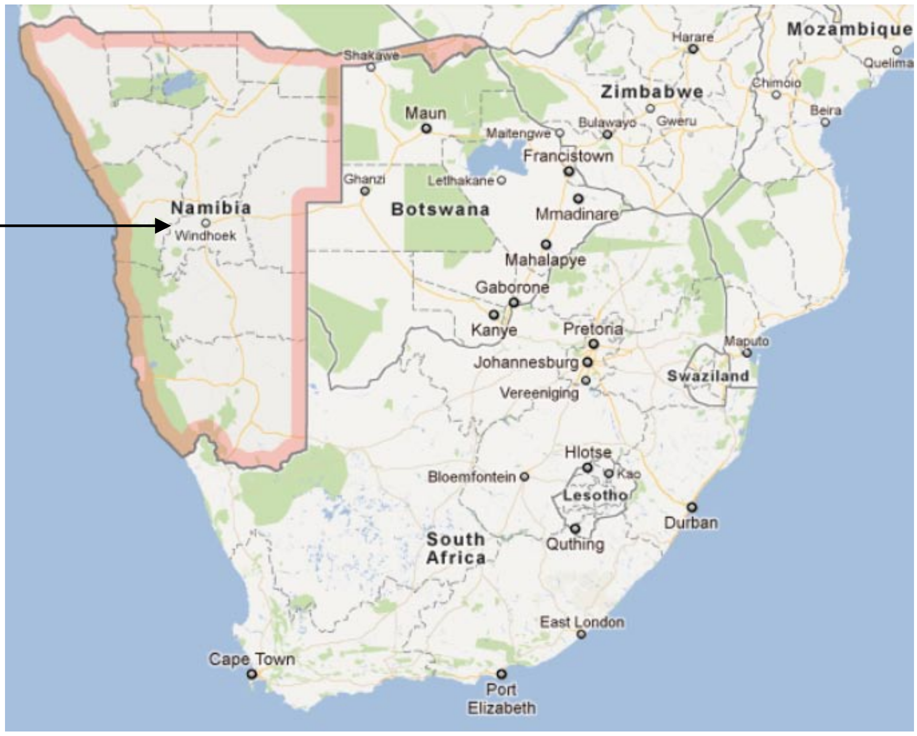
The project activity is located at a wastewater treatment plant in the north-western suburbs of Windhoek, Namibia. The GPS coordinates are: 22° 31' 46’’ S, 17° 02' 02’’ E.

Project location



Project location

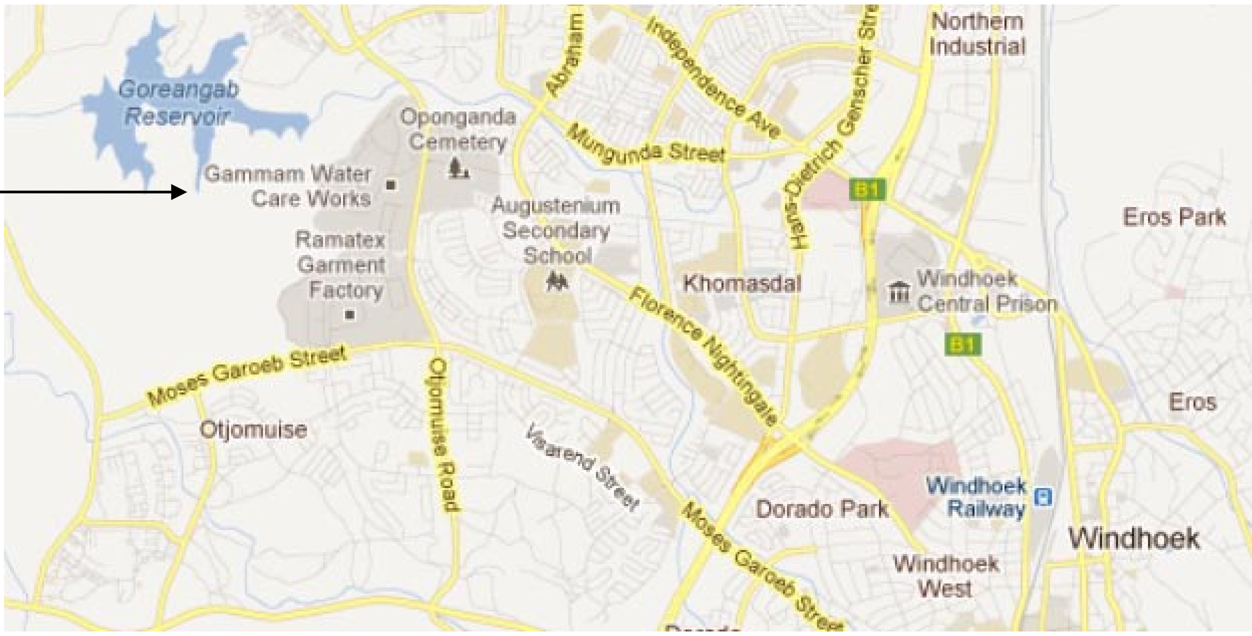


Figure 1: Project location (Retrieved from http://maps.google.co.za/)

A.4.2. Type and category (ies) and technology/measure of the small-scale project activity:

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Two baseline and monitoring methodologies are applicable to this project activity:

- AMS-I.C. Thermal energy production with or without electricity (Version 19)
- AMS-III.H. Methane recovery in wastewater treatment (Version 16)

This project aims to reduce greenhouse gas emissions at Gammams through the refurbishment of the primary sludge treatment system.

The existing situation at Gammams (baseline scenario)

Currently, the primary sludge that is withdrawn from the incoming waste stream at Gammams is anaerobically digested to stabilise the sludge prior to drying. The bulk of the sludge treatment infrastructure was built in 1970, with some additions and alternations in the 1980s. Over the last ten years, most of the original equipment has either broken down or has been decommissioned. An out of commission Jenbacher gas engine is still on site which was originally used for the generation of electricity and hot water prior to 2002.

The proposed project (project scenario)

The proposed project activity will seal off the anaerobic biodigesters at Gammans. The existing gas collection system will be repaired and upgraded, and the collected biogas will be used for:

1. Thermal energy production in a boiler. Emission reductions will not be claimed for this portion of the project as a new boiler will be installed.

2. Cogeneration. Two new gas engines built by Cape Advanced Engineering (Pty) Ltd (with the required switchgear, gas scrubbing, and heat exchange and synchronisation systems) will be installed for the generation of electricity from the available biogas. The electricity generated onsite will be fed to the water treatment plant, thus replacing the power that is currently sourced from predominantly coal-fired power stations. The waste heat from the engines will be fed to a heat exchanger for thermal application. The existing Jenbacher engine will also be refurbished.

The project activity forms part of a larger refurbishment of the primary sludge treatment system at Gammams. This refurbishment entails the automation of sludge draw-off and feeding system to the bio-digesters, maximised gas production, and better control. An automatically activated gas flare will be installed to ensure that any unused biogas (70% methane) is converted to CO_2 before release into the atmosphere.

Without the proposed CDM project, the City of Windhoek will continue to emit biogas into the atmosphere, and the water treatment plant will continue to source electricity from the grid.

Relationship between Cape Advanced Engineering (Pty) Ltd and the City of Windhoek

Cape Advanced Engineering (Pty) Ltd (hence forth referred to as CAE) will design, operate and maintain the new electricity generating plant, and the City of Windhoek (acting on behalf of Gammams) will supply CAE with thickened raw sludge from the primary settling tanks. In turn, CAE will supply Gammas with renewable electricity generated from biogas. The technology being applied in this project activity is environmentally safe and sound as CAE has extensive experience in the construction and operation of biogas plants.

Figure 2 below illustrates a flow diagram of the proposed project activity, together with the responsibility of CAE and the City of Windhoek.

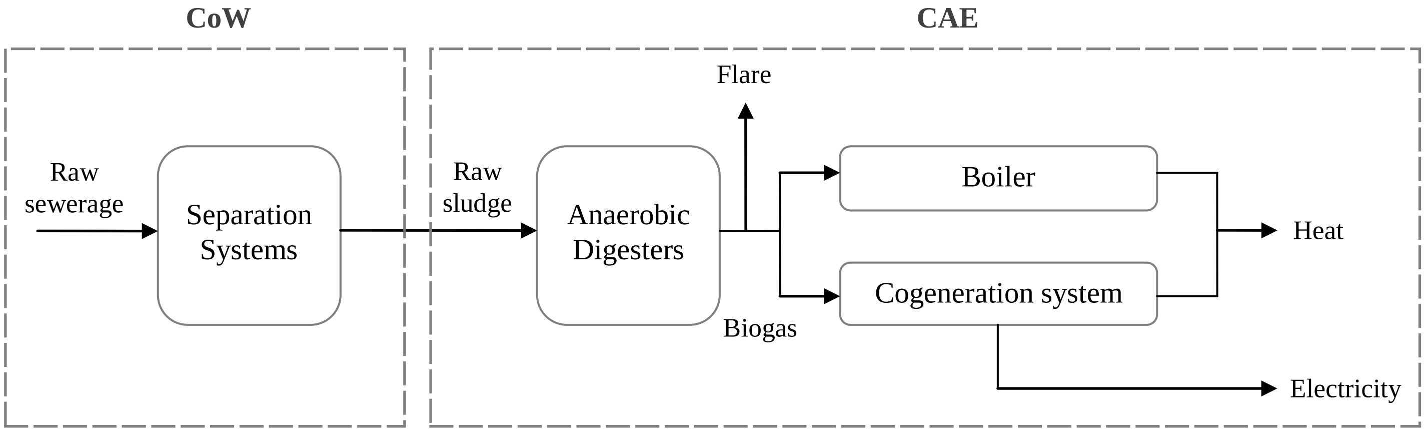

Figure 2: Flow diagram of project activity

A.4.3 Estimated amount of emission reductions over the chosen crediting period:

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Years	**Annual estimation of emission reductions in tonnes of CO_2e**
2013	9,082
2014	9,082
2015	9,082
2016	9,082
2017	9,082
2018	9,082
2019	9,082
2020	9,082
2021	9,082
2022	9,082
Total estimated reductions (tonnes of CO_2 e)	90,821
Total number of crediting years	10
Annual average over the crediting period of estimated reductions (tonnes of CO_2 e)	9,082

A.4.4. Public funding of the small-scale project activity:

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The City of Windhoek is a public institution and therefore a portion of the project will be publically funded. However, no Official Development Assistance (ODA) will be used in the development or in the implementation of this project.

A.4.5. Confirmation that the small-scale project activity is not a debundled component of a large scale project activity:

According to the 'Guidelines on assessment of debundling for SSC project activities' (Version 03) EB 54 Annex 13, a proposed small scale project activity shall be deemed to be a debundled component of a large project activity if there is a registered small-scale CDM project activity or an application to register another small-scale CDM project activity:

(a) *With the same project participants;*
(b) *In the same project category and technology/measure;*
(c) *Registered within the previous two years;*
(d) *Whose boundary is within 1 km of the project boundary of the proposed small-scale activity at the closest point.*

The size of this project falls well under the limits of a small-scale project activity. Nedbank/ Cape Advanced Engineering/ the City of Windhoek have not registered a similar project activity within a 1 km radius of the project boundary within the previous two years. Therefore, as per Appendix C of the 'Simplified modalities and procedures for small-scale CDM project activities[1]', this project activity is not a debundled component of a large-scale project activity.

SECTION B. Application of a baseline and monitoring methodology

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

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The approved baseline and monitoring methodology are:

- AMS-I.C. Thermal energy production with or without electricity (Version 19); and
- AMS-III.H. Methane recovery in wastewater treatment (Version 16).

The following methodological tools are used:

- Tool to calculate the emission factor for an electricity system (Version 02.2.1);
- Tool to determine project emissions from flaring gases containing methane (Version 01).

B.2 Justification of the choice of the project category:

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The project activity complies with the applicability criteria as set out in AMS-I.C. and AMS-III.H. This is shown below.

[1] http://unfccc.int/resource/docs/2005/cmp1/eng/08a01.pdf#page=43

Justification of the small-scale project activity as per AMS-I.C.:

Item	AMS-I.C.	Project activity
1.	*This methodology comprises renewable energy technologies that supply users with thermal energy that displaces fossil fuel use. These units include technologies such as solar thermal water heaters and dryers, solar cookers, energy derived from renewable biomass and other technologies that provide thermal energy that displaces fossil fuel.*	This project activity involves the use of renewable biogas for two different types of thermal applications - boiler heat and cogeneration.
2.	*Biomass-based cogeneration systems are included in this category. For the purpose of this methodology cogeneration shall mean the simultaneous generation of thermal energy and electrical energy in one process. Project activities that produce heat and power in separate element processes (for example heat from a boiler and electricity from a biogas engine) do not fit under the definition of cogeneration project.*	This project activity involves a biomass-based cogeneration system. Captured biogas (70% methane) will be sent to internal combustion engines which will see the simultaneous production of heat and electricity. The biogas will also be used for thermal application in a boiler.
3.	*Emission reductions from a biomass cogeneration system can accrue from one of the following activities:* *a) Electricity supply to a grid;* *b) Electricity and/or thermal energy (steam or heat) production for on-site consumption or for consumption by other facilities;* *c) Combination of (a) and (b).*	Option (b) is applicable to this project activity. Electricity and thermal energy is produced for on-site consumption at the Gammams Water Care Works.
4.	*The total installed/rated thermal energy generation capacity of the project equipment is equal to or less than 45 MW thermal (see paragraph 6 for the applicable limits for cogeneration project activities).*	This project activity involves cogeneration and thermal energy generation. The total rated capacity of all installed project equipment will be between 0.20 MW and 0.45 MW electrical, which is well within the limits specified by the methodology.
5.	*For co-fired systems, the total installed thermal energy generation capacity of the project equipment, when using both fossil and renewable fuel, shall not exceed 45 MW thermal (see paragraph 6 for the applicable limits for cogeneration project activities).*	Not applicable. The project activity does not involve a co-fired system.
6.	*The following capacity limits apply for biomass cogeneration units:* *a) If the project activity includes emission reductions from both the thermal and electrical energy components, the total installed energy generation capacity (thermal and electrical) of the project equipment shall not exceed 45 MW thermal. For the purpose of calculating this capacity limit the conversion factor of 1:3 shall be used for converting electrical energy to thermal energy (i.e. for renewable energy project activities,*	Option (a) is applicable. The project activity includes emission reductions for both the thermal and electrical energy components and, as such, the total installed energy generation capacity of the project equipment is 0.33 MW electrical (1 MW

	the maximal limit of 15 MW(e) is equivalent to 45 MW thermal output of the equipment or the plant); b) *If the emission reductions of the cogeneration project activity are solely on account of thermal energy production (i.e. no emission reductions accrue from the electricity component), the total installed thermal energy production capacity of the project equipment of the cogeneration unit shall not exceed 45 MW thermal;* c) *If the emission reductions of the cogeneration project activity are solely on account of electrical energy production (i.e. no emission reductions accrue from the thermal energy component), the total installed electrical energy generation capacity of the project equipment of the cogeneration unit shall not exceed 15 MW.*	thermal).
7.	*The capacity limits specified in the above paragraphs apply to both new facilities and retrofit projects. In the case of project activities that involve the addition of renewable energy units at an existing renewable energy facility, the total capacity of the units added by the project should comply with capacity limits in paragraphs 4 to 6, and should be physically distinct from the existing units.*	Not applicable. The project activity does not involve the installation of a new facility or a retrofit.
8.	*Project activities that seek to retrofit or modify an existing facility for renewable energy generation are included in this category.*	The project activity involves the modification of an existing facility for renewable energy generation.
9.	*New Facilities (Greenfield projects) and project activities involving capacity additions compared to the baseline scenario are only eligible if they comply with the related and relevant requirements in the "General Guidelines to SSC CDM methodologies".*	Not applicable. This is not a Greenfield project nor does it involve a capacity addition.
10.	*If solid biomass fuel (e.g. briquette) is used, it shall be demonstrated that it has been produced using solely renewable biomass and all project or leakage emissions associated with its production shall be taken into account in the emissions reduction calculation.*	Not applicable. Solid biomass fuel is not used in this project activity.
11.	*Where the project participant is not the producer of the processed solid biomass fuel, the project participant and the producer are bound by a contract that shall enable the project participant to monitor the source of the renewable biomass to account for any emissions associated with solid biomass fuel production. Such a contract shall also ensure that there is no double-counting of emission reductions.*	Not applicable. Solid biomass fuel is not used in this project activity.
12.	*If electricity and/or steam/heat produced by the project activity is delivered to a third party i.e. another facility or facilities within the project boundary, a contract between the supplier and consumer(s) of the energy will have to be entered into that ensures there is no double-counting of emission reductions.*	Electricity will be generated by Cape Advanced Engineering which will be used by the City of Windhoek. A contract exists between these two parties.
13.	*If the project activity recovers and utilizes biogas for power/heat*	The project activity does

	production and applies this methodology on a standalone basis i.e. without using a Type III component of a SSC methodology, any incremental emissions occurring due to the implementation of the project activity (e.g. physical leakage of the anaerobic digester, emissions due to inefficiency of the flaring), shall be taken into account either as project or leakage emissions.	recover and utilise biogas for power and heat production. However, methodology AMS-I.C *is* combined with a Type III component of a SSC methodology (AMS-III.H.), and therefore paragraph 13 is not applicable.
14.	*Charcoal based biomass energy generation project activities are eligible to apply the methodology only if the charcoal is produced from renewable biomass sources provided:* *Charcoal is produced in kilns equipped with methane recovery and destruction* *facility; or* *If charcoal is produced in kilns not equipped with a methane recovery and destruction facility, methane emissions from the production of charcoal shall be considered. These emissions shall be calculated as per the procedures defined in the approved methodology AMS-III.K. Alternatively, conservative emission factor values from peer reviewed literature or from a registered CDM project activity can be used, provided that it can be demonstrated that the parameters from these are comparable e.g. source of biomass, characteristics of biomass such as moisture, carbon content, type of kiln, operating conditions such as ambient temperature.*	Not applicable. This project activity does not involve a charcoal based biomass energy generating activity.

The project meets the relevant applicability criteria in AMS-I.C, as demonstrated in the table above. Furthermore, the capacity of the proposed project activity will not exceed 15 MW, as per small-scale CDM requirements.

Justification of the small-scale project activity as per AMS III.H.:

Item	AMS III.H.	Project activity
1.	*This methodology comprises measures that recover biogas from biogenic organic matter in wastewater by means of one, or a combination, of the following options:* *a) Substitution of aerobic wastewater or sludge treatment systems with anaerobic systems with biogas recovery and combustion;* *b) Introduction of anaerobic sludge treatment system with biogas recovery and combustion to a wastewater treatment plant without sludge treatment;* *c) Introduction of biogas recovery and combustion to a sludge treatment system;* *d) Introduction of biogas recovery and combustion to an anaerobic wastewater treatment system such as anaerobic reactor, lagoon, septic tank or an onsite industrial plant;* *e) Introduction of anaerobic wastewater treatment with biogas recovery and combustion, with or without anaerobic sludge*	Option (c) is applicable. The project activity involves the sludge treatment system and not the wastewater treatment system – liquid sewerage exits the project boundary after primary sedimentation. The project activity involves the introduction of biogas recovery (the top of the bio-digesters will be sealed off to enable the capture of biogas) and combustion (new gas engines will be

	treatment, to an untreated wastewater stream; *f) Introduction of a sequential stage of wastewater treatment with biogas recovery and combustion, with or without sludge treatment, to an anaerobic wastewater treatment system without biogas recovery (e.g. introduction of treatment in an anaerobic reactor with biogas recovery as a sequential treatment step for the wastewater that is presently being treated in an anaerobic lagoon without methane recovery).*	installed to generate electricity and heat). The biogas will also be used for a thermal application in a boiler.
2.	*In cases where baseline system is anaerobic lagoon the methodology is applicable if:* *a) The lagoons are ponds with a depth greater than two meters, without aeration. The value for depth is obtained from engineering design documents, or through direct measurement, or by dividing the surface area by the total volume. If the lagoon filling level varies seasonally, the average of the highest and lowest levels may be taken;* *b) Ambient temperature above 15°C, at least during part of the year, on a monthly average basis;* *c) The minimum interval between two consecutive sludge removal events shall be 30 days.*	Not applicable. The baseline system is not an anaerobic lagoon.
3.	*The recovered biogas from the above measures may also be utilised for the following applications instead of combustion/flaring:* *a) Thermal or mechanical, electrical energy generation directly;* *b) Thermal or mechanical, electrical energy generation after bottling of upgraded biogas, in this case additional guidance provided in Annex 1 shall be followed; or* *c) Thermal or mechanical, electrical energy generation after upgrading and distribution, in this case additional guidance provided in Annex 1 shall be followed:* *i. Upgrading and injection of biogas into a natural gas distribution grid with no significant transmission constraints;* *ii. Upgrading and transportation of biogas via a dedicated piped network to a group of end users; or* *iii. Upgrading and transportation of biogas (e.g. by trucks) to distribution* *d) Hydrogen production;* *e) Use as fuel in transportation applications after upgrading.*	Option (a) is applicable. The recovered biogas is used for direct thermal and electrical energy generation.
4.	*If the recovered biogas is used for project activities covered under paragraph 3 (a), that component of the project activity can use a corresponding methodology under Type I.*	The project activity is covered under paragraph 3 (a) and, as such, methodology AMS-I.C. is used in conjunction with AMS-III.H.
5.	*For project activities covered under paragraph 3 (b), if bottles with upgraded biogas are sold outside the project boundary, the end-use of the biogas shall be ensured via a contract between the bottled biogas vendor and the end-user. No emission reductions*	Not applicable. The project activity is not covered under paragraph 3 (b).

	may be claimed from the displacement of fuels from the end use of bottled biogas in such situations. If however the end use of the bottled biogas is included in the project boundary and is monitored during the crediting period CO_2 emissions avoided by the displacement of fossil fuel can be claimed under the corresponding Type I methodology, e.g. AMS-I.C "Thermal energy production with or without electricity".	
6.	*For project activities covered under paragraph 3 (c) (i), emission reductions from the displacement of the use of natural gas are eligible under this methodology, provided the geographical extent of the natural gas distribution grid is within the host country boundaries.*	Not applicable. The project activity is not covered under paragraph 3 (c) (i).
7.	*For project activities covered under paragraph 3 (c) (ii), emission reductions for the displacement of the use of fuels can be claimed following the provision in the corresponding Type I methodology, e.g. AMS-I.C.*	Not applicable. The project activity is not covered under paragraph 3 (c) (ii).
8.	*In particular, for the case of 3 (b) and (c) (iii), the physical leakage during storage and transportation of upgraded biogas, as well as the emissions from fossil fuel consumed by vehicles for transporting biogas shall be considered. Relevant procedures in paragraph 11 of Annex 1 of AMS-III.H. "Methane recovery in wastewater treatment" shall be followed in this regard.*	Not applicable. The project activity is not covered under paragraphs 3 (b) and (c) (ii).
9.	*For project activities covered under paragraph 3 (b) and (c), this methodology is applicable if the upgraded methane content of the biogas is in accordance with relevant national regulations (where these exist) or, in the absence of national regulations, a minimum of 96% (by volume).*	Not applicable. The project activity is not covered under paragraphs 3 (b) and (c).
10.	*If the recovered biogas is utilized for the production of hydrogen (project activities covered under paragraph 3 (d)), that component of the project activity shall use the corresponding methodology AMS-III.O. "Hydrogen production using methane extracted from biogas".*	Not applicable. The project activity is not covered under paragraph 3 (d).
11.	*If the recovered biogas is used for project activities covered under paragraph 3 (e), that component of the project activity shall use corresponding methodology AMS-III.AQ. "Introduction of Bio-CNG in road transportation"."*	Not applicable. The project activity is not covered under paragraph 3 (e).
12.	*New facilities (Greenfield projects) and project activities involving a change of equipment resulting in a capacity addition of the wastewater or sludge treatment system compared to the designed capacity of the baseline treatment system are only eligible to apply this methodology if they comply with the relevant requirements in the "General guidelines to SSC CDM methodologies". In addition the requirements for demonstrating the remaining lifetime of the equipment replaced, as described in the general guidelines shall be followed.*	Not applicable. This is not a Greenfield project nor does it involve a capacity addition.
13.	*The location of the wastewater treatment plant as well as the source generating the wastewater shall be uniquely defined and described in the PDD.*	This has been described in sections A.2 and A.4.1.4.

14.	*Measures are limited to those that result in aggregate emissions reductions of less than or equal to 60 ktCO_2 equivalent annually from all Type III components of the project activity.*	The project activity involves emission reductions of 9,082 CO_2e/year

The project meets the relevant applicability criteria in AMS III.H, as demonstrated in the table above. Furthermore, the estimated emission reductions of the project activity will not exceed 60 ktCO_2e in any year of the crediting period, as per small-scale CDM requirements.

B.3. Description of the project boundary:

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As per methodologies AMC-I.C. and AMS-III.H., the project boundary covers the Gammams Water Care Works. This is the site where the wastewater and sludge treatment takes place. It is also the location of the power and heat generating equipment. All of the energy produced is consumed onsite. The national grid is also included in the project boundary for the purposes of determining the grid emission factor.

The project boundary is illustrated in
Figure 3 below.

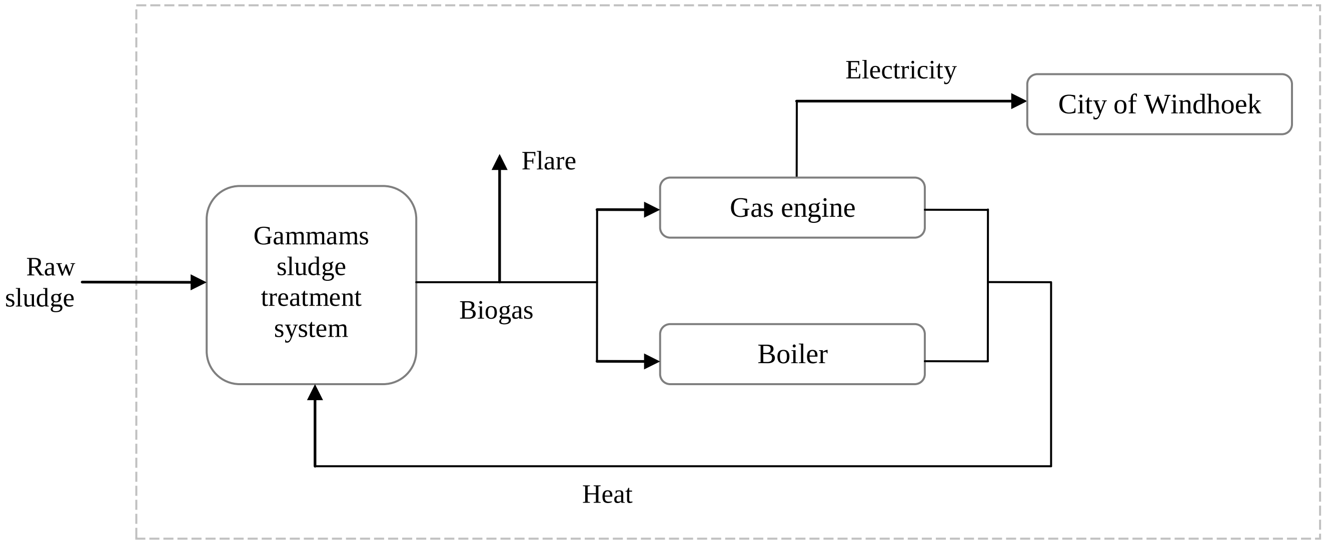

Figure 3: Project boundary

B.4. Description of baseline and its development:

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The baseline scenario of this project activity is based on methodologies AMS-I.C. (version 19) and AMS-III.H. (version 16).

1. Electricity generation component (AMS-I.C. version 19)

Methodology AMS-I.C. (version 16) is applied for the electricity generation component of this project. In the absence of the project activity, Gammams would continue to consume electricity from the grid. Thus, in accordance with paragraph 16 of AMS-I.C., '*the simplified baseline is the fuel consumption of the technologies that would have been used in the absence of the project activity, times an emission factor for* *the fossil fuel displaced'*. Therefore, for this project activity, the baseline shall be the amount of electricity that would have been consumed from the grid in the absence of the project activity (based on the amount of electricity generated by the gas engines) times by the emission factor of the grid.

Table 1 below presents all data used to determine the baseline emissions for the electricity generation component of the project activity.

Table 1: All data used to determine baseline emissions for the electricity generation component of the project activity

Parameter	Description	Value	Data source
$EG_{elec,y}$	Amount of electricity produced by the project activity during the year *y* (MWh)	2,917	Engine technical specifications.
$EF_{grid,y}$	Emission factor of the grid (tCO_2e/MWh	1.0368	Calculated in accordance with Version 02.2.1 of the 'Tool to calculate the emission factor for an electricity system'

2. Methane recovery component (AMS-III.H. version 16)

The project corresponds to type 1(c) of AMS-III.H. version 16. For this project, the baseline is the methane emissions from the existing sludge treatment system. Prior to the implementation of the project activity, primary sludge was withdrawn from the incoming waste stream at Gammams. The raw sludge was anaerobically digested in five reinforced concrete digesters, and the methane was emitted to the atmosphere. The dried sludge was stockpiled and used as soil conditioner/fertiliser by other public entities (schools, government gardens, sport fields, etc).

Table 2 below presents all data used to determine the baseline emissions for the methane recovery component of the project activity.

Table 2: All data used to determine baseline emissions for the methane recovery component of the project activity

Parameter	Description	Value	Data source
$S_{j,BL,y}$	Amount of dry matter in the sludge that would have been treated by the sludge treatment system *j* in the baseline scenario (t/day)	8.00	Calculated using a mass balance over the primary sedimentation tank.
$MCF_{s,treatment,BL,j}$	Methane correction factor for the baseline sludge treatment system j	0.8	Table III.H.1 in AMS.III-H. The baseline involves an anaerobic digester for sludge without methane recovery.
DOC_s	Degradable organic content of the untreated sludge generated in the year y (fraction, dry basis)	0.5	AMS.III-H. Domestic sludge is treated at the Gammams Water Care Works.
UF_{BL}	Model correction factor to account for model uncertainties	0.89	AMS.III-H.
DOC_F	Fraction of DOC dissimilated to	0.5	IPCC default value as specified

	biogas		by AMS-III.H.
F	Fraction of CH_4 in biogas	0.5	IPCC default value as specified by AMS-III.H.
GWP_{CH_4}	Global warming potential of methane	21	AMS.III-H.

In line with paragraph 26 of AMS-III.H. version 16, historical records of one year prior to the project activity have been used to determine the baseline emissions. The detailed calculations of the baseline emissions are provided in section B.6.1.

B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered small-scale CDM project activity:

According to paragraph 28 of the 'Simplified modalities and procedures for small-scale CDM project activities', a simplified baseline and monitoring methodology may be used for a small-scale CDM project activity if the project participants are able to demonstrate that the project activity would otherwise not be implemented due to the existence of one or more of the barriers. The attachment A to Appendix B corresponds to the list of barriers that project participants shall use in order to demonstrate that a small-scale project activity would not have occurred otherwise (i.e. is additional).This will be demonstrated below.

Barrier due to prevailing practice – 'First of its kind'

According to EB 63 Annex 11, 'a proposed project activity is the first-of-its-kind in the applicable geographical area if:

a) The project is the first in the applicable geographical area that applies a technology that is different from any other technologies able to deliver the same output and that have started commercial operation in the applicable geographical area before the start date of the project; and
b) Project participant selected a crediting period for the project activity that is "a maximum of 10 years with no option of renewal"'.

There is no other domestic wastewater treatment plant in Namibia that is generating electricity from biogas. The crediting period selected for this project activity is for 10 years without the option of renewal. Since this project activity fulfils both criteria (a) and (b), the project is first-of-its-kind project and therefore additional. Furthermore, there are no national policies in Namibia that require the capture and utilisation of biogas generated at waste water treatment plants.

Notice of prior consideration

Notice of prior consideration (in terms of EB 49 Annex 12) was given to the EB on 27/07/2010. The milestones in the project development are provided in the timeline below:

Date	*Activity*
30/11/2009	The City of Windhoek engages with Nedbank Capital regarding possible project financing and carbon credit registration.
07/06/2010	Project Idea Note (PIN) completed by the City of Windhoek regarding the refurbishing of the bio-digestion system at Gammams Water Care Works.
13/01/2010	Nedbank Capital offers to finance the project in exchange for acting as the exclusive carbon credit broker.

13/07/2010	The City of Windhoek recommends that the Local Tender Board awards the contract for the refurbishment of the digesters to Cape Advanced Engineering (Pty) Ltd.
27/07/2010	Notice of prior consideration submitted to UNFCCC.
31/10/2011	Promethium Carbon completes the PDD.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

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The emission reductions are calculated in accordance with two approved baseline and monitoring methodologies: AMS-I.C. (Version 19) and AMS.III.H. (Version 16).

<u>The calculations for methodology AMS-I.C. are shown below:</u>

Baseline Emissions

According to paragraph 16 of AMS-I.C., ‘for renewable energy technologies that displace technologies using fossil fuels, the simplified baseline is the fuel consumption of the technologies that would have been used in the absence of the project activity, times an emission factor for the fossil fuel displaced’.

Though thermal energy is generated in the project activity, it is not generated in the baseline. For this reason, the thermal portion of the project is excluded from the emission reduction calculations.

The baseline emissions from electricity displaced by the project activity are calculated using the equation below.

$$BE_y = EG_{elec,y} \times EF_{grid,y}$$

Where:

BE_y	Baseline emissions in year *y* (tCO_2e)
$EG_{elec,y}$	Amount of electricity produced by the project activity during the year *y* (MWh)
$EF_{grid,y}$	Emission factor of the grid (tCO_2e/MWh), calculated in accordance with Version 02.2.1 of the ‘Tool to calculate the emission factor for an electricity system’

The methodological choices made regarding the ‘Tool to calculate the emission factor for an electricity system’ (Version 02.2.1) are as follows:

- In terms of data vintages, the ex ante option was chosen to calculate the simple operating margin (OM). In this option a 3 year generation-weighted average are used for the grid power plants. Using this option also means that the emission factor is determined only once at the validation stage, thus no monitoring and recalculation is required during the crediting period.
- The simple operating margin emission factor ($EF_{grid,OMsimple,y}$) is chosen for the calculation method, seeing as low-cost/must-run resources constitute less than 50% of total grid generation in average of the five most resent years.
- For calculating of the combined margin emission factor: w_{OM} = 0.5 and w_{BM} = 0.5 (as specified by the applied tool – it is an ‘other’-type project).

Project emissions

$PE_y = 0$. There is no additional consumption of fossil fuels or electricity as a result of the project activity.

Leakage

Since the raw sewerage is processed within the project boundary, and the energy generating equipment currently being utilised is not transferred from outside the project boundary to the project, $LE_y = 0$.

Emission Reductions

Emission reductions are calculated using equation (13) of the applied methodology.

$$ER_y = BE_y - PE_y - LE_y$$ (AMS-I.C. equation 13)

Where:

ER_y	Emission reductions in year *y* (tCO_2e)
BE_y	Baseline emissions in year *y* (tCO_2e)
PE_y	Project emissions in year *y* (tCO_2e)
LE_y	Leakage emissions in year *y* (tCO_2e)

The calculations for methodology AMS-III.H. are shown below:

Baseline Emissions

According to AMS-III.H., the baseline emissions are calculated using equation (1) of the applied methodology.

$$BE_y = BE_{power.y} + BE_{ww,treatment,y} + BE_{s,treatment,y} + BE_{ww,discharge,y} + BE_{s,final,y}$$

(AMS-III.H. equation 1)

Where:

BE_y	Baseline emissions in year *y* (tCO_2e)
$BE_{power.y}$	Baseline emissions from electricity or fuel consumption in year *y* (tCO_2e)
$BE_{ww,treatment,y}$	Baseline emissions of the wastewater treatment systems affected by the project activity in year *y* (tCO_2e)
$BE_{s,treatment,y}$	Baseline emissions of the sludge treatment systems affected by the project activity in year *y* (tCO_2e)
$BE_{ww,discharge,y}$	Baseline methane emissions from degradable organic carbon in treated wastewater discharged into sea/river/lake in year *y* (tCO_2e)
$BE_{s,final,y}$	Baseline emissions from anaerobic decay of the final sludge produced in year *y* (tCO_2e)

The implementation of the project activity has negligible effect on the power consumption at the Gammams Water Care Works. Therefore, $BE_{power.y} = 0$.

The project activity does not involve wastewater treatment systems. Therefore, $BE_{ww,treatment,y} = BE_{ww,discharge,y} = 0$.

The sludge is used for soil application in the baseline scenario. Therefore, $BE_{s,final,y} = 0$.

Therefore,

$BE_y = BE_{s,treatment,y}$

The methane emissions from the baseline sludge treatment systems affected by the project activity ($BE_{s,treatment,y}$) are determined using the methane generation potential of the sludge treatment systems, as per equation (3) of the applied methodology:

$$BE_{s,treatment,y} = \sum_j S_{j,BL,y} \times MCF_{s,treatment,BL,j} \times DOC_s \times UF_{BL} \times DOC_F \times F \times \frac{16}{12} \times GWP_{CH_4}$$

(AMS-III.H. equation 3)

Where:

$S_{j,BL,y}$	Amount of dry matter in the sludge that would have been treated by the sludge treatment system *j* in the baseline scenario (t)
j	Index for baseline sludge treatment system
$MCF_{s,treatment,BL,j}$	Methane correction factor for the baseline sludge treatment system *j* (as per Table III.H.1. in AMS.III-H.)
DOC_s	Degradable organic content of the untreated sludge generated in the year *y* (fraction, dry basis).
UF_{BL}	Model correction factor to account for model uncertainties
DOC_F	Fraction of DOC dissimilated to biogas
F	Fraction of CH_4 in biogas
GWP_{CH_4}	Global warming potential of methane

Project emissions

According to AMS-III.H., the project emissions are calculated using equation (8) of the applied methodology.

$$PE_y = PE_{power.y} + PE_{ww,treatment,y} + PE_{s,treatment,y} + PE_{ww,discharge,y} + PE_{s,final,y} + PE_{fugitive,y} + PE_{biomass,y} + PE_{flaring,y}$$

(AMS-III.H. equation 8)

Where:

PE_y	Project activity emissions in the year y (tCO_2e)
$PE_{power.y}$	Emissions from electricity consumption in the year *y* (tCO_2e). These emissions are calculated in accordance with the 'Tool to calculate baseline, project and/or leakage emissions from fossil fuel consumption' (Version 01), using energy consumption data of all equipment/devices used in the project activity wastewater and sludge treatment systems and systems for biogas recovery and flaring/gainful use.

$PE_{ww,treatment,y}$	Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery, in year *y* (tCO_2e)
$PE_{s,treatment,y}$	Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery, in year y (tCO_2e).
$PE_{ww,discharge,y}$	Methane emissions from degradable organic carbon in treated wastewater in year *y* (tCO_2e)
$PE_{s,final,y}$	Methane emissions from anaerobic decay of the final sludge produced in year *y* (tCO_2e).
$PE_{fugitive,y}$	Methane emissions from biogas release in capture systems in year *y* (tCO_2e)
$PE_{biomass,y}$	Methane emissions from biomass stored under anaerobic conditions (tCO_2e)
$PE_{flaring,y}$	Methane emissions due to incomplete flaring in year *y* (tCO_2e)

The implementation of the project activity has negligible effect on the power consumption at the Gammams Water Care Works. Therefore, $PE_{power.y} = 0$.

The project activity does not involve wastewater treatment systems. Therefore, $PE_{ww,treatment,y} = PE_{ww,discharge,y} = 0$.

All five of the biodigesters are sealed to capture methane so $PE_{s,treatment,y} = 0$.

The sludge is used for soil application in aerobic conditions in the project activity. Therefore, $PE_{s,final,y} = 0$.

The project activity does not involve the storage of biomass. Therefore, $PE_{biomass,y} = 0$.

Therefore,

$$PE_y = PE_{fugitive,y} + PE_{flaring,y}$$

The project activity emissions from methane release in capture systems are calculated using method (a) of paragraph 30 of AMS-III.H.:

$$PE_{fugitive,y} = PE_{fugitive,ww,y} + PE_{fugitive,s,y} \quad \text{(AMS-III.H. equation 9)}$$

Where:

$PE_{fugitive,y}$	Methane emissions from biogas release in capture systems in year *y* (tCO_2e)
$PE_{fugitive,ww,y}$	Fugitive emissions through capture inefficiencies in the anaerobic wastewater treatment systems in the year *y* (tCO_2e)
$PE_{fugitive,s,y}$	Fugitive emissions through capture inefficiencies in the anaerobic sludge treatment systems in the year *y* (tCO_2e)

$PE_{fugitive,ww,y} = 0$ as the project activity does not wastewater treatment systems.

$$PE_{fugitive,s,y} = (1 - CFE_s) \times MEP_{s,treatment,y} \times GWP_{CH_4} \quad \text{(AMS-III.H. equation 12)}$$

Where:

CFE_s	Capture efficiency of the biogas recovery equipment used in the sludge treatment systems
$MEP_{s,treatment,y}$	Methane emission potential of the sludge treatment systems equipped with a biogas recovery system in year *y* (t)

$$MEP_{s,treatment,y} = \sum_l S_{l,PJ,y} \times MCF_{s,treatment,PJ,l} \times DOC_s \times UF_{PJ} \times DOC_F \times F \times \frac{16}{12}$$

(AMS-III.H. equation 13)

Where:

$S_{l,PJ,y}$	Amount of sludge treated in the project sludge treatment system *l* equipped with a biogas recovery system (on a dry basis) in year *y* (t)
$MCF_{s,treatment,PJ,l}$	Methane correction factor for the sludge treatment system equipped with biogas recovery equipment
UF_{PJ}	Model correction factor to account for uncertainties

The methane emissions due to incomplete flaring ($PE_{flaring,y}$) are calculated using version 01 of the 'Tool to determine project emissions from flaring gases containing methane'. The calculations for this tool can be found in Annex 4.

Leakage

$LE_y = 0$ as the project activity does not involve the transfer of equipment from another activity.

Emission Reductions

Emission reductions are calculated as:

$$ER_{y,ex\ ante} = BE_{y,ex\ ante} - PE_{y,ex\ ante} - LE_{y,ex\ ante}$$

Where:

$ER_{y,ex\ ante}$	Emission reductions in year *y* (tCO_2e)
$BE_{y,ex\ ante}$	Baseline emissions in year *y* (tCO_2e)
$PE_{y,ex\ ante}$	Project emissions in year *y* (tCO_2e)
$LE_{y,ex\ ante}$	Leakage emissions in year *y* (tCO_2e)

B.6.2. Data and parameters that are available at validation:

Data / Parameter:	$EF_{grid,y}$
Data unit:	tCO_2e/MWh
Description:	Emission factor of the grid
Source of data used:	Calculated from the 'Tool to calculate the emission factor for an electricity system' version 02.2.1.
Value applied:	1.0368
Justification of the choice of data or description of	Refer to Annex 3 for the grid emission factor calculations.

measurement methods and procedures actually applied :	
Any comment:	As per the applied tool, this value can be fixed ex-ante.

Data / Parameter:	$S_{j,BL,y}$
Data unit:	tonnes/day
Description:	Amount of dry matter in the sludge that would have been treated by the sludge treatment system j in the baseline scenario.
Source of data used:	Measured.
Value applied:	8.00
Justification of the choice of data or description of measurement methods and procedures actually applied :	The amount of sludge treated in the baseline sludge treatment system is calculated with a mass balance over the primary sedimentation tank.
Any comment:	

Data / Parameter:	$MCF_{s,treatment,BL,j}$
Data unit:	-
Description:	Methane correction factor for the baseline sludge treatment system *j*
Source of data used:	As per Table III.H.1. in methodology AMS.III-H.
Value applied:	0.8
Justification of the choice of data or description of measurement methods and procedures actually applied :	The baseline involves an anaerobic digester for sludge without methane recovery.
Any comment:	

Data / Parameter:	DOC_s
Data unit:	-
Description:	Degradable organic content of the untreated sludge generated in the year *y* (dry basis).
Source of data used:	Methodology AMS-III.H.
Value applied:	0.5
Justification of the choice of data or description of measurement methods and procedures actually applied :	Domestic sludge is treated at the Gammams water care works.
Any comment:	

Data / Parameter:	UF_{BL}

Data unit:	-
Description:	Model correction factor to account for model uncertainties
Source of data used:	Methodology AMS-III.H.
Value applied:	0.89
Justification of the choice of data or description of measurement methods and procedures actually applied :	Default value as per requirements in AMS-III.H. version 16.
Any comment:	-

Data / Parameter:	DOC_F
Data unit:	-
Description:	Fraction of DOC dissimilated to biogas
Source of data used:	IPCC default value
Value applied:	0.5
Justification of the choice of data or description of measurement methods and procedures actually applied :	As per requirements in AMS-III.H. version 16.
Any comment:	-

Data / Parameter:	F
Data unit:	-
Description:	Fraction of CH_4 in biogas
Source of data used:	IPCC default value
Value applied:	0.5
Justification of the choice of data or description of measurement methods and procedures actually applied :	As per requirements in AMS-III.H. version 16.
Any comment:	-

Data / Parameter	CFE_s
Data unit:	-
Description:	Capture efficiency of the biogas recovery equipment used in the sludge treatment systems
Source of data used:	AMS-III.H. Version 16
Value applied:	0.9
Justification of the choice of data or description of measurement methods	A default value shall be used as per requirements in AMS-III.H. version 16.

and procedures actually applied :	
Any comment:	-

Data / Parameter:	$MCF_{s,treatment,PJ,l}$
Data unit:	-
Description:	Methane correction factor for the sludge treatment system equipped with biogas recovery equipment
Source of data used:	As per Table III.H.1. in methodology AMS.III-H.
Value applied:	0.8
Justification of the choice of data or description of measurement methods and procedures actually applied :	The project involves an anaerobic digester for sludge without methane recovery.
Any comment:	

Data / Parameter:	UF_{PJ}
Data unit:	-
Description:	Model correction factor to account for model uncertainties
Source of data used:	Methodology AMS-III.H.
Value applied:	1.12
Justification of the choice of data or description of measurement methods and procedures actually applied :	Default value as per requirements in AMS-III.H. version 16.
Any comment:	-

B.6.3 Ex-ante calculation of emission reductions:

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<u>The calculations for methodology AMS-I.C. are shown below:</u>

$$BE_y = EG_{elec,y} \times EF_{grid,y}$$

Year	BE_y	$EG_{elec,y}$	$EF_{grid,y}$
	tCO_2/year	MWh/year	tCO_2/MWh
2013	3 024	2 917	1.0368
2014	3 024	2 917	1.0368
2015	3 024	2 917	1.0368
2016	3 024	2 917	1.0368
2017	3 024	2 917	1.0368
2018	3 024	2 917	1.0368

2019	3 024	2 917	1.0368
2020	3 024	2 917	1.0368
2021	3 024	2 917	1.0368
2022	3 024	2 917	1.0368

$$ER_y = BE_y - PE_y - LE_y$$

Year	ER_y	BE_y	PE_y	LE_y
	tCO_2/year	tCO_2/year	tCO_2/year	tCO_2/year
2013	3 024	3 024	0	0
2014	3 024	3 024	0	0
2015	3 024	3 024	0	0
2016	3 024	3 024	0	0
2017	3 024	3 024	0	0
2018	3 024	3 024	0	0
2019	3 024	3 024	0	0
2020	3 024	3 024	0	0
2021	3 024	3 024	0	0
2022	3 024	3 024	0	0

The calculations for methodology AMS-III.H. are shown below:

$$BE_y = BE_{power.y} + BE_{ww,treatment,y} + BE_{s,treatment,y} + BE_{ww,discharge,y} + BE_{s,final,y}$$

Year	BE_y	$BE_{power,y}$	$BE_{ww,treatment,y}$	$BE_{s,treatment,y}$	$BE_{ww,discharge,y}$	$BE_{s,final,y}$
	tCO_2/year	tCO_2/year	tCO_2/year	tCO_2/year	tCO_2/year	tCO_2/year
2013	7 277	0	0	7 277	0	0
2014	7 277	0	0	7 277	0	0
2015	7 277	0	0	7 277	0	0
2016	7 277	0	0	7 277	0	0
2017	7 277	0	0	7 277	0	0
2018	7 277	0	0	7 277	0	0
2019	7 277	0	0	7 277	0	0
2020	7 277	0	0	7 277	0	0
2021	7 277	0	0	7 277	0	0
2022	7 277	0	0	7 277	0	0

$$BE_{s,treatment,y} = \sum_j S_{j,BL,y} \times MCF_{s,treatment,BL,j} \times DOC_s \times UF_{BL} \times DOC_F \times F \times \frac{16}{12} \times GWP_{CH_4}$$

Year	$BE_{s,treatment,y}$	$S_{j, BL,y}$	$MCF_{s,treatment,BL,j}$	DOC_s	UF_{BL}	DOC_F	F	GWP_{CH4}
	tCO_2/year	t/year	-	-	-	-	-	tCO_2/tCH_4
2013	7 277	2 920	0.8	0.5	0.89	0.5	0.5	21
2014	7 277	2 920	0.8	0.5	0.89	0.5	0.5	21
2015	7 277	2 920	0.8	0.5	0.89	0.5	0.5	21
2016	7 277	2 920	0.8	0.5	0.89	0.5	0.5	21
2017	7 277	2 920	0.8	0.5	0.89	0.5	0.5	21
2018	7 277	2 920	0.8	0.5	0.89	0.5	0.5	21
2019	7 277	2 920	0.8	0.5	0.89	0.5	0.5	21
2020	7 277	2 920	0.8	0.5	0.89	0.5	0.5	21
2021	7 277	2 920	0.8	0.5	0.89	0.5	0.5	21
2022	7 277	2 920	0.8	0.5	0.89	0.5	0.5	21

$$PE_y = PE_{power.y} + PE_{ww,treatment,y} + PE_{s,treatment,y} + PE_{ww,discharge,y} + PE_{s,final,y} + PE_{fugitive,y} + PE_{biomass,y} + PE_{flaring,y}$$

Year	PE_y	$PE_{power,y}$	$PE_{ww,treatment,y}$	$PE_{s,treatment,y}$	$PE_{ww,discharge,y}$	$PE_{s,final,y}$	$PE_{fugitive,y}$	$PE_{biomass,y}$	$PE_{flaring,y}$
	tCO_2/year	tCO_2/year	tCO_2/year	tCO_2/year	tCO_2/year	tCO_2/year	tCO_2/year	tCO_2/year	tCO_2/year
2013	1 219	-	-	-	-	-	916	-	303
2014	1 219	-	-	-	-	-	916	-	303
2015	1 219	-	-	-	-	-	916	-	303
2016	1 219	-	-	-	-	-	916	-	303
2017	1 219	-	-	-	-	-	916	-	303
2018	1 219	-	-	-	-	-	916	-	303
2019	1 219	-	-	-	-	-	916	-	303
2020	1 219	-	-	-	-	-	916	-	303
2021	1 219	-	-	-	-	-	916	-	303
2022	1 219	-	-	-	-	-	916	-	303

$$PE_{fugitive,y} = PE_{fugitive,ww,y} + PE_{fugitive,s,y}$$

Year	$PE_{fugitive,y}$	$PE_{fugitive,ww,y}$	$PE_{fugitive,s,y}$
	tCO_2/year	tCO_2/year	tCO_2/year
2013	916	0	916
2014	916	0	916
2015	916	0	916
2016	916	0	916
2017	916	0	916
2018	916	0	916
2019	916	0	916
2020	916	0	916
2021	916	0	916
2022	916	0	916

$$PE_{fugitive,s,y} = (1 - CFE_s) \times MEP_{s,treatment,y} \times GWP_{CH_4}$$

Year	$PE_{fugitive,s,y}$	CFE_s	$MEP_{s,treatment,y}$	GWP_{CH4}
	tCO_2/year	-	t	tCO_2/tCH_4
2013	916	0.9	436	21
2014	916	0.9	436	21
2015	916	0.9	436	21
2016	916	0.9	436	21
2017	916	0.9	436	21
2018	916	0.9	436	21
2019	916	0.9	436	21
2020	916	0.9	436	21
2021	916	0.9	436	21
2022	916	0.9	436	21

$$MEP_{s,treatment,y} = \sum_l S_{l,PJ,y} \times MCF_{s,treatment,PJ,l} \times DOC_s \times UF_{PJ} \times DOC_F \times F \times \frac{16}{12}$$

Year	$MEP_{s,treatment,y}$	$S_{l,PJ,y}$	$MCF_{s,treatment,PJ,l}$	DOC_s	UF_{PJ}	DOC_F	F
	-	t	-	-	-	-	-
2013	436	2 920	0.8	0.5	1.12	0.5	0.5
2014	436	2 920	0.8	0.5	1.12	0.5	0.5
2015	436	2 920	0.8	0.5	1.12	0.5	0.5
2016	436	2 920	0.8	0.5	1.12	0.5	0.5
2017	436	2 920	0.8	0.5	1.12	0.5	0.5
2018	436	2 920	0.8	0.5	1.12	0.5	0.5
2019	436	2 920	0.8	0.5	1.12	0.5	0.5
2020	436	2 920	0.8	0.5	1.12	0.5	0.5
2021	436	2 920	0.8	0.5	1.12	0.5	0.5
2022	436	2 920	0.8	0.5	1.12	0.5	0.5

$$ER_{y,ex\ ante} = BE_{y,ex\ ante} - PE_{y,ex\ ante} - LE_{y,ex\ ante}$$

Year	ERy, ex ante	BEy, ex ante	PEy, ex ante	LEy, ex ante
	tCO2/year	tCO2/year	tCO2/year	tCO2/year
2013	6 058	7 277	1 219	-
2014	6 058	7 277	1 219	-
2015	6 058	7 277	1 219	-
2016	6 058	7 277	1 219	-
2017	6 058	7 277	1 219	-
2018	6 058	7 277	1 219	-
2019	6 058	7 277	1 219	-
2020	6 058	7 277	1 219	-
2021	6 058	7 277	1 219	-
2022	6 058	7 277	1 219	-

B.6.4 Summary of the ex-ante estimation of emission reductions:

Year	Estimation of project activity emissions (tCO_2e)	Estimation of baseline emissions (tCO_2e)	Estimation of leakage (tCO_2e)	Estimation of overall emission reductions (tCO_2e)
2013	1,219	10,301	0	9,082
2014	1,219	10,301	0	9,082
2015	1,219	10,301	0	9,082
2016	1,219	10,301	0	9,082
2017	1,219	10,301	0	9,082
2018	1,219	10,301	0	9,082
2019	1,219	10,301	0	9,082
2020	1,219	10,301	0	9,082
2021	1,219	10,301	0	9,082
2022	1,219	10,301	0	9,082
Total (tonnes of CO_2e)	12,189	103,011	0	90,821

B.7 Application of a monitoring methodology and description of the monitoring plan:

B.7.1 Data and parameters monitored:

Data / Parameter:	$EG_{elec,y}$
Data unit:	MWh/yr
Description:	Amount of electricity produced by the project activity during the year *y*
Source of data to be used:	Measured at project site
Value of data	2013 – 2022: 2,917
Description of measurement methods and procedures to be applied:	The electricity produced by the project activity will be monitored continuously and aggregated monthly for use in the emission reduction reports. The electricity meter will be calibrated in accordance with manufacturer specifications.
QA/QC procedures to be applied:	
Any comment:	

Data / Parameter:	$S_{l,PJ,y}$
Data unit:	tonnes/day
Description:	Amount of sludge treated in the project sludge treatment system *l* equipped with a biogas recovery system (on a dry basis) in year *y* (t)
Source of data to be used:	Measured in the project activity.
Value of data	8.00
Description of measurement methods	The amount of sludge treated in the project sludge treatment system will be calculated with a mass balance over the primary sedimentation tank.

and procedures to be applied:	
QA/QC procedures to be applied:	
Any comment:	

Data / Parameter:	$fv_{,CH4,h}$
Data unit:	-
Description:	Volumetric fraction of component *i* in the residual gas in the hour h where *i* = CH_4, CO, CO_2, O_2, H_2, N_2
Source of data to be used:	Measured in the project activity.
Value of data	0.7
Description of measurement methods and procedures to be applied:	The gas analyser will measure the volumetric fraction of methane continuously. Data will be aggregated monthly for use in the emission reduction reports.
QA/QC procedures to be applied:	
Any comment:	According to the flaring tool, project participants may only measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen.

Data / Parameter:	$FV_{RG,h}$
Data unit:	m^3/h
Description:	Volumetric flow rate of the residual gas in dry basis at NTP conditions in the hour h
Source of data to be used:	Measured in the project activity.
Value of data	33
Description of measurement methods and procedures to be applied:	The volumetric flow rate of the residual gas will be calculated through a mass balance over the anaerobic digesters.
QA/QC procedures to be applied:	
Any comment:	

Data / Parameter:	T_{flare}
Data unit:	°C
Description:	Temperature in the exhaust gas of the enclosed flare
Source of data to be used:	Measured in the project activity.
Value of data	>500
Description of measurement methods and procedures to be	The temperature in the exhaust gas of the enclosed flare will be monitored continuously and aggregated monthly for use in the emission reduction reports. The electricity meter will be calibrated in accordance with manufacturer

applied:	specifications.
QA/QC procedures to be applied:	
Any comment:	Used as a check for flare efficiency

B.7.2 Description of the monitoring plan:

>>
The monitoring plan will ensure that the project emission reductions are accurately monitored, recorded and reported.

The following parameters will be monitored onsite during the crediting period:

- Amount of electricity produced by the project activity.
- Amount of sludge treated in the project sludge treatment system.
- Volumetric fraction of methane sent to the flare during the time of maintenance on the gas engines.
- Gas flow rate to the emergency flare that destroys methane during the time of maintenance on the gas engines.
- Temperature in the exhaust gas of the enclosed flare.

All gas flow meters and gas analysers will be integrated into the central SCADA system for continuous monitoring and data logging. All data will be monitored continuously and aggregated monthly for use in the emission reduction reports, and meters will be calibrated in accordance with manufacturer specifications. Backup and archiving will be done according to the City of Windhoek standard practices. All monitored data will be kept for a minimum of two years after the end of the crediting period or the last issuance of CERs for this project activity, whichever occurs later.

B.8 Date of completion of the application of the baseline and monitoring methodology and the name of the responsible person(s)/entity(ies)

>>
Date of completion of application: 14/03/2012

Contact information for the entity responsible for the application of the baseline and monitoring information:
Promethium Carbon (Pty) Ltd
Coral House
20 Peter Place
Bryanston 2021
Johannesburg
Telephone: +27 11 706 8185

This entity is not a project participant.

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:

>>
As per version 05 page 28 of the Glossary of CDM Terms, ‘the start date shall be considered to be the date on which the project participant has committed to expenditures related to the implementation or related to the construction of the project activity’.

Therefore, the project start date will be the date that the internal combustion engines are ordered. According to the project plan, this is 01/07/2012.

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

>>
The lifetime of the internal combustion engines exceed the duration of the crediting period.

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

C.2.1. Renewable crediting period

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

>>
Not applicable. This section is intentionally left blank.

C.2.1.2. Length of the first crediting period:

>>
Not applicable. This section is intentionally left blank.

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

>>
01/01/2013 or the date that the project is registered under the CDM – whichever occurs later.

C.2.2.2. Length:

>>
10 years 0 months.

SECTION D. Environmental impacts

D.1. If required by the host Party, documentation on the analysis of the environmental impacts of the project activity:

>>
The project activity has a positive impact on the environment – it reduces electricity consumption from the national grid and reduces the amount of methane emitted to the atmosphere. However, according to

the Namibian Environmental Management Act, 2007 (Act No. 7 of 2007), any activity involving energy generation or waste and sewerage disposal may not be undertaken without an environmental clearance certificate.

D.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:

>>

The Namibian Ministry of Environment and Tourism issued a letter to the City of Windhoek on 30/03/2011. The letter states that that environmental clearance is issued for the project to proceed, on the condition that all key stakeholders are properly consulted and that their consent is taken into account prior to any development activities. The above condition is satisfied (refer to section E.).

SECTION E. Stakeholders' comments

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

>>

Advertisements were placed in Namibia's six major newspapers for a thirty day comment period. These newspapers are: Die Republikein (Afrikaans); The Namibian (English); Namibia Sun (English); Economist (English); Allgemeine Zeitung (German); and New Era (English).

The Economist and the Namibian Sun also published a short article on the project after seeing the notices in the newspapers (on 23/09/2011 and 13/10/11 respectively).

E.2. Summary of the comments received:

>>

The following stakeholders phoned / emailed to comment on the proposed project:
Gracy Tsipo
Mariska Kauani
Lorraine Gaoses
Angetto Craig (Namibian Sun newspaper)
Pearl Coetzee (Namibia Press Association)
Johanna Absalom (Economist)

All of the stakeholders were interested and wanted to find out more information. After telling them about the technical details of the project, they were all impressed with the initiative and had no objections.

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

>>

Although comments were received during the 30 day public comment period, the nature of the comments did not require any adjustments on the design, construction, or operation of the proposed project.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

The City of Windhoek is a public institution and therefore a portion of the project will be publically funded. However, no Official Development Assistance (ODA) will be used in the development or in the implementation of this project.

Annex 3

BASELINE INFORMATION

This section presents the calculations for the electricity grid emission factor using version 02.2.1 of the 'Tool to calculate the emission factor of an electricity system'.

Step 1: Identify the Relevant Electricity Systems

This tool will serve project activities that propose to displace grid electricity in South Africa and Namibia.

The project electricity system is defined by the spatial extent of the power plants that are physically connected through transmission and distribution lines to the project activity and that can be displaced without significant transmission constraints.

Similarly, a connected electricity system, e.g. national or international, is defined as an electricity system that is connected by transmission lines to the project electricity system. Power plants within the connected electricity system can be dispatched without significant transmission constraints, but transmission to the project electricity system has significant transmission constraints.

The DNAs of South Africa and Namibia have not published a delineation of the project electricity system and connected electricity systems. Also, the application of the criteria with regards to determining significant transmission constraints does not result in a clear grid boundary due to a lack of sufficient data. For these reasons the following was chosen for the reference system of this project:

- The project electricity system entails all of the Nampower and Eskom power plants in the South African and Namibian electricity grid.
- Due to a lack of data available in the public domain (in order to evaluate significant transmission constraints), all other power stations (non-Eskom, non-Nampower) and countries with power grids connected to South Africa and Namibia, are treated as connected electricity systems, and emission factors for imports from these systems are conservatively assumed to be 0 tCO_2/MWh.

All electricity generated by the Nampower and Eskom power stations is taken into consideration when calculating the grid emission factor; exports are not subtracted.

All the data for the Eskom power stations are obtained from the Eskom website, where they have a specific webpage dedicated to CDM grid emission factor related data (Eskom Holdings SOC Limited , 2011). This data includes commissioning dates, electricity generated, and fuel consumed.

All of the data for the Nampower power stations are obtained from the Nampower website. This data includes commissioning dates, electricity generated, and fuel consumed.

Data for the imported electricity are obtained from the Eskom annual report, where "*Total purchased for the Eskom system (GWh)*" is shown in the "*Statistical overview*" table on pg. 324 of the report (Eskom Holdings SOC Limited, 2011).

Step 2: Chose Whether to Include Off-Grid Power Plants in the Project Electricity System

This step is optional according to the tool. The grid emission factor is calculated from only grid power plants (Option I). Off-grid power plants are not included in the calculations.

Step 3: Select a Method to Determine the Operating Margin (OM)

The OM is calculated using the simple OM method (Option a). The simple OM method can be used provided that the low-cost/must-run resources constitute less than 50% of the total grid generation in average of the five most recent years.

The average percentage of low-cost/must-run resources amount to 0.00% of the total grid generation for this project electricity system. Therefore, Option (a) is applicable.

In terms of data vintages, the *ex ante* option were chosen to calculate the simple OM. In this option a 3 year generation-weighted average are used for the grid power plants. Using this option also means that the emission factor is determined only once at the validation stage, thus no monitoring and recalculation is required during the crediting period.

The data used in OM calculations are for the 3 year period of 1 April 2008 – 31 March 2011 (Eskom financial year runs from 1 April – 31 March). This is the latest available data.

Step 4: Calculate the Operating Margin Emission Factor According to the Selected Method

The simple OM emission factor ($EF_{grid,OMsimple,y}$) is calculated as the generation-weighted average CO_2 emissions per unit net electricity generation (tCO_2/MWh) of all generating power plants serving the system, not including low-cost/must-run power plants/units. Hence, the hydro and nuclear power plants are excluded from the calculation of the OM.

Option A is used for calculating the simple OM. The calculations in this option are based on the total net electricity generation and a CO_2 emission factor of each power plant.

Option A: Calculation based on average efficiency and electricity generation of each plant

Under this option, the simple OM emission factor is calculated based on the net electricity generation of each power plant and an emission factor of each power plant, as follows:

$$EF_{grid,OMsimple,y} = \frac{\sum_{m} EG_{m,y} \times EF_{EL,m,y}}{\sum_{m} EG_{m,y}}$$

Where:

$EF_{grid,OMsimple,y}$	Simple operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
$EG_{m,y}$	Net quantity of electricity generated and delivered to the grid by power unit *m* in the year *y* (MWh)
$EF_{EL,m,y}$	CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh)
m	All power units serving the grid in year y except low-cost/must-run power units
y	The relevant year as per data vintage chosen in Step 3

Determination of $EF_{EL,m,y}$

The emission factor for each power plant (*m)* was determined as follows (Option A1):

$$EF_{grid,OMsimple,y} = \frac{\sum_i \left(FC_{i,y} \times NCV_{i,y} \times EF_{CO2,i,y}\right)}{EG_y}$$

Where:

$EF_{grid,\ OMsimple,y}$	Simple operating margin CO_2 emission factor in year *y* (tCO_2/MWh)
$FC_{i,y}$	Amount of fossil fuel type *i* consumed in the project electricity system in year *y* (mass or volume unit)
$NCV_{i,y}$	Net calorific value (energy content) fossil fuel type *i* in year *y* (GJ/mass or volume unit)
$EF_{CO2,i,y}$	CO_2 emission factor of fossil fuel type *i* in year *y* (tCO_2/GJ)
EG_y	Net electricity generated and delivered to the grid by all power sources serving the system, not including low-cost/must-run power plants/units, in year *y* (MWh)
i	All fossil fuel types combusted in power sources in the project electricity system in year *y*
y	The relevant year as per data vintage chosen in Step 3.

Electricity imports are treated as one power plant, as per the tool guidance.

The constants used in calculations appear in the table below.

Constants used in calculations

Constants		
$NCV_{other\ bituminous\ coal}$	19.9	GJ/T
$NCV_{other\ kerosene}$	42.9	GJ/T
$EF_{CO2other\ bituminous\ coal}$	0.0895	tCO_2/GJ
$EF_{CO2,other\ kerosene}$	0.0708	tCO_2/GJ

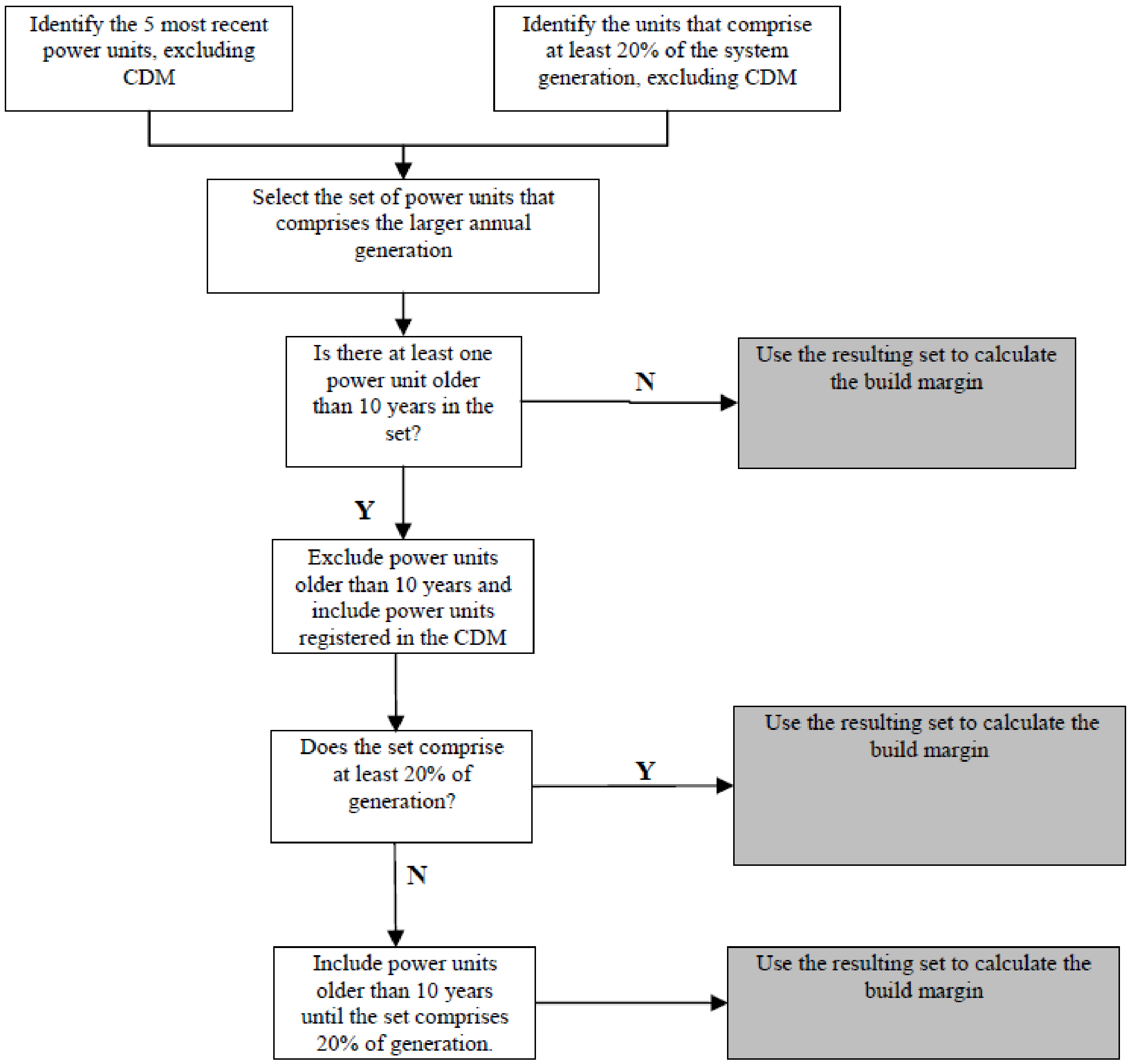
Using equation 6, the OM is calculated as **1.0148** tCO_2e/ MWh.

<u>Step 5: Calculate the Build Margin (BM) Emission Factor</u>

In terms of vintage of data, one Option 1 was selected: For the first crediting period, calculate the build margin emission factor *ex ante* based on the most recent information available on units already built for sample group *m* at the time of CDM-PDD submission to the DOE for validation.

The sample group of power units (*m)* used to calculate the build margin were determined as per the procedure delineated in the tool, consistent with the data vintages selected.

The following diagram summarizes the procedure of identifying the sample group:



The build margin emissions factor is the generation-weighted average emission factor (tCO_2/MWh) of all power units *m* during the most recent year *y* for which power generation data is available, calculated as follows:

$$EF_{grid,BM,y} = \frac{\sum_m EG_{m,y} \times EF_{EL,m,y}}{\sum_m EG_{m,y}} \qquad (13)$$

Where:

$EF_{grid,BM,y}$	Build margin CO_2 emission factor in year y (tCO_2/MWh)
$EG_{m,y}$	Net quantity of electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)
$EF_{EL,m,y}$	CO_2 emission factor of power unit *m* in year *y* (tCO_2/GJ)

m	Power units included in the build margin
y	Most recent historical year for which power generation data is available.

The CO_2 emission factor of each power unit m ($EL_{EL,m,y}$) should be determined as per the guidance in Step 4 (a) for the simple OM, using Option A1 using for *y* the most recent historical year for which power generation data is available, and using for *m* the power units included in the build margin.

If for a power unit *m* data on fuel consumption and electricity generation is available the emission factor ($EF_{EL,m,y}$) should be determined as follows:

$$EF_{EL,m,y} = \frac{\sum_i FC_{i,m,y} \times NCV_{i,y} \times EF_{CO2,i,y}}{\sum_m EG_{m,y}}$$

Where:

$EF_{EL,m,y}$	CO_2 emission factor of power unit *m* in year *y* (tCO_2/MWh)
$FC_{i,m,y}$	Amount of fossil fuel type *i* consumed by power unit *m* in year *y* (mass or volume unit)
$NCV_{i,y}$	Net calorific value (energy content) fossil fuel type *i* in year y (GJ/mass or volume)
$EF_{CO2,i,y}$	CO_2 emission factor of fossil fuel type *i* in year y (tCO_2/GJ)
$EG_{m,y}$	Net electricity generated and delivered to the grid by power unit *m* in year *y* (MWh)
m	All power plants/units serving the grid in year y except low-cost/must-run power plants/units
i	All fossil fuel types combusted in power plant/unit m in year y
y	The relevant year as per data vintage chosen in Step 3.

Using equation 13, the BM is calculated as **1.0589** tCO_2e/ MWh.

<u>Step 6: Calculate the Combined Margin (CM) Emission Factor</u>

The combined margin factor is calculated as follows:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times w_{OM} + EF_{grid,BM,y} \times w_{BM}$$

Where:

$EF_{grid,BM,y}$	Build Margin CO_2 emission factor in year y (tCO_2/MWh)
$EF_{grid,OM,y}$	Operating margin CO_2 emission factor in year y (tCO_2/MWh)
w_{OM}	Weighting of operating margin emissions factor (%)
w_{BM}	Weighting of build margin emissions factor (%)

The emission factors for the operating margin, the build margin, and the final combined margin appear in the table below.

CM emission factor

$EF_{grid,OM,y}$	1.0148
$EF_{grid,BM,y}$	1.0589
w_{OM}	0.5
w_{BM}	0.5
$EF_{grid,CM,y}$	**1.0368**

Annex 4

MONITORING INFORMATION

The steps in this tool were carried out to determine the methane emissions due to incomplete flaring. Only steps 5 and 7 were used as the default option for flare efficiency was used – enclosed flare with flare temperature > 500°C.

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

The quantity of methane in the residual gas flowing into the flare is the product of the volumetric flow rate of the residual gas ($FV_{RG,h}$), the volumetric fraction of methane in the residual gas ($fv_{CH4,RG,h}$) and the density of methane ($\rho_{CH4,n,h}$) in the same reference conditions (normal conditions and dry or wet basis).

It is necessary to refer both measurements (flow rate of the residual gas and volumetric fraction of methane in the residual gas) to the same reference condition that may be dry or wet basis. If the residual gas moisture is significant (temperature greater than 60ºC), the measured flow rate of the residual gas that is usually referred to wet basis should be corrected to dry basis due to the fact that the measurement of methane is usually undertaken on a dry basis (i.e. water is removed before sample analysis).

$$TM_{RG,h} = FV_{RG,h} \times fv_{CH4,RG,h} \times \rho_{CH4,n}$$ *(Flaring Tool 13)*

Where:

$TM_{RG,h}$	Mass flow rate of methane in the residual gas in the hour *h* (kg/h)
$FV_{RG,h}$	Volumetric flow rate of the residual gas in dry basis at normal conditions in hour *h* (m^3/h)
$fv_{CH4,RG,h}$	Volumetric fraction of methane in the residual gas on dry basis in hour *h*
$\rho_{CH4,n}$	Density of methane at normal conditions (0.716 kg/ m^3)

STEP 7: Calculation of annual project emissions from flaring

Project emissions from flaring are calculated as the sum of emissions from each hour h, based on the methane flow rate in the residual gas (TMRG,h) and the flare efficiency during each hour h ($\eta_{flare,h}$), as follows:

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} \times (1 - \eta_{flare,h}) \times \frac{GWP_{CH4}}{1{,}000}$$ *(Flaring Tool 15)*

Where:

$PE_{flare,y}$	Project emissions from flaring the residual gas stream in year *y* (tCO_2e)
$TM_{RG,h}$	Mass flow rate of methane in the residual gas in the hour *h* (kg/h)
$\eta_{flare,h}$	Flare efficiency in hour *h*
GWP_{CH4}	Global warming potential of methane valid for the commitment period (tCO_2e/tCH_4)

The results from the flaring tool are shown below:

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

Year	$TM_{RG,h}$	$FV_{RG,h}$	$fv_{CH4,RG,h}$	$\rho_{CH4,n}$
	kg.hr	m^3/hr	-	kg/m^3
2013	16.48	32.89	0.70	0.716
2014	16.48	32.89	0.70	0.716
2015	16.48	32.89	0.70	0.716
2016	16.48	32.89	0.70	0.716
2017	16.48	32.89	0.70	0.716
2018	16.48	32.89	0.70	0.716
2019	16.48	32.89	0.70	0.716
2020	16.48	32.89	0.70	0.716
2021	16.48	32.89	0.70	0.716
2022	16.48	32.89	0.70	0.716

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} \times \left(1 - \eta_{flare,h}\right) \times \frac{GWP_{CH4}}{1,000}$$

Year	$PE_{flare,y}$	$TM_{RG,h}$	$\eta_{flare,h}$	GWP_{CH4}
	tCO_2/year	kg.hr	-	tCO_2/tCH_4
2013	303.21	16.48	0.90	21
2014	303.21	16.48	0.90	21
2015	303.21	16.48	0.90	21
2016	303.21	16.48	0.90	21
2017	303.21	16.48	0.90	21
2018	303.21	16.48	0.90	21
2019	303.21	16.48	0.90	21
2020	303.21	16.48	0.90	21
2021	303.21	16.48	0.90	21
2022	303.21	16.48	0.90	21