SECTION D. Application of a monitoring methodology and plan

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

Landfill Villa Dominico conducts the approved monitoring methodology AM0011 for "Landfill gas recovery with electricity generation and no capture or destruction of methane in the baseline scenario". This monitoring methodology is based on Onyx Landfill Gas Recovery project – Trémembé – Brazil, No. NM0021.

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

The chosen monitoring methodology is designed for the project activities, that reduce greenhouse gas emissions through landfill gas capture and flaring. The conditions for the methodology to be applied are respected:

- This monitoring methodology is based on direct and continuous measurement of the actual quantity
  of landfill gas flared, the methane content in the flared landfill gas (% - using a continuous analyser) and when using a continuous flow meter, a continuous methane analyser.

- The basis for the monitoring of the emission reduction is the measuring of landfill gas amount and composition recovered for combustion.

- The methane content of the emissions from the flare will be analysed to determine the fraction of the methane destroyed.

- The emissions reductions are defined as the difference of emissions in the baseline situation and in the project situation.

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

This option is not applicable. Currently there is no monitoring system of the emissions at the landfill. The baseline scenario is determined by calculations described in Section D.2.1.4. If environmental law will change in the future, Van der Wiel Argentina will be informed by their lawyers, Dr. Kielmanovich and Dr. Flores Levalle. Depending on what kind of changes there will be come, Van der Wiel Argentina will adapt these changes according national and local regulatory framework into the baseline scenario, during the crediting period.

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

See section D.2.2.1.

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

See Section D.2.2.2.

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.2.1.3.1	Landfill Waste	Waste disposal	Metric tonnes	m	Continuous	100%	Daily: paper Monthly: electronic	Measured at weightbridge

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

In order to calculate the baseline emissions, an estimation of the potential landfill gas production has been performed. Van der Wiel Stortgas BV has developed a model to calculate landfill gas production. The quantity of methane projected to be generated during a given year is estimated using as a basis the First Order Decay model for landfill gas generation. The general formula of degradation used in this model depends on several parameters including age of waste, mass, waste composition (concentration in organic carbon) and waste temperature.

The model is driven by the input of the following key parameters:

(1) Total tonnage of disposed waste

(2) Organic carbon content means the total quantity of organic carbon contained in waste and is measured in kg/ton. The organic carbon content depends on the composition of waste.
By using bibliographical data and measurements in laboratory column tests or in instrumented cells, the organic carbon content value can be evaluated for municipal solid waste on 150 kg / Mg wet component.

(3) Methane generation decay rate is specified as an exponential rate of decomposition of the landfill refuse. Its value determines the amount of methane, that is released in a given disposal area during a specified time.

- Methane content in the landfill gas is 50%
- Molecular weight CH_4: 16.03
- Gas density of CH_4 : 0.72 kg/ Nm^3.

(4) Temperature in the refuse is expressed in °C. Temperature has an impact on the biodegradable carbon converted to landfill gas. Temperatures generally observed in landfills range 36 ^{0}C.

(5) Parameters, that have been applied by calculations:

- Parameter of gasification speed: 0.035
- Calorific value of the landfill gas: 5 kW
- Gas density of CO_2 : 1.99 kg/ m^3
- Heating value of landfill gas: 18 MJ/m^3

(6) Extraction efficiency

The recoverable landfill gas depends on the effectiveness of the extraction system. The rate of landfill gas recoverable generally ranges between 50 and 90% of the total production.
It was considered for this calculation that the extraction efficiency is 0 % during the filling period and 70 % one year after the area is covered and equipped with an extraction system.

(7) Assessment and uncertainties

The main uncertainty in the proposed project is the prediction of future emission levels, LFG production levels and LFG extraction efficiency, which are depending on a large number of practical and operational factors. However, the baseline emissions are in this case determined by measuring the real amount of extracted LFG, so this uncertainty does not affect the choice of the baseline scenario.

The quantity of methane projected to be generated during a given year is estimated using as a basis the First Order Decay model for landfill gas generation:

GHG = Collectable gas quantity m3/h x Hours per year x Methane content x Spec. mass x 21

GHG = GHG emissions [ton CO_2e/yr]
21= GWP of methane [ton CO_2e/ton methane]

The general formula of degradation used in this model depends on several parameters including age of waste, mass, waste composition (concentration in organic carbon) and waste temperature. At the moment the flaring of the biogas does not occur at the project landfill.

The actual quantity of methane emitted to the atmosphere is therefore equivalent with the quantity to be captured and flared.

• Decayable carbon in refuse	150	kg/ton
• Lag phase of methane production	0.7	year
• Half value for decomposing or organics	3.0-15.0	year
• Average landfill temperature	36	^oC
• Landfill gas collection efficiency	70	%
• Methane content in landfill gas	50	%
• Molecular weight CH_4	16.03	--
• Gas density of CH_4 at STN	0.72	kg/ m^3
• Gas density of CO_2 at STN	1.99	kg/ m^3
• Heating value of landfill gas	18	MJ/m^3

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

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 *(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.2.2.1.1	Total amount of landfill gas collected from the project wells and being send to the flares	Flow meter	Nm^3	m	Continuous	100%	Electronic	Corrected volume according LFG temperature and pressure. For no power plant is installed, all gas that passes the flow meter is being send to the flares.
D.2.2.1.2	Methane fraction in the landfill gas	Analyser	Vol. %	m	Continuous	100%	Electronic	Measured by continues gas quality analyser
D.2.2.1.3	Amount of flared methane	Programmable Logic Controller (PLC)	Tonnes CO2eq/h	c	Hourly	100%	Electronic	Measured conform complementary method (LFG temperature and pressure, flare temperature and working hours, $\%CH_4$, Nm^3LFG/h, oxygen content) Calculated according corrected LFG volume and methane value.
D.2.2.1.4	Total amount of flared methane	PLC	Tonnes CO2 eq.	c	Hourly	100%	Electronic	--
D.2.2.1.5	Combustion efficiency		%	m and c	Semi-annually	N/a	Electronic	Methane content of flare exhaust gas will be checked semi-annually, with monthly checks if the efficiency show significant deviations from previous values

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.2.2.1.6	Combustion temperature	Temperature transmitter	^{o}C	m	Hourly	100%	Electronic	There is a temperature transmitter to measure a combustion temperature of the flare.
D.2.2.1.7	Pressure of the LFG	Pressure transmitter	mBar	m	Hourly	100%	Electronic	This pressure shows the pressure of the gas and is used for determining the STP gas volume.
D.2.2.1.8	Amount of landfill gas collected from projected landfill	Flow meter	Nm^3/h	m	Daily	100%	Electronic	Corrected volume according landfill gas temperature and pressure. For no power plant is installed, all gas that passes the flow meter is being send to the flares.
D.2.2.1.9	Integrity of collection system	N/a		N/a	Monthly	N/a	Electronic	Visual control.
D.2.2.1.10	Temperature of landfill gas	Temperature transmitter	^{o}C	m	Continuous	100%	Electronic	
D.2.2.1.11	Operation hours flare	Hour counter	H	m	Continuous	100%	Electronic	
D.2.2.1.12	Consumed kWh’s	kWh counter	kWh	M	Continuous	100%	Electronic	

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

In the Section B.4. the direct and indirect project emissions have been defined.

Emissions that are likely to be less than 1% of the total project emission's impact are classified as "insignificant" and be further ignored in the project. As total project emission reduction over the 9 year project lifetime are approx. 5.300.000 tonnes CO_2, 1% amounts is 53.000 tonnes CO_2.

Transport of the equipment will be realised per ship. Emissions estimation depends on several factors, in particular CO_2 emission factor, usage of fuel and sort of fuel, as well as sort of ship. Regression analyses on fuel consumption versus gross tonnage are preformed for each ship class. The data are highly correlated (r>0.68). Assuming emission factor 3200 tonnes CO_2 per ton of fuel and full fuel consumption for solid bulk ship, at full power and linear regressions equations of consumption and at full power versus gross tonnage, the daily emission of diesel ship can be calculated as follow: 33,80 t/day * 3200 kg CO_2 /t fuel = 108.160 kg CO_2 / day (10,816 tonnes CO_2 per day), in 14 days 1.514.240 kg CO_2 (1.514,24 t CO_2).

Equipment will be manufactured circa 200 km from the harbour in Rotterdam and will be transported with a special truck transport. It has been estimated that diesel engine emits approximately 0,26 kg CO_2 per kilometre, what gives 0,52 tonnes CO_2. In total transport of the equipment from the Netherlands to Argentina is estimated on 1.514,24 t CO_2. It must added that emissions estimation from ship transport is calculated for a full loaded ship and not for a one container transport. Most of the equipment will be purchased locally and transported with trucks. Assuming the calculations above, emissions estimation for local transport will not be higher than 1% of the total baseline emissions.

D.2.3. Treatment of leakage in the monitoring plan

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

No leakages are associated with landfill gas extraction.

D.2.3.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

No leakages under AM0011

D.2.4. Description of formulae used to estimate emission reductions for the project activity (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

$$ER = (MD_{project} - MD_{reg}) * GWP_{CH_4} + EG * CEF_{electricity}$$

Where: ER are the emission reductions; $MD_{project}$ is the amount of methane actually destroyed/combusted during the year; MD_{reg} is the methane that would have been destroyed/combusted during a year in the absence of the project activity; GWP_{CH4} is the approved global warming potential value for methane (considered 21 throughout Villa Dominico lifetime for the purpose of estimating emission reductions); EG is net quantity of electricity displaced; and $CEF_{electricity}$ is the CO_2 emissions intensity of the electricity displaced.

Considering there is no regulatory or contractual requirement determining MD_{reg}, an adjustment factor is used in Villa Dominico case:

$$MD_{reg} = MD_{project} * AF$$

Moving on:

$$MD_{project} = MD_{flared} + MD_{electricity}.$$

$$MD_{flared} = LFG_{flare} * w_{CH_4} * D_{CH_4} * FE \ .$$

In this case, MD_{flared} is the quantity of methane destroyed by flaring (tCH_4), LFG_{flare} is the quantity of landfill gas flared during a year measured in normal cubic meters (Nm^3), w_{CH4} is the average methane fraction of the landfill gas as measured during a year and expressed as a fraction CH_4 volume per LFG volume, FE is the flare efficiency (the fraction of the methane destroyed) and D_{CH4} is the methane density expressed in tonnes of methane per cubic meter of methane (tCH_4/m^3CH_4), measured at STP. This value is in fact 0.0007168 tCH_4/Nm^3CH_4.

$$MD_{electricity} = LFG_{electricity} * w_{CH_4} * D_{CH_4}$$

Where $MD_{electricity}$ is the quantity of methane destroyed by generation of electricity and $LFG_{electricity}$ is the quantity of landfill gas fed into electricity generator.

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

Data *(Indicate table and ID number e.g. 3.-1.; 3.2.)*	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
D.2.1.3.1	Low	Waste are weighted at the weighbridge before disposing.
D.2.2.1.1	Low	Amount of methane is a reliable indicator subject to routine checks. Calibration is executed monthly through use of calibration gas with exactly 50% of methane content.
D.2.2.1.2	Low	Amount of methane is a reliable indicator subject to routine checks. Calibration is executed monthly through use of calibration gas with exactly 50% of methane content.
D.2.2.1.3	Low	Amount of methane is a reliable indicator subject to routine checks. Calibration is executed monthly through use of calibration gas with exactly 50% of methane content.
D.2.2.1.4	Low	Amount of carbon dioxide is a reliable indicator subject to routine checks.
D.2.2.1.5	Low	Semi-annual measurement and monthly checks if the efficiency shows significant deviations from previous values.
D.2.2.1.6	Low	Data reviewed as part of daily monitoring
D.2.2.1.8	Low	Monitoring data used immediately to adjust well vacuum
D.2.2.1.9	Medium	Ensure integrity of collection system
D.2.2.1.10	Low	Data reviewed as part of daily monitoring
D.2.2.1.11	Low	Data reviewed as part of daily monitoring
D.2.2.1.12	Low	Data reviewed as part of daily monitoring

Monitoring procedures have been formalised as part of documentation for NEN-ISO 9001:2000 certification.

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

To assure the correct service of the equipment en correct monitoring, the training of the Argentinean staff will be organised. Minimum two persons will be trained on the field of:

- general knowledge about the applied equipment at the landfill
- reading and recording data
- calibration methodology
- emergency situation (for instance by too high oxygen level or electricity breakdown).

Chosen trainees must have a good understanding the processes and technology of the installation of landfill gas extraction. Verification and training starts parallel with preparation works for the installation.

At the plant there is also a guidebook on landfill gas extraction and utilisation in English and Spanish available, where the operator can find an information about:

- operation manual
- drawings
- maintenance instructions
- description of parts of the equipment
- parameters for landfill gas composition, temperature and pressure.

Additionally the telephone helpdesk will be available with direct connection to the Netherlands, where the experts of Van der Wiel can give a technical advice.

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

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