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

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AM0028/Version 01
Catalytic N_2O destruction in the tail gas of Nitric Acid Plants"

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

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Same as B.1.1.

The monitoring is undertaken at each line separately.

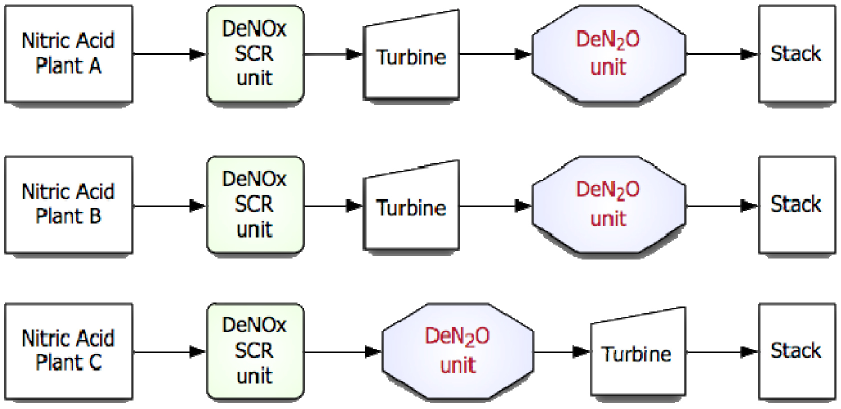

Figure 7: Overview of the Process Flow

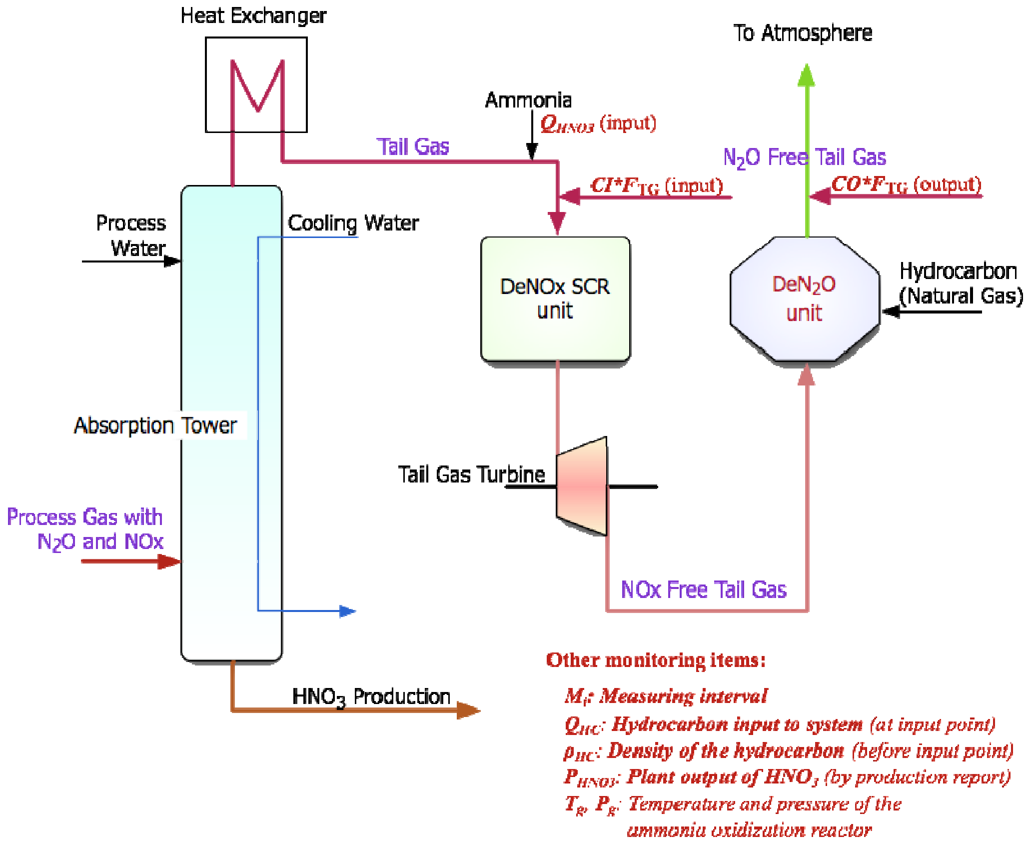

Figure 8: Monitoring Points of the N_2O Abatement System (for Plant A and B)

It is noted that “baseline” N_2O concentration shall be measured before $DeNO_X$ SCR for this project. This is because N_2O may be regenerated in the $DeNO_X$ SCR which will be installed as a part of the project.

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

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

ID number *(Please use numbers to ease cross-referencing to D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
P1	PE_y	*Monitoring system*	tCO_2e/yr	*c*	*Annually*	*100%*	*Electronic*	*Project emissions.*
P2	$PE_{ND,y}$	*Monitoring system*	tCO_2e/yr	*c*	*Annually*	*100%*	*Electronic*	*Project emissions from* N_2O *not destroyed.*
P4	$PE_{N2O,y}$	*Monitoring system*	tCO_2e/yr	*c*	*Annually*	*100%*	*Electronic*	N_2O *not destroyed by the facility.*
P5	$F_{TG,i}$	*Flow meter*	m^3/h	*measured continuously*	*Continuously*	*100%*	*Electronic*	*Volume flow of tail gas at* N_2O *destruction facility.* *Flow metering system will automatically record volume flow adjusted to standard temperature and pressure.*
P6	$CO_{N2O,i}$	*Non-dispersion infrared absorption analyzer*	tN_2O/m^3	*measured continuously*	*Continuously*	*100%*	*Electronic*	N_2O *concentration at destruction facility outlet.* *Non-dispersion infrared absorption analyzer (by ABB) is used instead of the gas chromatography specified in the original methodology.*
P7	M_i	*Measuring device, Data management system*	h	*measured continuously*	*Continuously*	*100%*	*Electronic*	*Measuring interval.*
P8	$PE_{NH3,y}$	*Monitoring system*	tCO_2e/yr	*c*	*Annually*	*100%*	*Electronic*	*Emissions from ammonia use in destruction facility.*

P9	$PE_{HC,y}$	Monitoring system	tCO_2e/yr	c	Annually	100%	Electronic	Emissions related to hydrocarbon (natural gas) for re-heating the tail gas The technology applied to this project activity does not use hydrocarbon as reducing agent, but use natural gas for re-heating the tail gas.
P10	$Q_{NH3,y}$	Measuring device	tNH_3/yr	m	Monthly	100%	Electronic	Project ammonia input.
P11	EF_{NH3}	IPCC	tCO_2e/tNH_3	c	Once	100%	Electronic	Ammonia production GHG emission factor. Default value of IPCC is applied. No need to measure.
P12	$HCE_{C,y}$	Monitoring system	tCO_2e/yr	c	Annually	100%	Electronic	Converted hydrocarbon emissions. The technology applied to this project activity does not use hydrocarbon as reducing agent, but use natural gas for re-heating the tail gas.
P13	$HCE_{NC,y}$	Monitoring system	tCO_2e/yr	c	Annually	100%	Electronic	Non-converted methane emissions. The technology applied to this project activity does not use hydrocarbon as reducing agent, but use natural gas for re-heating the tail gas.
P14	$Q_{HC,y}$	Measuring device	m^3	m	Daily	100%	Electronic	Hydrocarbon input. The technology applied to this project activity does not use hydrocarbon as reducing agent, but use natural gas for re-heating the tail gas.
P15	ρ_{HC}	Hydrocarbon supplier	t/m^3	m	Annually	100%	Electronic	Density of the hydrocarbon (natural gas). The parameter is provided by hydrocarbon supplier as the value(t/Nm^3) in normal condition (0 °C,1atm).
P16	EF_{HC}	Theoretical calculation	tCO_2/t	c	Once	100%	Electronic	Hydrocarbon emission factor. Carbon emissions factor of Methane (2.75tCO_2/tHC) applied to this project in conservative manner. The technology applied to this project activity

								does not use hydrocarbon as reducing agent, but use natural gas for re-heating the tail gas.
P17	$OXID_{HC}$	*IPCC*	%	*IPCC default value*	*Once*	*100%*	*Electronic*	*Hydrocarbon oxidization factor.* *99.5% is applied as the IPCC default value. because hydrocarbon* *(natural gas) is used as fuel for re-heating the tail gas.*
P18	$Type_{HC}$	*Hydrocarbon supplier*	-		*Once*	*100%*	*Electronic*	*Type of hydrocarbon (natural gas for this project)*
P19	$Q_{HNC,y}$	*Monitoring system*	m^3	*c*	*Annually*	*100%*	*Electronic*	*Methane used.* *This parameter is calculated as follows;* $Q_{HNC,y} = Q_{HC,y} *(C_{HNC,y} /100)$ *This parameter is shown in normal condition (0 ^{o}C,1atm).*
P20	$C_{HNC,y}$	*Hydrocarbon supplier*	%	*m*	*Annually*	*100%*	*Electronic*	*Methane content of hydrocarbon (natural gas)*
P21	$OXID_{CH4}$	*IPCC*	%	*IPCC default value*	*Once*	*100%*	*Electronic*	*Methane oxidization factor. 99.5% is applied as the IPCC default value because hydrocarbon* *(natural gas) is used as fuel for re-heating the tail gas.*

[All of the data are archived for “crediting period + 2 years”]

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

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Project emissions are defined by the following equation:

$$PE_y = PE_{ND,y} + PE_{DF,y} \quad (1)$$

where

PE_y : Project emissions in year y (tCO_2e/yr),
$PE_{ND,y}$: Project emissions from N_2O not destroyed in year y (tCO_2e/yr), and
$PE_{DF,y}$: Project emissions related to the operation of the destruction facility in year y (tCO_2e/yr).

Non-destroyed N_2O part is given by:

$$\begin{aligned} PE_{ND,y} &= PE_{N2O,y} * GWP_{N2O} \\ &= \sum_{i=1}^{n} F_{TG,i} * CO_{N2O,i} * M_i * GWP_{N2O} \end{aligned} \qquad (2)$$

where

$PE_{N2O,y}$: Project emissions of N_2O in year y (tN_2O/yr),
i : Interval,
n : Number of intervals during the year ($1/yr$)
$F_{TG,i}$: Volume flow rate tail gas at destruction facility during interval i (m^3/h),
$CO_{N2O,i}$: N_2O concentration in the tail gas of the N_2O destruction facility during interval i (tN_2O/m^3),
M_i : Length of measuring interval i (h), and
GWP_{N2O} : Global warming potential of N_2O = 310.

The technology applied to this project activity does not use hydrocarbon as reducing agent, but use natural gas as fuel for re-heating the tail gas. So, for this project, emissions related to hydrocarbon input (natural gas for re-heating the tail gas) are counted also as project emissions.

Destruction facility related emissions part is given by:

$$PE_{DF,y} = PE_{NH3,y} + PE_{HC,y} \qquad (3)$$

where

$$PE_{NH3,y} = Q_{NH3,y} * EF_{NH3}$$

$PE_{NH3,y}$: Project emissions related to ammonia input to destruction facility in year y (tCO_2e/yr),

$Q_{NH3,y}$: Ammonia input to the destruction facility in year y (tNH_3/yr), and

EF_{NH3} : GHG emissions factor for ammonia production = 2.14 as the default (tCO_2e/tNH_3),

$PE_{HC,y}$: Project Emissions related to hydrocarbon (natural gas) for re-heating the tail gas in year y (tCO_2e/yr),.

and

$$\begin{aligned} PE_{HC,y} &= HCE_{C,y} + HCE_{NC,y} \\ &= \rho_{HC} * Q_{HC,y} * OXID_{HC}/100 * EF_{HC} + \rho_{HNC} * Q_{HNC,y} * (1 - OXID_{CH4}/100) * \mathrm{GWP}_{CH4} \\ &= \rho_{HC} * Q_{HC,y} * OXID_{HC}/100 * EF_{HC} + \rho_{HNC} * Q_{HC,y} *(C_{HNC,y}*/100) * (1 - OXID_{CH4}/100) * \mathrm{GWP}_{CH4} \qquad (4) \end{aligned}$$

where

$HCE_{C,y}$: Converted hydrocarbon (natural gas) emissions in year y (tCO_2/yr),

$HCE_{NC,y}$: Methane emissions in year y (tCO_2e/yr),

ρ_{HC} : Hydrocarbon (natural gas) density (t/m^3),

$Q_{HC,y}$: Hydrocarbon (natural gas) input in year y (m^3),

$OXID_{HC}$: Oxidation factor of hydrocarbon (natural gas) (IPCC default value 99.5% is applied),

EF_{HC} : Carbon emissions factor of hydrocarbon (natural gas) (tCO_2/tHC),

ρ_{HNC} : Methane density (t/m^3),

$Q_{HNC,y}$: Methane used in year y (m^3)

$C_{HNC,y}$: Methane content of hydrocarbon (natural gas) (%),

$OXID_{CH4}$: Oxidation factor of methane (IPCC default value 99.5% is applied), and

GWP_{CH4} : Global warming potential of methane = 21.

In this project activity natural gas is not used as reducing agent but is used additional fuel for re-heating the tail gas. Fraction of Methane not converted is not measured due to unreasonable costs. So the OXID_{HC} (99.5%) and the OXID_{CH4} (99.5%) are set based on the IPCC default value.

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
B1	$P_{HNO3,y}$	*Production reports*	$tHNO_3/yr$	*m*	*Daily*	*100%*	*Electronic*	*Plant output of* HNO_3.
B2	$QI_{N2O,y}$	*Production reports*	tN_2O/yr	*c*	*Daily*	*100%*	*Electronic*	*Quantity of* N_2O *at inlet of destruction facility*
B3	$CI_{N2O,i}$	*Non-dispersion infrared absorption analyzer*	tN_2O/m^3	*measured continuously*	*Daily*	*100%*	*Electronic*	N_2O *concentration to be measured at inlet of destruction facility (before* $DeNO_X$ *SCR).* *Non-dispersion infrared absorption analyzer (by ABB) is used instead of the gas chromatography specified in the original methodology.*
B4	$QR_{N2O,y}$	*National legislation*	tN_2O/yr	*calculated*	*Date of regulation*	*100%*	*Electronic*	*Regulation I: annual quantity* N_2O *limited.* *In Pakistan, there is no regulation on* N_2O *emissions.*
B5	$RSE_{N2O,y}$	*National legislation*	$tN_2O/tHNO_3$	*calculated*	*Date of regulation*	*100%*	*Electronic*	*Regulation II:* N_2O *emissions per unit of nitric acid* *In Pakistan, there is no regulation on* N_2O *emissions.*
B6	CR_{N2O}	*National legislation*	tN_2O/m^3	*calculated*	*Date of regulation*	*100%*	*Electronic*	*Regulation III:* N_2O *concentration in tail gas limited.*

								In Pakistan, there is no regulation on N_2O emissions.
B7	$P_{HNO3,hist}$	Manufacturer's specifications	$tHNO_3$/yr	measured/ calculated	Once	100%	Electronic	Design capacity. Specified in Annex 4.
B8	$T_{g,hist}$	Production reports/ manufacturer's specifications	°C	measured/ calculated	Once	100%	Electronic	Historical operating temperature range of the ammonia oxidation reactor. Specified in Annex 4.
B9	$P_{g,hist}$	Production reports/ manufacturer's specifications	Pa	measured/ calculated	Once	100%	Electronic	Historical operating pressure range of the ammonia oxidation reactor, Specified in Annex 4.
B10	T_g	Measuring device	°C	measured	Continuous	100%	Electronic	Actual operating temperature ammonia oxidation reactors
B11	P_g	Measuring device	Pa	measured	Continuous	100%	Electronic	Actual operating pressure ammonia oxidation reactors
B12	Reg_{NOx}	National regulations, Ministry of Environment	tNO_X/m^3	calculated	Date of regulation	100%	Electronic	National regulation on NO_X emissions. Currently, 3000 mg/Nm^3.
B13	G_{sup}	Supplier information	-					Supplier of the ammonia oxidation catalyst. Specified in Annex 4.
B14	G_{com}	Annual reports, supplier information	%		Date of changing gauze composition	100%	Electronic	Composition of the ammonia oxidation catalyst
B15	$G_{sup,hist}$	Annual reports, supplier information	-		Once	100%	Electronic	Historical supplier of ammonia oxidation catalyst. Specified in Annex 4.
B16	$G_{com,hist}$	Supplier information	%		Date of start of use of catalyst	100%	Electronic	Historical composition of the ammonia oxidation catalyst.

								Specified in Annex 4.
B17	SE_{N2O}	*Monitoring reports*	$tN_2O/tHNO_3$	*calculated*	*Annually*	*100%*	*Electronic*	*N_2O emission rate per ton of nitric acid*
B18	$A_{\mathrm{OR,hist}}$	*Production reports/ manufacturer's specifications/ Literatuter*	tNH_3/day	*measured/ calculated*	*Once*	*100%*	*Electronic*	*Max. historical ammonia flow rate to the ammonia oxidation reactor.* *Specified in Annex 4.*
B19	$A_{\mathrm{OR},d}$	*Measuring device*	tNH_3/day	*measured*	*Continuous*	*100%*	*Electronic*	*Actual ammonia flow rate to the ammonia oxidation reactor*

[All of the data are archived for "crediting period + 2 years"]

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

>>

Baseline emissions are given by the following equation:

$$BE_y = BE_{\mathrm{N2O},y} * GWP_{\mathrm{N2O}} \tag{5}$$

where

BE_y : Baseline emissions in year y (tCO_2e/yr), and
$PE_{\mathrm{ND},y}$: Baseline emissions of N_2O in year y (tN_2O/yr).

Because the baseline scenario is concluded as no N_2O would be abated, $BE_{\mathrm{N2O},y}$ is expressed as:

$$BE_{\mathrm{N2O},y} = QI_{\mathrm{N2O},y}$$

$$= \sum_{i=1}^{n} F_{\mathrm{TG},i} * CI_{\mathrm{N2O},i} * M_i \tag{6}$$

where

$QI_{\mathrm{N2O},y}$: Quantity of N_2O supplied to the destruction facility in a year y (tN_2O/yr), and
$CI_{\mathrm{N2O},i}$: N_2O concentration in the N_2O destruction facility inlet during interval i (tN_2O/m^3),

Baseline emissions are limited to the design capacity of the existing nitric acid plant. If the actual production of nitric acid ($P_{HNO3,y}$) exceeds the design capacity ($P_{HNO3,max}$) then emissions related to the production above $P_{HNO3,max}$ will neither be claimed for the baseline nor for the project scenario.

If,

$$P_{HNO3,y} > P_{HNO3,max} \tag{7}$$

then,

$$BE_{N2O,y} = SE_{N2O,y} * P_{HNO3,max}$$
$$= QI_{N2O,y} * (P_{HNO3,max} / P_{HNO3,y}) \tag{8}$$

where

$BE_{N2O,y}$: Baseline emissions of N_2O in year y (tN_2O/yr),
$SE_{N2O,y}$: Specific N_2O emissions per output nitric acid in year y [= $QI_{N2O,y} / P_{HNO3,y}$] ($tN_2O/tHNO_3$),
$P_{HNO3,max}$: Design capacity ($tHNO_3/yr$), and
$P_{HNO3,y}$: Production of nitric acid in a year y ($tHNO_3/yr$).

<u>Procedures used to determine the permitted operating conditions of the nitric acid plant in order to avoid "overestimation of emission reductions":</u>

In order to avoid that the operation of the nitric acid production plant is manipulated in a way to increase the N_2O generation, thereby increasing the CERs, the following procedures relating to the operating temperature and pressure and the use of ammonia oxidation catalysts shall be applied.

1. Operating temperature and pressure of the ammonia oxidation reactor (AOR):

If the actual average daily operating temperature or pressure in the ammonia oxidation reactor (T_g and P_g) are outside a "permitted range" of operating temperatures and pressures ($T_{g,hist}$ and $P_{g,hist}$), the baseline emissions are calculated for the respective time period based on lower value between (a) the conservative IPCC default values of 4.05 $kgN_2O/tHNO_3$, (b) $SE_{N2O,y}$ and (c) any related value as a result of legal regulations (*e.g.*, $RSE_{N2O,y}$).

Required monitoring parameters:

- $T_{g,d}$: Actual operating temperature AOR on day d (°C),
- $P_{g,d}$: Actual operating pressure AOR on day d (Pa),
- $T_{g,hist}$: Historical operating temperature range AOR (°C), and
- $P_{g,hist}$: Historical operating pressure range AOR (Pa).

In order to determine the "permitted range" of the operating temperature and pressure in the ammonia oxidation reactor (AOR), the project applicant has the obligation to determine the operating temperature and pressure range by:

a) Firstly, data on historical temperature and pressure ranges; or, if no data on historical temperatures and pressures are available, then

b) Secondly, by range of temperature and pressure stipulated in the operating manual for the existing equipment; or, if no operating manual is available or the operating manual gives insufficient information, then

c) Thirdly, by literature reference (*e.g.*, from Ullmann's Encyclopedia of Industrial Chemistry, Fifth, completely revised edition, Volume A 17, VCH, 1991, P. 298, Table 3. or other standard reference work or literature source).

For the Pakarab plant, both a) and b) are available. Therefore, a) is applied as specified in the methodology.

As historical data on daily operating temperatures and pressures are available (*i.e.*, case a), statistical analysis shall be used for determining the permitted range of operating temperature and pressure. To exclude the possibility of manipulating the process, outliers of historical operating temperature and pressure shall be eliminated by statistical methods. Therefore, the time series data are interpreted as a sample from a stochastic variable. All data that are part of the 2.5% Quantile or that are part of the (100–2.5)% Quantile of the sample distribution are defined as outliers and shall be eliminated. The permitted range of operating temperature and pressure is then calculated based on the remaining historical minimum and maximum operating conditions.

If a permissible operating limit is exceeded, the baseline N_2O emissions for that period are capped at the conservative IPCC default value of 4.05 $kgN_2O/tHNO_3$.

2. Composition of ammonia oxidation catalyst:

The plant operator is allowed to use compositions of ammonia oxidation catalysts that are common practice in the region or have been used in the nitric acid plant during the last three years without limitation of N_2O baseline emissions.

In case the nitric acid plant operator wishes to change to a composition not used during the last three years, but is common practice in the region and supplied by a reputable manufacturer, or if it corresponds to a composition that is reported as being in use in the relevant literature, the plant operator is allowed to use these ammonia oxidation catalysts without limitation of N_2O baseline emissions.

In case the nitric acid plant operator changes the composition of ammonia oxidation catalysts and the composition is not common practice in the region and not reported as being in use in the relevant literature, the project applicant has to demonstrate (either by economic or other arguments) that the choice of the new composition was based on considerations other than an attempt to increase the rate of N_2O production. If the project applicant can demonstrate appropriate and verifiable reasons, the plant operator is allowed to use new ammonia oxidation catalysts without limitation of N_2O baseline emissions.

Pakarab uses several reputable manufacturers of ammonia oxidation catalyst. However, all the manufacturers produce catalyst according to the required composition of the plant. Therefore, Pakarab will not use any other ammonia oxidation catalysts which consist of difference composition.

The first composition of ammonia oxidation catalyst used during the crediting period shall be of the same kind of catalyst composition already in operation in the specific nitric acid plant. This is to avoid gaming at the beginning of the project activity.

In case the nitric acid plant operator changes the composition of ammonia oxidation catalysts and the composition is not common practice in the region and not reported as being in use in the relevant literature, and the project applicant cannot demonstrate appropriate and verifiable reasons for this. This is not the case for Pakarab.

Baseline emissions are limited to the maximum specific N_2O emissions of previous periods ($tN_2O/tHNO_3$), documented in the verified monitoring reports.

Required monitoring parameters:

- G_{sup} : Supplier of the ammonia oxidation catalyst,
- $G_{\mathrm{sup,hist}}$: Historical supplier of the ammonia oxidation catalyst,
- G_{com} : Composition of the ammonia oxidation catalyst,
- $G_{\mathrm{com,hist}}$: Historical composition of the ammonia oxidation catalyst, and
- $SE_{\mathrm{N2O},y}$: Specific N_2O emissions per ton HNO_3 in year y ($tN_2O/tHNO_3$).

3. Ammonia flow rate to the ammonia oxidation reactor:

If the actual daily ammonia flow rate exceeds the (upper) limit on maximum historical daily permitted ammonia flow rate, the baseline emissions for this operating day are calculated based on the conservative IPCC default values and are limited by the legal regulations. The upper limit on ammonia flow should be determined based on:

a) historical operating data on maximum daily average ammonia flow; or, if not existing, on

b) calculation of the maximum ammonia flow rate allowed as specified by ammonia oxidation catalyst manufacturer or on typical catalyst loadings; or, if not existing,

c) based on the literature.

If the daily ammonia input to the oxidation reactor exceeds the limit on permissible ammonia input, baseline N_2O emissions are capped at conservative IPCC default values.

For the Pakarab plant, both a) and b) are available. Therefore, a) is applied as specified in the methodology.

Required monitoring parameters on daily basis:

- $A_{OR,d}$: Actual ammonia input to oxidation reactor (tNH_3/day), and
- $A_{OR,hist}$: Maximum historical ammonia input to oxidation reactor (tNH_3/day).

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

n/a

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

>>

n/a

D.2.3. Treatment of leakage in the monitoring plan

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

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
L.1	ST_{BL}	Project operator and/or technology provider	MW	c	Once	100%	Electronic	*Not needed.* *There is no net change Steam Export for this project.*
L.2	ST_{PJ}	Project operator and/or technology provider	MW	c	Once	100%	Electronic	*Not needed.* *There is no net change Steam Export for this project.*
L.3	η_{ST}	Manufacturer information	%	c	Once	100%	Electronic	*Not needed.* *There is no net change Steam Export for this project.*
L.4	EF_{ST}	Certificate fuel supplier or default value	tCO_2e /MWh	e	Yearly	100%	Electronic	*Not needed.* *There is no net change Steam Export for this project.*
L.5	M_y	Measuring device, Data management system	h	c	Daily	100%	Electronic	*Not applicable.*
L.6	EE_{BL}	Project	MW	c	Once	100%	Electronic	*Not needed.*

		operator and/or technology provider						*There is no net change in tail gas utilization for this plant.*
L.7	EE_{PR}	Project operator and/or technology provider	MW	c	Once	100%	Electronic	*Not needed.* *There is no net change in tail gas utilization for this plant.*
L.8	η_r	Manufacturer information	%	c	Once	100%	Electronic	*Not applicable.*
L.9	EF_r	Certificate fuel supplier or default value	tCO_2e /MWh	e	Yearly	100%	Electronic	*Not applicable.*
L.10	EI_{TGH}	Measuring device or Project operator and/or technology provider	MWh	Measured or calculated	Monthly	100%	Electronic	*Not applicable.* *The technology applied to this project activity uses natural gas for re-heating the tail gas. However emissions from re-heating the tail gas are counted in* $PE_{HC,y}$*(P9).*
L.11	η_{TGH}	Manufacturer information	%	c	Once	100%	Electronic	*Not applicable.* *The technology applied to this project activity uses natural gas for re-heating the tail gas. However emissions from re-heating the tail gas are counted in* $PE_{HC,y}$*(P9).*
L.12	EF_{TGH}	Certificate fuel supplier or default value	tCO_2e /MWh	e	Yearly	100%	Electronic	*Not applicable.* *The technology applied to this project activity uses natural gas for re-heating the tail gas. However emissions from re-heating the tail gas are counted in* $PE_{HC,y}$*(P9).*
L.13	$LE_{\mathrm{RCS},y}$	*Monitoring system*	tCO_2e/yr	*c*	*Annually*	*100%*	*Electronic*	*Leakage related to the electricity consumption of* N_2O *destruction facility.*

L14	$EI_{RCS,y}$	*Monitoring device*	MWh/yr	*m*	*Monthly*	*100%*	*Electronic*	*Additional electricity input for N_2O destruction facility.*
L15	EF_{RCS}	*In-company data*	tCO2e /MWh	*e*	*Once*	*100%*	*Electronic*	*Fuel Emission Factor=1.2598 tCO_2e/MWh is applied as ex-ante value.*

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

>>

According to AM0028, the leakage LE_y is given as follows:

$$LE_y = LE_{s,y} + LE_{TGY,y} + LE_{TGH,y} \quad (9)$$

~~$+ L_{HC,y}$~~

where

$LE_{s,y}$: Emissions from net change steam export (tCO_2e/yr),
$LE_{TGU,y}$: Emissions from net change in tail gas utilization (tCO_2e/yr),
$LE_{TGH,y}$: Emissions from net change in tail gas heating (tCO_2e/yr), and
~~$L_{HC,y}$: Project emissions related to hydrocarbon (natural gas for this project) input to destruction facility in year y (tCO_2e/yr),~~.

For this project, the additional electricity is consumed for running of the N_2O destruction facility system. The technology applied to this project activity does not use hydrocarbon as reducing agent, but use natural gas as fuel for re-heating the tail gas and counted as project emission.

So, for this project formula (9) is rewritten as follows;

$$LE_y = LE_{RCS,y} \quad (9')$$

where

$LE_{RCS,y}$: Emissions from electricity demand for N_2O destruction facility

The component is as follows:

$$LE_{RCS,y} = EI_{RCS,y} * EF_{RCS} \tag{10}$$

where

$EI_{RCS,y}$: Additional electricity input for N_2O destruction facility (MWh/yr),
EF_{RCS} : Emissions factor for electricity consumption,

<u>Determination of conversion rates of hydrocarbons:</u>

~~Hydrocarbons can be used as reducing agent. However, this is not relevant for the technology used for this project. Instead, the same logic can be applied to the additional fuel combustion to reheat the gas and electricity consumption for regenerating catalytic system (treated as the “leakage”). As specified in Section E, the emissions associated with fossil fuel combustion and methane leakage are at the same level of indirect CO_2 from external electricity use. These are insignificant, *i.e.*, much lower than the uncertainty level of the total emission reductions by N_2O destruction. However, these emissions are relatively large in comparison to other CDM projects. Therefore the leakages are counted.~~

~~In the case of hydrocarbons with one carbon atom in the molecule (CH_4), the hydrocarbon is mainly converted to CO_2, while some remains intact. Hydrocarbon reducing agents with two or more carbon atoms in the molecule are completely converted to H_2O, CO, and CO_2.~~

~~If methane (CH_4) is present in the reducing agent, as with natural gas, a part leaves the N_2O destruction facility unconverted and is emitted to atmosphere. The fraction of unconverted methane depends on the amount of methane supplied to the reactor, the reactor operating temperature, and the quantity of catalyst supplied.~~

<u>~~Case 1: Fraction of Methane not converted will be measured:~~</u>

~~In order to measure the fraction of unconverted methane, an additional analyser is required. If the project-specific costs of this analyser for CH_4 are not unreasonable the methodology recommends the installation of the analyser.~~

<u>~~Case 2: Fraction of Methane not converted will not be measured due to unreasonable costs~~</u>

~~A conservative baseline approach is required, as follows:~~

- ~~If hydrocarbons with two or more carbon atoms are present as reducing agent:~~
  ~~In order to apply a conservative baseline approach the fraction of unconverted hydrocarbons is zero: ($OXID_{HC}$ = 0%). Hence, reducing agent GHG emissions are calculated based on the hydrocarbon CO_2 emission factor~~

- ~~If methane is present in the reducing agent, for example; as with natural gas:~~
  ~~In order to apply a conservative baseline approach the fraction of unconverted hydrocarbon is 100% ($OXID_{HC}$ = 100%). Hence, reducing agent GHG emissions are calculated based on the Global Warming Factor of the hydrocarbon.~~

~~The option to be adopted shall be decided on a case-by-case basis.~~

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.)

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The amount of emission reduction ER_y is given by

$$ER_y = BE_y - PE_y - LE_y \tag{10}$$

with the notation shown above.

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.
B1	*Low*	*Measurement devices will be subject to regular calibration, maintenance and testing regime to ensure accuracy.* *NDIR is designed to calibrate automatically without using gas cylinders.* *All monitoring equipment will be served, calibrated and maintained according to the manufacturers' instruction and international standards.* ***Check at the beginning of the project, e.g.*** - *The product acid flow meter (and online density meter, if installed) has been calibrated at the manufacturer's works; the calibration certificate shall be documented.* - *The product acid flow meter (and online density meter, if installed) has been installed and is being operated in accordance with the manufacturer's instruction.* ***Regular check during the project lifetime, e.g.,***

		• *Maintenance and checking are carried out as specified by the flow meter (and online density meter, if applicable) manufacturer. All work carried out is to be documented.* • *The acid density and concentration is measured regularly and compared with any online measurements. If the acid density/concentration measurement is made by means of a portable device the portable device is to be compared with laboratory results, or calibrated at supplier-specified intervals. All observations are to be recorded. If deviations are found appropriate remedial action is to be taken.* • *Plausibility checks may be made on a regular basis based on the ammonia nitrogen balance of the plant. (e.g. the input of ammonia nitrogen is the ammonia flow to the ammonia oxidation reactor. The outputs are N_2O at the inlet of the N_2O destruction facility and NO_X at the inlet of the N_2O destruction facility if no SCR is installed, otherwise an estimate can be made of the NO_X at the inlet of the SCR. The major output is product acid. An assumption must be made about the amount of ammonia nitrogen converted to elemental nitrogen, N_2. Before carrying out a plausibility check of this kind, the nitric acid plant should be operated at constant conditions at least for several hours to minimise the effects of tower sump pumpout and time delays between the ammonia oxidation reactor and the product nitric acid.)* *QA/QC shall be integrated in companies' quality management systems (e.g., ISO, EMAS)*
B10, B11	*Low*	*Regular calibration, maintenance and testing regime.*
P5	*Low*	*Flow meter will be subject to regular calibration, maintenance and testing regime to ensure accuracy.*
P6, B3	*Low*	*N_2O concentration measurement devices will be subject to regular calibration, maintenance and testing regime to ensure accuracy*
P7	*Low*	*Meters for measuring intervals will be subject to regular calibration, maintenance and testing regime to ensure accuracy.*
P10, P14, B17,L14 ~~*L10*~~	*Low*	*Meters will be subject to regular calibration, maintenance and testing regime to ensure accuracy.*

The parameters associated with leakage are insignificant (much below the uncertainty level). Therefore, no specific QA/QC are required.

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

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The measurement equipments will be calibrated on regular intervals as recommended by the manufacturer. Additionally, selected staff of Pakarab will be trained to operate the $DeNO_2$ and $DeNO_X$ system as well as the measurement system.

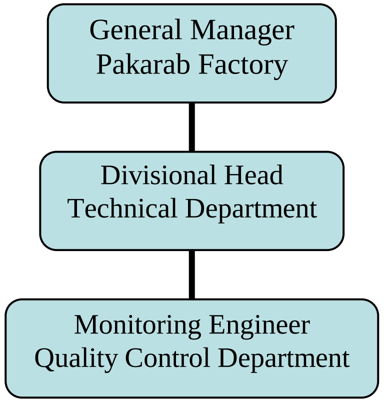
Pakarab has been operating the nitric acid plants since the commissioning of the plant and has sufficient and well-experienced staff. Pakarab has implemented Quality Standard ISO 9001-2000. Quality Plans No QP-7.1-NA(N)-01-01/QP-7.5-NA(0)-01-00 developed under Quality Standard ISO9001-2000 for monitoring and measurement of analytical work related to the plant.

Pakarab has been in production of the nitric acid for number of years and measurement of various production parameters including operation of analyzers which are managed by Quality Control Department (QCD) under Technical Department. The Monitoring of the N_2O for the project will be responsible by the QCD and the operation and maintenance of the N_2O Monitoring system will incorporate the ISO 9001-2000 standard procedures. The Monitoring of the relevant data will be done automatically by the N_2O Monitoring system and recorded onto the electric media.

In QCD, a Monitoring Engineer will be appointed to be responsible for the operation of the N_2O Monitoring system. Monitoring Engineer will follow the monitoring plan and report the data daily to the Divisional Head of the Technical Department who will report to the General Manager of the Pakarab Factory daily.

In case deviation in the Monitoring data is found, the Monitoring Engineer will study the operating parameters of the nitric acid plant to identify the reason for the deviation and take remedial measures. If the are no changes in the operating parameters of nitric acid plant, the Monitoring system will be examined and a sampling by Gas Chromatography will be conducted by QCD to counter check the performance of the Monitoring system. Once the default is identified, the Technical Department will introduce a correction to the default. The Monitoring Engineer will report such irregular event to the Divisional Head of the Technical Department through daily report.

An illustrative scheme of the operational and management structure is as follows:



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

>>

Name/Entity of the monitoring plan determination:

Dr. Naoki Matsuo and Mr. Kunihiro Ueno
Climate Experts Ltd. (Climate Experts Ltd. is not a project participant.)

Completion date:

06/12/2007 version 3.0