"Catalytic N2O destruction project in the tail gas of the Nitric Acid Plant of Abu Qir Fertilizer Co."

CDM project 0490

Tool for Ex-ante Estimation of Emission Reductions for 3rd Crediting Period

Version 01.1

Approved large scale methodology:
ACM0019 N2O abatament from nitric acid production, version 4.0

Input data for ex-ante estimation of NA plant II of AFC

Parameter	Description	Unit	Value	Sources
$P_{product,max}$	Design capacity	$tHNO_3$	700,800	Uhde technical information
$P_{production,y}$	Production of nitric acid in year y	$tHNO_3$	671,400	The average daily production over the 2nd CP was 1,865 $tHNO_3$ per operation day.
h_y	Number of hours in year during which the plant was in operation	h / a	8,640	The expected operating days were determined to be 360 per year (based on average operating hours over the 2nd CP). The regular yearly value of $h_{r,y}$ is considered during the 2nd CP conservatively.
$h_{r,y}$	Number of hours in year where the abatement system is by-passed, underperforming (for tertiary N2O abatement)	h / a	0	
-	Operating Days Forecast	d / a	360	
GWP_{N2O}	Global warming potential of N_2O valid for the commitment period	tCO_2e / tN_2O	298	Relevant decisions by the CMP
$V_{t,db,n}$	Volumetric flow of the gaseous stream in time interval t on a dry basis at normal conditions	Nm^3 dry gas / h	242,000	The average hourly volume flow rate at the exit of the destruction facility over the 2nd CP was around 241,832 Nm^3/h. Parameter is considered to be dry - Option A - according to the "Tool to determine the mass flow of a GHG in a gaseous stream".
$v_{i,t,db}$	Volumetric fraction of greenhous gas i in a time interval t on a dry basis at normal conditions	Nm^3 gas i / Nm^3 dry gas	1.15E-04	The average daily N_2O concentration over the historic period 1.13E-04. The value chosen for ex-ante calculation was rounded up conservatively.
$\rho_{i,t}$	Density of greenhouse gas i in the gaseous stream in time interval t at normal conditions	kg gas i / m^3 gas i	1.96	Calculated; By deriving equations from the “Tool to determine the mass flow of a GHG in a gaseous stream” a fixed value for the N_2O density at normal conditions was determined ($P_t = P_n$; $T_t = T_n$).
R_u	Universal ideal gas constant	Pa.m^3 / kmol.K	8,314	Tool to determine the mass flow of a greenhouse gas in a gaseous stream
MM_i	Molecular mass of greenhouse gas i (N_2O)	kg / kmol	44.02	Tool to determine the mass flow of a greenhouse gas in a gaseous stream
P_n	Total pressure at normal conditions	Pa	101,325	Tool to determine the mass flow of a greenhouse gas in a gaseous stream
T_n	Temperature at normal conditions	Kelvin	273.15	Tool to determine the mass flow of a greenhouse gas in a gaseous stream
$FC_{i,j,y}$	Quantity of fuel type i combusted in process j during the year y	Nm^3 / y	700,000	The average value of the hydrocarbon input (reducing agent natural gas) over the 2nd CP was around 693,058 Nm^3/a.
$\rho_{i,y}$	Weighted average density of fuel type i in year y	t/Nm^3	7.60E-04	Conservative hydrocarbon density
$w_{C,i,y}$	Weighted average mass fraction of carbon in fuel type *i* in year *y*	t C/ton	0.75	Conservative hydrocarbon mass fraction of carbon

		EMISSION REDUCTIONS	BASELINE EMISSIONS							PROJECT EMISSIONS				
Parameter ACM0019 v4		ER_y	BE_y	$EF_{existing,,y}$	$EF_{new,y}$	$P_{production,y}$	$P_{product,max}$	h_y	$h_{r,y}$	PE_y	$PE_{N2O,y}$	$PE_{CO2,tertiary,y} = PE_{FF,y} = PE_{FC,j,y}$	$F_{N2O,tail\ gas,h}$	h_y
Description		Emission reductions in year y	Baseline emissions in year y	N_2O emission factor for nitric acid plants that have used AM0028 or AM0034 in the first crediting period in year y	Baseline N_2O emission factor for nitric acid production in year y	Production of nitric acid in year y	Design capacity	Number of hours in year y during which the plant was in operation	Number of hours in year y where the abatement system is by-passed, underperforming or failed (for tertiary N_2O abatement)	Project emissions in year y	Project emissions of N_2O from the project plant in year y	Project emissions of CO_2 from the operation of the tertiary N_2O abatement facility in year y	Mass flow of N_2O in the gaseous stream of the tail gas in the hour h	Number of hours of operation in year y
Formula / TAG Number		(9) $ER_y = BE_y - PE_y$	(1) $BE_y = (\min\{P_{production,y}; P_{product,max}\} \times EF_{existing,y} + \max\{P_{production,y} - P_{product,max}; 0\} \times EF_{new,y}) \times (h_y - h_{r,y})/h_y \times GWP_{N2O} \times 10^{-3}$	(2) $EF_{existing,y} = \min\{EF_{historical}; EF_{default,y}\}$	-	-	-	-	(4) $F_{N2O,tail\ gas,h} > EF_{existing,y} \times P_{NA,h}$	(6) $PE_y = PE_{N2O,y} + PE_{CO2,tertiary,y}$	(7) $PE_{N2O,y} = \sum_1^{hy\text{-}hyr} F_{N2O,tail\ gas,h} \times GWP_{N2O} \times 10^{-3}$	(8) $PE_{CO2,tertiary,y} = PE_{FF,y}$	-	-
Unit		t CO_2e	t CO_2e	kg N_2O/t HNO_3	kg N_2O/t HNO_3	t HNO_3	t HNO_3	h	h	t CO_2e	t CO_2e	t CO_2	kg N_2O/h	hours
year 1	15/09 - 31/12/2020	**372,333**	414,406	7.00	2.50	198,661	207,360	2,556	0	42,074	41,642	432	54.66	2,556
year 2	2021	**1,218,331**	1,360,525	6.80	2.50	671,400	700,800	8,640	0	142,194	140,734	1,460	54.66	8,640
year 3	2022	**1,178,316**	1,320,510	6.60	2.50	671,400	700,800	8,640	0	142,194	140,734	1,460	54.66	8,640
year 4	2023	**1,138,300**	1,280,494	6.40	2.50	671,400	700,800	8,640	0	142,194	140,734	1,460	54.66	8,640
year 5	2024	**1,098,285**	1,240,479	6.20	2.50	671,400	700,800	8,640	0	142,194	140,734	1,460	54.66	8,640
year 6	2025	**1,058,270**	1,200,463	6.00	2.50	671,400	700,800	8,640	0	142,194	140,734	1,460	54.66	8,640
year 7	2026	**1,018,254**	1,160,448	5.80	2.50	671,400	700,800	8,640	0	142,194	140,734	1,460	54.66	8,640
year 8	01/01 - 14/09/2027	**688,787**	788,907	5.60	2.50	472,739	493,440	6,084	0	100,120	99,092	1,028	54.66	6,084
Crediting period		**7,770,876**	**8,766,232**							**995,355**				

Calculations as per "Tool to determine the mass flow of a greenhouse gas in a gaseous stream"

		OPTION A			
Parameter		**$F_{N2O,tail\ gas,h} = F_{i,t}$**	**$V_{t,db,n}$**	**$v_{i,t,db}$**	**$\rho_{i,t}$**
		Mass flow of N_2O in the gaseous stream of the tail gas in the hour h	**Volumetric flow of the gaseous stream in time interval t on a dry basis (at normal conditions)**	**Volumetric fraction of greenhouse gas *i* in the gaseous stream in a time interval *t* on a dry basis**	**Density of greenhouse gas i in the gaseous stream in time interval t**
Formula		**(5) $F_{i,t} = (V_{t,db,n} \times v_{i,t,db} \times 1.96\ kg/Nm^3)$**	-	-	-
Unit		**kg N_2O/h**	**Nm^3 dry gas / h**	**Nm^3 gas *i* / Nm^3 dry gas**	**kg gas *i* / Nm^3 gas *i***
year 1	15/09 - 31/12/2020	54.66	242,000	1.15E-04	1.96
year 2	2021	54.66	242,000	1.15E-04	1.96
year 3	2022	54.66	242,000	1.15E-04	1.96
year 4	2023	54.66	242,000	1.15E-04	1.96
year 5	2024	54.66	242,000	1.15E-04	1.96
year 6	2025	54.66	242,000	1.15E-04	1.96
year 7	2026	54.66	242,000	1.15E-04	1.96
year 8	01/01 - 14/09/2027	54.66	242,000	1.15E-04	1.96

Calculations as per "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"

		Option A - Approach "Volume unit" *)				
Parameter		**$PE_{FF,y} = PE_{FC,j,y}$**	**$COEF_{i,y}$**	**$FC_{i,j,y}$**	**$\rho_{i,y}$**	**$w_{C,i,y}$**
		CO_2 emissons from fossil fuel combustion in process j during the year y	**CO_2 emission coefficient of fuel type i**	**Quantity of fuel type *i* combusted in process *j* during the year *y***	**Weighted average density of fuel type i in year y**	**Weighted average mass fraction of carbon in fuel type *i* in year *y***
Formula		**(1) $PE_{FC,j,y} = \sum_i FC_{i,j,y} \times COEF_{i,y}$**	**(3) $COEF_{i,y} = w_{C,i,y} \times \rho_{i,y} \times 44/12$**	**FT-218002**	**-**	**-**
Unit		**t CO_2/yr**	**t CO_2/Nm^3**	**Nm^3/y**	**t/Nm^3**	**t C/ton**
year 1	15/09 - 31/12/2020	432	2.09E-03	207,123	7.60E-04	0.75
year 2	2021	1,460	2.09E-03	700,000	7.60E-04	0.75
year 3	2022	1,460	2.09E-03	700,000	7.60E-04	0.75
year 4	2023	1,460	2.09E-03	700,000	7.60E-04	0.75
year 5	2024	1,460	2.09E-03	700,000	7.60E-04	0.75
year 6	2025	1,460	2.09E-03	700,000	7.60E-04	0.75
year 7	2026	1,460	2.09E-03	700,000	7.60E-04	0.75
year 8	01/01 - 14/09/2027	1,028	2.09E-03	492,877	7.60E-04	0.75
Crediting period		**10,218**				

) Option A - Approach "Mass unit"

HAS NOT BEEN USED FOR DETERMINING EX-ANTE CO2 EMISSIONS FROM FOSSIL FUEL COMBUSTION

N_2O baseline emission factor

	$EF_{new,y}$	$EF_{default,y}$			$EF_{historical}$
Year	kg N_2O/t HNO_3	Low pressure (0 - 200 kPa)	Medium pressure (200 - 600 kPa)	High pressure (over 600 kPa)	kg N_2O/t HNO_3
2005	5.1				
2006	4.9				7.90
2007	4.7				7.74
2008	4.6				7.62
2009	4.4				7.87
2010	4.2				7.68
2011	4.1				7.80
2012	3.9				7.23
2013	3.7	5.5	8.4	12.6	
2014	3.5	5.3	8.2	12.4	
2015	3.4	5.1	8.0	12.2	
2016	3.2	4.9	7.8	12.0	
2017	3.0	4.7	7.6	11.8	
2018	2.8	4.5	7.4	11.6	
2019	2.7	4.3	7.2	11.4	
2020	2.5	4.1	7.0	11.2	
2021	2.5	3.9	6.8	11.0	
2022	2.5	3.7	6.6	10.8	
2023	2.5	3.5	6.4	10.6	
2024	2.5	3.3	6.2	10.4	
2025	2.5	3.1	6.0	10.2	
2026	2.5	2.9	5.8	10.0	
2027	2.5	2.7	5.6	9.8	
2028	2.5	2.5	5.4	9.6	
2029	2.5	2.5	5.2	9.4	
2030	2.5	2.5	5.0	9.2	