GENESIS	**Client:** *Altera Infrastructure LP* altera

Project Title	**Project Ref.**	**Ref No**
PPC Permit Application Support	*J76086A*	*217505C-001-CN-6200-0001*

CALCULATION SHEET

Emission Load Calculation - Rosebank Petrojarl FPSO

Rev No	Date	Description	Originator By	Checked By	Approved By	Client Approval
			[redacted]			
1	17-Apr-26	Issued for Client Use	[redacted]	[redacted]	[redacted]	[redacted]
0	19-Dec-25	Issued for Client Use	[redacted]	[redacted]	[redacted]	[redacted]

Project	PPC Permit Application Support			GENESIS	
Client	Altera Infrastructure LP	Project No:	J76086A		
Subject	Emission Load Calculation - Rosebank Petrojarl FPSO			CTR No.	
Calc. By	#REF!	Date	#REF!	Calc No.	217505C-001-CN-6200-0001
Checked By	#REF!	Date	#REF!	Rev	#REF!

OBJECTIVE

The objective of this calculation sheet is to estimate the emissions profiles/loads required in the PPC permit for the Petrojarl Rosebank FPSO and assess the predicted contribution to UKCS emissions of the installation for inclusion in supporting docs such as the BAT, SAT, EAJ and upload into to UK Energy Portal, etc.

BASIS

NO_x pollutant loads for the Solar Titan 130 Gas turbines Generators (GTGs) have been estimated using Original Equipment Manufacturer (OEM) information while operated in SoLoNO$_x^{TM}$ mode i.e. above 50% load (Ref 4). No other project specific warranted pollutant load data was available for the GTGs under normal operation i.e. operation in SoLoNO$_x^{TM}$ mode, therefore, all other pollutants have been determined using the default factors provided in the EEMs guidance (Ref 3). SO_x emissions have been estimated based on the default factor for turbines in the EEMs guidance (Ref 3) due to insufficient information on expected fuel gas concentration being available, this is deemed to be conservative based on the low Sulphur concentration in both import gas and associated fuel gas.

Additional consideration has been given to "Other Than Normal Operating Conditions" (OTNOC) within the emissions calculations which may lead to increased emissions. Vendor information outlined in Solar Turbine Product Information Letter (PIL) 170 (Ref 19), provides general vendor data for the Solar Titan 130 during start-up/shutdown operations and has been used to assess NO_x, CO, and UHC emissions related to turbine switchover operations. Application of other Solar PIL's have been assessed but screened out, PIL 167 for example as the information provided for cold weather operations falls outwith the average expected ambient temperature of the Rosebank GTG's in operation and is deemed unrepresentative.

CO_2 emissions have been estimated based on the associated fuel gas composition (Att4, Ref 2). EEMS factors (Ref 3) have been used for other sources where vendor data was not available.

ASSUMPTIONS

The following assumptions have been made:

1	Fuel gas and Diesel run hours and activity during the commissioning and production periods in 2026 have been provided by the client (Ref 1).
2	The Petrojarl Rosebank FPSO shall enter UK waters on 16/04/2026. The offshore commissioning period shall end on 18/11/2026. More detail on the schedule is given in Att 1.
3	Fuel gas and Diesel usage has been forecasted for 2027 and 2028 based on an assumed plant uptime of 85%. An additional 15% contingency has been added to all forecasts. Assumptions and considerations made for specific equipment in the forecast of 2027 and 2028 run hours are detailed in Att 1.
4	There are no turnarounds are scheduled for 2027 or 2028 as confirmed by the Client.
5	The main electrical power is provided by the SOLAR Titan 130 gas turbine in a 3oo4 configuration during normal production.
6	When the GTGs operate in the region of 50–100% load, Solars SoLoNO$_x^{TM}$ DLE technology is in operation, resulting in decreased NO_x emissions. A GTG NO_x emission factor for this operational range was derived from the OEM's guaranteed emission limit of 25 ppmv (Ref 4). In this range, NO_x emissions are the only warrantable emissions, and as such other emission factors for SoLoNO$_x$ mode were not derived. It was assumed on a conservative basis that 90% of GTG operations will be within 50-100% load.
7	Following on from assumption 6 above, 10% of operations are assumed to be outwith SoLoNO$_x$ DLE mode. For this case, emission factor for NO_x given in the EEMS Guidance was used (Ref 3).
8	It is assumed that there will be 4 turbine switch over events each year, and that there will be no black start due to the ability to import gas. PIL 170 provides the mass of emissions for NO_x, CO, UHC, VOC and CO_2 per start up or shutdown event (Att 3, Ref 19).
9	Consumption rates for all combustion equipment have been obtained from OEM datasheets and Operations & Maintenance manuals (Att 4 through Att 13).
10	Temporary equipment has not been included within the emissions calculations because they are in service for less than 500 hours (i.e. during commissioning activities only) and are therefore, not included on the ETS permit.

GENERAL CONVERSION FACTORS USED

Methane GWP	28	*Ref 7*
Nitrous Oxide GWP	265	*Ref 7*

RESULTS

The outputs to be included in the relevant permit application are presented in the in the tab "Emission Loads Calculation" which tabulates the annual emissions and pollutant loads for inclusion in the supporting docs such as the BAT, SAT, EAJ and upload into to UK Energy Portal, etc.

	REFERENCES
1	HC Emissions to Environment.pdf (Att 1)
2	Rosebank Data Request 16.09.25.xlsx (Att 4)
3	EEMS-Atmospheric Emissions Calculations (Issue 1.810a)
4	PJ5-04-R-80-DS-01002-001_03_01 - Solar Turbine Performances
5	DUKES Calorific Values and Density of Fuels (https://www.gov.uk/government/statistics/dukes-calorific-values)
6	J7333A-Y-RT-24000 D1 Summary of EEMS Recommendations
7	Global Warming Potentials (https://ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf)
8	PJ5-03-R-80-RA-00003-001_Essential eng Test datas and FAT diesel oil spec and consumption
9	Em gen.pdf
10	Pages from PJ5-03-R-55-RD-00200-001_02_01-Aux boiler Fuel consumption data
11	IG Generator Specification
12	PJ5-03-I-71-DS-00103-001_03_01 - Fire Pump Datasheets
13	Email Correspondence re Temporary Equipment Datasheet Information
14	NP-08_en
15	PD Pump PP-31 Datasheet
16	217505C-003-RT-6200-0001 Petrojarl Rosebank FPSO -BAT Assessment
17	DB Email with Rosebank - Combustion Emissions Forecast
18	041-00076_APPL_13-3271_REVISED
19	Product Information Letter (PIL) 170 - EMISSION ESTIMATES START UP SHUT DOWN (Solar Turbines)
20	Solar Predicted Engine Performance TITAN_130-20501S_New Gas Fuel_ISO Inlet Conditions.pdf
21	Solar Predicted Engine Performance TITAN_130-20501S_Desiel Fuel_10degC.pdf
	ATTACHMENTS
1	Att 1 - Equip Runhours Estimate
2	Att 2 - Genesis Gas Properties
3	Att 3 - EF Calculations
4	Att 4 - Fuel Gas Comp
5	Att 5 - GTG Consump
6	Att 6 - Ess Gen Consump
7	Att 7 - Em Gen Consump
8	Att 8 - Boiler Consump
9	Att 9 - IGG Consump
10	Att 10 - Fire Pump Consump
11	Att 11 - N2 Pump Consump
12	Att 12 - MEG Pump Consump
13	Att 13 - Quench Pump Consump
14	Att 14 - Gas GT Exhaust vol

GENESIS	Project:	PPC Permit Application Support
	Client:	Altera Infrastructure LP
Subject	Emission Load Calculation - Rosebank Petrojarl FPSO	

OBJECTIVE

The objective of this calculation sheet is to estimate the emissions profiles/loads required in the PPC permit for the Petrojarl Rosebank FPSO and assess the predicted contribution to UKCS emissions of the installation for inclusion in supporting docs such as the BAT, SAT, EAJ and upload into to UK Energy Portal, etc.

BASIS

- There will be a 7 month commissioning period from April through to November 2026. All GTGs will be commissioned on diesel prior to arrival in UK waters, 1 GTG running on diesel (28% load based on demands of installation base load) from arrival on station up to import of WoSPS gas, commissioning of all GTGs on fuel gas & auto-switch, 2 GTGs (75% load) running on fuel gas to support compressor commissioning, 3 GTGs (75% load) running on fuel gas after gas export starts, diesel contingency for trips.
- Fuel gas and Diesel usage has been calculated for 2026 using consumption rates obtained from OEM data sheets and run hour estimations provided by the client for all combustion equipment.
- Fuel gas and Diesel usage has been forecasted for 2027 and 2028 based on an assumed plant uptime of 85% per annum. An additional 15% contigency has been added to all forecasts. No turnarounds are scheduled for 2027 or 2028.
- The CO_2 emission factor for fuel gas consumed by the turbines was estimated using the fuel gas compositions provided in Att 4. Of the two samples, the one with the higher emission factor was used for a conservative approach.
- The turbines are assumed to be operating in DLE mode 90% of the time under normal operations calculated on the warrantable emissions of 25 ppmV (Att 3, Ref 4). NO_x emissions are the only project specific warrantable emissions provided by the OEM, and as such all other emission factors under SoLoNO$_x$ mode are derived using the default NOx emission factor obtained from EEMS guidance (Ref 3).
- Operation in non-SoLoNox mode (for the remaining 10% of the time in operation) use the emission factors taken from EEMS Guidance (Ref 3).
- Emissions related to start up and shut down events have been added to emission loads.

Calculated From Fuel composition (Alt 2)
Default factors for EEMS Guidance (Ref 3)

CALCULATION

	Source	Fuel use (tonnes)	CO_2	NOx	N_2O	SO_2	CO	CH_4	VOC	CO2e
2026	Gas (Turbines)	45,581	127,833	113.42	10.03	0.58	274.10	42.39	1.73	131,677
	Gas (Heaters/Boilers, etc)	48	138	0.12	0.01	0.00	0.03	0.00	0.00	141
	Diesel (Turbines)	6,622	21,190	89.39	1.46	13.24	6.09	0.22	1.95	21,582
	Diesel (Heaters/Boilers, etc)	16	51	0.04	0.00	0.03	0.01	0.00	0.00	52
	Diesel Engine	86	277	5.13	0.02	0.17	1.36	0.02	0.17	282
	Total	**52,353**	**149,489**	**208.11**	**11.52**	**14.03**	**281.59**	**42.62**	**3.86**	**153,734**
2018 UKCS CO2e Emissions			13,200,000					43,500	50,100	14,630,000
Total fuel use CO2e Emissions as a % of UKCS CO2e Emissions, 2018			1.13%					0.10%	0.01%	1.05%

Default Emissions Factors for Gas Consumptions (Ref 3) Plant Operations (te/te)				
Emission Gas	Turbine	Engine	Heater	Other
CO_2	2.8045	2.86	2.86	2.86
NOx	0.0061	0.0576	0.0024	0.0061
N_2O	0.00022	0.00022	0.00022	0.00022
SO_2	0.0000128	0.0000128	0.0000128	0.0000128
CO	0.006	0.0076	0.0006	0.003
CH_4	0.00092	0.0198	0.000089	0.00092
VOC	0.000036	0.0032	9.9E-07	0.000036

	Source	Fuel use (tonnes)	CO_2	NO_x	N_2O	SO_2	CO	CH_4	VOC	CO2e
2027	Gas (Turbines)	63,636	178,470	158.35	14.00	0.81	382.44	59.00	2.38	183,832
	Gas (Heaters/Boilers, etc)	74	211	0.18	0.02	0.00	0.04	0.01	0.00	216
	Diesel (Turbines)	548	1,754	7.40	0.12	1.10	0.50	0.02	0.16	1,787
	Diesel (Heaters/Boilers, etc)	25	79	0.07	0.01	0.05	0.02	0.00	0.00	80
	Diesel Engine	305	975	18.09	0.07	0.61	4.78	0.05	0.61	994
	Total	**64,588**	**181,489**	**184.09**	**14.21**	**2.57**	**387.79**	**59.08**	**3.15**	**186,909**
2018 UKCS CO2e Emissions			13,200,000					43,500	50,100	14,630,000
Total fuel use CO2e Emissions as a % of UKCS CO2e Emissions, 2018			1.37%					0.14%	0.01%	1.28%

Default Emissions Factors for liquid fuel (Ref 3) Consumption Plant Operations (te/te)			
Emission Gas	Turbine	Engine	Heater
CO_2	3.2	3.2	3.2
NOx	0.0135	0.0594	0.0028
N_2O	0.00022	0.00022	0.00022
SO_2	0.002	0.002	0.002
CO	0.00092	0.0157	0.00071
CH_4	0.0000328	0.00018	7.05E-06
VOC	0.000295	0.002	0.0000282

	Source	Fuel use (tonnes)	CO_2	NO_x	N_2O	SO_2	CO	CH_4	VOC	CO2e
2028	Gas (Turbines)	63,636	178,470	158.35	14.00	0.81	382.44	59.00	2.38	183,832
	Gas (Heaters/Boilers, etc)	74	211	0.18	0.02	0.00	0.04	0.01	0.00	216
	Diesel (Turbines)	548	1,754	7.40	0.12	1.10	0.50	0.02	0.16	1,787
	Diesel (Heaters/Boilers, etc)	25	79	0.07	0.01	0.05	0.02	0.00	0.00	80
	Diesel Engine	305	975	18.09	0.07	0.61	4.78	0.05	0.61	994
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2018 UKCS CO2e Emissions			13,200,000					43,500	50,100	14,630,000
Total fuel use CO2e Emissions as a % of UKCS CO2e Emissions, 2018			1.37%					0.14%	0.01%	1.28%

RESULTS/CONCLUSIONS:

N2O and CH4 only used in the calculation of the CO2e emissions.

	2026	2027	2028	
The forecast emissions for diesel and fuel gas equate to	11.52	14.21	14.21	tonnes of N2O emitted.
The forecast emissions equate to	153,734	186,908.85	186,908.85	tonnes of CO2e.
The total CO_2e emissions associated with the forecast equates to approximately	1.05	1.28	1.28	% of UKCS CO_2e emissions (2018) (OGUK, 2019).
The total CO_2 emissions associated with the forecast equates to approximately	1.13	1.37	1.37	% of UKCS CO2 emissions (2018) (OGUK, 2019).
The total CH4 emissions associated with the forecast equates to approximately	0.10	0.14	0.14	% of UKCS CH4 emissions (2018) (OGUK, 2019).
The total VOC emissions associated with the forecast equates to approximately	0.008	0.01	0.01	% of UKCS VOC emissions (2018) (OGUK, 2019).

Equipment Name & Model	Tag No	Full year 2026 Annual Hrs	Operational Mode Assumptions
Main Gas Turbine Generator - SOLAR Titan 130 gas turbine	80-DE-001A	5600	Rated mechanical power at 10oC ambient temperature, 60% humidity and 0m elevation on import fuel gas (spec as per WoSPS pipeline expected composition). All GTGs will be commissioned on diesel prior to arrival in UK waters, 1 GTG running on diesel (assumed approx 90% load based on demands of installation base load) from arrival on station up to import of WoSPS gas, commissioning of all GTGs on fuel gas & auto-switch, 2 GTGs (~70% load) running on fuel gas to support compressor commissioning, 3 GTGs (~70% load) running on fuel gas after gas export starts, diesel contingency for trips.
Main Gas Turbine Generator - SOLAR Titan 130 gas turbine	80-DE-001B	5600	
Main Gas Turbine Generator - SOLAR Titan 130 gas turbine	80-DE-001C	5600	
Main Gas Turbine Generator - SOLAR Titan 130 gas turbine	80-DE-001D	5600	
Essential Generator - MAN STX 7L27/38 diesel engine	80-DD-501	48	Commissioned before arrival in UK waters, 1 period of test run planned, contingency for unplanned events.
Emergency Generator - MTU 20V4000P63 diesel engine	84-DD-501	48	Commissioned before arrival in UK waters, 3 periods of test runs planned, contingency for unplanned events.
Auxiliary Boiler AALBORG OL 12.5T/H	55-FB-501	96	In operation before well clean up 19/10/26 thru' 18/11/26 when vapour recovery in service.
Inert Gas Generator HAMWORTHY MOSS 5700m3/h	64-VV-501	48	
Fire Pump - CUMMINS QSK60 D(M) diesel engine	71-DD-553	12	Commissioned before arrival in UK waters, 3 periods of test runs planned for each pump
Fire Pump - CUMMINS QSK60 D(M) diesel engine	71-DD-558	12	
Fire Pump - CUMMINS QSK60 D(M) diesel engine	71-DD-564	12	
Fire Pump - CUMMINS QSK60 D(M) diesel engine	71-DD-571	12	

Run hours data for Table 4-1 in BAT Assessment and Portal SAT