



Shell U.K. Limited




Project Title
Penguins ETS and PPC Support

Project Ref.
J75738D

Calculation No
204226C-004-CN-6200-0035

**UK ETS
Penguins PPC and ETS Permit Application Supporting Calculation**

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Project	Penguins ETS and PPC Support				
Client	Shell U.K. Limited	Project No:	J75738D		
Subject	Penguins PPC and ETS Permit Application Supporting Calculation			CTR No.	280
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OBJECTIVE

The objective of this calculation sheet is to utilise previous calculations from J75159, updated as required, to estimate the emissions profiles needed in the GHGE and PPC Permit Applications for the Penguins FPSO.

SHEET DESCRIPTIONS

- 1 Front Sheet
- 2 Overview
- 3 Permit Application Data
- 4 Emissions Calculations
- 5 Basis of Calculations for GTG
- 6 Basis of Calculations for HP Compressor
- 7 Basis of Calculations for EDG
- 8 Basis of Calculations for FW Pump Diesel Engine Package
- 9 Basis of Calculations for IGG
- 10 Basis of Calculations for TEMPSCs
- 11 Basis of Calculations for Flaring
- 12 Basis of Calculations for Cargo Tank Venting
- 13 Basis of Calculations for Fugitive Emissions
- 14 Attachment 1 - GTG Runtimes
- 15 Attachment 2 - Gas Composition
- 16 Attachment 3 - Vendor Emissions Data
- 17 Attachment 4 - GTG Data at Low Loads
- 18 Attachment 5 - Cross Check

METHODOLOGY

Pollutant loads for the turbines have been estimated using vendor information for NO_x, CO, and UHC emissions. Project specific pollutant data was available for GTGs (Ref 7). No project specific pollutant data was available for the HP compressor, so general vendor data for the Solar Titan 130 was used (Ref 30). SO_x emissions have been estimated based on the SO_x content of the fuel gas in line with the EEMS guidance (Ref 17) for the turbines and exhaust gas parameters from the vendor information. Sheets 5 to 13 describe the approaches applied to each emissions source. EEMS factors (Ref 17) have been used for other sources where vendor data was not available. CO₂ emissions are estimated based fuel/flare gas composition. For diesel use, CO₂ emissions are estimated using the national inventory factor (Ref 28).

GTGs operate in SoLoNO_x when they are above 50% load when running on fuel gas (Ref 30). It has been assumed that 1 GTG will be operating in SoLoNO_x mode all year. 1 GTG will supply power to support residual base load needs and auxiliary power when offloading. This GTG is expected to shift in load between 30%-50% between cargo offloads. NO_x and CO concentrations are larger at the 30% load when the GTG is not in SoLoNO_x. A conservative approach has been applied where the emissions from one GT are estimated based on operating at 50% load and the other at 30% load. In reality, both GTGs will operate in SoLoNO_x mode during cargo offloading, which is expected to occur weekly during the first few years of production.

The following assumptions have been made:

- The molecular weight of the GTD (HP Compressor) exhaust gas was assumed to be similar to the GTGs.
- For the equipment operating on fuel gas, fuel gas and exhaust gas were assumed to be an ideal gases.
- UHC in turbine exhaust is assumed to be methane with a GWP of 28.
- The flaring rates will be similar to those detailed in the Flare and Vent Cargo Tank Vent Gas Dispersion Study (Ref. 13). An oxidation factor of 0.98 has been assumed.
- Turbine performance data at -7 degC has been used to determine pollutant rates.
- Vendor pollutant concentrations at 15% O₂ reference conditions have been used to derive pollutant rates for turbine emissions.
- HP Compressor is assumed to operate for 3 months in first year.

The outputs have been cross checked against default EEMS factors applied to fuel gas and diesel consumption (Sheet 18).

The data required in the permit application portals are presented in Sheet 3.

GENERAL CONVERSION FACTORS USED


Methane GWP	28	<i>Ref 29</i>
Flare OxF	0.98	<i>Ref 17</i>
Gas oil/Diesel EF	3.19	<i>Ref 28</i>
Sulphur in Diesel	0.10%	<i>Ref 16</i>

RESULTS

Outputs to be included in the relevant permit application are presented in the Permit Application Data sheet

References

- 1 Penguins Field Redevelopment Project Select Phase, Greenhouse Gas and Energy management Plan, document number ORP04206A-14-SH-002 rev. A1
- 2 UniSim Simulation Model, Run 1-5.
- 3 Marine Protection Norway – IGG Utility Data Sheet, document number 14-15-606-001 rev. 2.
- 4 Electrical Load Estimate, document number PRD-PT-GEN-00-D-EA-4329-00001, rev. R02
- 5 Relief, Flare & Vent report, PRD-PT-GEN-00-D-PX-7722-00001
- 6 Penguins Redevelopment Project, GHG (Greenhouse Gas) & Energy Efficiency Plan, document number PRD-PT-GEN-S-PX-7180-00003 rev. A01
- 7 Gas Turbine Performance Curves, P3NG-4-0306-01-F29-00001
- 8 API 616 Turbine Equipment Data Sheet, P3NG-4-0304-01-C08-00003-1
- 9 Utility Consumption index, P3NG-4-0302-01-01-C06-00001-1
- 10 Mechanical Datasheet for Diesel Engine and Generator for Fire Water Pump(A-7101A/B/C), PRD-PT-TOPS-71-E-MR-2105-00001
- 11 Electrical Load Schedule, PRD-PT-TOPS-00-E-EA-4329-00001
- 12 Electrical Load Schedule - Prolonged Outage, PRD-PT-TOPS-00-E-EA-4329-00011
- 13 Flare and Cargo Tank Vent Dispersion Study, PRD-PT-GEN-00-E-HX-6874-00001
- 14 Environmental Statement Report, PRD-PT-GEN-00-D-HE-0702-00007, Rev A01
- 15 IPS Shutdown Hierarchy, PRD-PT-GEN-79-E-IN-2312-00002-001
- 16 <https://imorules.com/GUID-2E402236-C5A9-4D94-9BDB-4737FA3CEDD2.html>
- 17 <https://assets.publishing.service.gov.uk/media/5a75bdb1ed915d6faf2b5551/atmos-calcs.pdf>
- 18 Gas Turbine Data Sheet : P3NG-4-0304-01-C08-00003
- 19 HP Compressor Data Sheet HP Compressor: P3NG-4-0304-01-C08-00004
- 20 Gas Turbine Performance Curves, P3NG-4-0306-01-F29-00001_3A
- 21 Emergency Generator Data Sheet, P3NG-4-0302-01-C06-00001
- 22 Passive Fire Protection Assessment, PRD-PT-GEN-00-E-HX-0704-00005, Rev R01
- 23 Boat - Technical Specification, Norsafe AS, P3NG-2-0102-L01-C17-00001, Rev 1
- 24 Generator Data and Curves, P3NG-4-0306-01-F35-00001_Rev 2
- 25 Volatile Organic Compounds, P3NG-4-0306-01-C17-00018_02
- 26 Oil & Gas UK, EEMS Atmospheric Emissions Calculations, 11-Nov-2008
- 27 Engine Performance Curve Titan 130-20502S as of 02-Jul-2018
- 28 UK Government GHG Conversion Factors (<https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022>)
- 29 Global Warming Potentials (https://ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf)
- 30 Solar Product Information Letter 176 (P3NG-4-0306-01-C17-00017_02)
- 31 Frequently Asked Questions (FAQs) - Medium Combustion Plant. Last Updated 10/10/2023
- 32 Email from Solar with Estimated Emissions concentrations at low loads for the Solar Taurus 70-10301S

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PERMIT APPLICATION DATA

This sheet provides:

- 1) the fuel gas, flare gas, and diesel consumption of Penguins for inclusion in the GHGE Permit Application process via METS
- 2) associated pollutant loads and emissions profiles from the qualifying combustion plant for inclusion in the PPC Application process via the UK Energy Portal

ETS Permit Application

Source Stream Categorisation - 2024 Hookup and Commissioning

Source	Source Description	Source Category	CO2 (t) (Ref 1 & 2)		Proportion of Total installation emissions
			Forecasted 2024-2025		
F1	Fuel Gas	Major	31269		51.3%
F2	Gas Oil/Diesel	Major	21695		35.6%
F3	HP Flare	Minor	2196		3.6%
F4	LP Flare	Deminimis	372		0.6%
F5	Propane	Marginal	10		0.0%
F6	Acetylene	Marginal	1		0.0%
F7	Flare Pilots	Deminimis	42		0.1%
F8	Import Gas	Major	5412		8.9%
Total			60997		100.0%

Source Stream Categorisation - Post Commissioning

Source	Source Description	Source Category	CO2 (t) (Ref 1 & 2)		Proportion of Total installation emissions
			Avg 2026-38		
F1	Fuel Gas	Major	122936		88.6%
F2	Gas Oil/Diesel	Major	7983		5.8%
F3	HP Flare	Minor	3294		2.4%
F4	LP Flare	Deminimis	559		0.4%
F5	Propane	Marginal	5		0.0%
F6	Acetylene	Marginal	1		0.0%
F7	Flare Pilots	Deminimis	42		0.0%
F8	Import Gas	Minor	3976		2.9%
Total			138796		100.0%

PPC Permit Application

Emissions Profiles

Item No.	Equipment	Fuel type	NOx (mg/Nm3)	SOx (mg/Nm3)	CO (mg/Nm3)	CH4 (mg/Nm3)	VOCs (mg/Nm3)	Dust (PM)	Reference (e.g. vendor OEM guaranties, performance)
1	Solar Taurus 70-10301S	Fuel Gas (50% load)	51	0	31	18	N/A	N/A	Ref 7, Ref 8
2		Fuel Gas (30% load)	179	0	10,918	5,974	N/A	N/A	
3		Diesel	197	49	62	18	N/A	N/A	Ref 7, Ref 8
4	Solar Titan 130-2020502S	Fuel Gas	86	0	125	36	N/A	N/A	Ref 30
5	Emergency Generator 16V4000 P833A	Diesel	N/A	N/A	N/A	N/A	N/A	N/A	Profiles not determined – units operated < 500 hours per year or <1 MWth
6	Firewater Pump 16V4000 P83 3B	Diesel	N/A	N/A	N/A	N/A	N/A	N/A	
7	Firewater Pump 16V4000 P83 3B	Diesel	N/A	N/A	N/A	N/A	N/A	N/A	
8	Firewater Pump 16V4000 P83 3B	Diesel	N/A	N/A	N/A	N/A	N/A	N/A	
9	Inert Gas Generator	Diesel	N/A	N/A	N/A	N/A	N/A	N/A	Profiles not determined - Out of Scope of MCP (Ref 31)

Emissions Loads (including flaring)

Year	NOx (tonnes)	SOx (tonnes)	CO (tonnes)	CH4 (tonnes)	VOCs (tonnes)	CO2 (tonnes)	Dust (tonnes)
2024	137	13	2,134	1,220	3	60,988	N/A
2025	278	7	5,858	3,321	3	143,996	N/A
2026	279	3	6,750	3,810	3	144,528	N/A

Emissions Loads (excluding flaring)

Year	NOx (tonnes)	SOx (tonnes)	CO (tonnes)	CH4 (tonnes)	VOCs (tonnes)	CO2 (tonnes)	Dust (tonnes)
2024	137	13	2,134	1,165	3	58,377	N/A
2025	278	7	5,858	3,239	3	139,994	N/A
2026	279	3	6,750	3,729	3	140,526	N/A