UK Government

Environmental and Emissions Monitoring System (EEMS)

Atmospherics Emissions Guidance

Phase 1 – 2026

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Contents

Document Control

Revision	Issue Date	Description of Changes
Draft	01/09/2025	Issued to Industry for engagement, as ‘Draft shared for comment’
1.0	20/08/2026	Final version for publishing

Abbreviations

Adage	Age Adjustment Factor
AD	Activity Data
AEM	Annual Emissions Report
Amu	Atomic Mass Unit
AWT	Atomic Weight
C_{mol}	Component Molecular Percentage
C_{wt}	Component Weight Percentage
CF	Combustion Factor
CFCs	Chlorofluorocarbons
CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
DECC	Department of Energy and Climate Change
DESNZ	Department for Energy Security and Net Zero
DLE	Dry Low Emission
DLN	Dry Low NOx
EA	Environment Agency
EEMS	Environmental and Emissions Monitoring System
EF	Emission Factor
EF_{tur}	Turbine Emission Factor
Eff	Efficiency

EPER	European Pollutant Emissions Register
F-gas	Fluorinated Gases
FI	Average Annual Fuel Flow Rate
GWP	Global Warming Potential (CO_2 Equivalence Factor)
g/s	Grams per second
GHG	Greenhouse Gas
H_2S	Hydrogen Sulphide
HCFCs	Hydrochlorofluorocarbons
HFCs	Hydrofluorocarbons
LCI	Large Combustion Installation
LCP	Large Combustion Plant
LDAR	Leak Detection and Repair
MAP	Methane Action Plan
MCI	Medium Combustion Installation
MCP	Medium Combustion Plant
M_{com}	Combusted Emission Mass
M_{em}	Total Mass of Emissions
M_{eq}	CO_2 Equivalent Emission Mass
METS	Manage your UK Emissions Trading Scheme
MoDUs	Mobile Drilling Units
M_{mix}	Mass of Combustible Feed in Pre-Combusted Mixture
MMSCFD	Million Standard Cubic Feet per Day
MRV	Monitoring, Reporting and Verification
M_{tot}	Total Mass of Feed
M_{tur}	Annual Mass of Turbine Fuel Consumed

MWT	Molecular Weight
MWT_{ave}	Average Molecular Weight
MW_{th}	Megawatt thermal (Fuel Net Thermal Input)
N	Number of Moles
NAEI	National Atmospherics Emissions Inventory
Nc	Quantity of Components
NCV	Net Calorific Value
N2	Nitrogen gas
N_2O	Nitrous Oxide
NMVOC	Non-methane Volatile Organic Compound
NO_x	Nitrogen Oxides
NSTA	North Sea Transition Authority
OCGT	Open Cycle Gas Turbine
ODS	Ozone Depleting Substances
OEUK	Offshore Energies UK
O&G	Oil and Gas
OGA	Oil & Gas Authority
OGMP 2.0	Oil and Gas Methane Partnership 2.0
Op	Operational Hours
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
OxF	Oxidation Factor
PFCs	Perfluorocarbons
PT	Power Turbine
PRTR	Pollutant Release and Transfer Registers
PPC	Pollution, Prevention and Control

ppmv	Parts per million by volume
ppm wt	Parts Per Million by Weight
S	Sulphur
SEPA	Scottish Environment Protection Agency
SF_6	Sulphur Hexafluoride
SO_2	Sulphur Dioxide
t/t	Tonne(pollutant)/tonne(fuel)
UK	United Kingdom
UKCS	United Kingdom Continental Shelf
US-EPA	United States Environment Protection Agency
UK ETS	United Kingdom Emissions Trading System
UKOOA	United Kingdom Offshore Operators Association
ULSD	Ultra Low Sulphur Diesel
UNEP	United Nations Environment Programme
VOC	Volatile Organic Compound
WONS	Well Operations Notification System
Wt_r	Relative Weight
wt%	Weight Percentage
W_{th}	Turbine Thermal Input

1. Introduction

The UK Government, through the Climate Change Act 2008 **[Ref 1]** has committed to achieving net zero by 2050 using 1990 emissions as a baseline. The Energy White Paper **[Ref 2]** presents the changes that will be required to achieve net zero by 2050 in the UK energy sector and sets out the changes required for the UK oil and gas (O&G) sector. The North Sea Transition Deal (NSTD) **[Ref 3]** is aimed at delivering the commitments set out in the oil and gas chapter of the Energy White Paper and has committed to the reduction of greenhouse gas (GHG) emissions from all offshore O&G operations, to make the UK Continental Shelf (UKCS) a net zero basin by 2050.

1.1 Context

The Environmental and Emissions Monitoring System (EEMS) is the environmental database of the UK offshore O&G industry and is a hosted solution on the UK Energy Portal, accessed via the internet. It has been the central reporting repository for offshore pollutants including GHG emissions over the last two decades and remains strategic in informing the UK National Atmospheric Emissions Inventory (NAEI). The North Sea Transition Authority (NSTA) also utilise EEMS data for informing emissions profiles and benchmarking of the sector in line with the NSTD targets and their 'OGA Plan **[Ref 4]** to reduce UKCS greenhouse gas emissions' published in 2024. The EEMS system is maintained by the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED), which is part of the Department for Energy Security and Net Zero (DESNZ).

OPRED is responsible for regulating environmental and decommissioning activities for offshore O&G operations in the UK. As the environmental regulator of the offshore O&G industry, it is ultimately responsible for EEMS, requiring accurate and timely data to be submitted to the system using a consistent methodology by the UK offshore O&G industry. The data allows the regulator to monitor the environmental performance of the offshore O&G industry and for reports to be generated for other government bodies and by Offshore Energies UK (OEUK) industry association.

OPRED's mission is to drive up the environmental performance of the offshore O&G industry, ensuring they minimise their impact on the environment and support the UK's net zero transition. OPRED's legislative requirements (See Section 2.1) ensure that key elements of EEMS are completed annually by operators in the O&G sector, with this data playing a vital role for recording emissions and discharges, to be analysed and used by OPRED, the NSTA, the UK government, OEUK as well as other stakeholders.

1.2 Scope

1.2.1 Purpose and Limitations of the Phase 1 review

This Phase 1 update focuses on improving the clarity, structure and usability of the EEMS atmospheric emissions guidance. It consolidates and updates existing guidance documents, reflects current regulatory reporting requirements, and introduces a limited number of changes to emissions calculation methodologies and recommended pollutant emission factors. It is not a comprehensive review of all EEMS calculations, emission factors or reporting requirements. Further changes may be considered as part of future phases of the EEMS review project. This guidance also incorporates approved updates and new EEMS NOx emission equations for gas turbine models operating on the UK Continental Shelf (UKCS).

1.2.2 The specific changes that have been implemented

The following changes have been incorporated into this guidance:

- The previous EEMS calculation **[Ref 5]** and guidance documents **[Ref 6]** have been reviewed and consolidated into this single guidance document.

- Guidance has been updated to reflect current regulatory reporting requirements and the role of EEMS in supporting regulatory and UK emissions reporting obligations.

- Atmospheric return-specific guidance has been added for each EEMS atmospheric emissions return that operators are required to submit annually.

- Revised and updated pollutant emission factor recommendations have been introduced for selected pollutants, including NOx, SO_2 and CO, where sufficient evidence supported a change. Greenhouse gas emission factors (CO_2, CH_4 and N_2O) have not been reviewed as part of this Phase 1 update.

    - **NOx default emission factor** for diesel consumption in gas turbines – **0.01724 tNOx/t** as explained in Appendix A2.2 NOx equations for operation on diesel fuel and Explanatory Notes Default Emission Factors for diesel (gas oil) and fuel oil consumption in combustion plant

    - **SO_2 default emission factor** for diesel consumption combustion plant – **0.002tSO_2/t** as explained in Sections 2.6 Combustion Emission Factors and Appendix A3 - EEMS Combustion Default Factors

    - **CO default emission factor** for gas consumption combustion plant **0.006tCO/t** – implemented into this guidance from the OPRED 2015 recommendation for the CO factor as explained in Appendix A3 - EEMS Combustion Default Factors

    - **CO_2 default emission factor** for diesel consumption combustion plant **3.19tCO_2/t** – implemented into this guidance to align with the UK Greenhouse Gas Inventory that is presented on an annual basis to the United Nations Framework Convention on Climate Change.

- New and revised NOx emission equations have been incorporated for relevant gas turbine models, including newer turbine types operating in the UKCS.
    - Compliance monitoring data from the current UKCS offshore fleet of Large Combustion Plant (LCP) and other non-LCP open cycle gas turbines (OCGT) on PPC permits have been reviewed and their profiles properly reflected in the EEMS NOx equation database, for both standard combustion models and for any dry low emission (DLE) / dry low NOx (DLN) models.
    - New equations have been generated for use with the newer gas turbine models and upgrades – See Appendix A2 - Turbine NOx Emission Factor Polynomial Coefficients.
    - The availability of turbine model-specific equations for diesel fuel consumption has been improved in addition to gas fuel consumption, to lower the uncertainty of using standard fixed value defaults (as defined in Appendix A3).
    - The equations for other non-LCP gas turbines are reviewed. However, given that these non-LCP gas turbines are not monitored as frequently as the LCP gas turbines, there is less empirical test data available, and fewer changes have been made. These models will be kept under review in future phases of work.
- Background information, objectives, reporting processes and explanatory text have been restructured and rewritten to improve clarity and consistency. For further information, refer to the explanatory notes at the end of the guidance.

1.2.3 Changes not included in this Phase 1 update

For clarity, this update does not introduce a full review of greenhouse gas emission factors, all EEMS calculation methodologies, or wider system functionality changes within EEMS. Future phases of the EEMS review may consider these areas.

This guidance is:

- Not changing any GHG (CO_2, CH_4, N_2O) default Emission Factors (EF) at this stage (Phase 1) but recommending operators to align CO_2 with ETS reporting including alignment of the default CO_2 emission factors for gas fuel and diesel.
- Not proposing changes to fugitive emissions and tanker loading requirements / methods but clarifying existing requirements. These may form part of future reviews.

1.3 Structure

Please note this guidance is specific to atmospheric emissions that are within the scope of pollutants set in EEMS.

The purpose of this guidance is for use by operators in the offshore O&G industry to assist with reporting of atmospheric emissions. The frameworks that set out these emissions are given in Section 2.

The guidance is structured to:

- provide an overview of the reporting requirements (Section 2);
- explain the approach taken in EEMS to determine quantities of atmospheric pollutants (Sections 2, 3 and Appendix A3) and how this approach is applied to emissions sources (Sections 4, 5, 6, 7, 8, Appendices A2 and A3);
- describe the default emission factors used in EEMS and recommend when it is appropriate to use them (Sections 4, 5 and 6); and
- provide guidance on the EEMS forms used by operators to complete their data submission (Section 3 and Appendix A1).
- provide explanatory notes at the back of the guidance on the origins of many of the default emission factors used in EEMS, with recommendations for further review.

2. Reporting Requirements

2.1 Relevant Legislation

The UK government is a signatory to several international treaties including the United Nations Framework Convention on Climate Change (UNFCCC), the Convention on long-range transboundary air pollution (CLRTAP) and the Paris Agreement Enhanced Transparency Framework (PA-ETF) with obligations to report emissions of gases that pollute the environment. These international agreements have associated national legislation.

The UK left the European Union on 31 January 2020, and the post-transition arrangements took effect from 1 January 2021. Following EU Exit, relevant EU-derived environmental requirements were retained in UK law and amended through EU Exit statutory instruments so that they continue to operate within the UK domestic regulatory framework. For the purposes of this guidance, references to legislation or reporting obligations should therefore be read as references to the relevant UK legislation, retained EU law and subsequent UK amendments, as applicable. This includes the EU Exit amendments relevant to offshore environmental regulation, ozone-depleting substances and fluorinated greenhouse gases, together with the UK Emissions Trading Scheme framework. These changes maintain the requirement for operators to submit annual EEMS atmospherics returns. They clarify that annual reporting must be undertaken in accordance with the applicable UK statutory framework and OPRED reporting requirements.

Legislation requires operators to submit annual emissions data in accordance with qualifying criteria defined in each regulation. The relevant legislative provisions that EEMS reflects are as follows:

- Offshore Combustion Installations (Pollution Prevention and Control) Regulations 2013 (as amended) (OCI PPC Regulations 2013) **[Refs 7 and 8]**
- Fluorinated Greenhouse Gases (F-gas) Regulations 2015 (as amended) **[Refs 9 and 10]**
- Ozone-Depleting Substances Regulations 2015 (ODS Regulations 2015) **[Ref 11]**
- Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 **[Ref 12]**
- UK Pollutant Release and Transfer Register (UK-PRTR) – Implementing the requirements of the UN-ECE Kiev Protocol on PRTRs **[Ref 13]**
- The OGA Strategy (In accordance with the Petroleum Act 1998) **[Ref 14]**
- OGA Plan (reduce UKCS Greenhouse Gas Emissions) – requirement to report GHG emissions in Carbon Dioxide equivalent **[Ref 4]**

EEMS atmospherics data is provided annually and used in the compilation of the National Atmospheric Emissions Inventory (NAEI) which comprises the UK GHG inventory (GHGI) and the air quality pollutant inventory (AQPI) **[Ref 15]**. EEMS data is used within the NAEI evidence base for assessing UK progress in relation to national targets e.g. carbon budget assessments.

An overview of the EEMS reporting requirements and reporting process is shown in Table 1 and Figure 1:

Table 1: EEMS Reporting Requirements

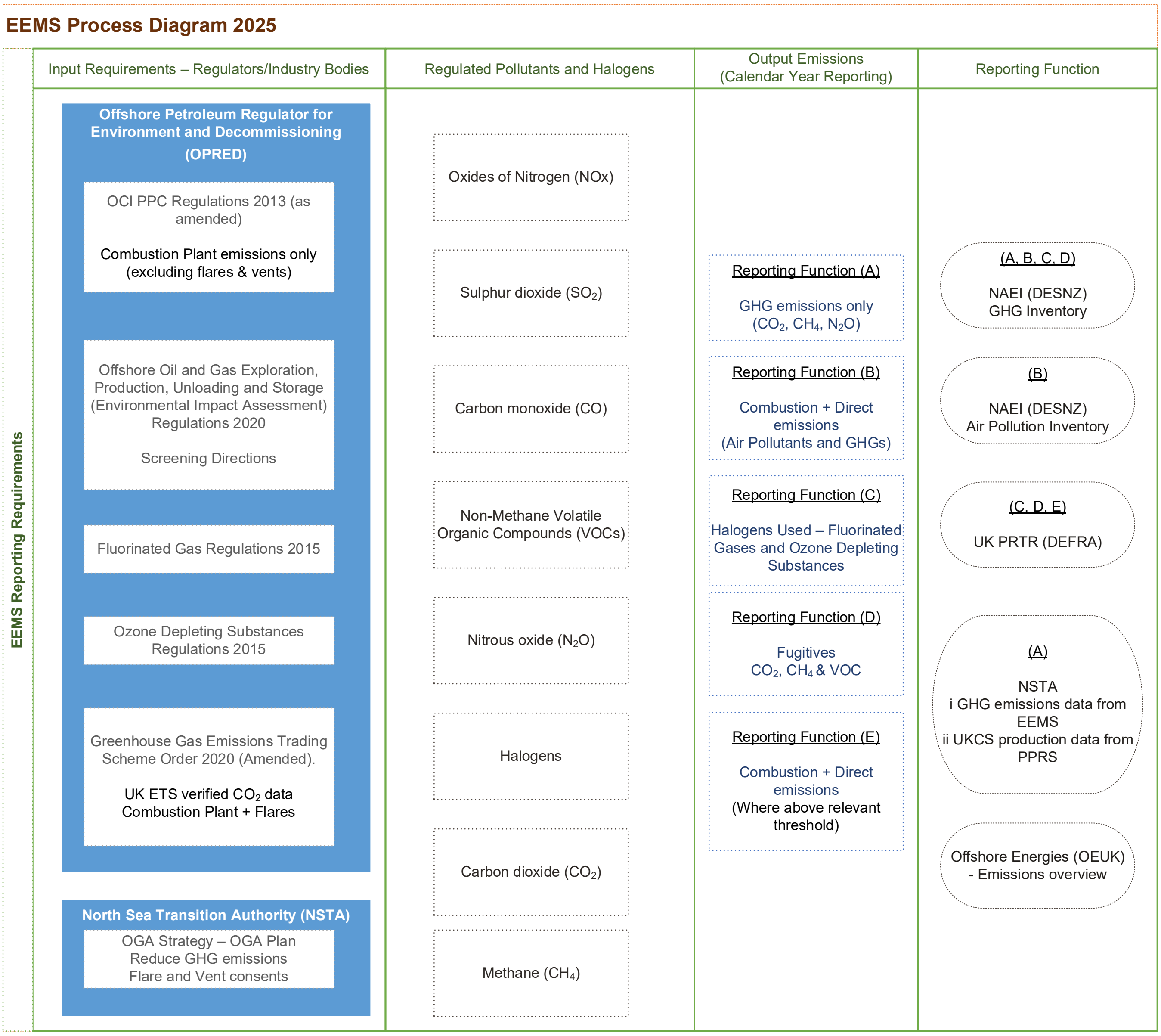
EEMS Reporting Requirements:				
GHGs / Pollutants	**UKCS Regulator and Reporting Obligations** **Offshore Petroleum Regulator for Environment and Decommissioning (OPRED)**	**UKCS Regulator and Reporting Obligations** **North Sea Transition Authority (NSTA) - Oil & Gas Authority (OGA)**	**International Reporting Obligations** **UNFCCC** **UN-ECE / CLRTAP** **Paris Agreement**	**UN-ECE Kyiv Protocol**
Carbon Dioxide (CO_2)	There is an expectation to report CO_2 emissions into EEMS aligned with MRV data of the UK ETS, where applicable.	The OGA Strategy [Ref 14] OGA Plan to reduce UKCS greenhouse gas emissions [Ref 4]	National Inventory System (GHG and Air Quality)	UK – Pollutant Release and Transfer Register (PRTR) Regulation (EC) No 166/2006
Oxides of Nitrogen (NOx)	Offshore Combustion Installations (Pollution Prevention and Control) Regulations 2013 (as amended) - Regulation 9(2) [Refs 7 and 8] Offshore Oil and Gas Exploration, Production,	N/A	National Inventory System (GHG and Air Quality)	UK – Pollutant Release and Transfer Register (PRTR) Regulation (EC) No 166/2006

	Unloading and Storage (Environmental Impact Assessment) Regulations 2020 [Ref 12]			
Sulphur Dioxide (SO_2)	Offshore Combustion Installations (Pollution Prevention and Control) Regulations 2013 (as amended) - Regulation 9(2) [Refs 7 and 8] Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 [Ref 12]	N/A	National Inventory System (GHG and Air Quality)	UK – Pollutant Release and Transfer Register (PRTR) Regulation (EC) No 166/2006
Carbon Monoxide (CO)	Offshore Combustion Installations (Pollution Prevention and Control) Regulations 2013 (as amended) - Regulation 9(2) [Refs 7 and 8] Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact	N/A	National Inventory System (GHG and Air Quality)	UK – Pollutant Release and Transfer Register (PRTR) Regulation (EC) No 166/2006

	Assessment) Regulations 2020 [Ref 12]			
Methane (CH_4) – Methane slip (Combustion plant)	Offshore Combustion Installations (Pollution Prevention and Control) Regulations 2013 (as amended) – Regulation 9(2) [Refs 7 and 8] Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 [Ref 12]	OGA Plan to reduce UKCS greenhouse gas emissions [Ref 4]	National Inventory System (GHG and Air Quality)	UK – Pollutant Release and Transfer Register (PRTR) Regulation (EC) No 166/2006
Methane (CH_4) – Flare, venting & fugitives	Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 [Ref 12]	The OGA Strategy [Ref 14] OGA Plan to reduce UKCS greenhouse gas emissions [Ref 4]	National Inventory System (GHG and Air Quality)	UK – Pollutant Release and Transfer Register (PRTR) Regulation (EC) No 166/2006
Non-methane Volatile Organic Compounds (NMVOCs)	Offshore Combustion Installations (Pollution Prevention and Control) Regulations 2013 (as amended) [Refs 7 and 8]	N/A	National Inventory System (GHG and Air Quality)	UK – Pollutant Release and Transfer Register (PRTR)

	Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 [Ref 12]			Regulation (EC) No 166/2006
Nitrous Oxide (N_2O)	Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 [Ref 12]	The OGA Strategy [Ref 14] OGA Plan to reduce UKCS greenhouse gas emissions [Ref 4]		UK – Pollutant Release and Transfer Register (PRTR) Regulation (EC) No 166/2006
Fluorinated Greenhouse Gases (F-gases)	Fluorinated Greenhouse Gases (F-gas) Regulations 2015 and 2018 (as amended) [Refs 9 and 10]	N/A		UK – Pollutant Release and Transfer Register (PRTR) Regulation (EC) No 166/2006
Ozone Depleting Substances (ODS)	Ozone-Depleting Substances Regulations 2015 (ODS Regulations 2015) [Ref 11]	N/A		UK – Pollutant Release and Transfer Register (PRTR) Regulation (EC) No 166/2006

Figure 1: EEMS Reporting Process



2.2 Reporting of Emission Gases

Operators must report atmospheric pollutants which are within the scope of the current UK policy and legislative requirements as set out in Section 2.1. They cover both GHG emissions and other emissions. In this document, these emissions are referred to in general as ‘emission gases’ and include:

- Carbon Dioxide (CO_2);
- Nitrogen Oxides (NO_x);
- Nitrous Oxide (N_2O);
- Sulphur Dioxide (SO_2);
- Carbon Monoxide (CO);
- Methane (CH_4);
- Non-methane Volatile Organic Compounds (NMVOCs) - volatile organic compounds’ (VOC) shall mean organic compounds from anthropogenic and biogenic sources, other than methane, that are capable of producing photochemical oxidants by reactions with nitrogen oxides in the presence of sunlight **[Ref 16]** and
- Halogens – Fluorinated Greenhouse Gases and Ozone Depleting Substances.

Atmospheric emissions are required to be reported in EEMS as the total annual mass of that pollutant and / or GHG emissions.

Activity data and mass emissions must be submitted for installations from the following sources:

- Combustion plant emissions arising from generation of power and/or heat from the burning of gas, diesel (gas oil) and fuel oil - split by plant categories ‘turbines’, ‘engines’, and ‘heaters/boilers’ from their point sources (exhaust stacks) **[Refs 7 and 8]**;
- Emissions from Fluorinated Greenhouse Gases **[Refs 9 and 10]**
- Emissions from Ozone Depleting Substances **[Ref 11]**

In addition, the following sources are reported in-line with UK pollutant release and transfers register (UK-PRTR) and national atmospherics emissions inventory (NAEI) reporting requirements the activity data and mass emissions must be submitted by installations with the following sources:

- Emissions from drilling activities: Installations and Mobile Drilling Units (MoDUs), Well testing and diesel use **[Refs 13 and 15]**.
- Combustion flares burning associated gas from point sources (flare stack(s)) **[Refs 13 and 15]**.
- Direct emissions from venting, direct process emissions, oil loading to shuttle tankers from storage tanks on installations and fugitive emissions **[Refs 13 and 15]**.

Activity data is the total use of fuels or materials consumed or produced by a process relevant for the calculation-based monitoring methodology, mass in tonnes or (for gases) volume in normal cubic metres. For EEMS purposes total use returns are required in mass (tonnes) **[Refs 13 and 15]**. It is best practice that UK Emissions Trading Scheme (UK ETS) verified activity data should be used, where applicable in the determination of CO_2 mass emissions for combustion plant and flares.

2.3 Determination of Mass Emissions

2.3.1 General approaches

The determination of the mass emissions of a pollutant is effectively based on the relationship between the mass concentration e.g. mg/Nm^3 and mass rate e.g. g/s, and the integration of mass rate of the emission gas over time, emitted from a particular emission source or group of similar emission sources, as defined in Section 2.2. The integration of mass rate over time gives the total mass emission e.g. in tonnes for the reporting year.

A clear distinction can be made between the following three monitoring and reporting methods:

- The use of a Continuous Emissions Monitoring System (CEMS) also referred to as an Automated Monitoring System (AMS), in which the concentration and mass rate of an emission gas is **measured** at a particular frequency by an in-situ gas analyser and is continually reported within the CEMS reporting user interface.
- The use of a Predictive / Parametric Emissions Monitoring System (PEMS) also referred to as a Continuously Calculated Emissions Monitoring System (CCEMS), in which the concentration and mass rate of an emission gas is **estimated from measurements of surrogate process parameters** taken at a particular frequency and is continually reported within the PEMS user interface.

The use of representative Emission Factors (EFs) for the reporting period, typically based on the activity level of the process, along with any other relevant factors such as oxidation factor (OxF). Further discussion provided in section 2.7.1 EFs typically express the relationship between the mass of a particular emission gas per unit of activity data such as kg-emission/kg-fuel-input (engineering units kg/kg) or kg-emission/unit-of-fuel-energy-input (engineering units kg/kWh or kg/MJ). Representative emission factors for some emission-gases e.g. NOx and CO are derived from periodic stack emission monitoring as discussed in section 2.7.2. Others are derived from fuel composition (e,g, CO2 and SO2). Conversion between different EF engineering units for combustion processes may require knowledge of the fuel net calorific value (NCV) and density; e.g. from an energy to a mass basis. EEMS EF are consistently expressed on an engineering unit mass basis of “tonnes of emission-gas per tonne of fuel” (equivalent to kg/kg) whereas other EFs in industry literature may be more commonly based on “mass of emission-gas per energy unit” e.g. kg/kWh, lb/MMBtu, te/GJ.

Where gas chromatograph data of the fuel gas, flare gas, or vent gas is available, it should be used to calculate EF's for CO_2, CH_4, NMVOC and SO_2 as being more accurate than generic UKCS EF defaults as described in Section 2.6 and Appendix A3

The approach selected for determination of mass emissions from the three main reporting methods outlined above must be agreed with OPRED via an installation's PPC permit for the emission gases in question. CEMS and PEMS are potential continuous approaches to emission monitoring that offer higher granularity of emission profiles (on an hourly, daily, and monthly basis), where regularly maintained and calibrated and do not rely on simple EFs. On the other hand, simple EFs are a relationship that have been empirically determined as suitable for applying to measured activity data to give representative estimates of mass emissions for specific emission gases.

This guidance document focuses on the use of representative EFs as this is the most common approach currently adopted in the offshore O&G sector for the calculation and reporting of mass emissions to EEMS, as evidenced in the annual returns. Where approved PEMS are in place, the results from these systems may be used directly for EEMS reporting in-lieu of the EF approach, where agreed with OPRED via an installation's PPC permit. OPRED has drafted a PEMS technical guidance note (TGN) in July 2026 to aid operators implement PEMS systems within PPC permits at UKCS installations. This TGN builds on the OEUK PEMS technical note from May 2023.

2.3.2 Examples of the Emission Factor Reporting Method

Where direct monitoring results are not available, emissions calculations (to calculate the mass of CO_2 for example from a specified activity) use activity data (AD), such as total fuel consumption or flow to flare/vent, a related emission (EF) and only for combustion activity either an assumed standard oxidation factor (OxF) or otherwise approved combustion efficiency. The masses of each emission gas can be calculated by multiplying the AD by the EF and by an OxF:

$$M(is) = AD(s) \times EF(is) \times OxF(is) \qquad \text{2-1}$$

Where

M(is) is the emitted mass of a specific emission gas(i) for a given source(s);

AD(s) is the source(s) activity data;

EF(is) is the emission factor for the emission gas(i) relevant to the emission source(s); and

OxF(is) is the oxidation factor for the emission gas(i) relevant to the emission source(s).

For gas venting, direct process emissions and cold flaring there is no combustion reaction, and an oxidation factor is not applied, these emissions should be reported as a vent category or where applicable in direct process emissions category and not as combustion – see sections 5.1 and 5.2 for further detail. Any pollutant emissions in a vent category are the emitted mass of those pollutants, which are determined from the gas composition. The mass of gas vented must be entered into EEMS, it calculates pollutants if the gas composition in the 'Export (Installation)' return is populated.

2.3.3 PPC Compliance Reporting – Total mass emissions

In calculating and reporting annual mass emissions to EEMS, for permitted installations the permit holder may use the standard EEMS EFs within the system. However, to achieve higher accuracy, use of plant specific EFs that have been determined as being more relevant to the combustion plant on the installation, is preferable in accordance with the methods described in Table 2.1. The operator should undertake a comparison of any proposed plant specific EFs against the default values / equations. Justification for using such plant specific EFs must be presented to and agreed with OPRED as part of a PPC permit variation. If the latter approach is to be adopted, then the permit holder should submit their proposed alternative approach to OPRED for review at least 3 months before the permit holder's planned date for the use of the alternative approach. For information on reporting emissions from combustion plant on fixed installations that do not require PPC permits refer to 'small emitters' in Section 8

For example, the results from periodic stack emissions monitoring (see below) may be used for generating accurate plant-specific EFs for use in subsequent EEMS reporting, following review and agreement with OPRED.

2.4 Emission Factors

For EFs, there are several reporting methods that can be used depending on the nature of the process by which an emission gas is formed. Table 2.1 shows the most common methods for deriving EFs and their applicability.

EFs should be derived using the method that minimises uncertainty in the data, dependent on the formation process of the emission gas and the available empirical data analysis. Some EFs may require a combination of methods to achieve a sufficiently low level of uncertainty under the PPC permit.

Gas composition can be used to determine EFs based on the component mole percentages of the gas, which can be used directly to determine EFs for vented or fugitive emissions. Gas composition can also be used to determine the quantities of combustion products from stoichiometric reactions which are used with the OxF to calculate relevant EFs.

NO_x emissions from turbines (the primary source of NO_x on the UKCS), however, require special consideration since emissions are largely via thermal formation (Section 2.7.1) and are sensitive to many factors including load, maintenance, combustion technology and any abatement equipment. From the mass of fuel consumed, net calorific value and operating hours, the average thermal input for each turbine can be determined and used to estimate a suitable EF.

Measured data is preferred when traceable to measurement standards because methods derived from measurements ensure that estimates are directly representative of the fuels burned and prevailing operating conditions across the period of measurement, thus improving accuracy. In the absence of appropriate data or emissions monitoring systems, default EFs can be used. Table 2.1 below summarises the preferred methods to derive EFs.

Table 2.1: Methods for Deriving Emission Factors

Reporting Method	Method	Summary - explanation
A)	Directly measured EFs.	EF derived from empirical test data e.g. emissions monitoring data, as a function of activity data or as a function of load or thermal input. Site specific EFs must be discussed and agreed with OPRED prior to reporting. Emissions monitoring requirements are stipulated by OPRED for offshore combustion plant under the permitting process **[Ref 29]**. 2.7 Combustion Emission Factors (EF Activity Type 2)
B)	EFs from fuel compositional analysis based on first principle analytical methods – typically for well-defined emission source streams where the emission gas is a function of the known fuel composition.	EF determined by compositional analysis data e.g. fuel gas online gas chromatograph or periodic gas samples collected / analysed EF. Only applicable for specific pollutants, e.g. carbon dioxide, sulphur dioxide, where emissions are directly proportionate to the fuel composition. 2.5 Compositional Analysis (EF Activity Types 1 and 3)
C)	EFs from compositional analysis based on process models – typically for more complex emission source streams or processes.	Process dynamic simulation models e.g. HYSYS / UNISIM models Typically used where online composition is not taken and/or

		where it is difficult to access the process stream safely for the purpose of periodic sampling. Section 2.5 Compositional Analysis (EF Activity Types 1 and 3)
D)	Default EFs – from empirical or other representative test / analysis.	EEMS published default factors – see Section 2.7 and Appendix A3.

One or more of methods A), B), or C) are appropriate for the pollutant concerned and are preferred approaches to assessing emission factors to be used for EEMS reporting. Emission Factors derived by these methods should be compared against the appropriate default emission factors established in method D). Where there are differences, a site-specific or plant-specific EF based on methods A), B), or C) should be considered instead of the defaults in method D). In the absence of data using method(s) A), B), or C), then the default EF in method D) should be used.

EFs can be characterised and split into different **activity types** depending on the emission type and emission source category as shown in Table 2.2 for the current scope of atmospheric emission returns in EEMS.

Table 2.2: Emission Factors Characterised by Activity Type

EF Activity Type	Emission Type	Emission Source Category	Relevant Section of Guidance
1	**Combustion emissions** directly determined from fuel composition and combustion efficiency (CO2, SO2). Local EFs determined using gas composition data if available (preferably) - alternatively default EFs may be used.	• Flaring • Turbines • Engines • Heaters / Boilers • Other plant equipment	Section 2.6, Section 4, Section 6
2	**Combustion emissions** dependent upon activity data such as fuel consumed and EFs derived in relation to combustion plant type and load (NOx, CO, CH_4, NMVOC, N_2O).	• Flaring • Turbines • Engines • Heaters / Boilers • Other plant equipment	Section 2.7, Section 4 Appendix A2
3	**Direct emissions** without combustion (CH_4, NMVOC, CO_2 venting). Local EFs determined using gas composition data if available - alternatively default EFs may be used.	• Gas venting including cold flaring • Direct processes • Oil loading	Section 5.1, 5.2 Direct Process Emissions 5.3 Oil Loading Section 6
4	**Inventory derived emissions** from usage or stock changes as it is assumed all chemicals used are emitted (halogenated gases).	• Refrigeration • Fire-fighting • Cleaning • Analytical agents	Section 7

5	**Fugitive emissions** are based on EEMS default or knowledge of component numbers including joints, valves and pumps, and the application of a fugitive default EF for each category of component. This gives a total emission figure, and gas composition is used to calculate individual components (CH_4, NMVOC & CO_2).	• Joints • Valves • Pump seals	Section 2.8.4 Section 5.5

Please refer to the following Sections for the relevant default EFs:

- Section 4 outlines when to use default EFs for calculating the emissions from the combustion of fuel gas and liquid fuels and from flaring.
- Section 5 outlines when to use default EFs for calculating the emissions from venting, direct processes, oil loading and fugitives.

2.5 Compositional Analysis (EF Activity Types 1 and 3)

It is preferable to derive EFs from fuel and gas composition, where there is direct relationship between the pollutant and compositional analysis of the fuels. This applies in particular to Activity Types '1' and '3' in Table 2.2.

This Section of the guidance explains how the gas composition reported by operators is used in EEMS to calculate the mass fractions of individual species, which are then used as EFs directly or to determine EFs from combustion.

UK ETS permitted installations must use their gas compositional data for use in EEMS calculation factors, because this is data that has been verified under the UK ETS.

The UK ETS data, where available should be used to derive the CO_2 emission factor using all the components of the gas composition and to derive VOCs, CH_4, N_2 and H_2S components for use in EEMS calculations, where it is relevant.

Where composition data is derived from either a process simulation model or measured analytically (i.e. via gas chromatographs), any gas mixture calculations must align with BS EN ISO 6976 (2016) and ISO 14912:2003(E) **[Refs 17 and 18]**.

The composition of these gaseous mixes is normally expressed as component mole percentages (C_{mol}) i.e. what percentage of the total molecules are made up from each species. This is normally measured using gas chromatography, either online using an installed gas chromatograph, or offline using laboratory chromatograph to analyse samples of gaseous mixes taken from an installation's fuel, flare, or vent systems using an approved analytical standard.

Component mole percentages can be used to calculate emission factors for directly vented or fugitive and certain combustion emissions. Gas composition data, reported on a dry gas basis, typically includes component mole percentages for:

- CH_4
- C2-C8 and above hydrocarbons (VOCs)
- CO_2
- N_2
- H_2S

By combining these mole percentages with their molecular weights, it is possible to calculate the component weight percentages (Cwt) and the average molecular weight (dry) of the emission gas mix (MWT_{ave}).

Component mole percentages must be submitted by users of EEMS for all fuel, flare, and vent gases. Fuel gas can be used as a default, in the absence of the flare and vent composition data, but this may lead to inaccuracies. In addition, the VOC molecular weight (VOC MWT) should also be submitted. If unavailable operators are to use the default for the UKCS of 40.

This is representative of the proportions of non-methane hydrocarbons in the typical associated gas, where Ethane, Propane and Butane are the main non-methane hydrocarbon components.

The relative weight (Wt_r) for an emission gas component (i) can be calculated from its component mole percentage and molecular weight.

$$\mathbf{Wt_r(i) = C_{mol}(i)/100 \times MWT(i)} \qquad 2\text{-}2$$

The average molecular weight of the mix (MWT_{ave}) is calculated as the sum of all the relative weights, Wtr(i) in the mix.

$$\mathbf{MWT_{ave} = \textstyle\sum_i Wt_r(i)} \qquad 2\text{-}3$$

From MWT_{ave} the standard molar density of the mix can be calculated using Equation.

$\rho_{std} = MWT_{ave} / V_{mol}$ g . m-3

Finally, the component weight percentage (C_{wt}(i)) can be calculated:

$$\mathbf{C_{wt}(i) = Wt_r(i) / MWT_{ave} \times 100} \qquad 2\text{-}4$$

The above calculation should be performed for all available (and defaulted) gas compositions i.e. fuel, flare, and vent. They are required in the emission source calculations that follow, where these are based on gas composition analysis.

From the component weight percentages (Cwt(i)) the mass of each emission gas component in the original mix can be calculated:

$$\mathbf{Mmix(i) = C_{wt}(i) / 100 \times M_{tot}} \qquad 2\text{-}5$$

This is only valid if the entire sample consists only of the listed gases i.e. the sum of C_{mol} = 100%. If this is not the case and there is a contribution from other gases, the calculation will need to take these into account.

The VOC MWT(i) varies depending on the fuel gas used and where the VOC MWT(i) is unknown it is acceptable to use the default value of 40. Use of this default value results in only a minor source of error in the calculation of the EF: generally <0.5% error for gases with methane component weights of >25%, although relatively high component weights of ethane magnify the error.

EEMS only requires key gas components to be entered into the returns, this is because in the absence of inerts in the fuel gas there is no benefit calculating gas specific combustion factors or in not adopting the average VOC molecular weight value for all gas mixes.

If no specific gas composition data is available, the EEMS database uses default emissions factors based on a typical composition which is built into the system and calculates any required fields if the gas composition fields are left empty as standard.

2.6 Combustion Emission Factors (EF Activity Type 1)

EFs for combustible components of fuels relate to the amount of combustible fuel(s) consumed to the amount of combustion products produced and are based on the chemical equation of the combustion reaction.

Default EFs for CO_2, CH_4, non-methane VOCs (NMVOC) and SO_2 are provided in EEMS to enable the calculation of these emissions, where gas composition data is not available. EEMS default EFs are derived from chemical equations governing the chemical reaction process, these are explained in Appendix A3 .

2.7 Combustion Emission Factors (EF Activity Type 2)

EFs for combustible components of fuels that are not determined by stoichiometric combustion of gas components as described in Section 2.6, they are more relevant to emission gases that fall under EF Activity Type '2' in Table 2.2. They relate to mechanisms of emission gas formation that rely on alternative characteristics of the combustion plant or combustion flares and the amount of combustion products produced are not simply based on the balanced chemical equation of the combustion reaction. The most common emission gases of this activity type include NO_x, CO, and UHC. Some part of UHC, due to incomplete combustion may comprise Methane (CH_4) manifested as 'methane-slip', with the rest as NMVOCs.

2.7.1 General Principles

NO_x emissions from combustion plant and combustion flares may be formed via a combination of different formation mechanisms. The most significant of which is generally 'thermal NOx'. Thermal NO_x is produced by the high temperature oxidation of the Nitrogen found in the combustion air. In combustion plant such as gas turbines, engines, and heaters / boilers, thermal NO_x is sensitive to design specifics of the combustion burners / chamber (including firing temperature and residence time) as well as to the operating load of the plant. For gas turbines significant differences occur between Standard Annular Combustion (SAC) and lean-burn Dry Low NO_x (DLN) / Dry Low Emission (DLE) combustion burner designs, which are the two main alternative design principles utilised in the UKCS. Even within each design category (SAC or DLN / DLE) there may be significant differences between different combustion plant equipment models and designs. In addition to the generally predominant thermal NOx, fuel-bound-NO_x may also be produced where there are appreciable amounts of nitrogen in the fuel gas mixture. Whilst this is true generally for a fuel such as residual oil or coal, in the context of UKCS combustion plant, fuel-bound NO_x is only relevant in cases where fuel gas or flared gas mixtures contain an appreciable proportion of Mol% as nitrogen. Empirical experience from the results of UKCS stack emission tests indicates that the additional impact of fuel-bound NO_x is worth considering for turbines and engines where fuel gas mixture contains greater than 2% Mol% of Nitrogen. Most UKCS fuel gas mixtures reported to EEMS (in common with gas compositions used under UK ETS calculation) contain less than this 2% N_2. Where this is not the case operators are encouraged to re-evaluate plant-specific NO_x factors aligned with higher % N_2 in their fuel, based on their empirical test results. A third NOx formation mechanism called 'prompt NOx' thought to occur due to the reaction of atmospheric nitrogen with combustion radicals during early stages of combustion is less significant in gas turbines.

CO in combustion plant is a product of incomplete combustion, although the reasons may be nuanced. One reason can be insufficient residence time within the combustor. Another can be incomplete mixing to complete the final stage of fuel carbon oxidation. In general, these phenomena increase away from the optimum design load of the combustion plant. CO emissions are generally lowest closest to the rated design duty of SAC gas turbines. NO_x emissions which (due to firing temperature) are generally highest at such rated duties. Whereas, for DLN or DLE combustion plants where the combustion systems are more complex, CO emissions may be more variable; especially where incomplete mixing can occur in lean-burn systems when mechanical device or control instrumentation device tolerances are not maintained, given that such devices are critical to effective lean-burn combustion.

UHC emissions from combustion plant and combustion flares, like CO emissions, are generally a product of incomplete combustion, the CH_4 component of which is generally referred to as 'methane-slip'. Again, this can vary depending on combustion plant or flare type, duty / load, and atmospheric conditions. Combustion plant that are lean-burn / DLE systems may be more sensitive to poor maintenance practices than their SAC counterparts or if the combustion parameters are not mapped and tuned correctly.

2.7.2 Evolution of Emission Factors

EEMS provides different reference emission factors for different types of combustion plant and combustion flares, based on empirical experience. Many of these originated in work undertaken by UKOOA and partner organisations in the 1980's and 1990's as the UKCS was expanding. More recent work has been undertaken based upon industry empirical test data, most of which has been collected via compliance monitoring required under PPC permit conditions. Following the implementation of the LCP BREF (2021) **[Ref 19]**, there is a permit requirement for annual emissions monitoring of LCP (Open Cycle Gas Turbines) OCGTs.

This document reflects the latest analysis undertaken by OPRED based on the empirical test data. In particular, it reflects an up-to-date review of NO_x emission factors for gas turbines, and preliminary assessment of other combustion plant emission factors – refer to Appendix A2 Turbine NOx Emission Factor Polynomial Coefficients. Further work being coordinated by OPRED is expected to refine the analysis of CO and UHC (including Methane-slip) emissions and review of other relevant emission factors, as more empirical data is collated and will be incorporated in Phase 2 guidance.

2.7.3 Turbine NO_x Emission Factors (EF Activity Type 2)

NO_x emissions from turbines requires special consideration. The EF varies with combustion firing temperature, which varies with load, which in turn is related to the rate of fuel combustion or, over a fixed period, to mass of fuel used. Turbine NO_x emissions are the primary source of NO_x from offshore production installations. The EF is dependent on the type of turbine and the load of the turbine, which relates to the rate of fuel combustion.

In the absence of directly measured data or emissions monitoring systems, the following information should be submitted to determine the EF for turbine NO_x emissions:

- turbine make and model;
- EEMS turbine reference (previously referred to as 'UKOOA' reference);
- fuel oil / fuel gas mass consumption (activity data);
- turbine operating hours; and
- average net calorific value (NCV).

The annual average fuel flow rate is calculated using the mass of fuel consumed annually and the annual hours of operation.

$$Fl = M_{tur} / Op \qquad 2\text{-}6$$

Where:

- M_{tur} is the mass of gas / liquid fuel consumed by the turbine annually (te);
- Op is the number of hours of operation for the turbine in a year (hr); and
- Fl is the average annual gas / liquid fuel flow rate (te hr^{-1}).

The average fuel net thermal input of the turbine is then found:

$$W_{th} = Fl \times NCV / 3600 \qquad 2\text{-}7$$

Where:

- NCV is the average calorific value of the fuel (MJ te^{-1});
- W_{th} is the thermal input of the turbine (MW(th)); and
- 3600 converts the result to appropriate time units (hours to seconds).

NO_x emissions are dependent on the type and power of the turbine. SAC gas turbines, NOx emissions increase with load and increase in flame temperature. The actual relationship can be expressed as an empirical second order polynomial relating the average fuel thermal input of the turbine (W_{th}) in MW to the NO_x EF in terms of tonnes of NO_x emissions per tonne of fuel input:

$$EF_{tur}(NO_x) = a + b \times W_{th} + c \times W_{th}^{2} \qquad 2\text{-}8$$

Each make and model of SAC turbine has an assigned EEMS reference and an approved set of polynomial coefficients a, b, and c. The coefficients are turbine specific and can be found in Appendix A2 . There are also three generic turbines listed that are to be used as a default for turbines not listed in Appendix A2.

Note: The NO_x emission factors for SAC gas turbines should not be used for DLN / DLE gas turbines. This is because DLN/DLE emissions are a function of the effectiveness of the lean-burn control of combustion and are not a direct function of load or fuel thermal input. Appendix A2 includes recommendations relating to selection of suitable DLE / DLN emission factor(s).

The NO_x mass emission (tonnes) from each SAC turbine can then be calculated by multiplying the mass of fuel input (tonnes) by the NO_x emission factor in te-NO_x/te-fuel:

$$M_{tur}(NO_x) = EF_{tur}(NO_x) \times M_{tur} \qquad 2\text{-}9$$

The total gas / liquid fuel consumed can be calculated by summing the mass of fuel for each turbine:

$$M_{tot} = \sum tur\ M_{tur} \qquad 2\text{-}10$$

The total NO_x emission can be calculated by summing the mass for each turbine:

$$M_{em}(NO_x) = \sum tur\ M_{tur}(NO_x) \qquad 2\text{-}11$$

An effective NO_x emission factor for all turbines can then be inferred by:

$$EF(NO_x) = M_{em}(NO_x) / M_{tot} \qquad 2\text{-}12$$

2.8 Direct Emissions (EF Activity Type 3)

Direct emissions occur in the absence of combustion, when gases are emitted directly to the atmosphere from individual process components such as venting, loading from cargo / storage tanks and fugitives.

$$EF(i) = C_{wt}(i) / 100 \qquad \text{2-13}$$

In other words, the EF for direct emissions are equal to the composition weight percentages calculated from the composition mole percentages and molecular weights of the released gas mix.

The mass of each emissions gas can then be determined and summed for each direct emission source:

$$M(i) = EF(i) * M_{tot} \qquad \text{2-14}$$

Further information on the calculation steps and emissions factor defaults is provided in Section: 5 Default Emission Factors: Direct sources & Appendix: A1.2 Direct – Installation (AtmosDirectInst)

This section has been identified for future improvement, as noted in Table 3.2, Future phase review areas.

2.8.1 Direct Emissions of Carbon Dioxide

CO_2 emissions may occur at UKCS O&G installations where the removal of constituent GHG from petroleum occurs whether by a chemical or physical process. The commonest relevant process is the stripping of CO_2 in an ‘amine plant’ to reduce the inherent CO_2 in the produced hydrocarbon gas to acceptable levels to satisfy either the entry specification of the export pipeline to shore, or for entry or exit specification of an onshore reception / processing gas terminal.

Where the CO_2 is being removed from hydrocarbons (e.g. where there is an amine plant on an offshore installation) suitable offline calculations should be undertaken (preferably based on metered flow rates) to quantify the mass emissions associated with CO_2 venting (direct emission of process CO_2).

It should be noted that the GHG Emissions Trading Scheme (Amendment) (No.2) Order 2024 **[Ref 20]** included process emissions from CO_2 venting from upstream oil and gas. This is a new regulated activity introduced in 2025 for upstream O&G installations already regulated under a UK ETS permit. The expectation is the reporting of direct process CO_2 emissions to EEMS should align with the monitoring, reporting, and verification data submitted via the UK ETS and following the guidance **[Ref 21]**. Operators should seek specific guidance from OPRED should EEMS reporting clarification be required.

2.8.2 Direct Emissions of Sulphur Dioxide

There are no direct emissions of SO_2 because it is not a standard component within UKCS associated gas compositions and by default are given EEMS default EFs of zero for all direct emission operations.

SO_2 emissions are generated by combustion of sulphur compounds in fuels e.g. H_2S as described in Appendix A3.3.

2.8.3 Direct Emissions of Methane and NMVOC

Offshore transfer of crude oil to tankers may contribute to estimates of total facility CH_4 and NMVOC emissions.

The emission source 'Oil Loading' in EEMS relates specifically to the emissions generated during transfer of crude oil or condensate from an offshore installation's storage tanks to the cargo storage tanks of a third-party shuttle tanker (Ship). These emissions from 'Oil loading' are categorised in EEMS under the emission category 'Ship'. For transparency, the convention in EEMS is that the oil loading emissions should be reported separately to other sources of vented emissions on the installation and therefore they should not be reported under the emission source 'Gas Venting'.

It should be noted that this category of emissions is only relevant where the installation exports crude oil or condensate via offshore shuttle tanker as opposed to via pipeline to shore. This therefore applies to installations which are Floating Production Storage and Offloading (FPSO) vessels, Floating Storage and Offloading (FSO) vessels, Floating Storage Units (FSU) or platforms which store crude oil in cargo tanks / cells on the installation and export the crude via offloading in batches using offshore tanker loading buoys.

2.8.4 Fugitive Emissions

Fugitive emissions are unintentional releases from plant components. Any pressurised equipment has the potential to leak, typically occurring through valves, flanges, seals, or related equipment associated with "live" hydrocarbon system components (API, 2009) **[Ref 22]**.

The current EEMS methodology for estimating fugitive emissions dates back over a decade, and where operators have more advanced and accurate methods for estimating fugitive emissions e.g. within their Leak Detection and Repair (LDAR) or Oil and Gas Methane Partnership 2.0 (OGMP 2.0 plans) they may use such data instead.

EEMS contains a traditional methodology for calculating estimates of CO_2, CH_4 and NMVOC fugitive emissions gases based on data input by the operator in relation to the number of various plant component types:

- Connections;
- Valves;

- Open Ended Pipes;
- Pumps; and
- Other.

The plant component types have default EFs depending on installation, hydrocarbon type (gas, light crude and heavy crude) and are adjusted for the age of the installation to estimate the effect of age and build-technology on the likely leak rates.

EEMS also requires the number of each plant component type in hydrocarbon service on all installations to be submitted.

Gas composition must be entered in EEMS, or fugitive pollutants will not be calculated under this methodology.

The mass of each emission gas (CO_2, CH_4 and NMVOC) is found for each plant component using:

$$M_{em}(i) = Nc \times EF \times Ad_{age} \times C_{wt}(i) / 10 \qquad 2\text{-}15$$

Where:

- $M_{em}(i)$ is the mass of emission gas(i) released by a plant component(te);
- Nc is the total number of a particular plant component;
- EF is the emission factor for the component type, location and hydrocarbon type (kg year^{-1} component^{-1});
- Ad_{age} is the age adjustment factor based on the commissioning date of the installation or terminal; and
- $C_{wt}(i)$ is the component weight percentage of emission gas(i).

3. System User Guidance – Atmospheric Emissions

3.1 Overview

Returns for offshore O & G installations are required on an annual basis with a submission date of 31st March, to report the previous calendar year's emissions. Emissions generated by support vessels, seismic vessels, helicopters and tankers on route to installations are not required to be reported as they are not directly attributable to activities on the installation but relate to the operation of field(s).

EEMS requires certain data inputs by 'the operator' to enable an emissions output. The emissions are determined in the system either by calculation or manual entry from the operator's specific data information. The term 'operator' is used here in the context of the person submitting the EEMS return and could be a person acting on behalf of and with authority from the actual operator and permit holder.

PPC and ETS permit identifiers information should be provided where installations have the relevant approved permits.

The EEMS reporting process is split over several worksheets which work together to generate the overall emissions results. In the event of a nil return, the worksheets must still be submitted. Where data is related to a permit and it has been surrendered e.g. PPC permit, the operator is not required to make a submission for the calendar year following the permit ceasing to have effect for those emissions. For example, if the permit was surrendered in May 2025, there is no submission required for the 2026 calendar year onwards. If a PPC permit is surrendered part-way through a reporting year, the operator must submit a return for that calendar year. To submit a part-year return, contact OPRED@energysecurity.gov.uk.

An option for simulating atmospheric calculations in EEMS allows the operator to enter in potential atmospheric returns and run the simulation to see what the atmospheric calculations would be if these returns were submitted. Instructions on how to complete atmospherics calculation simulations are provided in Appendix A1.

EEMS is accessed by authorised users via the UK Energy Portal - https://itportal.energysecurity.gov.uk.

Requests for further information and assistance should be directed to OPRED. More information can be found here: https://www.gov.uk/guidance/oil-and-gas-eems-database.

A full list of worksheets within EEMS (for atmospheric emissions) are listed in Table 3.1 and guidance for each return type is provided in Appendix A1.

Table 3.1: Atmospherics Returns Sheets

Return Type (Simulation)	Description
AtmosConsumInst	Data relating to the fuel consumption by combustion plant – refer to Table 3.2 for more detailed breakdown
AtmosDirectInst	Atmospheric emissions for gas venting (cold flaring), oil loading, fugitive emissions, and direct process emissions – refer to Table 3.2 for more detailed breakdown.
AtmosDrill	Drilling emissions reported by mobile installations only (MoDU) – refer to Table 3.2 for more detailed breakdown.
AtmosExportInst	Data relating to the export mass and density of the gas, condensate and oil being exported from the installation – refer to Table 3.2 for more detailed breakdown.
AtmosHalogenInst	Halogens - Mass of each halogen on the installation must be reported, using the assumption that the mass of halogen use is equal to the mass of halogen emission. It is the emitted mass that must be reported – refer to Table 3.2 for more detailed breakdown.
AtmosSmallEmitter	The facility is a small emitter and does not have a UK ETS permit – refer to Table 3.2 for more detailed breakdown.
AtmosTurbGas	NO_x emissions from turbines should be calculated using the turbines' fuel gas consumption, operating hours, fuel NCV and the relevant EEMS turbine equation; see Section 2.7.3.
AtmosTurbOil	NO_x emissions from turbines should be calculated using the turbines' diesel consumption, operating hours, fuel NCV and the relevant EEMS turbine equation; see Section 2.7.3.

Table 3.2: Atmospherics - Return Types, Sources and Categories

Consumption (Installation)

Facility Type	Return Type	Emission Source	Emission Category	Notes - current requirements	Notes - future
Installation - Fixed **installations with combustion plant of total rated thermal input capacity at or above 20MW.**	**AtmosConsum (Installation)** i.e. combustion activities	Diesel Consumption	Engines	Returns should reflect the fuel activity data used in combustion plant disaggregated to the equipment categories shown. Activity data (fuel used) should be aligned with verified ETS reports.	
			Heaters / Boilers		
			Turbines		
		Fuel Oil Consumption	Engines	Returns should reflect the fuel activity data used in combustion plant disaggregated to the equipment categories shown.	
			Heaters / Boilers		
			Turbines		
		Gas Consumption	Engines	Returns should reflect the fuel activity data used in combustion plant disaggregated to the equipment categories shown. Activity data (fuel used) should be aligned with verified ETS reports.	
			Heaters / Boilers		
			Turbines		
			Turbines (small emitter)		
			Others		
		Gas Flaring	Routine - Operational	Returns should be either 'Gross' or broken down by current categories shown. If providing 'Gross' data then sub-categories should be left blank. Activity data should be aligned with verified ETS reports, as ideally also should EF and OF .	**Future phase review areas:** Future alignment with NSTA Flaring & Venting categories is under consideration.
			Maintenance		
			Upsets - Emergency		
			Gross		

Facility Type	Return Type	Emission Source	Emission Category	Notes - current requirements	Notes - future
Installation - Fixed	**TurbGas** i.e. combustion activities	Gas (Fuel Gas) Consumption	Turbines	Returns should reflect the make and model UKOOA reference, fuel flow rate (activity data), net calorific value and run hours to calculate the average net thermal input used in the turbines. This is then used to generate a representative NOx EF using the appropriate EF equation.	
Installation - Fixed	**TurbOil** i.e. combustion activities	Diesel (Gas Oil) Consumption	Turbines		
Installation - Fixed (Small-emitters) **installations with combustion plant of total rated thermal input capacity below 20MW.**	**AtmosConsum (Installation)** i.e. combustion activities	Diesel Consumption	Engines	Returns should reflect the fuel activity data used in combustion plant disaggregated to the equipment categories shown.	**Future phase review areas:** Small emitter - facility type identifier required - EEMS modification. Consideration as to whether this category should correspond to Medium Combustion Installations (MCI).
			Heaters / Boilers		
			Turbines		
		Fuel Oil Consumption	Engines	Returns should reflect the fuel activity data used in combustion plant disaggregated to the equipment categories shown.	
			Heaters / Boilers		
			Turbines		
		Gas Consumption	Engines	Returns should reflect the fuel activity data used in combustion plant disaggregated to the equipment categories shown.	
			Heaters / Boilers		
			Turbines		
			Turbines (small emitter)		
			Others		
		Gas Flaring	Gas	Returns should be gross emissions	**Future phase review areas:** Future alignment with NSTA F&V guidance is under consideration.
			Oil		

Direct (Installation)

Facility Type	Return Type	Emission Source	Emission Category	Notes - current requirements	Notes - future
	AtmosDirect (Installation) i.e. non-combustion activities	Gas Venting	Operational (Routine)	Returns should be either 'Gross' or broken down by current categories shown. If providing 'Gross' data then sub-categories should be left blank.	**Future phase review areas:** Future alignment with NSTA Flaring & Venting categories is under consideration.
			Maintenance		
			Emergency (Upsets/Other)		
			Gross		
		Direct Process	Process removal of CO_2 emissions	Returns should capture any venting of gas from dedicated process units - such as CO_2 stripped using amine plant. This should be aligned with verified ETS reports	
		Oil Loading	Ship	Returns should match the crude oil / condensate exported to shuttle tanker (ship) and the related cargo tank emissions at the installation. Utilisation of EEMS factors is good practice, although operators may wish to consider the use of process engineering calculations that are aligned with their asset Methane Action Plan (MAP).	**Future phase review areas:** Improvement to emission factors to reflect advances in oil cargo transfer operational procedures may be beneficial. Further clarification as to whether to include or exclude emissions arising at the shuttle tanker itself.
		Fugitives	Connections	Returns should match the estimation of pipework components aligned with	**Future phase review areas:** Improvement to emission factors to reflect advances in Monitoring
			Valves		

			Open Ended Pipes	EEMS calculation procedures. Where direct emission masses of CO_2, CH_4 and NMVOC fugitive emissions are available from an in-house system, these can be reported.	& Reporting of fugitive emissions may be beneficial. Refer to OEUK Methane Action Plan Guideline (2025) for further detail. This is under consideration.
			Pumps		
			Other		

Facility Type	Return Type	Emission Source	Emission Category	Notes - current requirements	Notes - future
Installation - Fixed (Small-emitters) **installations with combustion plant of total rated thermal input capacity below 20MW.**	**AtmosDirect (Installation)** i.e. non-combustion activities	Gas Venting	Operational (Routine)	Gross returns should be either 'Gross' or broken down by current categories shown. If providing 'Gross' data then sub-categories should be left blank.	**Future phase review areas:** Future alignment with NSTA F&V guidance is under consideration.
			Maintenance		
			Emergency (Upsets/Other)		
			Gross		

Facility Type	Return Type	Emission Source	Emission Category	Notes - current requirements	Notes - future
Installation - Mobile (Permitted) **Mobile offshore drilling unit (MODU) installations**	**AtmosDirect (Installation)** i.e. non-combustion activities	Gas Venting	Operational (Routine)	Gross returns should be either 'Gross' or broken down by current categories shown. If providing 'Gross' data then sub-categories should be left blank.	**Future phase review areas:** Future alignment with NSTA F&V guidance is under consideration.
			Maintenance		

subject to screening directions in relation to approved drilling activities.			Emergency (Upsets/Other)		
			Gross		

Export (Installation) – Compositional Data

Facility Type	Return Type	Data Source	Composition Source	Export Data	Notes - current requirements	Notes - future
Installation	**AtmosExport (Installation)**	Carbon Dioxide (CO_2)	Fuel Gas	Gas, Condensate & Oil	Atmos Returns should include the compositional analysis of fuel gas, flare gas and vent gas. For fuel gas the conversion of a pre-combustion fuel mass to post-combustion gas mass is based on emission factors which are calculated from the mole percentage composition and average molecular weight of the fuel gas.	
			Flare Gas			
			Vent Gas			
		Carbon Monoxide (CO)	Fuel Gas	Gas, Condensate & Oil		
			Flare Gas			
			Vent Gas			
		Nitrogen Oxides (NOx)	Fuel Gas	Gas, Condensate & Oil		
			Flare Gas			
			Vent Gas			
		Sulphur Oxides (SOx)	Fuel Gas	Gas, Condensate & Oil		
			Flare Gas			
			Vent Gas			
		Methane (CH_4)	Fuel Gas	Gas, Condensate & Oil		
			Flare Gas			
			Vent Gas			
		NMVOC	Fuel Gas	Gas, Condensate & Oil		
			Flare Gas			
			Vent Gas			

Drilling (AtmosDrill)

Facility Type	Return Type	Emission Source	Emission Source	Notes - current requirements	Notes - future
Installation - Mobile (Permitted) **Mobile offshore drilling unit (MODU) installations subject to screening directions in relation to approved drilling activities**	**AtmosDrill (Installation)** Well Testing	Gas Flaring	Well Testing	Summary of gas flaring and diesel consumption during drilling activities on mobile installations. **For fixed installations gas flaring and diesel consumption during drilling operations are included on the Atmospheric Emissions - Consumption (Installation) report.**	**Future phase review areas:** 1. Future alignment with OPRED Screening Direction permits and NSTA WONS well notifications to be confirmed. 2. Review of emissions factors and combustion efficiency.
		Diesel Consumption			

Halogen (Installation)

Facility Type	Return Type	Compound	Data Fields	Notes - current requirements	Notes - future
Installation	**AtmosHalogen (Installation)**	Chlorofluorocarbons (CFC)	Quantity on Facility (kg). Quantity emitted (kg).	This is to be used to report the quantity and emission of halogenated compounds on the facility on an annual basis. The quantities of Hydrofluorocarbon compounds, perfluorocarbon compounds and sulphur hexafluoride on the facility at the end of the reporting period and used during the reporting period must be reported.	
		Hydrochlorofluorocarbons (HCFC)			
		Halons			
		Hydrofluorocarbons (HFC)	CO_2 Equivalent Factor (GWP). Quantity emitted (CO_2 Equivalent). Totals for HFCs, PFCs and SF6.		
		Perfluorocarbons			
		Sulphurhexafluoride (SF6)			

3.2 Things have changed, what should I do?

Where your EEMS Return may need a change, or have a query, you must first contact OPRED and explain the situation via OPRED@energysecurity.gov.uk.

Changes may relate to fuel consumption, emission factors and turbine information or additions which may be required due to errors in initial equipment reporting or combustion plant throughout the year. To request to amend submitted data you will need to complete and submit an EEMS Return change request. Depending on the amendment to the return a non-compliance report may need to be raised, please refer to the IRS guidance **[Ref 23]** for further information.

All non-compliances must be reported to the Department using the Integrated Reporting Service (IRS) which is hosted within the UK Energy Portal.

Where an amendment to an EEMS Return is required – A change request form is available here: https://assets.publishing.service.gov.uk/media/5fdc934fd3bf7f3a317b72ef/amendlockeddata.docx

4. Default Emission Factors: Combustion

This Section outlines when to use default EFs for calculating the emissions from the combustion of fuel gas, liquid fuels and flaring.

OPRED encourages operators to use installation specific factors, where reliable empirical test data is available. Installation specific factors should be assessed on a case-by-case basis in relation to the size of the mass emissions from the combustion plant on the installation.

Typical examples:

- CO_2 emissions should align with the monitoring, reporting, and verification data submitted via the UK ETS given that the ETS requirements stipulate site specific factors to the highest tier.
- SO_2 EFs should be derived from the analysis of site-specific gas samples.
- NO_x EFs from turbines should be determined using the methodology described in Section 2.7.

4.1 Gas Consumption

4.1.1 Application of Emission Factors in EEMS

The total mass of gas consumed, and emissions gas should be included for each combustion plant, including turbines, engines, heaters and other plant.

4.1.2 Application of Emission Factors

Due to the sampling requirements under the UK ETS, it is recommended that site specific CO_2 and SO_2 EFs should be calculated based on fuel gas sampling and analysis, i.e. where practicable the CO_2 EF used in EEMS reporting should be consistent with UK ETS reporting.

The NO_x EF for turbines is to be calculated using the methodology described in Section 2.7 and Appendix A3 using the assigned UKOOA reference and associated set of polynomial and linear coefficients a, b, and c, reported in Appendix A2.

Where emissions monitoring shows that the "UKOOA" (EEMS) equation is not representative and would lead to misreporting, an alternative calculation method must be considered. In such cases, a manual NOx figure should be calculated using an appropriate approach agreed with OPRED through the PPC permit.

Where EFs cannot be determined, then the default values in Table 4.1 should be used. The use of default factors assumes 100% combustion efficiency and that all fuel gas is consumed in the turbines, if no source breakdown is provided.

Table 4.1 Default emission factors for gas consumption plant operations

Emission Gas	Turbine EF (t/t)	Engine EF (t/t)	Heater EF (t/t)	Other EF (t/t)
CO_2	*Values used in UK ETS AEM Report based on ISO17025 UKAS accredited analysis of sampled gas composition / Gas chromatograph analysis*			
SO_2	*Values used in UK ETS AEM Report based on ISO17025 UKAS accredited analysis of sampled gas composition / Gas comp chromatograph analysis*			
NO_x	*Equation 2-8 or 0.0061**	0.0576	0.0024	0.0061
N_2O	0.00022	0.00022	0.00022	0.00022

CO	0.0060	0.0076	0.0006	0.0030
CH_4	0.00092	0.0198	0.000089	0.00092
NMVOC	0.000036	0.0032	0.0000099	0.000036
[Refs 5, 24 and 25] * Where an installation has different turbine models, the most appropriate NO_x EF should be applied. The return may include both the relevant EEMS equation and the default NO_x factor.				

4.2 Diesel Consumption

4.2.1 Application of Emission Factors in EEMS

The total mass of diesel consumed, and each emission gas should be included for each combustion plant, including turbines, engines, heaters and other plant. For diesel consumption, the sulphur content of the diesel should be submitted along with fuel consumption and emissions breakdown.

4.2.2 Application of Emission Factors

Installations included in the UK ETS typically use CO_2 EFs from the national UK GHG Inventory **[Ref 26]** unless site specific values are used. The CO_2 EF reported via EEMS should be consistent with that used for UK ETS reporting.

The NO_x EF for turbines is to be calculated using the methodology described in Section 2.7 using the assigned UKOOA reference and associated set of polynomial coefficients a, b, and c, reported in Appendix A2.

- Where the sulphur content of diesel is known, then the SO_2 EF should be calculated using the approach described in Section 2.6 and Appendix A3. For operators using other liquid fuels, site specific SO_2 EFs must be calculated. Default EF values for diesel consumption emissions are shown in Table 4.2. Use of default factors assumes the following:
- $C_{wt}(S)$ of low sulphur diesel is 0.1% as per Equation 0-21; and
- S content of Ultra-Low Sulphur Diesel (ULSD) is 10ppm wt% as per Equation 0-23
- The use of low sulphur Diesel is most common offshore due to concerns relating to combustion plant reliability, if operated on USLD.

Table 4.2 Default emission factors for diesel consumption plant operations

Emission Gas	Turbine EF (t/t)	Engine EF (t/t)	Heater EF (t/t)
CO_2	*UK GHG Inventory Values used in ETS Annual emissions monitoring (AEM) Report*		
NO_x	0.01724	0.0594	0.0028
N_2O	0.00022	0.00022	0.00022
SO_2	0.002	0.002	0.002
SO_2 ULSD	Section 4.2.2 and Appendix A3		
CO	0.00092	0.0157	0.00071
CH_4	0.0000328	0.00018	0.00000705
NMVOC	0.000295	0.002	0.0000282
[Refs 5, 24 and 25] Note: SO_2 EF default now reflects low sulphur diesel.			

4.3 Fuel Oil Consumption

Fuel oil is typically heavy petroleum residue blends, requiring pre-heating prior to combustion in heavy duty marine engines **[Ref 27]**.

4.3.1 Application of Emission Factors in EEMS

The total mass of fuel oil consumed, and emissions gas should be included for each combustion plant, including turbines, engines, heaters, and other plant. The sulphur content of the fuel oil should also be submitted with fuel consumption and emission gas breakdown.

4.3.2 Application of Emission Factors

Where site specific data has been permitted to be used, the EFs should be calculated using the methodology described in Section A3.2 and Appendix A3. Where this is not possible then default values in Table 4.2 should be used. Use of the default factors assumes that the sulphur content of fuel oil is 1.0% as per Equation 0-21.

The NO_x EF for turbines is to be calculated using the methodology described in Section 2.7 using the assigned UKOOA reference and associated set of polynomial coefficients a, b, and c, reported in Appendix A2.

In the absence of data from a verified system the default emission factors in Table 4.2 should be used (see previous section).

4.4 Gas Flaring

4.4.1 Application of Emission Factors in EEMS

The total mass of gas flared, and emission gas is required to be broken down by routine operations, maintenance, and upsets or others. If it is not possible to submit the figures by flare source then, a gross figure should be submitted.

4.4.2 Application of Emission Factors

Because of the requirements under UK ETS, it is recommended that site specific EFs should be calculated based on gas sampling and analysis or process models, i.e. the EFs used in EEMS reporting should be consistent with UK ETS reporting. Where EFs cannot be determined then the default values in Table 4.3 should be used. Use of default EFs assumes the following:

- A combustion efficiency of 100% for sulphur, as any unburnt sulphur compounds remaining after combustion are assumed to convert to SO_2 in the atmosphere.
- For all other flare gases, a combustion efficiency of 98% can be assumed **[Ref 28]**.
- Where compositional data is provided emission factors for CH_4 and NMVOC will be calculated.

Table 4.3 Default emission factors for gas flaring

Emission Gas	Natural Gas [1] EF (t/t)	Associated Gas [2] EF (t/t)
CO_2	*Values used in UK ETS AEM Report based on ISO17025 UKAS accredited analysis of sampled gas composition and gas chromatographs* *Where installation specific EFs are derived from process modelling based on industry standard models and are approved in the UK ETS GHG permit.*	
SO_2*	*Based on analysis of gas samples*	
NO_x	0.0012	0.0012
N_2O	0.000081	0.000081
CO	0.0067	0.0067

CH_4	0.018	0.010
NMVOC	0.002	0.010
[Refs 5, 24 and 25] * A default sulphur content of 6.4 ppm wt% can be assumed for non-UK ETS installations, i.e. SO_2 = 0.0000128 (Equation 0-18, else a site-specific value determined from gas analysis should be used).		

1) Gas flaring at a gas installation is defined as - Natural Gas.
2) Gas flaring at an oil installation is defined as - Associated Gas.

5 Default Emission Factors: Direct sources

This Section outlines when to use default EFs for calculating the emissions from venting, direct processes, oil loading, and fugitives. Data should be submitted for the masses of total emissions, and for the breakdown of emission gases for each source of direct emissions.

5.1 Gas Venting

Gas can be vented for operational, maintenance and emergency reasons. Total mass vented and total mass of emissions gas should be submitted for each category. Where this is not possible, then a gross value should be reported.

Gas venting category includes dedicated vents and cold flaring where gas passes through the flare without ignition – effectively venting of gas through the flare system. All such emissions of non-combusted hydrocarbons (CH_4 and NMVOCs) should be included in this EEMS return.

It is preferable to use known compositional data to calculate specific EFs, that can be based on design or modelling data if gas samples are not available. Where, this is not possible then the default EFs can be used.

Emission levels of most vented emissions gases are negligible in comparison to combustion when compared to historic reports of emissions data and gas composition analysis. The predominant emissions gases associated with hydrocarbon venting are methane and non-methane. Therefore, default EFs are only provided for the two main contributors of vented gas, CH_4 and NMVOC. All other emission gases, including CO_2 and SO_2, have default EFs equal to 0. Where there is direct process emissions see section 5.2.

Table 5.1 Default emission factors for gas venting

Emission Gas	Natural Gas EF (t/t) - Gas Platform	Associated Gas EF (t/t) - Oil Platform
CH_4	0.9	0.5
NMVOC	0.1	0.5
[Refs 5, 24 and 25]		

5.2 Direct Process Emissions

There are no default emissions factors for direct process emissions, because these are unique to the process and gas composition for each installation.

5.3 Oil Loading

5.3.1 Application of Emission Factors in EEMS

Oil loading emissions are categorised into the following types:

- offshore loading to shuttle tankers (vessels).

5.3.2 Application of Emission Factors

This category of emissions relates to the vaporisation of hydrocarbons at an installation during the loading of crude oil from the installation to the shuttle tanker. The emission gas masses may be calculated using the default values provided. Utilisation of EEMS factors is good practice, although operators may wish to consider the use of process engineering calculations that are aligned with the asset Methane Action Plan (MAP). It is assumed that crude loading into vessels contributes to CH_4 and NMVOC emissions only. All other emission gases, including CO_2 and SO_2, have default EFs equal to 0. The activity data for this calculation is the total mass of crude oil in tonnes transferred from the installation to the shuttle tanker.

The methodology used in EEMS has not changed for over a decade. Refer to Appendix A3 for more detailed discussion of this category and how it is handled in the NAEI.

Table 5.2 Default emission factors for oil loading

Emission Gas	Ship (Offshore) EF (t/t)
CH_4	0.000017
NMVOC	0.002*
[Refs 5, 24 and 25] *VOC for offshore ship loading currently assumes to be double the onshore ship loading due to the additional loading required from offshore installation (FPSO/FSO) to offshore shuttle tankers.	

5.4 Storage Tanks

EEMS no longer covers atmospheric emissions from onshore terminals. Therefore, this section is no longer required.

5.5 Fugitive Emissions

5.5.1 Application of Emission Factors in EEMS

Fugitive emissions are categorised into the following plant component types:

- connections;
- valves;
- open ended pipes;
- pumps; and
- other.

5.5.2 Application of Emission Factors

Where direct emission masses of CO_2, CH_4 and NMVOC fugitive emissions are available from an in-house system, these can be reported. If unavailable, fugitive emissions will be calculated based on the facility types, plant component, the age of the installation and default emission factors referred to in Tables 5.3, 5.4and 5.5 **[Ref 28].** If component counts are unavailable, default component counts for generic platform types are available, as shown in Table 5.5.

The calculation is dependent on vent gas mole composition being submitted or fugitive pollutants will not be calculated. Therefore, a mole composition for fuel gas is mandatory.

Table 5.3: Default Component Counts

Number of Components on Generic Platforms						
Facility Type*	**A**	**B**	**C**	**D**	**E**	
Connections	1114	2363	2792	3483	8289	
Valves	514	1348	1036	1572	3002	
Pumps	0	0	0	0	0	
Other	113	389	338	313	622	

***Facility Types:**

A wellhead gas platform 150 MMSCFD
B gas treatment/compression platform 330 MMSCFD
C small simple oil platform 40000 BPD & 10 MMSCFD
D medium complexity oil platform 75000 BPD & 10 MMSCFD
E large oil/condensate platform 80000 BPD & 540 MMSCFD

Table 5.4 Default emission factors for fugitive emissions (kg year-1 / component-1) or kg emission /component-year

Location	Offshore
HC TYPE	All
Connections	0.946
Valves	4.52
Open Ended	8.94
Pumps	1.72
Other	60.9

Table 5.5 Installation / Terminal age adjustment factor for fugitive emissions

Commissioning date	Age Adjustment Factor
Before 1980	1.5
Between 1980 and 1988	1.3
After 1988	1.0
[Ref 28]	

Each plant component type has a default emission factor and requires adjustment depending on the age of the installation or terminal.

6 Default Emission Factors: Drilling

Data is required to be submitted for the mass of emission gases, and total consumed gas and diesel during well testing activities for all wells. Sulphur content of the diesel used should also be reported.

6.1 Well Testing – Flare Gas

The following data must be provided in-line with permit conditions of the screening direction:

- EIA Direction permit reference number (as generated by the portal in relation to OPRED and NSTA approvals);
- Hydrocarbon type – (None, Oil, Gas or N/A); and
- Total flare gas testing activity data in mass.

6.1.1 Application of Emission Factors in EEMS

EFs are applied to the total consumed mass of gas used during well testing activities.

6.1.2 Application of Emission Factors

Where gas composition of the test gas is available, it should be used to calculate EF's for CO_2, CH_4, NMVOC and SO_2 as described in Section 2.6 and Appendix A3 or default EFs should be used if there is no test gas data, please refer to Table 6.1. A combustion efficiency of 95% [Ref 5] is assumed except for sulphur, which is assumed to be 100% because of the atmospheric conversion of any unburnt sulphur compounds to SO_2.

Table 6.1 Default emission factors for Flare gas - well testing

Emission Gas	Oil EF (t/t)	Gas EF (t/t)
CO_2	3.19	2.8
NO_x	0.0037	0.0012
N_2O	0.000081	0.000081
SO_2	0.0000128	0.0000128
CO	0.018	0.0067
CH_4	0.025	0.045

NMVOC	0.025	0.005
[Refs 5, 24 and 25]		

6.2 Diesel Consumption – Combustion Plant

6.2.1 Application of Emission Factors in EEMS

EFs are applied to the total consumed mass of diesel used by all combustion plant during all drilling operations.

6.2.2 Application of Emission Factors

Where EFs are used for other reporting purposes, e.g. UK ETS reporting, then they should be reported consistently to EEMS. If the diesel $C_{wt}(S)$ is not known then it can be assumed to be 1% for heavy fuel oil, 0.1% for diesel, or 0.0010- 0.0015% for ULSD and the EF for SO_2 can be determined using the methodology described in Section 2.7.2. If verified system data is not available to calculate site specific EFs then the default EFs can be used. If specific data is known, then the relevant EF calculations will override the default factors.

Table 6.2 Default emission factors for diesel consumption during well testing

Emission Gas	EF (t/t)
CO_2	3.19
NO_x	0.0594
N_2O	0.00022
SO_2	0.002
CO	0.0157
CH_4	0.00018
NMVOC	0.002
[Refs 5, 24 and 25]	

7 Reporting of Halogens

Halogenated compounds are used for cleaning, firefighting, and refrigeration. They are also known as fluorinated gases (F-Gases) and / or Ozone- depleting substances (ODS). Operators who have equipment that contains more than 5 tonnes CO_2 equivalent of F-gas / ODS must report to OPRED quantities and types of F-gas and ODS contained in systems and any releases from equipment on an installation-by-installation basis. EEMS is used to fulfil this requirement.

The above is also a requirement for non-production installations working on the UKCS / in a UK port or during transit within the UKCS.

Where an F-gas or ODS release has been previously reported through Integrated Reporting Service (IRS) this must also be included in your EEMS return. Where stock cylinders are present on an installation, only releases shall be reported to EEMS - not the stock cylinder inventory.

7.1 Halogenated Compounds

Quantities of F-gases and ODS emitted and stored at installations must all be reported, but not including stock cylinder inventory.

Halogenated compounds are listed in Table 7.1:

Table 7.1: Halogenated Compounds

ODS	F-Gases
Chlorofluorocarbons (CFCs)	Hydrofluorocarbons (HFCs)
Hydrochlorofluorocarbons (HCFCs)	Perfluorocarbons (PFCs)
Halons	Sulphur Hexafluoride (SF_6)

Whilst the data is inputted into EEMS as kilograms, emissions of HFCs, PFCs and sulphur hexafluoride (SF_6), i.e. F-Gases, are further reported as carbon dioxide equivalent (CO_2e) emissions:

$$M_{eq}(CO_2) = M_{em}(k) \times GWP(k) \qquad 7\text{-}1$$

Where:

- $M_{eq}(CO_2)$ is the mass of emissions equivalent to CO_2 (te);
- $M_{em}(k)$ is the mass of emissions related to species (k) (tonnes); and
- GWP(k) is the CO_2 equivalent factor for the halogenated compounds.

Global warming potential (GWP) for F-gases can be found in the non-exhaustive list at https://www.gov.uk/guidance/fluorinated-gases-f-gases#hfcs

Should an operator use a halogenated compound that is not listed in EEMS, they should inform OPRED via email so that EEMS can be updated.

Further information on F-Gases and ODS can be found at gov.uk: Oil and gas: offshore environmental legislation - GOV.UK

F-Gases:

https://assets.publishing.service.gov.uk/media/66ea868024c4f1826d81bcd0/F-gas_Guidance_September_2024.pdf

ODS:

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8 Small Emitters

Installations with combustion plant that has a maximum total rated thermal input of less than 20MW are classified in EEMS as small emitters. Emissions are reported using a simplified format to provide a greater transparency of oil and gas industry emissions.

The impact of using default EFs compared to calculating site specific factors was found to be minimal due to the relatively low mass of most emission gases generated by this installation type compared to that of larger installations. Therefore, the reporting process for small emitters is simplified with the use of default EFs.

Reporting requires the operator to provide the total mass of fuel use for each type of plant, for both fuel gas and diesel, and the total mass of natural and associated gas flared and vented. For small emitters with monitoring systems in place, the actual emission masses calculated using the default factors should be compared to one another, to ensure correct reporting using the streamlined approach.

Table 8.1 Default combustion EFs for non-UK ETS Installations (Small Emitters)

Emission Gas	Fuel Gas EF **(t/t)**				Diesel EF **(t/t)**		
Source	Turbine	Engine	Heater	Other	Turbine	Engine	Heater
CO_2	2.86				3.19		
NO_x	0.0061	0.0576	0.0024	0.0061	0.01724	0.0594	0.0028
N_2O	0.00022				0.00022		
SO_2	0.0000128				0.001997		
CO	0.0060	0.0076	0.0006	0.0030	0.00092	0.0157	0.00071
CH_4	0.00092	0.0198	0.000089	0.00092	0.0000328	0.00018	0.00000705
NMVOC	0.000036	0.0032	0.0000099	0.000036	0.000295	0.002	0.0000282
[Refs 5, 24 and 25]							

Table 8.2 Default flaring EFs for non-UK ETS Installations (Small Emitters)

Emission Gas	Flaring (t/t)		Venting (t/t)	
Source	Natural Gas	Associated Gas	Natural Gas	Associated Gas
CO_2	2.8		-	-
NO_x	0.0012		-	-
N_2O	0.000081		-	-
SO_2	0.0000128		-	-
CO	0.0067		-	-
CH_4	0.018	0.010	0.9	0.5
VOC	0.002	0.010	0.1	0.5
[Refs 5, 24 and 25]				

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Note: The public website links to all references shown were accessed on March 2025 and were correct at the time of access.

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33. AEAT-0524 NAEI UK GHG inventory report – Appendix 3 Energy naei.energysecurity.gov.uk/sites/default/files/reports/empire/ghg/ukghgi_90-99_append_3-4.pdf

34. Ricardo Energy and Environment report ED12848 dated 29/7/2022 "UK GHG Inventory Improvements: Upstream Oil and Gas http://naei.energysecurity.gov.uk/reports/uk-ghg-inventory-improvement-upstream-oil-and-gas

35. Offshore PPC Guidance https://assets.publishing.service.gov.uk/media/64ddd3133fde6100134a53e5/Offshore_PPC_Guidance__v1_August_2023.pdf

36. Flaring and venting guidance – Oil & Gas Authority https://www.nstauthority.co.uk/media/7647/flaring-and-venting-guidance_june-2021-final.pdf

Appendices

Appendix A1 - EEMS Reporting Guidance

The following information covers the reporting process work sheets as discussed in Section 3.

A1.1 Consumption – Installation (AtmosConsumInst)

This return sheet presents an overview of the emissions generated by total fuel consumption and by total gas flaring for the installation for the reporting calendar year.

Not all data fields in this sheet require populating. If there is no site-specific monitoring data related to the individual emissions generated by plant, then entries can be left blank and EEMS default EFs will be used to calculate the emissions. The ‘Total Use (t) for fuel for each turbine, engine and heater’ and ‘Sulphur (%)’ entries are marked with an asterisk and are mandatory for the user to complete.

Gas / Diesel / Fuel Oil Consumption – Combustion Plant Operations

The mandatory entries are the total mass used of fuel (gas, diesel and fuel oil) in tonnes, for each plant type (turbines, engines, heaters and other). The C_{wt}(S) in diesel and fuel oil must be provided to calculate specific SO_2 emissions. If no C_{wt} is entered, then EEMS will use a default value (see Section 4 for EF default values). The value of the C_{wt}(S) should be provided by the fuel supplier and entered into the system as a percentage with up to two decimal places.

Where the installation has an approved online emissions monitoring system, such as CEMS or PEMS, the relevant gas-specific emissions data should be entered in tonnes for each plant and fuel type. If these fields are left blank, EEMS will calculate annual pollutant emissions in tonnes using the system’s default emission factors and the total fuel value entered by the user.

If no emissions monitoring or plant specific data is available for turbine NO_x emissions then the TurbGas and TurbOil return sheets must be completed. If the operator completes both the turbine specific sheets and the ConsumInst sheet then the data in the latter sheet takes precedence and overwrites the additional data.

Gas Flaring

For gas flaring the provision of the data 'Type' must be selected, either by 'Breakdown' or on a 'Gross' basis. If the breakdown of the total mass of gas flared is known by purpose:

- Routine;
- Maintenance;
- Upsets/Other;
- Gross.

then the breakdown option must be selected and the values entered accordingly - if not then the gross figure must be provided. If the installation has approved monitoring systems, then for both mass breakdown and gross entry, post combustion emission gas masses should be entered for some or all gases depending on availability.

For fuel usage and gas flaring, the total use should be reported to two decimal places with a maximum use of 30,000,000.00 tonnes. Post combustion emissions of pollutant gases entry can be reported up to two decimal places up to a maximum of 999,999.99 tonnes.

A1.2 Direct – Installation (AtmosDirectInst)

This return sheet summarises the direct atmospheric emissions for gas venting, direct process emissions, oil loading and fugitive emissions.

Gas Venting

Reporting for gas venting follows a similar process as flaring. First the selection of breakdown or gross reporting must be chosen. If the breakdown is known then the respective masses of gas vented for each purpose must be provided:

- Operational (normal operations);
- Maintenance;
- Emergency.

In either case, if monitoring systems e.g. metered data are in place recording emissions data, either all or some of the individual gas emission masses can be entered - if they are left blank then EEMS will calculate them using the gas composition provided in EEMS or a representative gas composition and default emission factors (as provided in Appendix A3). Gas venting category includes dedicated vents and cold flaring where gas passes through the flare without ignition, all such emissions of non-combusted hydrocarbons (CH_4 and NMVOC) should be included in this EEMS return.

Direct Process Emissions

Data entry for direct process emissions must be provided where there are specific process emissions; for example, if the installation has an acid gas removal plant. If the installation does have direct process emissions, then the 'Add New Emission' button should be used. A separate entry should be made for each piece of process plant resulting in direct emissions. The total emissions mass and a complete breakdown of individual gas emission masses, in tonnes, must be provided as there is no calculation methods presented for this source of emission.

Oil Loading

Oil loading to shuttle tankers typically results in hydrocarbon emissions of CH_4 and NMVOC. These emissions must be reported as they generate the majority of the total evaporative emissions from the process of transferring oil into the tanker(s). The total mass of gas lost must be provided in tonnes, and if there are approved monitoring systems e.g. metered data are in place any specific gas emission data produced can be entered. Please note this is emissions from oil loading from the installation's cargo / storage tanks into the shuttle tanker(s) when hydrocarbon saturated vapour is displaced and not emissions associated with the shuttle tankers themselves.

The relevant 'activity data' in EEMS for this emission category is the annual total mass of oil / condensate transferred (exported) via this process over a calendar year. This data should be provided in the annual EEMS return irrespective of whether the EEMS default emission factors are used for reporting emissions or whether the operator elects to over-ride these using site-specific emission factors based on the technologies and practices used at the installation.

Emissions from oil loading should not be reported in the 'Venting category'.

Fugitive Emissions

Fugitive emissions come from leaks in plant and installation connections, valves, open ended pipes, pumps and other vulnerable sources. The number of each component must be reported into EEMS - if the actual numbers are unknown then estimates or default values for a generic installation should be used. Each field entry has a different maximum number which can be entered, as shown below:

- Connections – 25,000
- Valves – 10,000
- Open Ended Pipes – 5,000
- Pumps – 5,000
- Other – 5,000

Fugitive emissions consider CO_2, CH_4 and VOCs. If measures have been taken to record this data, then it should be entered. If there is no provision of gas emission mass then EEMS will estimate the expected emission mass based on the number of components, the age of the installation, default emission factors and gas compositional data, as described in Section 5.5.

A1.3 Drilling (AtmosDrill)

Mobile installations should report drilling emissions only where drilling occurred during the reporting year. For this return sheet, PPC and UK ETS GHG Order permit identifiers are not required; however, the EIA Direction permit code must be provided, together with the operation start and completion dates.

Note: Where the Atmospheric Calculation Simulation refers to a “Chemical Permit”, use the EIA Direction permit code instead.

Fixed installations inherently already provide emissions associated with any drilling activity in ConsumInst, so these would have already been accounted for in the return.

If there has been no drilling undertaken under an OPRED approved permit, then a nil return must be submitted. This is done by clicking ‘Nil Return’ at the top of the sheet.

Well Testing – Flare Gas

For each mobile installation where wells have been tested, each well tested must be listed. The EIA Direction permit reference (as generated by the portal in relation to OPRED and NSTA approvals) number should be entered in the mandatory ‘Well’ field and the hydrocarbon type (none, gas, oil or N/A) of the reservoir fluid should be selected if known. The mass of gas routed to flare during drilling must be reported in tonnes.

Diesel Consumption – Combustion Plant

Emissions generated by engine diesel consumption during drilling are reported using the same method as used for diesel consumption during production in ‘ConsumInst’. The total drilling diesel consumption must be submitted in tonnes. Individual gas emission masses can be reported if they have been generated by an approved monitoring system e.g. metered data are in place. If no emission values are provided, then EEMS will calculate the mass of pollutant gases using default factors (as per Table 6.2). However, the sulphur content of the diesel being consumed must be reported as the C_{wt} provided by the supplier. This value will be used to calculate SO_2 emissions if no value is recorded by monitoring systems.

A1.4 Export - Installation (AtmosExportInst)

The export return sheet provides data relating to the export mass and density of the gas, condensate and oil being exported from the installation via pipeline.

Data Source

The data source in the export sheet for the emission gases must be provided and can be entered as calculated, estimated or measured:

- Selecting ‘calculated’ instructs the system to use either data entered by the operator, or if no data is provided, default values are used to calculate the emission masses e.g. if no composition is provided to use typical data.
- ‘Measured’ instructs the system that site-specific monitoring system data has been entered by the operator and no calculation is required for the respective emission gases.

Defining the data source as ‘estimated’ instructs the system that the data provided has been based on prior emission data or data that is typical of a similar installation.

There is also an option to select N/A. This selection should be made if there are no emissions to be reported due to no export activity or if the export is made via tanker transfer and has been accounted for in ‘DirectInst’ via the Oil Loading fields..

Export Data

The annual mass breakdown of gas, condensate and oil exported from the installation for the year being reported must be supplied in tonnes and the average density of both condensate and oil for the reporting period must also be entered.

Gas Composition

For fuel, flare and vent gas, the composition (% mol) should be entered if known. This data could be determined from an approved emissions monitoring system(s) on the installation or from sampling analysis. These fields are not mandatory but if specific data is known, then the accuracy of the emissions data determined by EEMS will be improved and will provide a better representation of an installation(s) emissions.

Installations typically have monitoring systems in place to check fuel gas composition, and if this is the case, then the results should be entered. If a composition is provided for fuel gas but not for flare or vent gases - EEMS will also use the fuel gas composition to complete calculations for flaring and venting emissions.

If no compositional data is reported then EEMS will use a default gas composition which is inbuilt to the system to complete the emissions calculations for fuel gas consumption, flaring and venting.

A1.5 Halogen – Installation (AtmosHalogenInst)

Installations are required to keep detailed records of the halogen inventory. The amount (kg) on the facility (On Facility) of each halogen requires to be entered into each field in the return. The mass of each halogen on the installation must be reported and, using the assumption that the mass of halogen use is equal to the mass of halogen emission, the emitted mass must be reported. The emitted (Emitted) mass is the difference between the initial mass on the facility and the final reported inventory mass on the facility, considering any additional deliveries throughout the year.

A1.6 SmallEmitters (AtmosSmallEmitter)

This worksheet should only be completed if the combustion plant has a maximum total rated thermal input of less than 20MW. If the installation being reported is greater than this, the worksheet should not be submitted. All fields on this worksheet are voluntary reporting fields and accurate data should be provided using appropriate default factors.

Total Gas and Diesel Fuel Use

The total mass(t) used of each fuel used (gas and diesel) is required to be reported for each type of plant: turbines, engines and heaters. Other fuel gas use must also be reported.

Total Flare and Vent Gas

The total mass of natural and associated gas that is flared and vented for the installation must be reported individually (in tonnes).

A1.7 Gas Turbine Emissions - Gas (AtmosTurbGas)

This worksheet summarises the total fuel gas (t) consumed by all the gas turbines on the installation and includes data such as running hours and net calorific value (NCV). Data presented in this worksheet is used to calculate the total NO_x emission mass generated by turbines using fuel gas, if no specific NO_x emission data is provided for turbines on the ConsumInst sheet.

PPC permit holders are required to report the make, model and EEMS turbine reference of each gas turbine on the installation. When EEMS reporting is due, the 'AtmosTurbGas' return is selected and the following mandatory fields must be completed:

- Turbine Ref ;
- Make and Model;
- EEMS turbine reference (previously referred to as 'UKOOA' reference);
- Fuel gas mass consumption (activity data for EF);

- Turbine operating hours; and
- Average NCV (MJ/t).

The EEMS turbine reference instructs EEMS which of the polynomial equations to use when calculating the NO_x EF for a specific turbine.

Before a new installation with qualifying gas turbines comes online, the operator's Atmospheric Return form in EEMS must be set up to:

- list the qualifying GTGs assigned to the offshore installation;
- record each turbine's make, model and start date; and
- assign each turbine an EEMS reference and the corresponding polynomial coefficients.

OPRED will provide assistance to configure the Atmospheric Return form in the EEMS portal. However, the operator remains responsible for ensuring the gas turbine information entered in the system is accurate. The operator should provide this information to OPRED in good time before the installation's first Atmospheric EEMS Return submission deadline.

The operator must report to EEMS the individual masses of fuel gas used for each turbine in tonnes, the annual operational hours for each turbine (to a maximum of 8760 hours or 8784 hours in a leap year) and the average NCV (MJ/t) for the respective fuel gases used. This data is used to calculate the average annual gas fuel flow rate (t/hr) which is then used, with the NCV, to determine the average thermal input of each turbine (MW) in the given year.

Using the thermal input of the turbine and the turbine specific polynomial factors, EEMS calculates the EF and then the mass of NO_x emissions for each turbine, as explained in Section 2.7.

The total mass of fuel gas consumed by all turbines entered on this sheet must correspond to the total turbine fuel gas consumption on the ConsumInst worksheet or the EEMS report will not run properly. The fuel mass reported on this sheet is used for NO_x emission calculations, whereas the fuel mass on ConsumInst is used for calculating the emissions of the other emission gases.

The make, model and EEMS turbine reference of each gas turbine should only need to be populated once, as it will be saved in EEMS. However, operators (permit holders) must ensure the gas turbine reference list is maintained and EEMS is kept up to date and is aligned with the approved PPC permit.

Where a new turbine model(s) needs to be added to an operator's annual return. The operator must contact OPRED and provide information on each turbine make and model. OPRED will assign the appropriate polynomial or linear equation of the specified gas turbine.

If the NOx emission mass from fuel gas consumption by all turbines on the installation is available from such an in-house system, it should be reported on the appropriate section of the Atmospheric Emissions - Consumption report. If, in error, both this report and turbine NOx emission masses from fuel gas consumption on the Atmospheric Emissions - Consumption are submitted, the consumption report will take precedence and this report will be ignored.

A1.8 Liquid Fuel Turbine Emissions – Oil (AtmosTurbOil)

This worksheet summarises the total liquid fuel (diesel and fuel oil) consumed by all the turbines on the installation and includes running hours and net calorific value (NCV). If no specific NO_x emission data is provided for turbines on the ConsumInst sheet, the data presented in this worksheet is used to calculate the total NO_x emission mass generated by turbines using liquid fuel.

PPC permit holders are required to report the make, model and UKOOA reference of each turbine on the installation using a liquid fuel. When EEMS reporting is due, the 'AtmosTurbOil' return is selected, and the following mandatory fields must be completed:

- Turbine Ref;
- Make and Model;
- EEMS turbine reference (previously referred to as 'UKOOA' reference;
- Fuel oil mass consumption (activity data for EF);
- Turbine operating hours; and
- Average NCV (MJ/t).

The EEMS turbine reference instructs EEMS which of the polynomial equations to use when calculating the NO_x EF for a specific turbine.

The operator must report to EEMS the individual masses of liquid fuel used for each turbine in tonnes, the annual operational hours for each turbine (to a maximum of 8760 hours) and the average NCV for the respective liquid fuels used. This data is used to calculate the average annual liquid fuel flow rate (t/hr) which is then used, with the NCV, to determine the thermal output of each turbine (MW).

Using the thermal output of the turbine and the turbine specific polynomial factors, EEMS calculates the NO_x EF and then the mass of NO_x emissions for each turbine, as explained in Section 2.7.

The total mass of liquid fuel consumed by all turbines entered on this sheet must correspond to the total turbine liquid fuel consumption on the ConsumInst worksheet or the EEMS report will not run properly. The fuel mass reported on this sheet is used for NO_x emission calculations whereas the mass on ConsumInst is used for calculating the emissions of the other emission gases.

The make, model and EEMS turbine reference of each gas turbine should only need to be populated once as it will be saved in EEMS. However, operators (permit holders) must ensure the gas turbine reference list is maintained and EEMS is kept up to date and aligns with the approved PPC permit.

If an NOx emission mass from fuel gas consumption by all turbines on the installation is available from such an in-house system, it should be reported on the appropriate section of the

Atmospheric Emissions - Consumption report. If, in error, both this report and turbine NOx emission masses from fuel gas consumption on the Atmospheric Emissions - Consumption are submitted, the consumption report will take precedence and this report will be ignored.

A1.9 EEMS Atmospherics Calculation Simulation

EEMS atmospheric returns may be derived from atmospheric calculation simulations for individual pollutant species. This allows you to enable the data input and calculations prior to submitting atmospheric returns.

Atmospheric returns are accessed through the EEMS Dashboard and ‘Atmos. Calc. Simulations’ function must be selected. Access is granted to users with the ‘EEMS_RETURNS_EDIT’ privilege which is setup by the permit holder and possessed by users who are in the Data Entry or Data Submitter role for an operator linked to an approved permit issued by OPRED.

Creating a new Simulation

The screen from the dashboard after selecting ‘Atmos. Calc Simulations’ is used to manage simulations. Users can search existing simulations using the search criteria and Search button in the ‘Simulation List’. Only EEMS Operators on a user's team can view simulations, due to restrictions.

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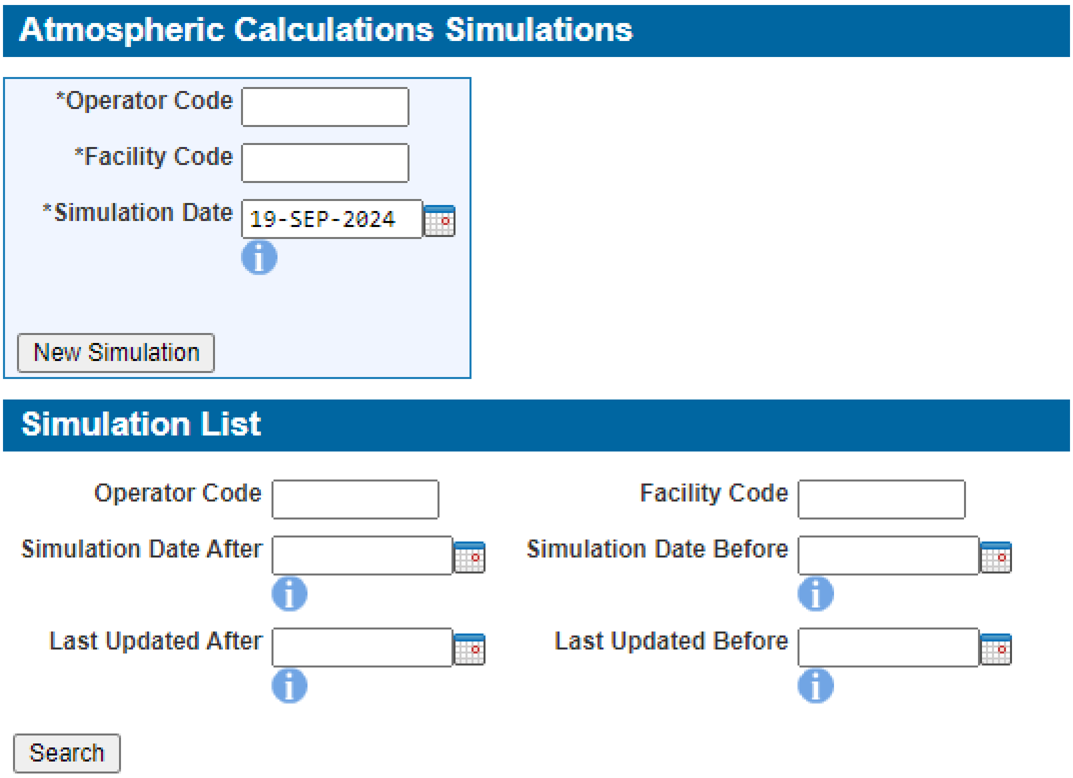


On the same screen you can create a new simulation from ‘Atmospheric Calculations Simulations’. Complete the ‘Operator code’ and ‘Facility code’ and then select a ‘Simulation Date’. The simulation date determines the year for which the simulated returns apply. When ‘New Simulation’ is selected these fields are validated:

- An operator with the operator code must exist and you must have access to the operator, i.e. be a member of the team.
- The facility must exist.
- The simulation date must be after 28th March 2010.
- Only one simulation may exist for an Operator, Facility and Year.

Once a new simulation has successfully been created you are taken into the screen for preparing / editing a simulation.

Preparing a Simulation Return

Preparing a simulation consists of adding returns and filling in values. Returns are represented by a list of tabs spanning the screen horizontally.

A return is added by clicking the dropdown labelled “Add Return” and selecting a value from the list that appears.

To view and complete a return, click the return type link in the tab (shown above as Consuminst, DirectInst etc). This will change the area underneath the tabs to be the online form for that return type.

View Simulation Results

When you are ready to view the atmospheric calculations for the values entered press “Run Simulation”.

A complete simulation is presented in a table of results

To display calculations, click the Expand icon at the start of the row (+). This will fold-out calculations in the space below. These can be hidden again by clicking the contract icon (-) at the start of the row.

The ‘Expand All’ and ‘Contract All’ links at the start of the table allow you to quickly display or hide all calculations.

Calculation rows alternate in colour to help distinguish what belongs to a row.

Appendix A2 - Turbine NO_x Emission Factor Polynomial Coefficients

The approach taken for determining the emissions of NOx from combustion plant is described in Section 4 of this guidance. This includes the application of polynomial equations for gas turbines to improve the uncertainty of the estimation of NOx emissions from combustion plant, based on the profile of NOx emissions with load and fuel thermal input. This is an important element of EEMS emission factors because gas turbines account for the vast majority of NOx emissions from UKCS fixed installations as regulated under PPC.

The turbine NOx emission factor polynomials were developed in the early 2000's as a UKOOA industry initiative supported by stakeholders, with the work led under contract to UKOOA by leading consultancies who both had extensive onshore experience and some offshore experience of stack testing gas turbines and using test data to baseline the profile of emissions from standard combustion gas turbines. The work developed NOx polynomial equations for the predominant makes and models of gas turbines operating in the UKCS at that time, was consolidated in 2004-2005 and was integrated into EEMS and the 2008 EEMS guidance.

NOx polynomials and EFs have been in development over the years in several stages following:

- the work that two consultancies (AEA Technology and Advantica) did under contract to UKOOA in setting up the original data sets for 2025 and 2008 EEMS guidance.
- the significant baseline testing an EF work done between 2008 and 2015. This work informed the DECC-Genesis review of 2015 **[Ref 24]**
- the significant LCP testing that has taken place since 2017 in response to the LCP BREF [Ref 19] requirements under the Offshore Combustion Installation (PPC) Regulations 2013 (as amended) and the requirements under the Offshore emissions monitoring guidance **[Ref 29]**. This has resulted in an improvement in the test data for baselining purposes.

A review undertaken in 2014-2015 led to some minor changes and additions to the EEMS NOx polynomials based on analysis of data sets from the preceding decade **[Refs 24 and 25]**.

Additionally, in the two decades since the initial UKOOA-led work was undertaken, more advanced gas turbine models have been installed on some UKCS installations. This includes more modern aero-derivative models, latest upgrades and performance enhancements of existing turbine models, and also some Dry Low NOx (DLN) / Dry Low Emission (DLE) combustion models at some installations, especially on single gas fuel as opposed to dual fuel duties. There is further discussion in this Appendix on NOx emissions from combustion plant employing Dry Low Emission (DLE) / Dry Low NOx (DLN) / lean burn combustion as part of NOx abatement. Determining emission factors for these combustion plant should be approached differently to standard combustion and the equations presented in Table A2.1 except for **EEMS ref 'DLE – DLN'** do not apply.

Each standard annular combustion (SAC) turbine make and model has an assigned EEMS Turbine reference and an approved set of polynomial coefficients a, b, and c. as described in Section 2.7. The coefficients are based on data collected from offshore stack monitoring of NO_x emissions from different models of gas turbines operating on fuel gas, and in a few cases also when operating on diesel fuel.

The **GE LM2500 family** of turbines has expanded significantly in the UKCS over the past decade and now reflects the base **LM2500 (2nd generation model)**, the **LM2500+ (3rd generation model)** and the **LM2500+G4 (4th generation model)**. From 1/1/2026 new EEMS equations are provided for each of these different standard combustion models.

Most Rolls Royce Avon (re-branded Siemens SGT-A20) gas turbines in the UKCS have been upgraded to the **Avon 1535** model over the years. From 1/1/2026 new equations are available for the **Avon 1535**. This includes two variants; the Avon coupled to the **Cooper Rolls RT48** free power turbine and the Avon coupled to the **EGT EAS-1** free power turbine. Both variants are found in the UKCS and have only slight differences.

Most Rolls Royce RB211 (re-branded Siemens SGT-A35) gas turbines in the UKCS have been upgraded to the **RB211-24G** model over the years to achieve improved reliability, performance efficiency, and emissions, although not necessarily increased maximum power output where the prevailing free power turbine and / or gearbox has not been uprated. No change is being made to the existing emission factor equations for the RB211-24C and the RB211-24G.

Most **GE Frame 5** gas turbines in the UKCS are of model PG5341 or PG5371 (single spool PG5001 on power generation), some with uprated performance enhancement kit (PEK). From 1/1/2026 new equations are provided for the **GE Frame 5** gas turbines.

The **Solar Mars** equation is relevant to both the Mars 90 and Mars 100 models. From 1/1/2026 new equations for gas and diesel (gas oil) are provided for the **Solar Mars** gas turbines.

The emission factor equations for the **GE LM5000** and the **GE LM6000** have been reviewed to remove negative coefficients with new equations available from 1/1/2026.

From 1/1/2026 a default emission factor is provided for use with **DLE / DLN** versions of GE, Rolls Royce, Solar, and Siemens gas turbines where these are operating in DLE/DLN mode aligned with 25ppmv OEM specifications, corresponding to the LCP NOx BAT-AEL of 50mg/Nm3 for new gas turbines. Several such units operate across the UKCS. This default should only be used where DLE/DLN units are demonstrated as operating in active low emission mode and have compliance test data to evidence this. The equation may be used for all models of DLE/DLN whether LCP or not (below 50 MWth rating). However, where a DLE/DLN gas turbine operates outside active DLE/DLN mode for significant normal operating periods then site-specific factors should be developed and discussed with OPRED.

The **Alstom GT10**, **Alstom GT40**, and **GE LM1600** units previously operating in the UKCS have ceased operation as part of installation cessation of production. There are no current plans to review or update the NOx equations for these turbine models.

Following integration into the Siemens range, the **Alstom Tornado** has been re-branded the **Siemens SGT-200** gas turbine. From 1/1/2026 this entry is available in EEMS as the re-named the **Tornado (SGT-200)**.

Appendix A2.1 NOx equations for operation on gas fuel

Table A2.1 is a summary of coefficients currently in EEMS for gas fuel consumption that will be available for use in EEMS returns from 1/1/2026.

Table A2.1: Fuel gas - Updates to gas fuel turbine EEMS NOx coefficients

EEMS Ref	a	b	c	Update Date
ABB - GT35 (Siemens SGT-500)	0.00433917	0.00004965	0.00000515	2026
Aeroderivative	0.00000000	0.00016100	0.00000000	No change
Allison - 501	0.00003478	0.00048261	0.00000000	No change
Alstom - GT10_low_NOx	0.00099087	0.00000457	0.00000000	Disabled
Alstom - GT40	0.00085095	0.00007453	0.00000000	Disabled
DLE - DLN	0.00200000	0.00000000	0.00000000	2026
GE - Frame5	0.00351465	0.00006382	0.00000038	2026
GE - Frame6	0.00084248	0.00007876	0.00000000	No change
GE - LM1500	0.00038019	0.00009252	0.00000060	Disabled
GE - LM2500	0.00266072	0.00006842	0.00000182	2026
GE - LM2500+	0.00228718	0.00019503	0.00000066	2026
GE - LM2500+G4	0.00442911	0.00016439	0.00000093	2026
GE - LM5000	0.00215345	0.00012369	0.00000010	2026
GE - LM6000	0.00600679	0.00000312	0.00000155	2026
Industrial - LESS THAN 35MW	0.00090800	0.00032300	0.00000000	No change
Industrial - more THAN 35MW	0.00081300	0.00007800	0.00000000	No change
RR - Avon 1535 EAS-1 (SGT-A20)	0.00154106	0.00011437	0.00000019	2026
RR - Avon 1535 RT48 (SGT-A20)	0.00168730	0.00013548	0.00000007	2026
RR - MaxiAvon	0.00079130	0.00010372	0.00000032	Disabled
RR - Olympus	0.00095420	0.00002028	0.00000029	Disabled
RR - RB211-24C	0.00105220	0.00012786	0.00000039	No change
RR - RB211-24G	0.00077481	0.00015447	0.00000137	No change
Solar - Centaur	0.00053441	0.00046559	0.00000000	No change
Solar - Mars	0.00230809	0.00032298	0.00000365	2026
Solar - Saturn	0.00016566	0.00083434	0.00000000	No change

Solar - Taurus	0.00002012	0.00040077	0.00000000	No change
Solar - Titan 130	0.00000000	0.00030000	0.00000000	No change
Solar - Titan 250	0.00000000	0.00005000	0.00000000	No change
Tornado (SGT-200)	0.00044161	0.00027920	0.00000000	No change

The following pages provide further graphical illustration on the main changes in emission factor polynomials from 1/1/2026, aligned with the last column in the table above.

ABB - GT35 (SGT-500) – Gas Fuel

This is a new EEMS polynomial for the **ABB – GT35 (SGT-500) gas turbine**.

The very original aeroderivative GT35 design dates to 1956 with an introductory ISO rating of 9 MWe and 24.5% thermal efficiency. Experience with the power generation model led to it being modified for use for mechanical drive. By 1998 the re-design and uprating of the GT35 had reached ISO rating of 18 MWe and 32% thermal efficiency. The modern-day unit is ISO rated by Siemens at 19.1 MWe with 33.6% efficiency for power generation and 34.8% efficiency for mechanical drive.

The GT35 units on the UKCS are located on installations built in the 1980's and 1990's, with units having had various upgrades over time. There are a mixture of power generation and mechanical drives units. The new equation is based on analysis of test data from these units for the period 2010 – 2024, along with limited OEM and US-EPA data **[Ref 30].** The GT35 has a relatively high NOx footprint, with exceedance above the LCP BAT-AEL of 350mg/Nm3 (corresponding to ~0.014 teNOx/te.fuel.gas) when operating at high duties.

[Sources: ABB Stal ASME paper 98-GT-26, Siemens website, OPRED records]

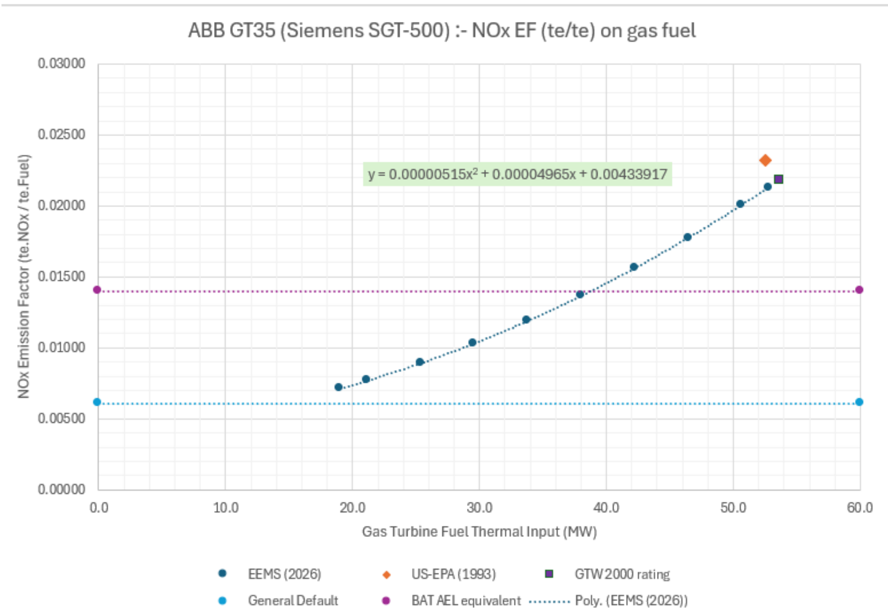
Turbine Type

UKOOA Reference: ABB - GT35 (SGT-500)

Fuel Type: GAS

Factor History

	*From	To	*Factor A	*Factor B	*Factor C
☐	01-JAN-2026		0.00433917	0.00004965	0.00000515



GE Frame 5 – Gas Fuel

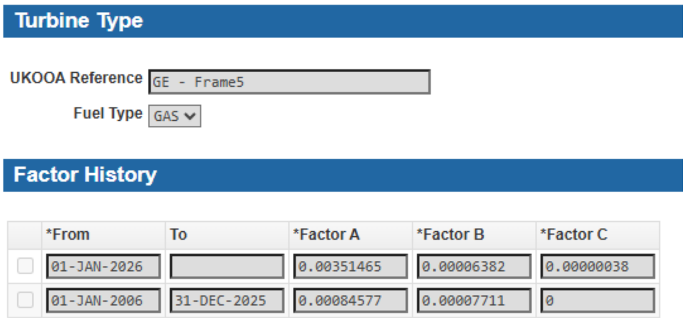
There is an updated EEMS polynomials for the GE Frame 5 gas turbine.

The GE PG5001 (Frame 5) is a heavy-duty industrial gas turbine introduced in the 1950s which became very popular over the next 2 decades used in the power generation and oil and gas industries. The Power generation model PG5341 was introduced by GE in 1978 and the uprated PG5471 was introduced in 1988. Most Frame 5 power generation units on UKCS installations match one of these model ratings, and some will have had ‘performance enhancement kit’ (PEK) material and reliability improvements over the years.

The GE Frame 5 new (updated) polynomial equation should be used from 1/1/2026

The equation is based on analysis of available test data from variable load compliance data take at UKCS installations between 2010 and 2025.

Note: The Frame 5 emission factor profile does not exceed the LCP BAT AEL of 350mg/Nm3 (corresponding to ~0.014 teNOx/te.fuel.gas) across its normal operating range.



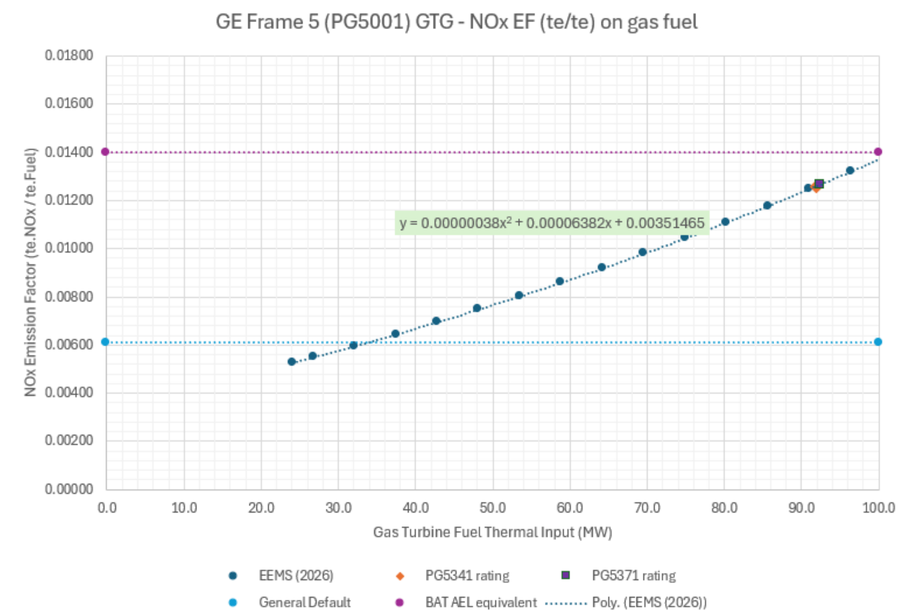
Turbine Type

UKOOA Reference: GE - Frame5

Fuel Type: GAS

Factor History

	*From	To	*Factor A	*Factor B	*Factor C
☐	01-JAN-2026		0.00351465	0.00006382	0.00000038
☐	01-JAN-2006	31-DEC-2025	0.00084577	0.00007711	0



GE LM2500 (Second Generation only) – Gas Fuel

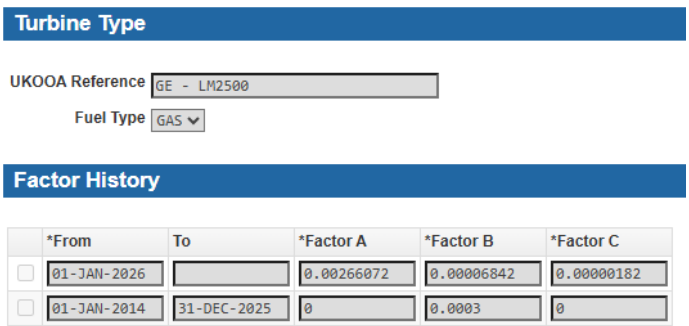
There is a new EEMS polynomial for the **GE LM2500 second generation gas turbine**. The first generation LM2500PC introduced by GE in 1973 was soon upgraded to the 2nd generation LM2500PE incorporating CF6 aero-engine HP turbine technology [Source: GER-3431 1983]. It was later re-designed to produce the 3rd generation LM2500+ and later still the 4th generation LM2500+G4 which both include significant aero-design enhancements [Source: GE website: industrial and marine gas turbines].

From 1/1/2026 this new EEMS polynomial replaces the existing generic LM2500 equation which was found to be over-estimating NOx emissions for the 2nd generation LM2500, because when last revised (2014) it had been based on emissions monitoring information from LM2500, LM2500+ and LM2500+G4 data sets.

Separate equations now exist for all three models of the LM2500 variants.

The LM2500 new equation is based on analysis of available test data from variable load compliance data take at UKCS installations between 2018 and 2025. OEM data from the US-EPA also aligns well. There are now few LM2500 (2nd generation) standard combustion units operating in the UKCS. There are also some LM2500 DLE/DLN units. Most of the LM2500 variants operating in the UKCS are LM2500+ or LM2500+G4.

Note: The LM2500 NOx footprint is below the LCP BAT-AEL of 350mg/Nm3 (corresponding to ~0.014 teNOx/te.fuel.gas) at most normal operating duties.



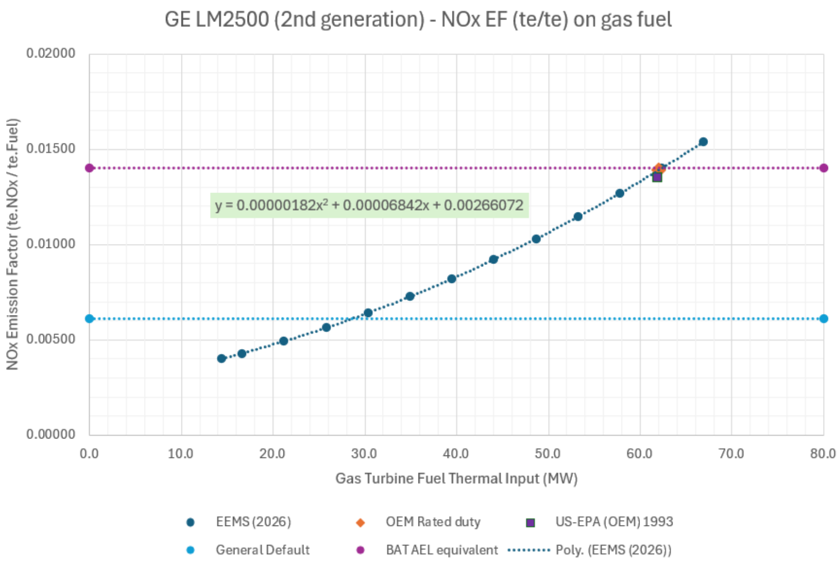
Turbine Type

UKOOA Reference: GE - LM2500

Fuel Type: GAS

Factor History

	*From	To	*Factor A	*Factor B	*Factor C
☐	01-JAN-2026		0.00266072	0.00006842	0.00000182
☐	01-JAN-2014	31-DEC-2025	0	0.0003	0



GE LM2500+ (Third Generation only) – Gas Fuel

There is a new EEMS polynomial for the **GE LM2500+ third generation gas turbine**.

The LM2500+ first launched on the market by GE in 1998, is a later gas turbine design and uprating of the 2nd generation LM2500. Due to extra stages, the LM2500+'s axial air compressor has an increased pressure ratio of 23.1:1 compared to the 18:1 of the LM2500, giving ~20% more power, but a significantly higher NOx emissions profile.

This LM2500+ polynomial should be used (from 1/1/2026) instead of the 'LM2500' polynomial. Separate equations now exist for all three models of the LM2500 variants.

The LM2500+ new equation is based on analysis of available test data from variable load compliance data take at UKCS offshore installations between 2019 and 2025. There are also some LM2500+ DLE/DLN units for which this equation does not apply; see alternative DLE/DLN new equation.

Note: The LM2500+ NOx emission factor profile shows exceedance of the LCP BAT AEL of 350mg/Nm3 (corresponding to ~0.014 teNOx/te.fuel.gas) above mid-load operation.

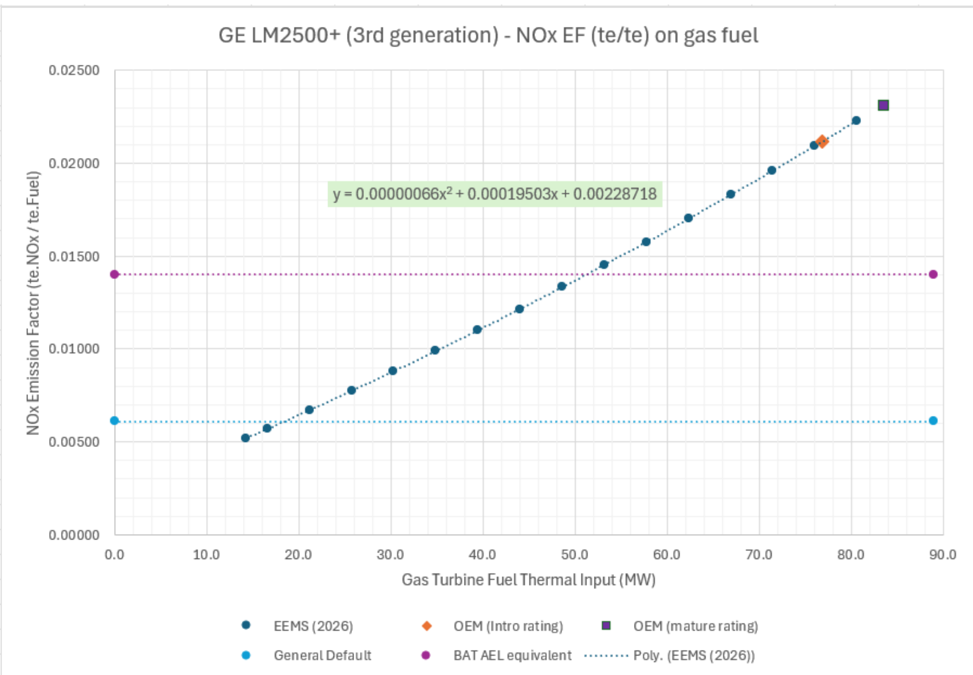
Turbine Type

UKOOA Reference: GE - LM2500+

Fuel Type: GAS

Factor History

	*From	To	*Factor A	*Factor B	*Factor C
☐	01-JAN-2026		0.00228718	0.00019503	0.00000066



GE LM2500+G4 (Fourth Generation only) – Gas Fuel

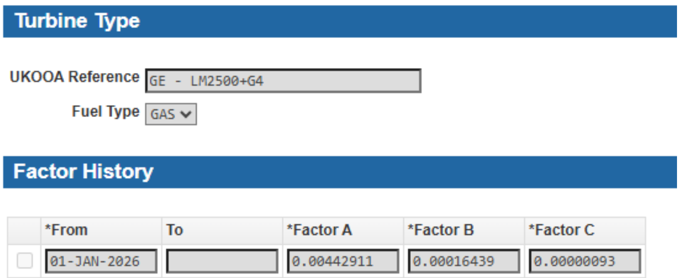
There is a new EEMS polynomial for the **GE LM2500+G4 fourth generation gas turbine**.

The LM2500+G4 first launched on the market by GE in 2005, is a later design and uprating of the 3rd generation LM2500+. The design modifications from LM2500+ to LM2500+G4 include increase in airflow, slightly higher exhaust gas temperatures, and a slightly higher pressure-ratio, giving more power, but also giving a slightly higher NOx emissions profile.

This LM2500+G4 polynomial should be used (from 1/1/2026) instead of the 'LM2500' polynomial. Separate equations now exist for all three models of the LM2500 variants.

The LM2500+G4 new equation is based on analysis of available test data from variable load compliance data take at UKCS installations between 2017 and 2025.

Note: The LM2500+G4 NOx emission factor profile shows exceedance of the LCP BAT AEL of 350mg/Nm3 (corresponding to ~0.014 teNOx/te.fuel.gas) above mid-load operation.



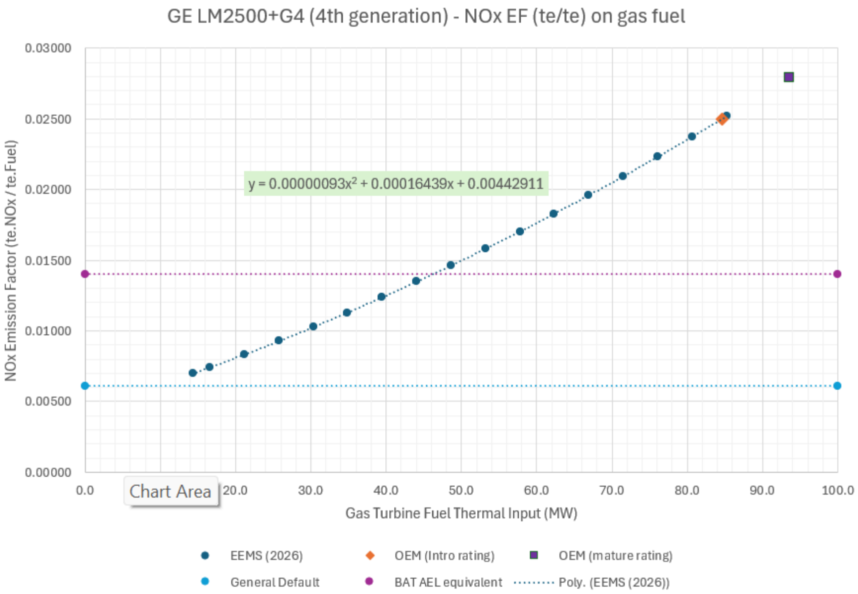
Turbine Type

UKOOA Reference: GE - LM2500+G4

Fuel Type: GAS

Factor History

	*From	To	*Factor A	*Factor B	*Factor C
☐	01-JAN-2026		0.00442911	0.00016439	0.00000093



GE LM5000 – Gas Fuel

There is an updated EEMS polynomial for the GE LM5000 gas turbine.

The GE LM5000 is an aeroderivative gas turbine first introduced in 1978 to the power generation and later to the marine and industrial market, as described in GE ASME paper 89-GT-13. It is derived from the same CF6 aeroengine as the LM2500 but on a different development path to the LM2500+, LM2500+G4 and LM6000. GE started production of the LM6000 in 1992 and stopped production of the LM5000 in 1997 the same year it launched the LM2500+. The LM6000 and LM2500+ replaced the need for the LM5000 in the GE aero-derivative range. GE support for existing LM5000 units continued till 2016 and then for some further years via GE parts supply and a limited number of GE-licenced overhaul bases; this support has now also been discontinued leaving existing units as ‘obsolescent’.

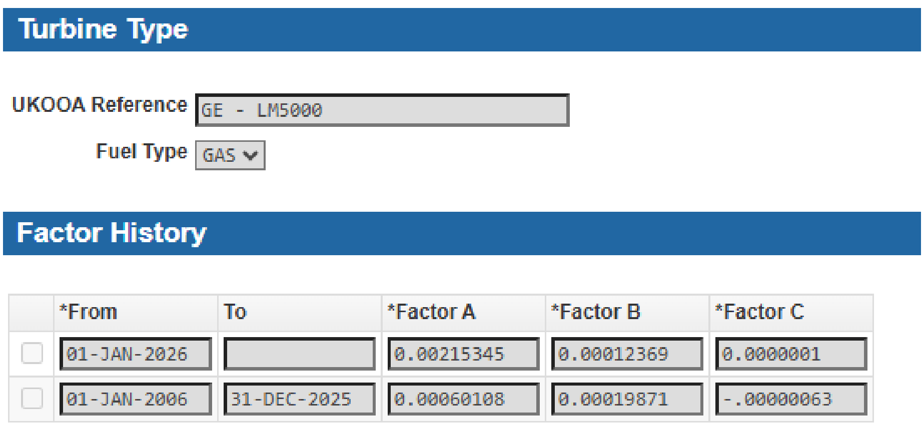
There remain very few operational LM5000 units across the UKCS. Most of these are being retired / upgraded due to the ‘obsolescence’ issues, typically with units from the LM2500 variants of gas turbines (LM2500, LM2500+, or LM2500+G4) depending on duty.

[Sources: GE paper ASME 89-GT-13, GE website, OPRED PPC permit records.]

The GE LM5000 new (updated) polynomial equation should be used from 1/1/2026

The equation is based on analysis of available test data from variable load compliance data take at UKCS installations between 2010 and 2025.

Note: The LM5000 emission factor profile approaches the LCP BAT AEL of 350mg/Nm3 (corresponding to ~0.014 teNOx/te.fuel.gas) close to the top of its operating range.



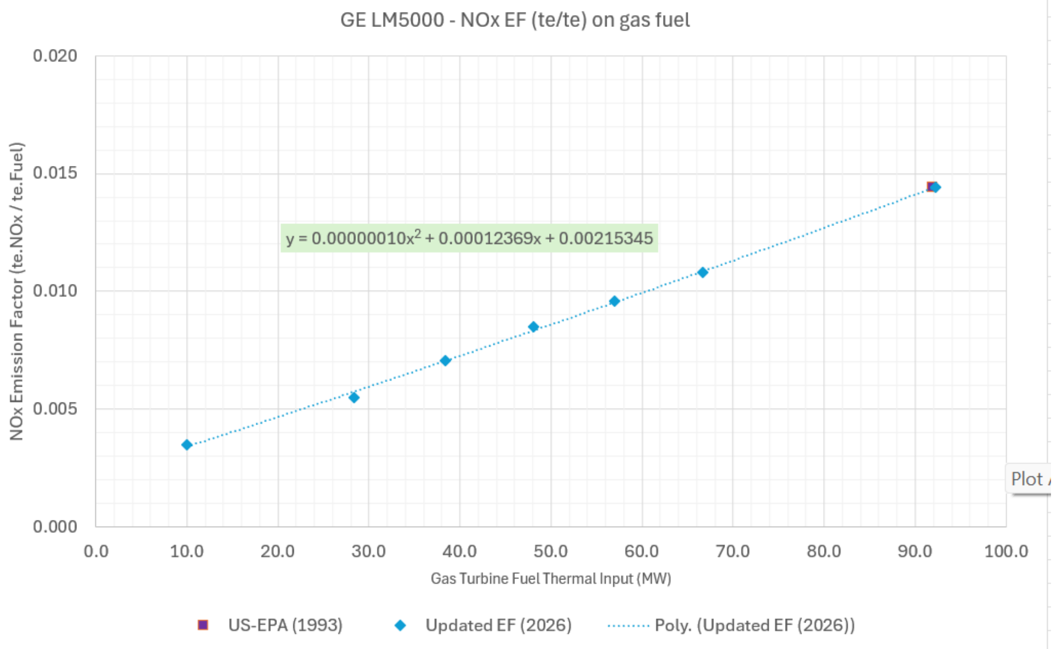
Turbine Type

UKOOA Reference: GE - LM5000

Fuel Type: GAS

Factor History

	*From	To	*Factor A	*Factor B	*Factor C
	01-JAN-2026		0.00215345	0.00012369	0.0000001
	01-JAN-2006	31-DEC-2025	0.00060108	0.00019871	-.00000063


GE LM5000 - NOx EF (te/te) on gas fuel
0.020
0.015
0.010
0.005
0.000
NOx Emission Factor (te.NOx / te.Fuel)
y = 0.00000010x² + 0.00012369x + 0.00215345
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Gas Turbine Fuel Thermal Input (MW)
US-EPA (1993)
Updated EF (2026)
Poly. (Updated EF (2026))
Plot

GE LM6000 – Gas Fuel

There is an updated EEMS polynomial for the GE LM6000 gas turbine.

GE started production of the LM6000 in 1992. Like the LM2500 variants and its LM2500+ and LM2500+G4 its heritage is in the CF6 aero-engine design. The LM6000 was first launched by GE as the LM6000PA model with an uprated LM6000PC model being launched a few years later. Along with the GE Frame 6 gas turbine the LM6000 is one of the largest gas turbine power ratings used in the North Sea oil and gas industry.

There remain very few operational LM6000 units at fixed installations across the UKCS, and there is limited emissions test data available across the load range. A few older LM6000PA units have been retired, and the few LM6000 that remain are LM6000PC.

The GE LM6000 new (updated) polynomial equation should be used from 1/1/2026

The equation is based on analysis of available test data from variable load compliance data for LM6000PC taken at UKCS installations between 2010 and 2025.

Note: The LM6000 NOx emission factor profile is one that exceeds the LCP BAT AEL of 350mg/Nm3 (corresponding to ~0.014 teNOx/te.fuel.gas) at high load operation.

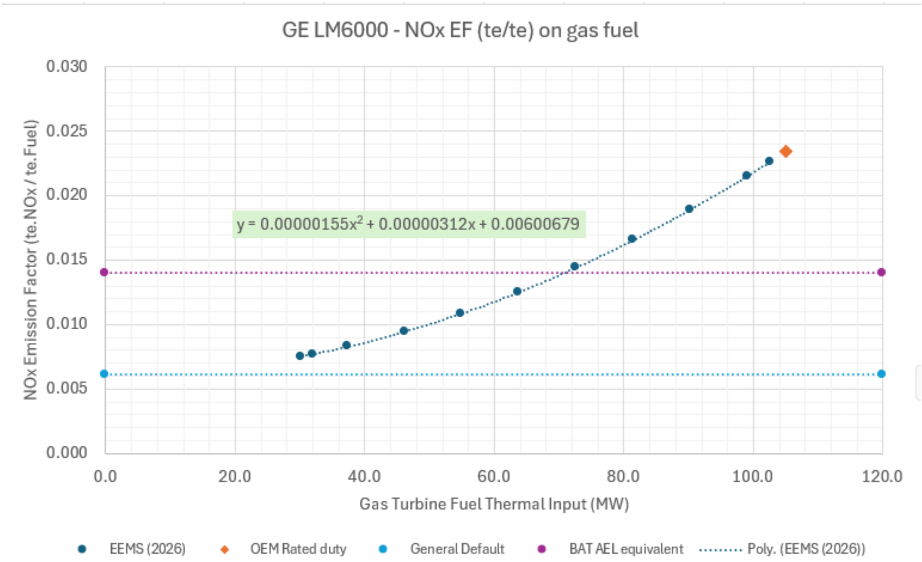
Turbine Type

UKOOA Reference: GE - LM6000

Fuel Type: GAS

Factor History

	*From	To	*Factor A	*Factor B	*Factor C
☐	01-JAN-2026		0.00600679	0.00000312	0.00000155
☐	01-JAN-2006	31-DEC-2025	0.01341005	-.00028893	0.00000434



Rolls Royce Avon 1535 RT48 (SGT-A20) – Gas Fuel

There are new EEMS polynomials for the Rolls Royce Avon 1535 gas turbine including slightly different equations for the Avon with RT48 power turbine (PT) and with EAS-1 PT.

The Avon was the first axial flow jet engine developed by Rolls Royce in the 1950s and later converted for industrial use in the 1960s, used in the oil and gas industry both onshore and offshore. Avon models and up-ratings have been the 1533, 1534, and 1535, and their sub-marks. The Avon gas turbines in the UKCS are generally now all upgraded to the 1535 model including the 1535-200 (introduced by RR in 2009) with power and efficiency enhancements and improved combustion. Siemens acquired the Rolls-Royce Energy aero-derivative gas turbine and compressor business in 2014 and rebranded the Avon the SGT-A20.

The Avon 1535 RT48 new polynomial equation should be used from 1/1/2026

The equation is based on analysis of available test data from variable load compliance data take at UKCS installations between 2010 and 2025. There are still a reasonable number of Avon gas turbines operating in the UKCS.

Note: The Avon 1535 emission factor profile does not exceed the LCP BAT AEL of 350mg/Nm3 (corresponding to ~0.014 teNOx/te.fuel.gas) across its normal operating range.

RR – Avon 1535 RT48 (SGT-A20): Emission Factor Polynomial and Graphical Illustration

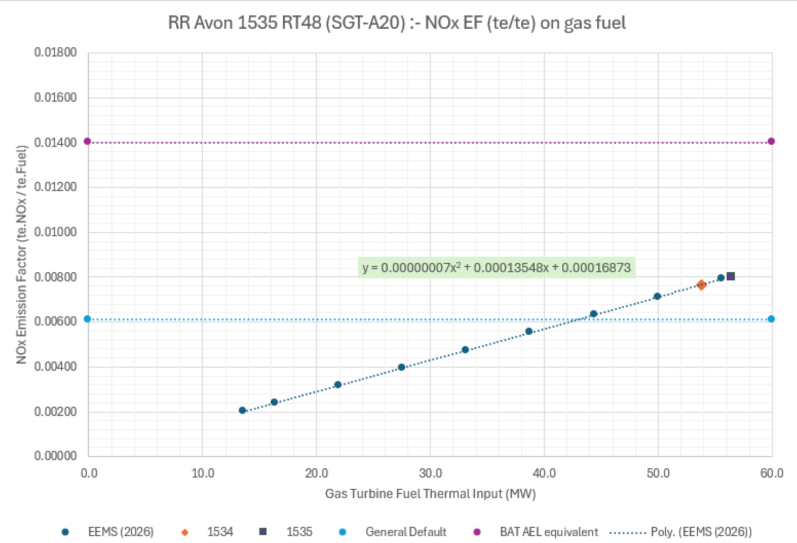
Turbine Type

UKOOA Reference: RR - Avon 1535 RT48 (SGT-A20)

Fuel Type: GAS

Factor History

	*From	To	*Factor A	*Factor B	*Factor C
	01-JAN-2026		0.0016873	0.00013548	0.00000007



Rolls Royce Avon 1535 EAS-1 (SGT-A20) – Gas Fuel

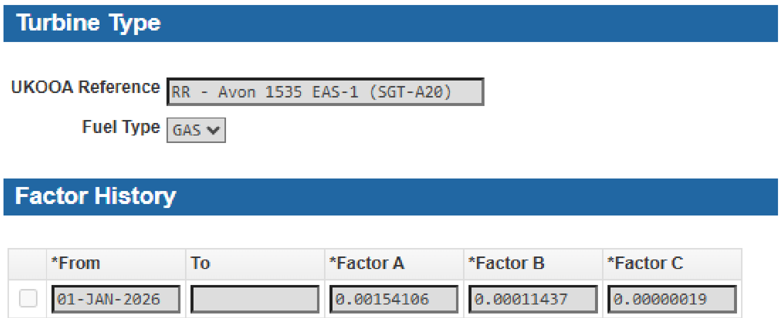
There are new EEMS polynomials for the Rolls Royce Avon-1535 gas turbine including slightly different equations for the Avon with RT48 power turbine (PT) and with EAS-1 PT.

The Avon was the first axial flow jet engine developed by Rolls Royce in the 1950s and later converted for industrial use in the 1960s, used in the oil and gas industry both onshore and offshore. Avon models and up-ratings have been the 1533, 1534, and 1535, and their sub-marks. The Avon gas turbines in the UKCS are generally now all upgraded to the 1535 model including the 1535-200 (introduced by RR in 2009) with power and efficiency enhancements and improved combustion. Siemens acquired the Rolls-Royce Energy aero-derivative gas turbine and compressor business in 2014 and rebranded the Avon the SGT-A20.

The Avon-1535 EAS-1 new polynomial equation should be used from 1/1/2026

The equation is based on analysis of available test data from variable load compliance data take at UKCS installations between 2010 and 2025. There are still a reasonable number of Avon gas turbines operating in the UKCS.

Note: The Avon-1535 emission factor profile does not exceed the LCP BAT AEL of 350mg/Nm3 (corresponding to ~0.014 teNOx/te.fuel.gas) across its normal operating range.

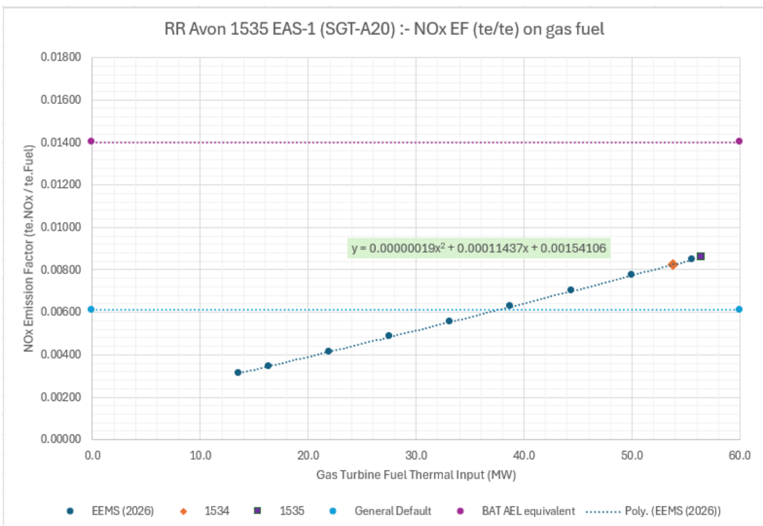

Turbine Type

UKOOA Reference: RR - Avon 1535 EAS-1 (SGT-A20)

Fuel Type: GAS

Factor History

	*From	To	*Factor A	*Factor B	*Factor C
	01-JAN-2026		0.00154106	0.00011437	0.00000019



Rolls Royce RB211-24G (SGT-A35) – Gas Fuel

The EEMS polynomial equation for the RB211-24G gas turbine has been re-assessed. There has been no indication from the analysis that this equation needs to be updated.

The equation is based on analysis of available test data from variable load compliance data take at UK onshore and UKCS offshore installations over the last two decades.

The RB211 aero-derivative industrial gas turbine was introduced to the market in 1974 as the model RB211-22A with a rating of 24 MW. Further up-ratings occurred during the 1980’s to the RB211-24-A, RB211-24C, and in the 1990’s to the RB211-24G

The RB211 industrial aeroderivative engine was matched to a number of different power turbines by different equipment packagers for use in the oil and gas industry. The most prominent of these packagers in Europe were Copper Rolls with the RT56 and later the RT62 power turbine, and European Gas Turbines (EGT) with the ERB1 power turbine. The Cooper Rolls packages are also traditionally designated the Coberra 6556, Coberra 6562, and Coberra 6762 depending on combination of RB211C/G engine with RT56/RT62 power turbine.

There are a significant number of RB211-24G units operating in the UKCS. Although some of these were originally RB211-24C units in many cases their aeroderivative gas generators have been upgraded to RB211-24G to benefit from many of the enhancements of the RB211-24G aero-engine upgrade. However, not all the accompanying power turbines have been uprated from RT56 to RT62 power limits, some remaining as RT56 or ERB1 power turbine packaged configuration. They enjoy emissions, reliability, and efficiency improvements but not full maximum power upgrade in some cases, as maximum power can be dictated by the power turbine or gearbox in some configurations

Note: The RB211-24C and RB211-24G units have a high NOx emission factor profile. However, being a reasonably modern high efficiency gas turbine, the standard EEMS default of 0.0061 teNOx/te.gas.fuel is not suitable. The NOx emission factor profile shows exceedance of the LCP BAT AEL of 350mg/Nm3 (corresponding to ~0.014 teNOx/te.fuel.gas) at high load operating duties.

i. RR – RB211-24G

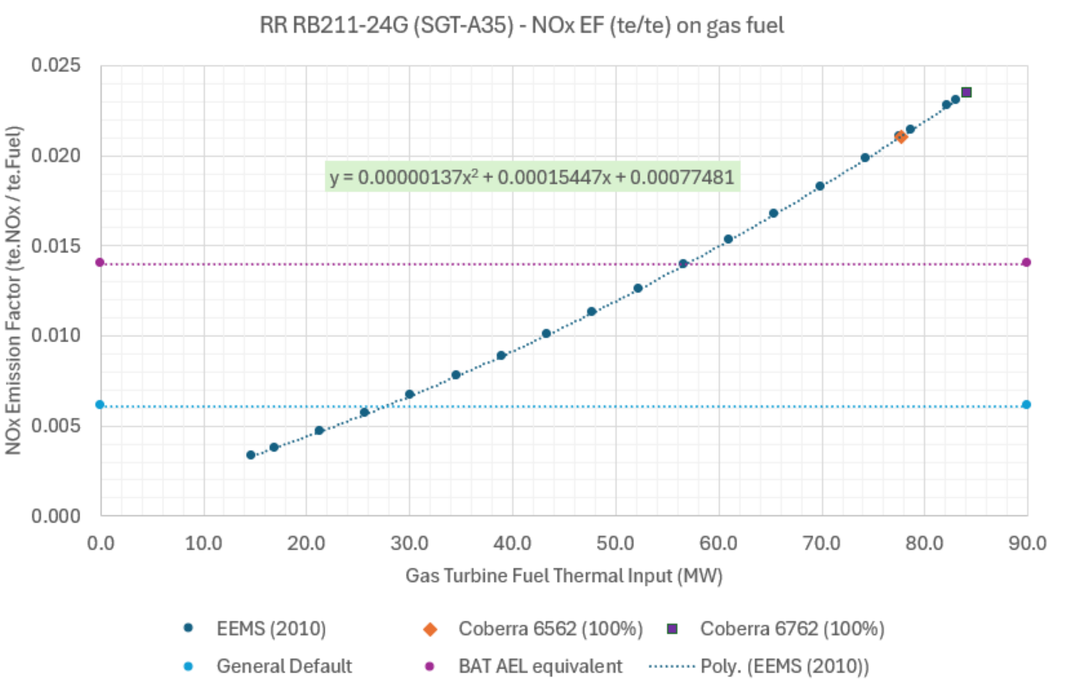
Turbine Type

UKOOA Reference: RR - RB211-24G

Fuel Type: GAS

Factor History

	*From	To	*Factor A	*Factor B	*Factor C
	01-JAN-2006		0.00077481	0.00015447	0.00000137



ii. RR – RB211-24C

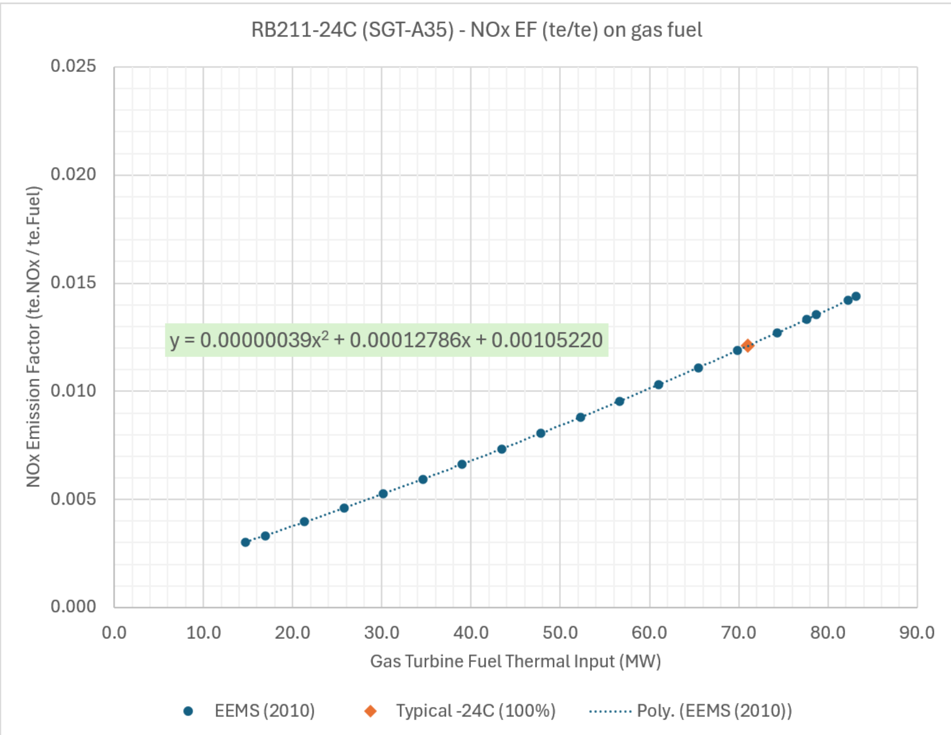
Turbine Type

UKOOA Reference: RR - RB211-24C

Fuel Type: GAS

Factor History

	*From	To	*Factor A	*Factor B	*Factor C
☐	01-JAN-2006		0.0010522	0.00012786	0.00000039



Solar Mars (Mars 90 and Mars 100) – Gas Fuel

There is a new EEMS polynomial for the Solar Mars gas turbine.

This equation is suitable for the Mars 90 and Mars 100 models. It replaces (from 1/1/2026) the existing Solar Mars equation as it was noted to significantly under-estimate NOx emissions.

The equation is based on analysis of available test data from variable load compliance data take at UKCS installations between 2011 and 2025 OEM data from the US-EPA (1993) [**Ref 30**] also aligns well. There are a significant number of Solar Mars units operating in the UKCS. **The new equation should be used from 1/1/2026 to improve reporting.**

Note: The Solar Mars is a medium-sized gas turbine with rated fuel thermal input below 50MWth and is therefore not LCP. However, being a reasonably modern high efficiency gas turbine, the standard EEMS default of 0.0061 teNOx/te.gas.fuel is not suitable.

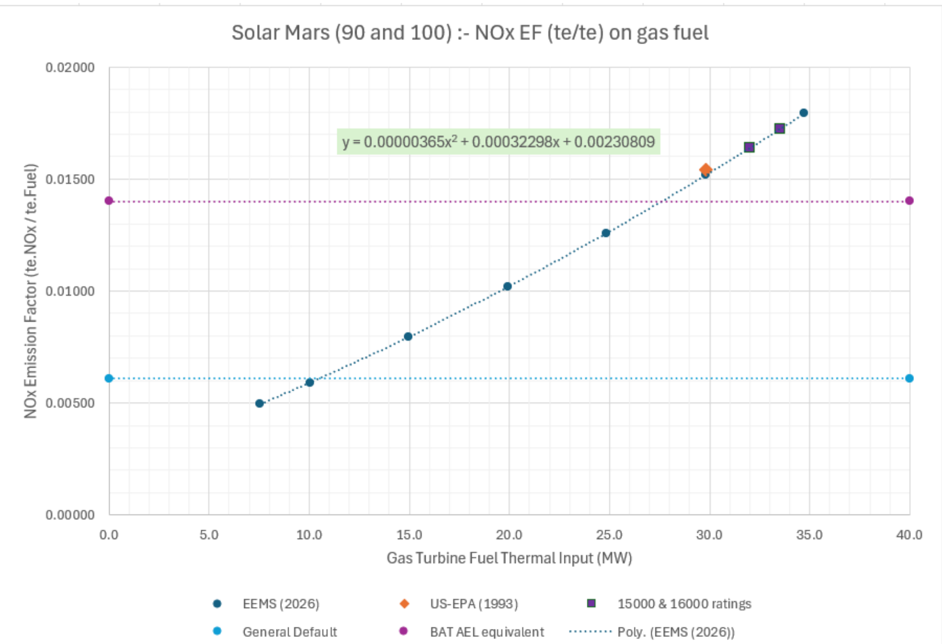
Turbine Type

UKOOA Reference: Solar - Mars

Fuel Type: GAS

Factor History

	*From	To	*Factor A	*Factor B	*Factor C
	01-JAN-2026		0.00230809	0.00032298	0.00000365
	01-JAN-2006	31-DEC-2025	0.00057563	0.00032588	0



Dry Low Emission (DLE) / Dry Low NOx (DLN) – Gas Fuel

A new EEMS polynomial is added for the gas turbines operating with DLE/DLN combustion systems properly tuned, maintained, and in ‘DLE/DLN active’ mode.

Since the 1990’s the main gas turbine OEMs have produced DLE/DLN combustion systems for many of their existing gas turbine models for application in new and/or retrofit installations, as an advancement on standard annular combustion (diffusion flame combustion). Unlike low-emission solutions that came before them (such as steam injection ‘wet’ systems) these DLE/DLN combustion solutions are ‘dry’ and are based on lean pre-mixed combustion. Unlike standard ‘diffusion flame’ combustion where higher pressure ratios and combustor inlet temperature lead to higher thermal efficiency but higher NOx, a pre-mixed system with flame control is insensitive to both.

Most DLE/DLN combustion systems deployed in gas turbines models used in the offshore oil and gas industry are designed to achieve below 25 ppmv NOx emissions at optimum operating duties. **This is a requirement of BAT to comply with the LCP NOx BAT-AEL for new gas turbines of 50mg/Nm3 (corresponding to ~0.002 teNOx/te.fuel.gas).**

In practice, as well as the main lean pre-mixed combustion circuit DLE/DLN systems make use of a pilot circuit to help with combustion stability, especially at low load duty where engine fuel demand and gas path temperatures are low. Examples of three OEM implementations of DLE/DLN combustion:

- GE implementation of DLE/DLN for their aero-derivative gas turbines uses a triple-burner-ring configuration (A, B, C burner rings there the ‘B’ is the pilot). Combined with a variable air bleed system this solution can cover the 25% to 100% operating load range via transition from BC to AB to ABC modes of burner ring configuration, with some loss of efficiency at high air bleed duties.
- Solar Turbines and the Siemens implementation of DLE/DLN on the other hand employ a main pilot fuel circuit and a pre-mixed circuit and tend to only be in ‘active’ DLE/DLN mode above 50% of ISO rated duty. For all DLE/DLN implementations, at very low operating loads, where higher proportion of pilot may be required, NOx can be higher than at full load. In contrast, for standard combustion systems (with diffusion flame) NOx is highest at the highest loads.

The new EF of 0.002 teNOx/te.fuel.gas can be used from 1/1/2026 for gas turbines evidenced to be operating in DLE/DLN mode at normal duty, otherwise a GT-specific analysis should be undertaken. CO and UHC may also be high outside DLE/DLN mode, and in such operating modes it may not be appropriate to use the standard CO and UHC defaults in EEMS. OPRED should be consulted for situations where sub-optimal operation outside of DLE/DLN modes is not just OTNOC but part of routine operation.

Turbine Type

UKOOA Reference: DLE - DLN

Fuel Type: GAS

Factor History

	*From	To	*Factor A	*Factor B	*Factor C
☐	01-JAN-2026		0.002	0	0

Appendix A2.2 NOx equations for operation on diesel fuel

Table 2.2 is a summary of coefficients currently in EEMS for diesel fuel consumption that will be available for use in EEMS returns from 1/1/2026.

Table A2.2: Diesel (Gas Oil) - Updates to gas fuel turbine EEMS NOx coefficients

EEMS Ref	a	b	c	Update Date
ABB - GT35 (Siemens SGT-500)	0.00286699	0.00026117	0.00000302	2026
Aeroderivative	0.01724000	0.00000000	0.00000000	No change
GE - Frame5	0.00777591	0.00007647	0.00000058	2026
GE - LM2500	0.00394155	0.00028995	0.00000052	2026
GE - LM2500+	0.00394155	0.00028995	0.00000052	2026
GE - LM2500+G4	0.00394155	0.00028995	0.00000052	2026
GE - LM6000	0.00873276	0.00001342	0.00000209	2026
Industrial	0.01724000	0.00000000	0.00000000	No change
Industrial - LESS THAN 35MW	-	-	-	No change
RR - Avon 1535 EAS-1 (SGT-A20)	0.00443001	0.00011922	0.00000064	2026
RR - Avon 1535 RT48 (SGT-A20)	0.00443001	0.00011922	0.00000064	2026
RR - MaxiAvon	0.00077766	0.00010670	0.00000224	Disabled
Solar - Mars	0.00683327	0.00038807	0.00000415	2026
Solar - Titan 130	0.01724000	0.00000000	0.00000000	Disabled

The following pages provide further graphical illustration on the main changes in emission factor polynomials from 1/1/2026

ABB - GT35 (SGT-500) – Diesel (Gas Oil)

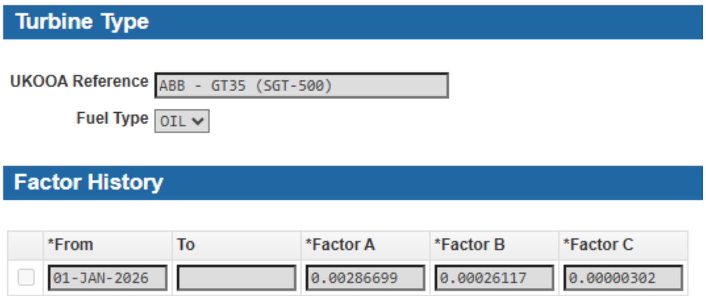
There is a new EEMS polynomial for the **ABB – GT35 (SGT-500) gas turbine**.

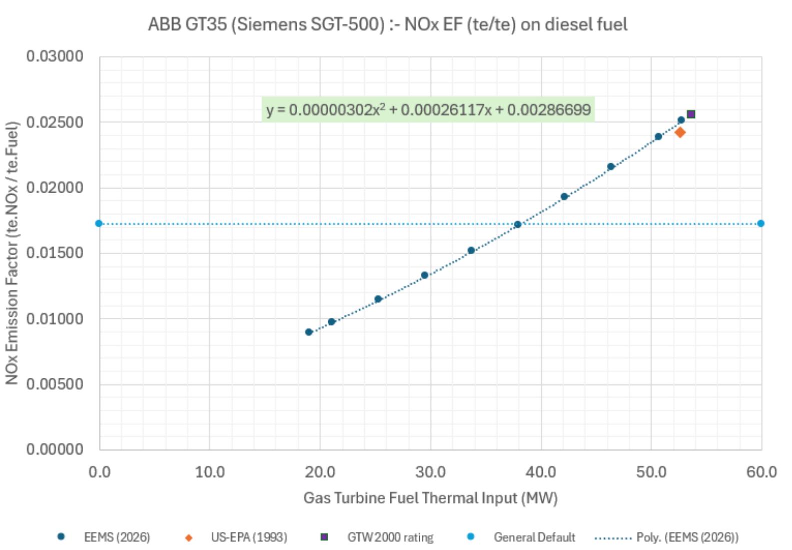
The GT35 units on the UKCS are located on installations built in the 1980’s and 1990’s, with units having had various upgrades over time. There are a mixture of power generation and mechanical drives units. The power generation units tend to be dual fuel but operate preferentially on gas fuel. The mechanical drive units tend to be on export gas compression duty and operate on gas fuel only (are not configured for diesel).

The new diesel equation is based on analysis of limited test data from power generation GT35 units for the period 2010 – 2024, along with limited OEM and US-EPA data **[Ref 32]**.

The new equation can be used from 1/1/2026 in place of the generic default to improve reporting of NOx emissions on diesel.

Note: The GT35 has a relatively high NOx footprint which is above the updated generic EEMS default of 0.01724 te.NOx/te.Diesel at high operating duties, but below it at low operating duties.





GE Frame 5 – Diesel (Gas Oil)

There is a new EEMS polynomial for the **GE Frame 5 gas turbine**.

Most existing Frame 5 power generation (PG5001) units operating at fixed installations in the UKCS are dual fuel PG5341 or PG5741 models and can operate on diesel instead of gas. The smaller number of existing twin shaft Frame 5 units on mechanical drive (gas compression) duty operate on gas only.

The new diesel equation is based on analysis of test data from power generation Frame 5 units for the period 2010 – 2024, along with limited OEM data.

The new equation can be used from 1/1/2026 in place of the generic default to improve reporting of NOx emissions on diesel.

Note: The Frame 5 has a NOx footprint below the updated generic EEMS default of 0.01724 te.NOx/te.Diesel at most operating duties, apart from close to maximum rating.

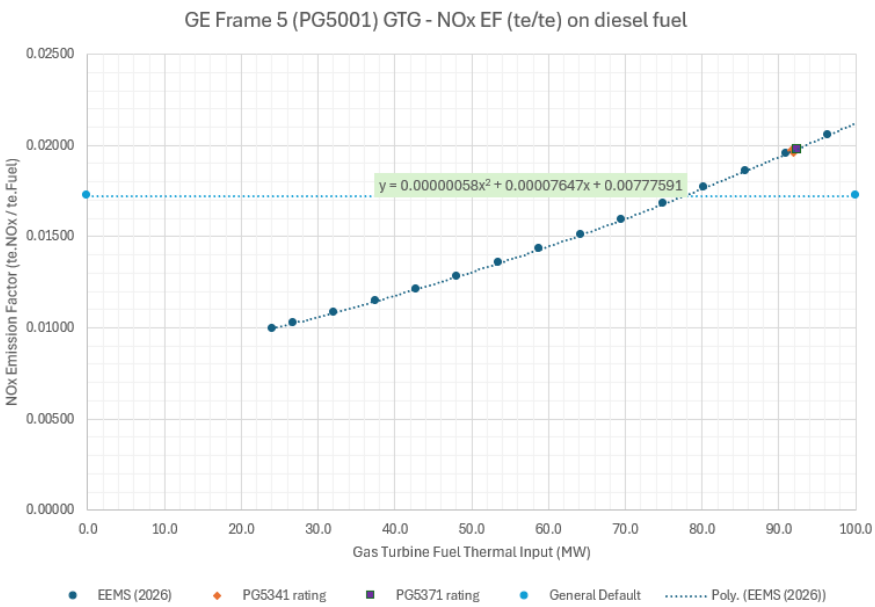
Turbine Type

UKOOA Reference: GE - Frame 5

Fuel Type: OIL

Factor History

	*From	To	*Factor A	*Factor B	*Factor C
☐	01-JAN-2026		0.00777591	0.00007647	0.00000058



GE LM2500, LM2500+, LM2500+G4 – Diesel (Gas Oil)

There is a new EEMS polynomial for the **LM2500 variants of gas turbines**.

Most units operating at fixed installations in the UKCS are LM2500+ or LM2500+G4 gas turbine models as opposed to LM2500 (second generation). The existing second generation LM2500 units in the UKCS are on mechanical drive (gas compression) duty and do not operate on diesel.

The new diesel equation is based on analysis of limited test data from power generation LM2500+ and LM2500+ units for the period 2010 – 2024, along with limited OEM and US-EPA data **[Ref 30]**. Unlike the equations on gas fuel, there is insufficient wealth of test data on diesel to adequately make a distinction between the two models on diesel fuel.

The new equation can be used from 1/1/2026 in place of the generic default to improve reporting of NOx emissions on diesel.

Note: The LM2500+ and LM2500+G4 have a relatively high NOx footprint which is above the updated generic EEMS default of 0.01724 te.NOx/te.Diesel at high operating duties, but below at low operating duties.

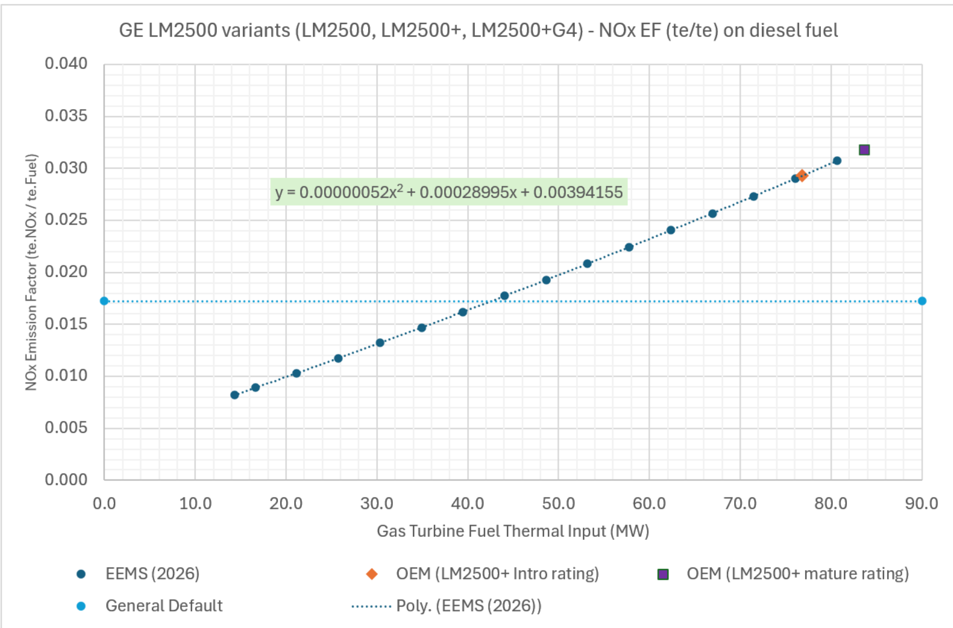
Turbine Type

UKOOA Reference: GE - LM2500

Fuel Type: OIL

Factor History

	*From	To	*Factor A	*Factor B	*Factor C
	01-JAN-2026		0.00394155	0.00028995	0.00000052
	01-JAN-2014	31-DEC-2025	0.0056	0.000232	0.000003



GE - LM6000 – Diesel (Gas Oil)

There is a new EEMS polynomial for the **LM6000 gas turbines**.

There remain very few operational LM6000 units at fixed installations across the UKCS, and there is limited emissions test data available across the load range. A few older LM6000PA units have been retired, and the few LM6000 that remain are LM6000PC.

The GE LM6000 new (updated) polynomial equation should be used from 1/1/2026

The equation is based on analysis of available test data from variable load compliance data for LM6000PC taken at UKCS installations between 2010 and 2025.

Note: The LM6000 has a relatively high NOx footprint which is above the updated generic EEMS default of 0.01724 te.NOx/te.Diesel at mid to high operating duties, but below at low operating duties.

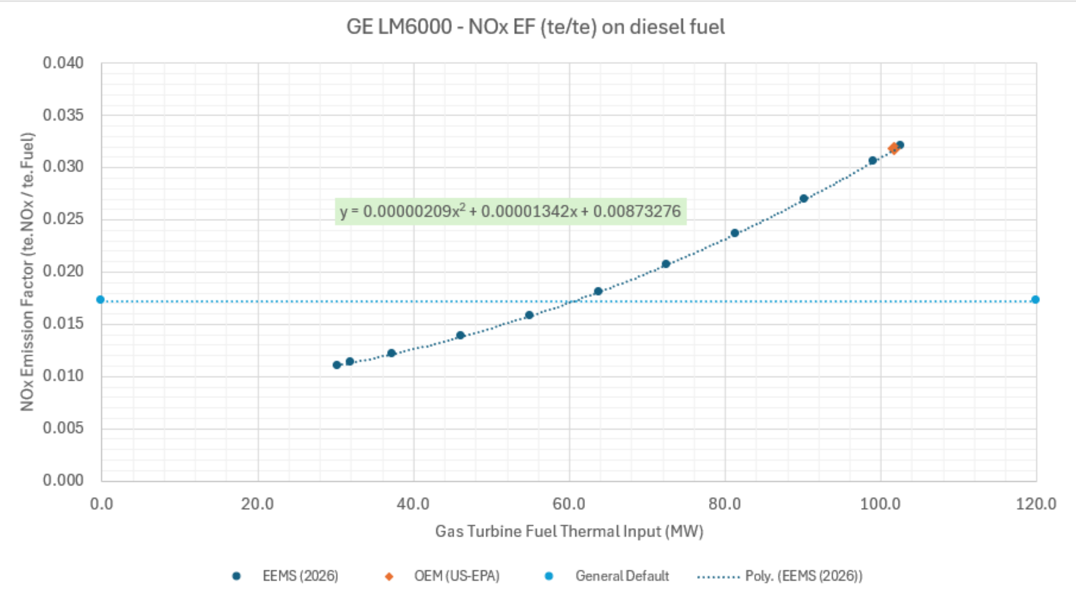
Turbine Type

UKOOA Reference: GE - LM6000

Fuel Type: OIL

Factor History

	*From	To	*Factor A	*Factor B	*Factor C
	01-JAN-2026		0.00873276	0.00001342	0.00000209
	01-JAN-2006	31-DEC-2025	0.00602494	0.00018944	0



Rolls Royce Avon 1535 (SGT-A20) – Diesel (Gas Oil)

There is a new EEMS polynomial for the **RR Avon 1535 gas turbine**.

Most existing Avon power generation units operating at fixed installations in the UKCS are dual fuel and can operate on diesel instead of gas. The existing Avon units on mechanical drive (gas compression) duty do not operate on diesel but gas only.

The new diesel equation is based on analysis of test data from power generation Avon 1535 units for the period 2010 – 2024, along with limited OEM data. Unlike the equations on gas fuel, there is insufficient spread of test data on diesel to adequately make a distinction between the RT48 and EAS-1 power turbine variants. A common equation has therefore been derived for both variants.

The new equation can be used from 1/1/2026 in place of the generic default to improve reporting of NOx emissions on diesel.

Note: The Avon 1535 has a NOx footprint which is below the updated generic EEMS default of 0.01724 te.NOx/te.Diesel at normal operating duties across the load range.

i). EAS-1

Turbine Type

UKOOA Reference: RR - Avon 1535 EAS-1 (SGT-A20)

Fuel Type: OIL

Factor History

	*From	To	*Factor A	*Factor B	*Factor C
☐	01-JAN-2026		0.00443001	0.00011922	0.00000064

ii). RT48

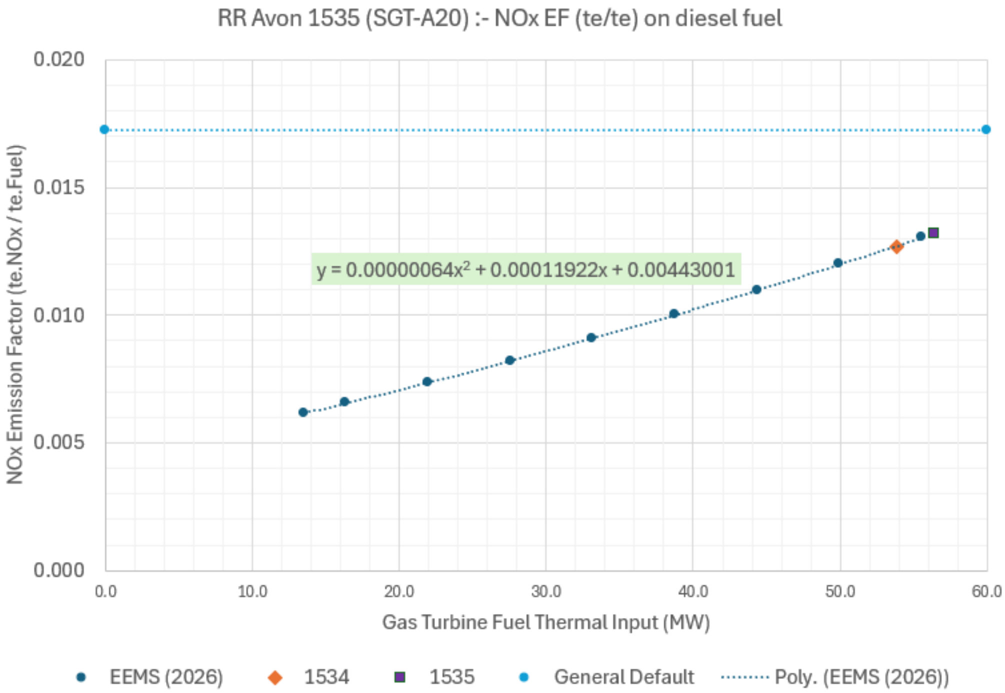
Turbine Type

*UKOOA Reference: RR - Avon 1535 RT48 (SGT-A20)

*Fuel Type: OIL

Factor History

	*From	To	*Factor A	*Factor B	*Factor C
☐	01-JAN-2026		0.00443001	0.00011922	0.00000064


RR Avon 1535 (SGT-A20) :- NOx EF (te/te) on diesel fuel
0.020
0.015
0.010
0.005
0.000
NOx Emission Factor (te.NOx / te.Fuel)
y = 0.00000064x² + 0.00011922x + 0.00443001
0.0
10.0
20.0
30.0
40.0
50.0
60.0
Gas Turbine Fuel Thermal Input (MW)
EEMS (2026)
1534
1535
General Default
Poly. (EEMS (2026))

Solar Mars – Diesel (Gas Oil)

There is a new EEMS polynomial for the **Solar Mars gas turbine**.

Most existing Solar Mars units operating at fixed installations in the UKCS are Mars 90 or Mars 100 models. Some of the power generation units can operate on diesel instead of gas. The Solar Mars units on mechanical drive (gas compression) duty operate on gas only, as also do a few of the power generation units.

The new diesel equation is based on analysis of test data from power generation Solar Mars units for the period 2010 – 2024, along with limited OEM data.

The new equation can be used from 1/1/2026 in place of the generic default to improve reporting of NOx emissions on diesel.

Note: The Solar Mars has a relatively high NOx footprint which is above the updated generic EEMS default of 0.01724 te.NOx/te.Diesel at high operating duties, but below it at low duties.

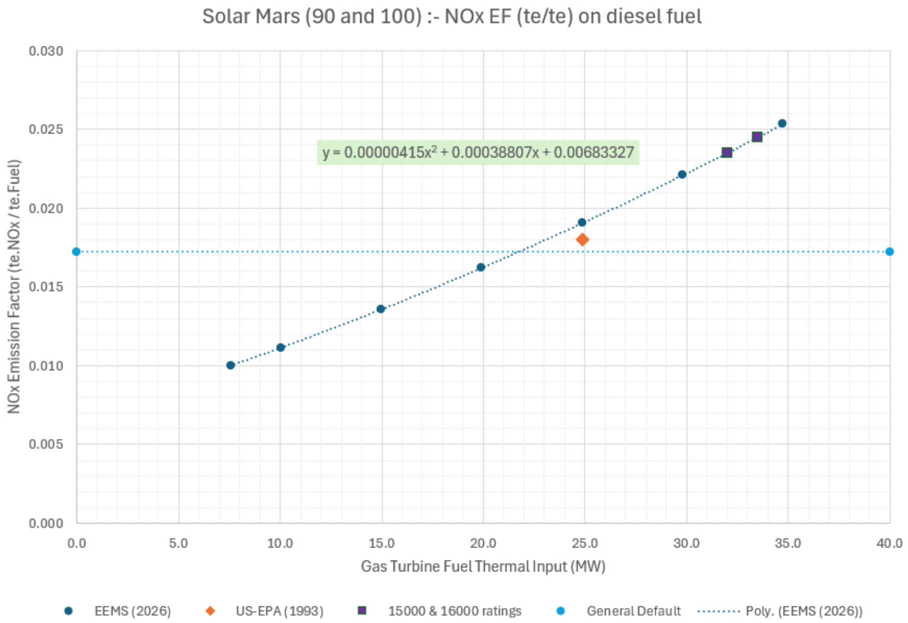
Turbine Type

UKOOA Reference: Solar - Mars

Fuel Type: OIL

Factor History

	*From	To	*Factor A	*Factor B	*Factor C
☐	01-JAN-2026		0.00683327	0.00038807	0.00000415



Appendix A3 - EEMS Combustion Default Factors

As referred to in Section 2.6 combustion emission factors are based on the chemical equations (see below) governing the combustion reaction. Using combustion emission factors and the efficiency of the combustion reaction, the amount of combustion product (i) can be calculated from the amount of combustible gas (j) in the original pre-combustion gas $M_{mix}(j)$.

A3.1 General Principles to Determine Emission Factors

Using EFs and reaction efficiencies the mass of combustion product (i) is calculated from the amount of combustible gas (j) in the original pre-combustion gas mix $M_{mix}(j)$:

$$M_{com}(j \rightarrow i) = EF(j \rightarrow i) \times M_{mix}(j) \times Eff(j \rightarrow i) / 100 \qquad 0\text{-}1$$

Where:

- $M_{com}(j \rightarrow i)$ is the mass of combustion product (i) created by a combustion reaction consuming combustible gas (j) (tonnes);
- $EF(j \rightarrow i)$ is the combustion factor for combustion product (i) created by a combustion reaction consuming combustible gas (j);
- $M_{mix}(j)$ is the mass of combustible gas (j) in the pre-combustion mix (tonnes); and
- $Eff(j \rightarrow i)$ is the combustion efficiency of the combustion reaction consuming combustible gas (j) and creating combustion product (i) (%).

$M_{mix}(j)$ can be found by multiplying the percentage of component (j) by weight in the feed mixture ($C_{wt}(j)$) by the total mass of feed (M_{tot}):

$$M_{com}(j \rightarrow i) = EF(j \rightarrow i) \times C_{wt}(j) / 100 \times M_{tot} \times Eff(j \rightarrow i) / 100 \qquad 0\text{-}2$$

The total mass of the combustion product (i) is found by summing the above for each combustion reaction to produce the overall mass of combustion product (i):

$$M_{com}(i) = (\sum_j \; EF(j \rightarrow i) \times C_{wt}(j) / 100 \times Eff(j \rightarrow i) / 100) \times M_{tot} \qquad 0\text{-}3$$

Assuming the combustion efficiencies are equal for all reactions for a single emission source the above equation simplifies:

$$M_{com}(i) = (\sum_j \; EF(j \rightarrow i) \times C_{wt}(j) / 100 \,) \times Eff(j \rightarrow i) / 100 \times M_{tot} \qquad 0\text{-}4$$

Relating this to equation 0-1 an overall combustion factor is implied for combustion product (i):

$$EF(i) = \sum_j \; EF(j \rightarrow i) \times C_{wt}(j) / 100 \qquad 0\text{-}5$$

A3.2 CO_2 Emissions Factor

CO_2 emissions derive from the oxidation of carbon containing compounds in fuel gas, oil, diesel, and flare gases during their combustion.

The combustion factor is found by calculating the mass ratios of the emission product to the combustible feed component. The masses are derived by multiplying the combustion stoichiometric coefficients by the molecular weight for each component.

For gaseous fuels, CO_2 is a product from the combustion of hydrocarbons:

- **Methane (CH_4)** is the main compound of offshore gaseous fuels.
- **Non-methane VOCs (NMVOCs)** are present to varying degrees depending on the source of the gaseous fuel with the highest prevalence of ethane and propane.

Using Equation 2-10 0-6

$$EF(CO_2) = EF(CH_4 \rightarrow CO_2) \times C_{wt}(CH_4) / 100 + EF(VOC \rightarrow CO_2) \times C_{wt}(VOC) / 100$$

Methane Combustion

The balanced equation for the combustion of methane is:

$$CH_4 + 2 \times O_2 \rightarrow CO_2 + 2 \times H_2O$$

Methane combustion requires 1 molecule of CH_4 to produce 1 molecule of CO_2. Therefore, relating the molecular weight of combustible products consumed and created the combustion factor for CH_4 is calculated for complete combustion of CH_4.

$$EF(CH_4 \rightarrow CO_2) = 1 \times MWT(CO_2) / 1 \times MWT(CH_4) \quad \text{0-7}$$

$$= 44.0098 / 16.04276$$

$$= 2.74328$$

Non-methane VOC Combustion (NMVOCs)

NMVOCs are composed of a HC mixture which can include ethane, propane, iso-butanes and iso-pentanes etc. in varying proportions and so it is not possible to create a simple equation to determine the EF, in the absence of full gas composition breakdown. Assuming an average VOC MWT_{ave} of 40 atomic mass unit (amu) does enable a representative EF to be determined for nmVOCs and typically results in only a minor source of error in the calculation of the EF, although relatively high component weights of ethane magnify the error.

Another possibility is assuming a default fraction of carbon by mass in VOC of 0.6 as per IPCC guidelines which does enable an EF to be determined **[Ref 31]**. However, relatively high component weights of ethane may lead to significant underestimates of CO_2 emissions.

To calculate a more accurate EF for CO_2 from VOCs compositional analysis from gas sampling and laboratory analysis reports should be used. These reports provide a VOC component breakdown in weight % which operators can use to calculate site specific EFs using the number of carbon atoms in each VOC and the molecular weights of the VOC and CO_2. This is the preferred approach in line with the UK ETS highest tier for EF determination. Given that many UKCS installations with PPC permits also have ETS permits this approach is preferred.

The EF can be calculated as follows:

$$EF(CO_2) = (C_{wt}(x) / 100) \times [N_C(X) \times 12 / MWT(X)] \times [MWT(CO_2)/12] \quad \text{0-8}$$

Where:

- $C_{wt}(x)$ is the laboratory analysis weight percentage all contributing VOCs;
- $N_C(X)$ is the number of carbon atoms in the contributing VOC;
- $M_{WT}(CO_2)$ is the molecular weight of CO_2 (g/mol);
- $M_{WT}(X)$ is the molecular weight of the contributing VOC; and
- $[N_C(X) \times 12 / M_{WT}(X)]$ is the fraction of carbon by mass in the contributing VOC.

If laboratory analysis is unavailable then the default EF for VOC combustion is:

$$\boxed{EF_{VOC\rightarrow CO2} = 3.143 - (6.286 / MWT(VOC))} \quad \text{0-9}$$

Assuming MWT (VOC) to be 40 amu, the EF of VOCs to CO_2 becomes a single value of 2.986 and the overall CO_2 EF is determined using:

$$\boxed{EF(CO2) = 2.74328 \times C_{WT}(CH4) + 2.986 \times C_{WT}(VOC) / 100} \quad \text{0-10}$$

If the default IPCC fraction of carbon by mass in VOC of 0.6 is used the derived EF from VOC would be 2.2.

$$EF(CO_2) = (C_{wt}(VOC)_x / 100) \times 0.6 \times [44/12] = 2.2 \times (C_{wt}(VOC) / 100)$$

The overall CO_2 EF is then determined for contributions from methane and VOC:

$$EF(CO_2) = 2.74328 \times Cwt(CH_4) / 100 + 2.2 \times Cwt(VOC) / 100 \quad \text{0-11}$$

Inherent CO_2 Emission Factor

The CO_2 emissions generated by combustion, and therefore the individual component CO_2 EFs, are calculated based on stoichiometric reactions of HCs. However, fuel gas can contain a proportion of inherent CO_2 as a gas component, which must be accounted for in the emission calculation. Assuming one combustion efficiency for all reactions:

$EF(CO_2) = EF(CH_4 \rightarrow CO_2) \times C_{wt}(CH_4) / 100 + EF(VOC \rightarrow CO_2) \times C_{wt}(VOC) / 100) \times Eff/100 + C_{wt}(CO_2) / 100$ 0-12

$EF(CO_2) = (2.743\ 28 \times C_{wt}(CH_4) / 100 + [NC(VOC) \times 12 / MWT_{ave}(VOC)] \times 44/12 \times C_{wt}(VOC) / 100) \times Eff /$ 0-13

$100 + C_{wt}(CO_2) / 100$

Where:

- $NC_{ave}(VOC)$ is the average number of carbon atoms in the contributing VOCs;
- $MWT_{ave}(VOC)$ is the average molecular weight of the contributing VOCs; and
- $12 \times NC(VOC) / MWT_{ave}(VOC)$ is the average fraction of carbon by mass in the contributing VOCs.

A3.3 SO_2 Combustion Factor

SO_2 emissions derive from the oxidation of sulphur containing compounds in fuel gas, oil, diesel, and flare gases during their combustion. The typical sulphur containing compound is hydrogen sulphide (H_2S).

Hydrogen Sulphide Combustion (Fuel Gas)

During the combustion of hydrogen sulphide in a gaseous mix, 2 molecules of H_2S results in 2 molecules of SO_2 in the combustion products.

The balanced equation for the combustion of H_2S is:

2 x H2S + 3 x O2 → 2 x H2O + 2 x SO2

The SO_2 combustion factor for H_2S is the ratio of molecular weights of 2 x SO_2 to 2 x H_2S:

$EF(H_2S \rightarrow SO_2) = 2 \times MWT(SO_2) / 2 \times MWT(H_2S)$ 0-94

$= 64.0468 / 34.08188$

$= 1.8792$

Therefore, for a gaseous fuel mixture the SO_2 EF is found using:

$EF(SO_2) = EF(H_2S \rightarrow SO_2) \times C_{wt}(H_2S) / 100$ 0-105

$= 1.8792 \times C_{wt}(H_2S) / 100$

To calculate the EF for SO_2 when H_2S is combusted the respective C_{wt} is required. This is found using the MWT and atomic weight (AWT) of H_2S and S respectively.

$C_{wt}(H_2S) = MWT(H_2S) / AWT(S) \times C_{wt}(S)$ 0-116

$= 34.08188 / 32.006 \times C_{wt}(S)$

$= 1.06486 \times C_{wt}(S)$

When a mix of the emission gases is combusted e.g. as fuel gas, there is a principal combustion reaction creating SO_2, e.g. combusted H_2S. The presence of sulphur in gaseous fuels is reported in parts per million by weight (ppm wt), where 1 ppm wt = 0.0001 % wt, i.e. $C_{wt}(S)$. In EEMS, a typical sulphur concentration of 6.4ppm wt in H_2S is assumed. Applying Equation 0-5 and substituting Equation 0-12.

$EF(SO_2) = EF(H_2S \rightarrow SO_2) \times C_{wt}(H_2S) / 100 \times Eff / 100 + C_{wt}(SO_2) / 100$ 0-127

$= 1.8792 \times C_{wt}(H_2S) /100 \times Eff / 100 + C_{wt}(SO_2) / 100$

Assuming that there is no SO_2 in the gas composition and 100% combustion efficiency:

$EF(SO_2) = 1.8792 \times C_{wt}(H_2S) /100 \times Eff / 100 + C_{wt}(SO_2) / 100$ 0-138

$= 1.8792 \times 1.06486 \times 0.00064 /100$

$= 0.0000128$

Sulphur Combustion (Diesel)

During the combustion of Sulphur (S) in a liquid fuel 1 molecule of S results in 1 molecule of SO_2 in the combustion products.

$S + O_2 \rightarrow SO_2$

The SO_2 combustion factor for S is the ratio of molecular weights of SO_2 to S.

$EF(S \rightarrow SO_2) = MWT(SO_2) / MWT(S)$ 0-149

$= 64.0468 / 32.066$

$= 1.99734$

Therefore, for diesel the EF is:

$EF(SO_2) = EF(S \rightarrow SO_2) \times C_{wt}(S) / 100$ 0-20

$= 1.99734 \times C_{wt}(S) / 100$

The S content in diesel and heavy fuel oil is limited by the Council Directive 1999/32/EC to 0.1% and 1% by mass respectively. For each fuel composition, and assuming 100% combustion efficiency the default EFs can be calculated.

Diesel

$EF(SO_2) = 1.99734 \times 0.1 / 100 \times 1 = 0.001997$ 0-21

Heavy Fuel Oil

$EF(SO_2) = 1.99734 \times 1 / 100 \times 1 = 0.01997$ 0-22

Ultra-Low Sulphur Diesel

Ultra-Low Sulphur Diesel (ULSD) has been refined to give a sulphur content of 10-15ppm wt depending on source of origin. The operator should select the appropriate sulphur content for the calculation. Hence, where $C_{wt}(S)$ = 15 ppm wt or 0.0015 % wt and the EF can be calculated:

$EF(SO_2) = 1.99734 \times 0.0015 / 100 = 0.00003$ 0-23

Other Liquid Fuels

For operators who use other liquid fuels, e.g. self-generated liquid fuels (rather than those purchased in the standard commercial markets), the EFs should be calculated using data gathered from sampling and analysis to generate site specific EFs.

Note: As explained above the S content in diesel is limited by the Council Directive 1999/32/EC and Sulphur Content of Liquid Fuels (England and Wales) Regulations 2007 to 0.1% from January 2008 which was previously 0.2% from July 2000. The previous EEMS default emission factor of 0.004 te.SO2 per te.diesel has therefore been replaced with a new default of 0.002 te.SO2 per te.diesel.

-Table A3 EEMS Default Emission Factors (Tonne/Tonne)

Emission source	Emission category	CO_2	CO	N_2O	NOx	SO_2	CH_4	NMVOC
Diesel Consumption	Engines	3.19	0.0157	0.00022	0.0594	0.002	0.00018	0.002
Diesel Consumption	Heaters	3.19	0.00071	0.00022	0.0028	0.002	0.00000705	0.0000282
Diesel Consumption	Turbines	3.19	0.00092	0.00022	0.01724	0.002	0.0000328	0.000295
Fuel Oil Consumption	Engines	3.19	0.0157	0.00022	0.0594	0.002	0.00018	0.002
Fuel Oil Consumption	Heaters	3.19	0.00071	0.00022	0.0028	0.002	0.00000705	0.0000282
Fuel Oil Consumption	Turbines	3.19	0.00092	0.00022	0.01724	0.002	0.0000328	0.000295
Gas Consumption	Engines	2.86	0.0076	0.00022	0.0576	0.0000128	0.0198	0.0032
Gas Consumption	Heaters	2.86	0.0006	0.00022	0.0024	0.0000128	0.000089	0.0000099
Gas Consumption	Heaters (Small Emitter)	2.86	0.003	0.00022	0.0024	0.0000128	0.00092	0.000036

Gas Consumption	Others	2.86	0.003	0.00022	0.0024	0.0000128	0.00092	0.000036
Gas Consumption	Turbines	2.86	0.006	0.00022	0.0061	0.0000128	0.00092	0.000036
Gas Consumption	Turbines (Small Emitter)	2.86	0.003	0.00022	0.0061	0.0000128	0.00092	0.000036
Gas Flaring	GAS	2.80	0.0067	0.000081	0.0012	0.0000128	0.018	0.002
Gas Flaring	OIL	2.80	0.0067	0.000081	0.0012	0.0000128	0.01	0.01
Gas Venting	GAS	0.00	0.00	0.00	0.00	0.00	0.90	0.10
Gas Venting	OIL	0.00	0.00	0.00	0.00	0.00	0.50	0.50
Oil Loading	Rail/Truck	0.00	0.00	0.00	0.00	0.00	0.0001	0.00059
Oil Loading	Ship (Offshore)	0.00	0.00	0.00	0.00	0.00	0.000017	0.0020
Oil Loading	Ship (Onshore)	0.00	0.00	0.00	0.00	0.00	0.000017	0.0010
Well Testing	GAS	2.80	0.0067	0.000081	0.0012	0.0000128	0.045	0.005
Well Testing	OIL	3.19	0.018	0.000081	0.0037	0.0000128	0.025	0.025

Explanatory Notes

The majority of the original default emission factors used in the EEMS Atmospheric database are based on the 1998 AEA Technology Report for the industry body UKOOA (now OEUK) "Atmospheric Emissions Inventory Revised Guidelines" Report AEAT-3886 Issue 1 dated November 1998 **[Ref 28]**. Some of these emission factors were based on earlier work by UKOOA and the then DTI in relation to the 'SCOPEC' database which had already been set up to collect data on different environmental discharges. The review conducted by AEAT for UKOOA in 1998 leant heavily on comparisons with US-EPA "Compilation of Air Pollution Emission Factors from Stationary Source (AP-42)" Edition 5 **[Ref 32]**.

The AEAT-3886 report emphasised that the recommended emission factors reflected the knowledge at the time, and that at best, emission factors only represented a good estimate. Since the 1998 report further reviews of EEMS emission factors have taken place in 2005, 2010, and 2015 with only minor changes to standard emission factors and with more detailed changes to the gas turbine specific NOx emission factors covered separately in Appendix A2 of this update. These reviews were largely focused on updates to empirical data from UKCS installations. The current review and update of the EEMS guidance by OPRED in Phase 1 for 2026 reporting and 2027 / 2028 (Phase 2) seeks to re-evaluate the standard emission factors in use with regards to them remaining 'fit-for-purpose' and recommending where any changes may be appropriate. Phase 1 of this guidance update contains an initial assessment and recommendations on emission factors and reporting categories. Phase 2 will implement some recommendations and incorporate stakeholder comments from Phase 1 and further recommendations for changes.

One general comment is that there was limited empirical test data from the UKCS at the time the AEAT-3886 report was compiled, and there was a significant dependence on comparisons with international standards such as US-EPA AP-42. Since then and aligned with the requirements under the Offshore Combustion Installation PPC Regulations 2013 (as amended) there has been significantly more empirical data collected via PPC compliance monitoring reports (periodic stack testing) to recognised stack sampling methods. This empirical data from UKCS compliance monitoring is being used to inform this review of EEMS emission factors guidance.

Another general observation relates to the engineering units used in the EEMS database of emission factors. These are on a "mass of emission pollutant per unit mass of fuel basis" e.g. tonnes of pollutant / tonne of fuel. Other standards and sources use emission factors based on "mass of emission pollutant per unit energy of fuel" basis, where the unit of energy may be on a 'net' (lower heating value) basis or on a 'gross' (higher heating value) basis. These include US-EPA standard emission factors and IPCC standard emission factors for example. When making comparisons between EEMS and other sources of emission factors it is useful to note that:

- Current standard EEMS emission factors for UKCS gas fuel are based on fuel gas compositions with a typical Molecular weight of 22.0. The AEAT-3886 report from 1998 recommended emission factors in 'tonne/tonne' after comparison with US-EPA AP-42

Edition 5 emission factors in 'mass per unit energy' terms (e.g. lb/Btu) and using a typical UKCS Net Calorific Value (NCV) of 41.9 MJ/kg.

- EEMS emission factors for UKCS marine diesel oil are based on a typical Net Calorific Value (NCV) of 42.6 MJ/kg, which is in line with the UK National Inventory.

Default Emission Factors for fuel gas consumption in combustion plant:

- **CO_2 Emission Factor:** The EEMS CO_2 standard emission factor of 2.86 tCO_2/tonne is based on the AEAT-3886 report. It derives from the complete combustion of a hydrocarbon fuel gas mixture with an average molecular weight of 22. The composition of fuel gas mixtures varies significantly across the UKCS but is generally of slightly lower molecular weight than this (less-heavy hydrocarbons than this assumption). Since the advent of the Emissions Trading Scheme (ETS), permitted installations are required to sample fuel gas (or a validated proxy such as export gas) and to calculate accurate CO_2 emission factors for ETS 'highest tier' compliance. OPRED has reviewed records of UK ETS emission factors for fuel gas across the UKCS ETS permits for the years 2021, 2022, and 2023. These consistently show that whilst the emission factor at individual installations is typically stable over time, there is a wide spread of CO_2 emission factors across different installations, ranging from a minimum of 2.12 tCO_2/tonne to a maximum of 2.84 tCO_2/tonne. Using available information from the METS IT system, the median value for ETS permits in 2023 reporting was 2.67 tCO_2/tonne and the mean was 2.65 tCO_2/tonne. It is therefore considered that the current standard EEMS default EF of 2.86 tCO_2/tonne is slightly conservative for UKCS installations, given that in most cases it will overestimate CO_2 emissions from accurate activity data (in tonnes of fuel used), an overestimate of ~7% compared to the median or mean. It is partly for this reason that OPRED recommends in this latest guidance that operators of production installations should preferentially utilise their accurate ETS-derived CO_2 emission factors when determining CO_2 emissions from activity data for EEMS returns, in preference to using the EEMS default. However, for other purposes such as 'general project estimating' the use of the 2.86 tCO_2/tonne value remains a useful default given that it lies conservatively at the top end of the range for typical UKCS fuel gas compositions.
- Aside from CO_2, all other standard EEMS emission factors for combustion plant relate to standard combustion processes and exclude low-emission technology such as lean burn, dry low emissions (DLE), dry low NOx (DLN), and post combustion scrubbing. Where an installation is operating plant with combustion technology other than standard combustion, then it is recommended that plant-specific emission factors are determined from test data and compared with the EEMS defaults in order to select an appropriate set of emission factors for the combustion plant.
- **CO Emission Factor turbines:** The AEAT-3886 report recommended a change in the standard CO emission factor for turbines from 0.0027 tCO/t to 0.003 tCO/t as was integrated in the 2008 EEMS guidance. The EEMS review of emission factors in 2015 recommended that this should be increased to the current EEMS default of 0.006 tCO/t as considered at the time to be more representative of the spread of CO emissions data being collected via stack sampling across the UKCS. Further review of recent stack monitoring data (of LCP gas turbines over the period 2021-2024) under Phase 1 of this OPRED guidance update (2024 / 2025) suggests the following; firstly, that for many gas turbines the standard emission factor is an overestimate when operating efficiently at well-loaded conditions (typically above 40-50% of rated duty) but on the other hand it can often be an underestimate where turbines operate at lower loads. Secondly, the

relationship is non-linear with load, decreasing significantly as load increases, and increasing significantly on deceleration to lower loads. Thirdly, that CO emissions can be sensitive to turbine efficiency degradation factors such as time since overhaul. Therefore, where recent local test data is available (e.g. for annual compliance for LCP turbines), it is recommended that operators use such test data in cases where the standard CO EF may be deemed inappropriate. However, the default of 0.006 tCO/t is considered an appropriate average surrogate in the absence of robust site test data and is considered to be suitable for continued use as a default for small to medium gas turbines (non-LCP) where there is no periodic monitoring requirements in the PPC permit conditions.

- **CO Emission Factor – heaters / boilers:** The AEAT-3886 report (1998) recommended a change to the CO emission factor for heaters/boilers from 0.0008 tCO/t to 0.0006tCO/t, as reflected in the 2008 guidance. The review in 2015 did not recommend any update due to limited empirical data. The requirements for periodic emissions monitoring of boilers in the UKCS has been a recent development within PPC permit conditions (LCP from 2021 and MCP from 2024). Initial review by OPRED of available PPC compliance test data from UKCS boilers suggests that the current EEMS emission factor is not accurate in many cases. Review of 2024 and 2025 compliance data on boilers is ongoing with the potential to recommend an updated default emission factor in Phase 2 of this guidance update. There are far fewer boilers / heaters than turbines and engines across the UKCS, so the extent of empirical test data remains relatively small.
- **CO Emission Factor – engines:** The 1998 AEAT-3866 report recommended a change to the CO emission factor for engines from 0.0096 tCO/t to 0.0076tCO/t, as reflected in the 2008 guidance and the current EEMS factors. OPRED notes that there are relatively few gas engines and dual fuel engines operating across the UKCS, and most of these operate with non-standard lean burn combustion systems; for which OPRED recommend that local plant-specific emission factors are used. Therefore, no changes are currently planned for the EEMS CO default EF for gas engines.
- **N_2O Emission Factor – all combustion plant:** The N_2O standard emission factor in EEMS was not derived based on the AEAT-3886 report. Rather, it is based on analysis undertaken by UKOOA in their SCOPEC (1999) in which a value of 0.000516 kgN_2O/therm was quoted for own use gas referred to in the AEAT-0524 UK GHG inventory report. **[Ref 33]**. Converting this to EEMS units of t/t using a conversion factor of 9.4782 therms/GJ (gross) and a fuel gas calorific value of ~46 MJ/kg (gross) equates to the current EEMS factor of 0.00022 tN_2O/tonne. It should be noted that this local sector emission factor used in the UKCS reporting is around 3 times higher than the US-EPA AP-42 default emission factor of 0.003 lb/MMBtu (which is based on very limited source tests). Further, both EEMS and US-EPA are significantly higher than the default IPCC emission factors for energy industries used in other UK sectors. Recognition of these differences is contained in the Ricardo NAEI GHG inventory report of 2022 **[Ref 34]**. There are currently no plans to change the EEMS default, but further consideration may be made in Phase 2 guidance.
- **NOx Emission Factor** - Default emissions factors are based on report AEAT-3886 (Ref 20). For gas turbines the alternative approach outlined in Appendix A2 should be used where polynomial equations have been defined for a turbine model.
- **SO_2 Emission Factor** - The default value of 0.0000128 tSO_2/t is based on the AEAT-3886 report and is derived based on a sulphur content in the fuel gas of 6.4ppm by weight. However, it is recommended that operators use an EF derived from the actual

hydrogen sulphide content of their fuel gas composition where this is known - as explained in Section 2 of this guidance. Based on its hydrogen sulphide content associated gas can be described as either 'sour gas' (typically more than 4 ppm of H_2S – the typical maximum entry specification for transmission gas) or as 'sweet gas' (no or negligible amounts of H_2S, where the limit of standard measurement detection is typically ~0.5 ppm).

- **CH_4 Emission Factor** - Like CO the variation of CH_4 (Methane-slip) emissions from combustion plant is a function of operating load, combustion efficiency, and performance degradation of individual plant. The EEMS default factors for engines, heaters / boilers and turbines are based on recommendations in the AEAT-3886 report and have not been changed since then. Unlike NOx and CO there is currently no requirement under PPC regulations for routine periodic monitoring of methane slip for LCP and MCP combustion plant. However, OPRED Offshore PPC guidance **[Ref 35]** expects methane-slip to be measured as part of 'full-suite' baseline testing for establishing initial baseline data for an installation and for comparison with EEMS factors. In addition, since the publication of the OEUK Methane Action Plan (MAP) for the UKCS sector in 2021 there is an expectation for operators to include methane monitoring from combustion plant within their Asset-specific MAP and indeed this is a contributing measurement approach to 'bottom up' measurements under the United Nations Environment Programme UNEP OGMP2.0 framework guidance. Furthermore, this supports the obligations of the sector to provide improvements in methane monitoring to contribute to the UKCS emission reduction targets under the NSTD. Evidence from UKCS emissions monitoring over the last 20 years has demonstrated that improvements to fidelity and accuracy of methane reporting can be achieved by substituting use of plant-specific emission factors in place of the EEMS standard defaults. Further analysis and discussion of methane slip is anticipated in the Phase 2 guidance scope.
- **NMVOC Emission Factors** for combustion plant are based on the AEAT-3886 report, based on comparisons with US-EPA AP42.

Default Emission Factors for diesel (gas oil) and fuel oil consumption in combustion plant:

- **CO_2 Emission Factor** - The EEMS CO_2 standard emission factor of 3.2 tCO_2/tonne is based on the AEAT-3886 report and is derived based on 100% conversion of carbon to CO2 and assuming 87% by weight of carbon in the diesel. The corresponding value for diesel CO_2 emission factor under the UK ETS based on the UK National Inventory is 3.19 tCO_2/tonne. OPRED recommends that under Phase 2 of the 2024 / 2025 EEMS review project the EEMS default is re-aligned with the 3.19 value.
- **CO Emission Factor** - The EEMS defaults for engines, heaters / boilers, and turbines are based on AEAT-3886 report and are derived from US-EPA AP42 Edition 5 factors. In practise, as per operation on fuel gas there is a wide variation of emission factor depending on load, efficiency, and performance degradation. Therefore, where plant-specific data is available from PPC compliance testing reports OPRED recommends that plant specific factors are derived, approved with OPRED, and used instead.
- **N_2O Emission Factor** – EEMS currently defaults to the same value of 0.000022 tN_2O/t as used for fuel gas. Once again this is considered to be conservatively higher than the US-EPA AP-42 default and also significantly higher than the IPCC defaults for the

energy sectors. No recommendations for changes to EEMS are proposed at this point pending further analysis in Phase 2.

- **NOx Emission Factor** - The EEMS defaults for engines, heaters / boilers, and turbines are based on AEAT-3886 report and are derived from US-EPA AP42 Edition 5 factors. The value of 0.0135 tNOx/t for turbines corresponds to a concentration of around 350 mg/Nm3 at 15%O2. In practice, compliance test data indicates that this is likely to be reasonable estimate for UKCS small to medium gas turbines but is a potential underestimate for many LCP gas turbines at normal loads. Therefore, for LCP gas turbines operators are required to use the NOx polynomials in Appendix A2 where these are available for a given LCP turbine model. Where no polynomial is available for an LCP the value of 0.01724 tNOx/t should be used. The value of 0.0594 tNOx/t/ for engines corresponds to a concentration of around 1500 mg/Nm3 at 15%O2. This is considered appropriate for most small to medium diesel engines with no NOx abatement. However, for dual fuel engines it will be more appropriate to consider the use of plant-specific factors.
- **SO_2 Emission Factor** - This is a function of the amount of sulphur in the diesel fuel specification. The current EEMS default of 0.004 tSO_2/t is based on the AEAT-3886 report which assumed a weight fraction of 0.002 sulphur in line with regulations at the time. The current European limits on low sulphur diesel place a weight fraction limit of 0.001 sulphur. It is therefore proposed that the EEMS default is changed from 0.004 tSO_2/t to 0.002tSO_2/t as part of Phase 2 of this project.
- **CH_4 Emission Factor** - The EEMS default factors for engines, heaters / boilers and turbines are based on recommendations in the AEAT-3886 report and have not been changed since then. By nature, they are low being several orders lower than the equivalent factors on gas fuel and are deemed of lower significance / priority for refinement. Further analysis and discussion of methane slip is anticipated in the Phase 2 guidance scope.
- **NMVOC Emission Factor for combustion plant** are based on the AEAT-3886 report, based on comparisons with US-EPA AP42, and based on a ratio of methane to non-methane VOC of 90:10.

Default Emission Factors for gas flaring:

- **CO_2 Emission Factor** - The EEMS CO_2 standard emission factor of 2.80 t CO_2/tonne is based on the AEAT-3886 report and is derived on the same basis as the default for fuel gas in combustion plant except that a combustion efficiency of 0.98 is used instead of 1.0. i.e. 2.86 tCO_2/t x 0.98 = 2.80 tCO_2/t.
- **N_2O Emission Factor** - Similar to fuel gas this EF is based on analysis undertaken by UKOOA in their SCOPEC report of 1999 in which a value of 0.000088 ktN_2O/Mm3 was quoted. Converting this to EEMS units of tN_2O/t equates to the current EEMS factor of 0.000081 tN_2O/tonne. It should be noted that this local sector emission factor used in the UKCS reporting is only marginally higher than the US-EPA AP-42 default emission factor and significantly higher than the default IPCC emission factors for energy industry flaring used in other UK sectors. Recognition of these differences is contained in the Ricardo NAEI GHG inventory report of 2022 **[Ref 34]**. There are currently no plans to change the EEMS default, but further consideration may be made in Phase 2 guidance.
- **CO Emission Factor** - The EEMS default of 0.0067 tCO/t is based on the AEAT-3886 report in which it was updated from a previous UKOOA value of 0.0087 tCO/t. This update was aligned with US EPA AP42 relating to emissions from industrial flares.

- **NOx Emission Factor** - The EEMS default of 0.0012 tNOx/t is based on the AEAT-3886 report in which it was updated from a previous UKOOA value of 0.0015 tNOx/t. This update was aligned with US EPA AP42 relating to emissions from industrial flares.
- **CH_4 and NMVOC emission factors** - The current EEMS guidance assumes a combined emission factor of 0.020 t/t. For natural gas fuels (rich in CH_4 and typical of gas production installations) the standard default assumption is a 90:10 split between CH_4 and NMVOC; this equates to a CH_4 emission factor of 0.018 tCH_4/t and a NMVOC emission factor of 0.002 tNMVOC/t. For associated gas (such as oil production installation low-pressure separator gas with a higher proportion of heavier hydrocarbons) the standard default assumption is a 50:50 split, giving a default emission factor of 0.010 tCH_4/t for both CH_4 and NMVOC emissions. These are generic guidelines, and it is recommended that where plant specific flare gas compositions are known (e.g. as required under UK ETS monitoring and reporting) then the operator should utilise these instead. Note that currently EEMS does not automatically utilise the 'export components' fuel gas composition input to EEMS for this calculation, and therefore it should be done outside of EEMS. However, the merits of improved automation will be reviewed further in Phase 2 of the EEMS project.

Default Emission Factors for gas venting:

- Combustion pollutants are not relevant to the 'gas venting' category and only CH_4 and NMVOC emission factors are relevant in EEMS. Any direct CO_2 venting should be reported separately under the 'direct process emissions' category, and going forward should align with the 'vented CO_2 from CO_2 removals' category within the UK ETS which came into force from 1st April 2025.
- Similar to the assumptions for the typical split of CH4 and NMVOC for UKCS gas as used in the gas flaring assumptions, the EEMS default emission factors assume a methane rich 'natural gas' case of 90:10 for gas installations and a 50:50 split for associated gas from oil installations. As before where operators have records of their actual gas compositions (e.g. from their ETS monitoring and reporting records) then these should be used to derive a more representative split. Note that the current EEMS defaults are also conservative from the perspective that they ignore any non-hydrocarbon components in the vent gas composition.

NB. There are no considerations or proposals in this Phase 1 report to change the EEMS reporting sub-categories for gas flaring and gas venting. However, the merits of aligning these with the NSTA Flare and Vent guidelines **[Ref 36]** are to be considered in Phase 2 of the EEMS project.

Default Emission Factors for crude oil tanker loading:

- The default EEMS emission factors for CH_4 and NMVOC emissions for oil tanker loading are based on the AEAT-3886 report. These were derived from US EPA AP-42 Table 5-2-6 and based on a ratio of 15:85. In addition, the NMVOC emission factor derived from AP-42 was increased by a factor of x10 to align with UKOOA practice at the time in order to account for crude oil washing of oil tanks on large tankers. However, it should be noted that this practice does not align well with the intent that the EEMS returns for a fixed oil and gas installation should reflect the installation emissions only, not those of the oil tankers themselves.

- There is currently no specific regulatory requirement which mandates that emissions from Offshore Tanker Loading (OTL) must be reported into EEMS, however, it is best practice to do so. In recent years discussions between OPRED and key stakeholders including the NAEI team led by Ricardo Energy and Environment (working under contract to DESNZ) have recognised that the accuracy of the data sets on OTL operations being input to EEMS has a relatively high uncertainty. This was one aspect of reporting which was researched by the NAEI national inventory team and as outlined in their 2022 assessment report ED12848 "UK GHG Inventory Improvements: Upstream Oil and Gas" **[Ref 34]**, when they researched using produced hydrocarbons activity data from the NSTA PPRS instead of EEMS for the determination of OTL methane and NMVOC emissions.
- This is displayed by the NAEI national inventory team stating in their 2022 assessment report that *"For the emissions of methane and NMVOC from oil loading at OTLs, the study team assessed the available EEMS and PPRS data and has opted to derive a method that uses the NSTA's PPRS activity data on oil production per month. The PPRS monthly operator reports provide a more time series consistent activity dataset for oil produced and loaded to shuttle tankers for export; hence for this specific source the PPRS is directly used to underpin a method that is associated with lower uncertainty than using EEMS data alone".*
- Operators are encouraged to continue to use the EEMS methodology for reporting this activity data as described in this guidance until the outcomes and recommendations from Phase 2 are implemented. OPRED's intention is to have further discussions with key stakeholders including NAEI, NSTA and OEUK during Phase 2 of this EEMS project to consider potential improvements to this category of EEMS reporting, if deemed appropriate.

Default Emission Factors for well testing:

- The EEMS default emission factors for well testing are in line with those for gas flaring – see above. It is proposed that these remain aligned.

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