UKETS01 MRR - General guidance for installations

July 2025

Note

This document is intended to provide guidance for operators of installations. If there is any inconsistency between the guidance and legislation, the legislation prevails.

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Contents

1 Overview

This document provides guidance to operators of installations under the UK Emissions Trading Scheme (UK ETS) and is intended to help operators understand the key concepts and requirements of the Monitoring and Reporting Regulation (MRR).

The relevant legislation in this area is:

- **the Greenhouse Gas Emissions Trading Scheme Order 2020** (**The Order**) (https://www.legislation.gov.uk/uksi/2020/1265/contents) as amended from time to time
- **the Monitoring and Reporting Regulation (MRR)** (Commission Implementing Regulation (EU) 2018/2066 of 19 December 2018) on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council (disregarding any amendments adopted after 11 November 2020) as given effect for the purpose of the UK ETS by Article 24 of the Order, subject to the modifications made for that purpose from time to time
- **the Free Allocation Regulation** (**FAR**) (Commission Delegated Regulation (EU) 2019/331 of 19 December 2018) as it forms part of domestic law as amended from time to time
- **the Verification Regulation (VR)** (Commission Implementing Regulation (EU) 2018/2067 of 19 December 2018 on the verification of data and on the accreditation of verifiers pursuant to Directive 2003/87/EC of the European Parliament and of the Council (disregarding any amendments adopted after 11 November 2020), as given effect for the purpose of the UK ETS by Article 25 of the Order, subject to the modifications made for that purpose from time to time.

2 The UK ETS compliance cycle

2.1 Overview of the compliance cycle

The monitoring, reporting and verification (MRV) of emissions play a key role in the credibility of any emission trading scheme. Without MRV, compliance would lack transparency and be much more difficult to track and enforce. This holds true also for the UK ETS. It is the complete, consistent, accurate and transparent monitoring, reporting and verification system that creates trust in emissions trading. It is this system that ensures that operators meet their obligation to surrender sufficient allowances.

The annual process of monitoring, reporting, verification of emissions (MRV) and the surrendering of allowances are often referred to as the 'compliance cycle'. Figure 1 shows the main elements of this cycle.

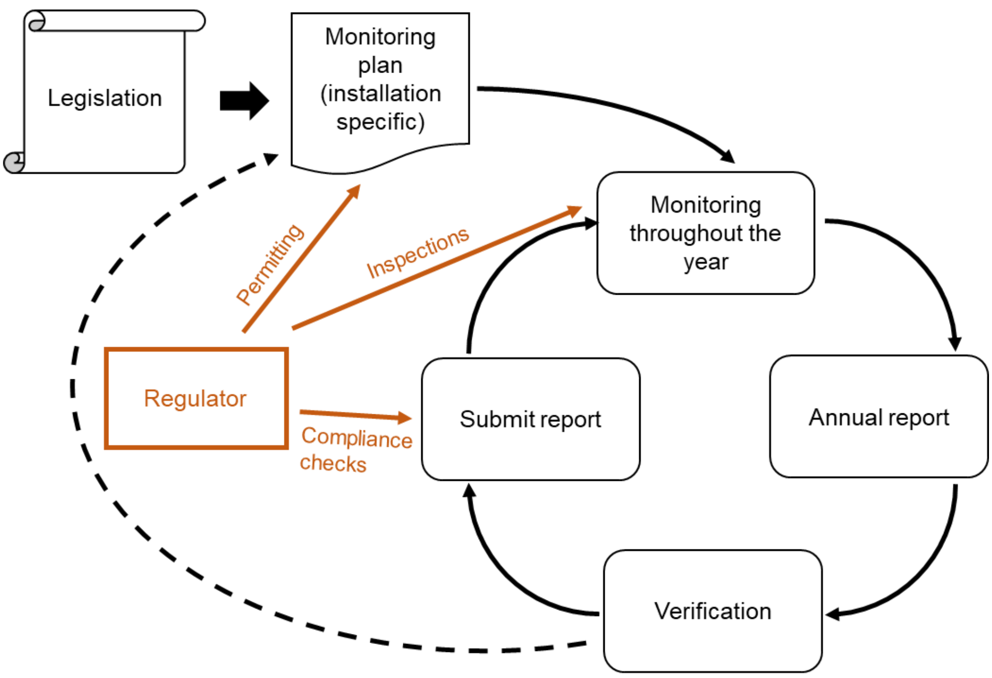

Figure 1: principle of the UK ETS compliance cycle

On the right side of the figure is the 'main cycle':[1] the operator monitors the emissions throughout the year. After the end of the calendar year and by 31 March of the following year, the operator must prepare the annual emissions report (AER), seek verification, and submit the verified report to the regulator. The operator must surrender allowances

[1] For simplification, the surrender of allowances has not been included in the picture. Similarly, the picture also ignores the processes of free allocation and trading of allowances.

in the Registry by 30 April equal to its reportable emissions in the previous calendar year. Thereafter the monitoring continues, as shown in the figure.

The monitoring process needs a firm basis. Resulting data must be sufficiently robust to create trust in the reliability of the UK ETS, including the fairness of the surrender obligation, and it must be consistent over time. The operator of an installation must ensure that the monitoring methodology is documented in writing and cannot change it arbitrarily. In the case of the UK ETS, this written methodology is called the monitoring plan (as per Figure 1). It is part of the permit that authorises the installation to carry out regulated activities under the UK ETS.

Figure 1 also shows that the monitoring plan, although specific for an individual installation, must follow the requirements of the applicable legislation, particularly the MRR. As a result, the MRV system of the UK ETS can balance strict rules applying to all UK ETS installations whilst allowing sufficient flexibility for individual circumstances.

2.2 Roles and responsibilities

The different responsibilities of operators, verifiers, and regulators are shown in Figure 2. The figure demonstrates the high level of control that is built into the MRV system. The monitoring and reporting of emissions are the main responsibility of the operators, who are also responsible for engaging the verifier and providing all relevant information to them. The regulator approves the monitoring plans, checks the emissions reports once received and carries out inspections. The regulator may make corrections to the verified emissions figure where errors are detected. The verifier is ultimately answerable to the accreditation body.

Note that the diagram below shows the operator must prepare a monitoring plan and open an account in the Registry during year N-1 and then monitoring is carried out in year N. This does not mean that monitoring begins from 1 January only. Operators must ensure that they apply for a permit and prepare a monitoring plan BEFORE regulated activities commence which can be at any time during the compliance year. As soon as a regulated activity commences, the operator MUST start monitoring their emissions. Operators should note that a regulated activity can commence during the equipment commissioning phase. If in doubt, the operator should consult their regulator who will confirm the date on which regulated activities commence at the installation.

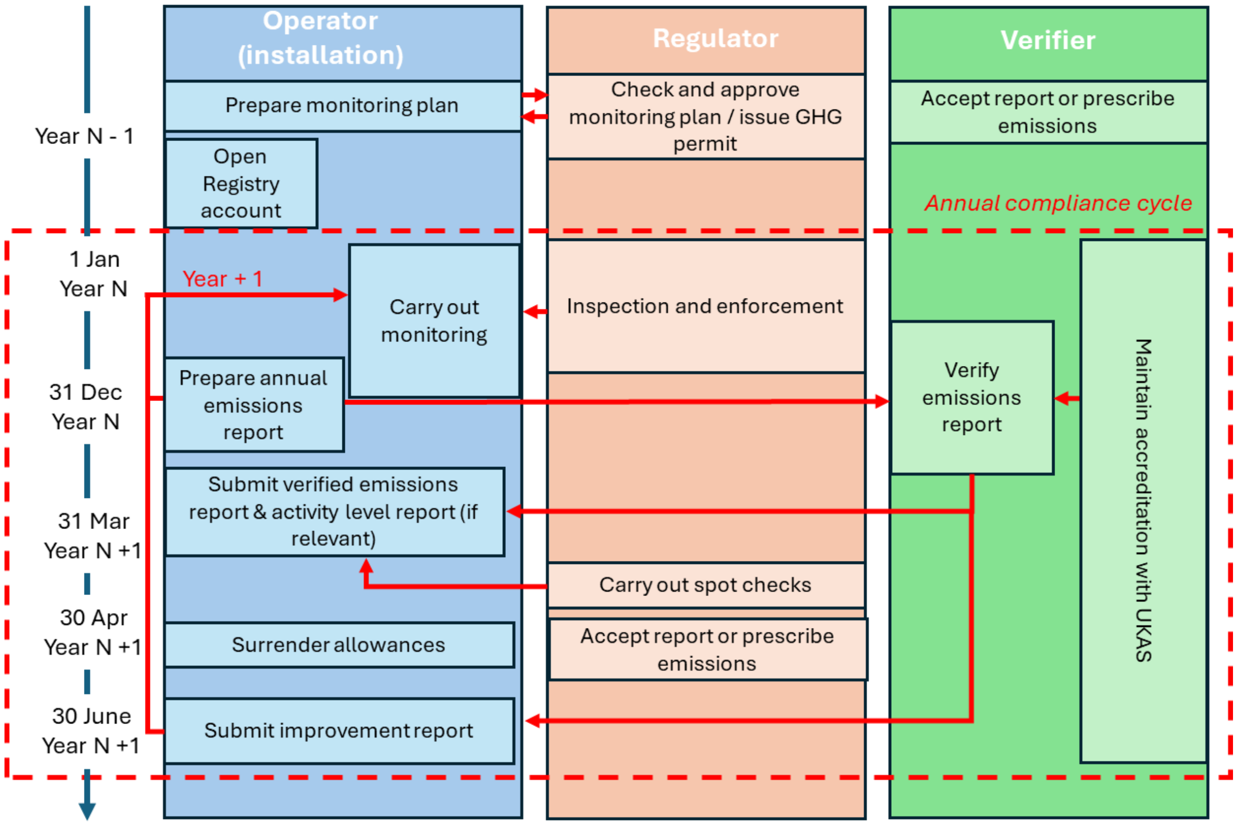

Figure 2: overview of responsibilities of the main actors in the UK ETS

2.3 The importance of the monitoring plan

The approved monitoring plan is the most important document for every installation participating in the UK ETS and serves as a manual for the operator's tasks. It should therefore be written in such a way that allows everyone, particularly new staff, to immediately follow the instructions. It also serves as the means to allow the regulator to quickly understand the operator's monitoring activities. Finally, for the verifier the monitoring plan acts as the guide against which the operator's emissions report is to be judged.

Typical elements of a monitoring plan include the following activities of the operator (applicability depends on the specific installation's circumstances):

- data collection (metering data, invoices, production protocols, etc.)
- sampling of materials and fuels
- laboratory analyses of fuels and materials
- maintenance and calibration of meters
- description of calculations and formulae to be used

- control activities (e.g. ‘four eyes principle’[2] for data collection or management of risk)
- data archiving (including protection against manipulation)
- regular identification of improvement possibilities within the installation boundary

The MRR reduces the administrative efforts here by allowing two approaches which should be considered when drafting monitoring plans:

- monitoring activities that are not critical in every detail, and which by their nature tend to be frequently amended, may be put into ’written procedures’, which are mentioned and described briefly in the monitoring plan. The relationship between the monitoring plan and written procedures is described in more detail in section 4.6.
- only changes which are ’significant’ need the approval by the regulator (Article 15 of the MRR, see section 4.7.1 below).

[2] The four-eyes principle means that a certain activity, i.e. a decision, transaction, etc., must be approved by at least two people. This control mechanism is used to facilitate delegation of authority and increase transparency.

3 Concepts and approaches

This chapter sets out the most important terms and concepts needed for developing a monitoring plan.

3.1 Underlying principles

Articles 5 to 9 of the MRR outline the guiding principles which operators must follow when fulfilling their obligations. These are:

Completeness (Article 5 of the MRR): The completeness of emission sources and source streams is at the very core of the UK ETS monitoring principles. To ensure completeness of emissions monitored, the operator must consider the following:

- Article 5 of the MRR requires that all the process and combustion emissions from all emission sources and source streams (see section 3.1) belonging to regulated activities are included
- further specific points to be considered for each activity are found in Annex IV to the MRR, under the heading 'scope' for each activity[3]
- Article 20 of the MRR requires that emissions from regular operations as well as from abnormal events including start-up, shutdown, and emergency situations are included.
- emissions from vehicles, such as forklift trucks, used within the installation are excluded. Note that the exclusion does NOT apply to machinery that is portable, i.e. on wheels, but which is stationary at the point of use, for example a standby generator or compressor. Standby generators and compressors and any other machinery that is stationary at the point of use must be listed as a source of emissions.

Consistency and comparability (Article 6(1) of the MRR): Monitoring and reporting shall be consistent and comparable over time. Regulators must approve all significant changes to an installation's monitoring plan. Because the same monitoring approaches are defined for all installations, from which operators may choose using the tier system (see section 3.5), the data created is also comparable between installations.

Transparency (Article 6(2)) of the MRR: All data collection, compilation and calculation must be made in a transparent way. This means that the data itself, the methods for obtaining and using them (in other words: the whole data flow from source

[3] The list under each activity is intended to be comprehensive but not exhaustive.

to end point) must be documented transparently, and all relevant information must be securely stored and retained allowing access by authorised parties only. In particular, the verifier and the regulator must be allowed access to this information (as per Article 10 of the Verification Regulation). Transparency is also in the operator's best interests as it makes it easier when existing and new staff transfer responsibilities, thus reducing the likelihood of errors and omissions. In turn this reduces the risk of over-surrendering allowances, or under-surrendering and incurring penalties. Without transparency, the verification activities are more onerous and time-consuming. Furthermore Article 67 of the MRR specifies that relevant data is to be stored for 10 years. Annex IX to the MRR lists the minimum data to be retained. In practice this means data and information relating to a particular emissions report must be retained for 11.25 years from the date when the relevant emissions report is submitted.

Accuracy (Article 7 of the MRR): Operators must take care that data is accurate, i.e., neither systematically nor knowingly inaccurate. Due diligence is required by operators, striving for the highest achievable accuracy. As the next point shows, 'highest achievable' may be read as where it is technically feasible and "without incurring unreasonable costs".

Integrity of the methodology and of the emissions report (Article 8 of the MRR): This principle is at the heart of every MRV system. The MRR explicitly mentions it and adds further elements that are needed for good monitoring:

- the monitoring methodology and the management of data must allow the verifier to achieve "reasonable assurance"[4] on the emissions report, i.e. the monitoring must be able to endure a quite intensive test
- data must be free from material misstatements and avoid bias
- the data must provide a credible and balanced account of an installation's emissions
- when looking for greater accuracy, operators may balance the benefit against additional costs. They must aim for 'highest achievable accuracy, unless this is technically not feasible or would lead to unreasonable costs'

Continuous improvement (Article 9 of the MRR): In addition to the requirement of Article 69, which requires the operator to submit improvement reports (e.g., for reaching higher tiers), this principle also is the foundation for the operator's duty of responding to the verifier's recommendations.

3.2 Source streams, emission sources and related terms

Emission source: Article 3(5) of the MRR defines 'emission source' to mean "*a separately identifiable part of an installation or a process within an installation, from*

[4] Article 3(18) of the Verification Regulation defines: "'*reasonable assurance' means a high but not absolute level of assurance, expressed positively in the verification opinion, as to whether the operator's or aircraft operator's report subject to verification is free from material misstatement*."

which relevant greenhouse gases are emitted or, for aviation activities, an individual aircraft". Thus, an emission source can be considered either as a physical part of the installation, or rather a virtual construction that defines the system boundaries of a process that leads to emissions.

As will be outlined below, different monitoring methodologies may be applied as defined by the MRR. For these methodologies, two other concepts have been found useful for ensuring the completeness of the emissions monitored: source streams and measurement points.

Source streams[5]: This term refers to all the inputs and outputs that must be monitored when using a calculation-based approach (see section 3.3). The wording is the result of the attempt to quickly express 'fuel or material entering or leaving the installation, with a direct impact on emissions'. In the simplest case it means the fuels 'streaming' into the installation and forming a 'source' of emissions. The same is true for raw materials which give rise to process emissions. In some cases, process emissions are calculated based on a product, such as burnt lime. In this case the product is the source stream. Furthermore, the term also includes mass streams going into and coming from the system boundaries of mass balances. This is justified by the fact that mass streams entering and leaving the installation are treated in principle by applying the same requirements[6] as for other source streams, as can be concluded from sections 3.4.1 and 3.4.3 below.

Measurement point (Article 3(43) of the MRR) means 'the emission source for which continuous emission measurement systems (CEMS) are used for emission measurement, or the cross-section of a pipeline system for which the CO_2 flow is determined using continuous measurement systems'. Briefly, this is the position (e.g. in the waste gas duct) for which the measurement data are obtained (where the probing for a continuous measurement system takes place).

The following terms are only relevant for the description of the installation, which must be included in the monitoring plan:

Emission points: The term is not defined explicitly by the MRR. However, it becomes clear when checking where the term is used by the MRR: point (4)(b) in section 1 of Annex I requires that the monitoring plan contains 'a list of all relevant emission points during typical operation, and during restrictive and transition phases, including breakdown periods or commissioning phases, supplemented by a process diagram were requested by the regulator'. In other words, the description of the installation in

[5] Article 3(4) of the MRR: "*'source stream' means any of the following:*
"(a) a specific fuel type, raw material or product giving rise to emissions of relevant greenhouse gases at one or more emission sources as a result of its consumption or production.
(b) a specific fuel type, raw material or product containing carbon and included in the calculation of greenhouse gas emissions using a mass balance methodology"

[6] The same requirements are valid for activity data, while other calculation factors (carbon content instead of emission factor) are used. However, as is shown in section 3.3.2, emission factor and carbon content can be calculated from each other. In terms of analytical chemistry, it is always the carbon content which is to be determined.

the monitoring plan should list all emission points by describing the points where the greenhouse gases are released from the installation, including fugitive emissions, if applicable.

3.3 Monitoring approaches

The MRR allows the operator to choose monitoring methodologies from a building block system based on different monitoring approaches. All types of combinations of these approaches are allowed, under the condition that the operator demonstrates that neither double counting nor data gaps in the emissions reporting will occur. The choice of methodology needs the approval of the regulator, which is given as part of the monitoring plan approval.

The following methodologies are available:

- calculation-based approaches:
    - standard methodology (distinguishing combustion and process emissions)
    - mass balance
- measurement-based approaches
- methodology not based on tiers (‘fall-back approach’)
- combinations of approaches

Note that the calculation-based approaches also require measurements. However, the measurement here is usually applied to parameters such as the fuel consumption, which can be related to the emissions by calculation, while the measurement-based approach always includes measurement of the greenhouse gas itself. These approaches are briefly outlined below.

3.3.1 Standard methodology

The principle of this method is the calculation of emissions by means of activity data (e.g. amount of fuel or process input material consumed) multiplied by an emission factor (and further factors). Figure 3 below illustrates this. The further factors are the oxidation factor for combustion emissions and the conversion factor for process emissions. Both are used for correcting the emissions numbers in case of incomplete chemical reactions.

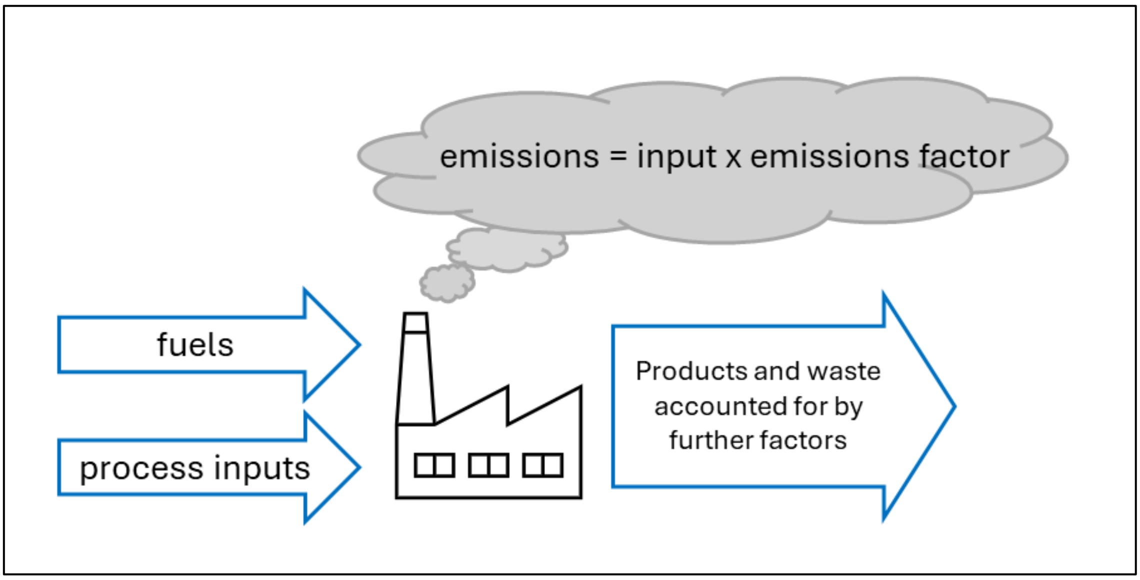

Figure 3: principle of the standard methodology for calculating emissions

Under this methodology, the following formulae are applied for CO_2 emissions:[7]

1. Combustion emissions[8] (Equation 1):

$$Em = AD \times EF \times OF$$

Where:

Em….. emissions [tCO_2]

AD….. activity data [TJ, t or Nm^3]

EF….. emission factor [tCO_2/TJ, tCO_2/t or tCO_2/Nm^3]

OF….. oxidation factor [dimensionless]

Factors with units in tonnes are usually to be used for solids and liquids. Nm^3 are usually used for gaseous fuels. To achieve numbers of similar magnitude, values are usually given in [$1,000Nm^3$] in practice.

Activity data of fuels (including if fuels are used as process input) must be expressed as net calorific value:

Equation 2:

$$AD = FQ \times NCV$$

[7] N_2O emissions are determined using measurement approaches, and for PFC special requirements are applicable. They are therefore not covered by this section.

[8] Article 3(11) of the MRR defines: "*'combustion emissions' means greenhouse gas emissions occurring during the exothermic reaction of a fuel with oxygen;*"

Where:

FQ...... fuel quantity [t or Nm^3]

NCV.... net calorific value [TJ/t or TJ/Nm^3]

Under certain conditions (where the use of an emission factor expressed as tCO_2/TJ incurs unreasonable costs, or where at least an equivalent accuracy of the calculated emissions can be achieved) the regulator may allow the operator to use an emission factor expressed as tCO_2/t fuel or tCO_2/Nm^3 (Article 36(2) of the MRR). In that case, instead using Equation 2, activity data is expressed as tonnes or Nm^3 fuel, and the NCV may be determined using a conservative estimate instead of using tiers unless a defined tier is achievable without additional effort (Article 26(5) of the MRR).

The UK ETS allows the emission factor of biomass (solid and gaseous) to be set to zero. The emission factor for bioliquid may only be set to zero if the fuel supplied can meet the sustainability criteria (see guidance document 'UKETS03 MRR - Reporting biomass in installations'). This applies for accounting purposes only, while CO_2 is physically emitted from the installation. Therefore, and for transparency purposes, where biomass is involved, the emission factor must be determined from the preliminary emission factor and the biomass fraction of the fuel:

Equation 3:

$$EF = EF_{pre} \times (1 - BF)$$

Where:

EF..... emission factor

EF_{pre}.. preliminary emission factor (i.e. according to Article 3(36), "*assumed total emission factor of a fuel or material based on the carbon content of its biomass fraction and its fossil fraction before multiplying it by the fossil fraction to produce the emission factor*")

BF..... biomass fraction [dimensionless]

Note: Equation 3 is valid because the emission factor of biomass is zero (assuming the sustainability criteria is met). For a mixed material this formula requires that the EF_{pre} is the weighted average value for the whole mixture. In that case, 'determining the biomass fraction' means 'determining the fraction of carbon in the mixture from biomass that complies with the RED[9] criteria'. The part of biomass which does not comply with those criteria must be reported separately, but for emission calculation the above

[9] RED means Directive 2009/28/EC on the promotion of the use of energy from renewable sources (also referred to as "RED I")

formula is correct. For reporting purposes, $FF + BF_{non-RED} + BF = 1$, where FF is the fossil fraction, $BF_{non-RED}$ the fraction of biomass carbon which is not complying with the RED criteria, and BF the biomass fraction of carbon which is zero-rated (see section 5.3.6 on how to report emissions from mixed fuels). Therefore, the overall standard formula for combustion emissions is:

Equation 4:

$$Em = FQ \times NCV \times EF_{pre} \times (1 - BF) \times OF$$

2. Process emissions[10] are calculated as:

Equation 5:

$$Em = AD \times EF \times CF$$

Where:

Em.... emissions [tCO_2]

AD.... activity data [t or Nm^3]

EF.... emission factor [tCO_2/t or tCO_2/Nm^3]

CF.... conversion factor [dimensionless]

Note that the activity data may refer to either an input material (e.g. limestone or soda ash), or to the resulting output of the process, e.g. the cement clinker or burnt lime. In both cases activity data is used with positive values due to the direct correlation with the emission value. Section 4 of Annex II to the MRR introduces for this purpose Method A (input based) and Method B (output based). Both methods are considered equivalent, i.e. the operator should choose the method which leads to the more reliable data, is better applicable with their equipment, and avoids unreasonable costs. Section 4 also contains provisions on the treatment of organic and mixed carbon contained in process materials. These special rules are explained in section 5.3.7.

Further activity specific details are listed in Annex IV to the MRR. Note that in case of more complex processes, mass balance will usually be the more suitable monitoring approach. Furthermore, N_2O process emissions always require a measurement-based approach,[11] and PFC process emissions are determined using a calculation-based approach which is discussed in section 5.4.

[10] Article 3(31) of the MRR defines: "*'process emissions' means greenhouse gas emissions other than combustion emissions occurring as a result of intentional and unintentional reactions between substances or their transformation, including the chemical or electrolytic reduction of metal ores, the thermal decomposition of substances, and the formation of substances for use as product or feedstock*"

[11] As an exception, N_2O from temporary occurrences of unabated emissions are estimated based on calculation, see section 7.2.

More details on the MRR's requirements for monitoring using the standard methodology are given in Chapter 5.

3.3.2 Mass balance approach

Like the standard approach, the mass balance[12] approach is a calculation-based method for determining the emissions of an installation. The standard approach is straightforward to apply in cases where a fuel or material is directly related to the emissions. However, in cases such as integrated steelworks or sites of the chemical industry, it is often difficult to relate the emissions directly to individual input materials, because the products (and wastes) contain significant amounts of carbon (e.g. bulk organic chemicals, carbon black, etc.). Thus, it is not enough to account for the non-emitted carbon by means of an oxidation factor or conversion factor. Instead, a complete balance of carbon entering and leaving the installation, or a defined part thereof is used (see Figure 4).

The following formula is applicable for mass balances:

Equation 6:

$$Em_{MB} = \Sigma_i (f \times AD_i \times CC_i)$$

Where:

Em_{MB}... emissions from all source streams included in the mass balance [tCO_2]

f........ factor for converting the molar mass of carbon to CO_2. The value of f is 3.664 tCO_2/tC (Article 25(1) of the MRR).

i......... index for the material or fuel under consideration.

AD_i..... activity data (i.e. the mass in tonnes) of the material or fuel under consideration. Ingoing materials or fuels are considered as positive, outgoing materials or fuels have negative activity data. Mass streams to and from stockpiles must be considered appropriately to give correct results for the calendar year.

CC_i...... The carbon content of the component under consideration. Always dimensionless and positive.

[12] For clarity reasons this document uses the term "material balance" for determining activity data based on batch metering (see section 5.1.2), while "mass balance" is strictly used for the calculation approach discussed in this section and in Article 25 of the MRR.

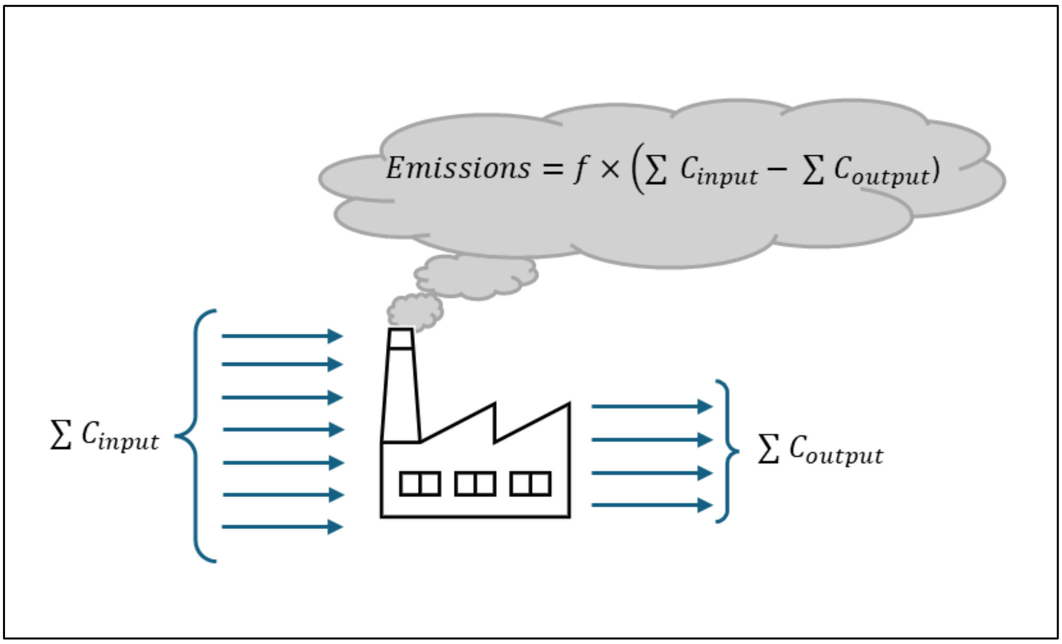

Figure 4: principle of mass balance approaches

If the carbon content of a fuel is to be calculated from an emission factor expressed as tCO_2/TJ, the following equation is used:

Equation 7:

$$CC_i = EF_i \times NCV_i / f \text{ (etc)}$$

If the carbon content of a material or fuel is to be calculated from an emission factor expressed as tCO_2/t, the following equation is used:

Equation 8:

$$CC_i = EF_i / f$$

The following should be considered when setting up a monitoring plan using a mass balance:

1. Emissions of carbon monoxide (CO) are not counted as outgoing source stream in the mass balance but are considered as the molar equivalent of CO_2 emissions (Article 25(2) of the MRR). This is easily accomplished by not listing the CO as outgoing material.

2. Where biomass materials or fuels are included in a mass balance, the CC_i is to be adjusted for the fossil fraction only. Where biomass is assumed to belong to output streams, the operator should provide a justification to the regulator for this assumption. The methodology proposed must avoid underestimations of emissions.

3. When other monitoring approaches are used and the operator uses a mass balance to cover only part of their processes, the operator must ensure that all

remaining input materials and fuels (i.e. those that are not monitored using other approaches) are covered under the mass balance. As it may be difficult to determine smaller amounts of carbon precisely, the operator should explore whether the material might be considered a de minimis source stream (see section 3.4.3). A conservative estimation approach for de minimis source streams is to assume that the amount of carbon leaving the installation in slag or wastes is zero i.e. all the carbon contained in a de minimis source stream is emitted. A similar estimation approach occurs when operators assume a conversion factor of 100% in the case of the standard methodology i.e. they assume that all raw material carbonates are converted to oxides.

3.3.3 Application of the mass balance approach

The mass balance approach may only be applied to activities for which the MRR explicitly stated this as an option. For combustion activities mass balance is only applicable if:

- the installation is a gas processing terminal (in this case section 1(B) of Annex IV allows use of a mass balance in accordance with Article 25 of the MRR)
- another regulated activity apart from the combustion activity is carried out and Annex IV to the MRR allows or requires the use of a mass balance in accordance with Article 25 of the MRR for that specific activity; or
- the proposed mass-balance methodology is applied to de-minimis source streams only. In this case the mass balance would qualify as an allowed estimation method.

When the activity does not foresee monitoring using mass balance such an approach can in principle only be applied as a fall-back approach pursuant to Article 22 of the MRR. Consequently, the operator must check and report regularly in accordance with Article 69(1) and (3) of the MRR whether the monitoring method can be improved, e.g. by installing measurement instruments. However, under specific circumstances the MRR also allows for a mass balance approach without explicitly mentioning it as such. Article 27(1) point (b) and Article 27(2) of the MRR allow determination of activity data based on aggregation of metering of quantities according to the following formula (also see section 6.1.2):

Equation 9:

$$Q = P - E + (S_{begin} - S_{end})$$

Where:

Q.......... quantity of fuel or material applied in the period

P.......... purchased quantity

E.......... exported quantity (e.g. fuel delivered to parts of the installation or other installations which are not included in the UK ETS)

S_{begin}....stock of the material or fuel at the beginning of the year

S_{end}..... stock of the material or fuel at the end of the year

The application of this approach is possible if all parameters, i.e. for S_{begin}, S_{end}, P and E are referring to the same source stream.

Example 1: An installation producing fine organic chemicals is using ethyl acetate as solvent for chemical reactions. Part of this solvent evaporates during the reaction and is combusted in an incinerator connected to the exhaust hood. The rest of the solvent is sold (“exported from the installation”) containing only minor contaminants with negligible impact on changing NCV or EF. In this case the amount of ethyl acetate burned in the incinerator is determined by level readings from the storage tanks, the purchased amounts and the amount sold. Therefore, this monitoring approach is fully in line with the requirements of Article 27(1) point (b) of the MRR.

Example 2: An installation similar to Example 1 is also using other solvents. Now a mixture of these solvents is exported from the installation. Mixing solvents impacts the NCV and EF. Due to this interdependency between the activity data and other calculation factors, the materials entering and leaving the installation cannot be considered one source stream. Therefore, this fuel/material balance cannot be considered to be covered by Article 27(1) point (b) of the MRR. Hence, a mass balance monitoring approach can only be used here if the installation is approved to apply it as a fall-back monitoring methodology under Article 22 of the MRR or all the solvents involved fall within the de minimis threshold.

More details on the MRR’s requirements for monitoring using a mass balance methodology are given in chapter 5.

Note that it may be useful to combine the mass balance approach and the standard approach, as the following example shows:

Example 3 - In this installation, two clearly separable parts exist: A gas-fired CHP plant, and a non-integrated steel production (electric arc furnace process). In such a case it is useful to combine the calculation-based approaches:

- CHP plant: standard methodology; source streams:
- natural gas (for simplicity it may be useful to include here all natural gas streams, including those belonging to the steel plant)
- steel plant: mass balance; source streams:
- ingoing: scrap, pig iron, alloying components
- outgoing: products, slag

3.3.4 Measurement-based approaches

In contrast to the calculation-based approaches, the greenhouse gases in the installation's off-gases are themselves the object of the measurement in the measurement-based approaches. This is difficult in installations with many emission points (stacks) or impossible in cases when an installation includes open furnaces and/or fugitive emissions.[13] On the other hand, the strength of the measurement-based methodologies is the independence of the number of different fuels and materials used (e.g. where many different waste types are combusted), and their independence of stoichiometric relationships (this is why N_2O emissions must be monitored in this way).

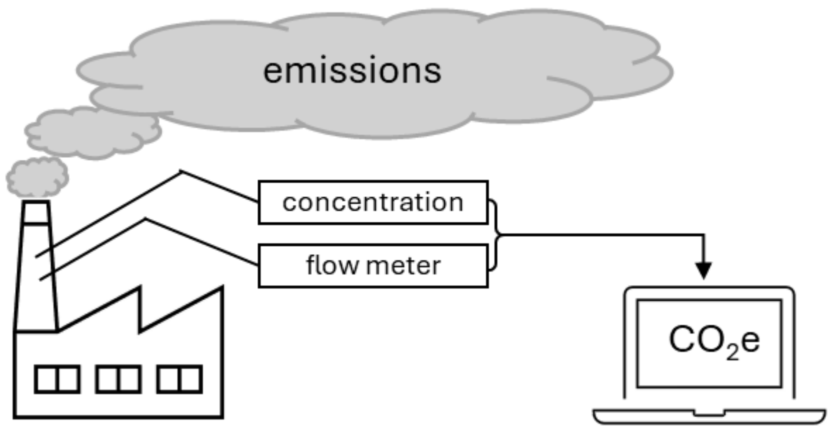

Figure 5: schematic of a continuous emission measurement system (CEMS)

[13] Fugitive emissions are emissions that are not released through a stack, chimney, vent, or other functionally equivalent opening. Instead, these emissions are typically released from leaks, equipment malfunctions, or other unintended releases during industrial processes.

The application of continuous emission measurement systems (CEMS)[14] requires two elements:

- measurement of the greenhouse gas (GHG) concentration;[15] and
- volumetric flow of the gas stream where the measurement takes place.

According to Article 43 of the MRR, the emissions are first to be determined for each hour[16] of measurement from the hourly average concentration and the hourly average flow rate. Thereafter all hourly values of the reporting year are summed up for the total emissions of that emission point. Where several emission points are monitored (e.g. two separate stacks of a power plant), this data aggregation is done first for each source separately, before adding the emissions of all sources to result in the total emissions.[17]

When it comes to subtracting the emissions from biomass from total emissions, Article 43(4) of the MRR allows for the following approaches to be utilised:[18]

- calculation-based approaches
- methods that use radiocarbon analyses of samples taken from the flue gas by continuous sampling (e.g. according to EN ISO 13833). Note that formally this is a calculation-based approach in MRR terminology, as it does not rely on continuous measurement
- the ‘balance method’ (based on ISO 18466), which is an estimation method in MRR terminology.

Further requirements for using CEMS are given in chapter 7 of this document.

3.3.5 Fall-back methodology

The MRR provides a very broad set of monitoring methodologies, along with tier level definitions that can be applied to nearly all installations in the UK ETS. Nevertheless, it is recognised that special circumstances may exist within installations for which the applying of the tier system is technically unfeasible or would lead to unreasonable costs

[14] Article 3(40) of the MRR defines: “*‘continuous emission measurement’ means a set of operations having the objective of determining the value of a quantity by means of periodic measurements, applying either measurements in the stack or extractive procedures with a measuring instrument located close to the stack, whilst excluding measurement methodologies based on the collection of individual samples from the stack.”*

[15] This may need additional corrections, such as for moisture content.

[16] Pursuant to Article 44(1), operators shall use shorter periods than an hour, where this is possible without additional costs. This takes account of the fact that many measurement systems generate automatically half-hourly values due to other requirements than the MRR. In such case, the half-hourly values are used.

[17] “Total” here means total of all emissions determined by CEMS. This does not exclude that further emissions from other parts of the installation are determined by calculation approaches.

[18] See ‘UKETS03 MRR - Reporting biomass in installations’ for further options to determine the biomass fraction.

for the operator. Although there might be other reasonably precise methods of monitoring, these circumstances would render the operator non-compliant with the MRR.

To avoid such scenarios, Article 22 of the MRR allows the operator to apply a non-tier methodology (also known as a 'fall-back methodology'), if:

- a calculation-based approach using at least tier 1 for at least one major or minor source stream (see section 3.4.3), is not possible without incurring unreasonable costs; and

- a measurement-based approach for the correlated emission source using tier 1 is also not possible without incurring unreasonable costs.

Note that this section is not applicable for de minimis or marginal source streams, because no-tier estimation methodologies are allowed for these anyway.

Where the above conditions are met, the operator may propose in the monitoring plan an alternative monitoring methodology, for which it can demonstrate that it can achieve the required overall uncertainty level for the emissions of the whole installation[19] In other words: Instead of complying with the uncertainty levels for individual source streams, one common uncertainty level for the emissions of the total installation is to be complied with. However, such individual monitoring approach has the drawback that it can't be easily compared with other approaches. Consequently, the operator must:

- every year carry out a full uncertainty assessment[20] for the installation's emissions and provide evidence that the required uncertainty level is met

- submit the result together with the annual emissions report (including for verification), and

- provide a justification for using the fall-back methodology demonstrating unreasonable costs or technical infeasibility in the regular improvement reports (see section 4.7) pursuant to Article 69 of the MRR. If the conditions are no longer met the operator must modify their monitoring plan and use a tier-based approach henceforth.

Note: Operators are advised to check carefully whether a tier-based approach for all major and minor source streams and emission sources is possible and whether a fall-back approach is appropriate.

[19] This overall uncertainty is less than 7.5% for category A installations, less than 5.0% for category B installations and less than 2.5% for category C installations. For categorisation of installations see section 3.4.

[20] ISO Guide to the Expression of Uncertainty in Measurement (JCGM 100:2008) is to be applied here. It is publicly accessible under http://www.bipm.org/en/publications/guides/gum.html.

Operators should strive to use ‘standard’ tier approaches for as many source streams and emission sources as possible, even if a fall-back methodology is required for a limited part of the installation’s emissions.

3.3.5.1 Use of fall-back methodologies and no tier approaches

The term ‘at least tier 1 under the calculation-based methodology’ implies that a no-tier approach is already applied for one source stream if not at least tier 1 is applied for one single parameter, i.e. the activity data or any calculation factor, except for de minimis source streams. Therefore, a fall-back methodology should only be applied to the specific part(s) of the calculation or measurement-based methodology that does not meet at least tier 1. For example, to the extent possible, available default values (see section 5.2.1) should be used for calculations and the no-tier approach should be limited to the parameters where no such factors are available.

> **Example 4 -** The amount of CO_2 emitted from a refinery gas source stream cannot be determined by applying tiers due to unreasonable costs. Due to the availability of default values for NCV and EF in Annex VI to the MRR (compliant with tier 1) the operator should apply a no-tier approach only for activity data. Only where the operator can demonstrate to the satisfaction of the regulator that the default values are not applicable (e.g. because they apply to another type of refinery gas composition), an estimation methodology for calculating directly the emissions by other means may be developed.

3.3.5.2 Activity data

For fall-back monitoring approaches for activity data the operator must first assess if the methodology applied really constitutes a no-tier approach. It can be distinguished between:

1. activity data is determined in accordance with Article 27 of the MRR[21] (i.e. continuous metering or aggregation of metering of quantities) but the uncertainty related to the measurement is higher than the uncertainty allowed under tier 1, or

2. activity data is not determined in accordance with Article 27 of the MRR. Note here that not complying with the requirements in this Article means that you don’t comply with any tier. Therefore, any such methodology must be considered as a fall-back approach and can only be applied if the application of at least tier 1 is not technically feasible or would incur unreasonable costs.

For (a) please be aware that an indirect measurement of activity data, e.g. by addition or subtraction of two or more fuel/material flows or batches can also be considered as complying with Article 27 of the MRR. For determination of the applied tier for such

[21] Article 27(1) of the MRR: “*The operator shall determine the activity data of a source stream in one of the following ways:*
(a) based on continual metering at the process which causes the emissions;
(b) based on aggregation of metering of quantities separately delivered taking into account relevant stock changes.“

cases, rules for error propagation must be applied (see Annex II of guidance document 'UKETS02 MRR/FAR - Uncertainty assessments for installations'). If the uncertainty achieved complies with the relevant tier 1 requirements, then the determination of activity data is not a fall-back approach.

If assessment shows that the approach is a fall-back approach, the operator must demonstrate that applying at least tier 1 of a 'conventional' tier approach is technically not feasible or would incur unreasonable costs.

Example 5: (assessing whether the approach proposed is to be considered a fallback): A fine organic chemical plant is burning contaminated organic solvents in an incinerator with a heat recovery boiler. Installing a measurement instrument for the solvent flow (minor source streams) would incur unreasonable costs. The operator proposes calculating the activity data by an energy balance taking into account the measurable heat (i.e. steam) produced and the energy input from natural gas used for auxiliary firing. This approach is clearly not complying with the requirements of Article 27 of the MRR and should be considered as a fall-back approach. In this case the operator will have to demonstrate pursuant to Article 22 of the MRR that the application of at least tier 1 is not technically feasible or would incur unreasonable costs.

3.3.6 Combinations of approaches

Except where Annex IV requires specific methodologies to be applied for some activities, the MRR allows the operator to combine the different approaches outlined above, on the condition that no data gaps and no double counting occur. Where different approaches would lead to similar tier levels, the operator may use other criteria for choosing the methodology, such as:

- which methodology gives the more reliable results, i.e. where are the more robust measurement instruments used, fewer observations needed, etc.?
- which method has the lower inherent risk (see section 4.6), i.e. which methodology is easier to control by a second data source, where are fewer possibilities to make errors or omissions?

Example 6: the following fictitious installation might use all possible approaches simultaneously. It consists of the following elements:

1. A coal-fired boiler: a measurement-based methodology is used (note: if this were monitored using the standard approach, combustion emissions from coal and the associated process emissions from the use of limestone in the flue gas desulphurisation would have to be monitored separately).
2. Production of iron & steel (electric arc furnace):

   a) natural gas used for heating: simplest approach is the standard methodology

b) steel making: a mass balance is used (ingoing: scrap, pig iron, alloying components; outgoing: products, slag).

3. In addition, that installation operates a recycling plant (activity non-ferrous metal production and processing), where scrap stemming from electronic devices are burned in a rotary kiln. All scrap is treated as one (major) source stream. Due to the big heterogeneity of that material a fall-back methodology must be used (the carbon content might be estimated from a combined heat and mass balance of this kiln).

3.4 Categorisation of installations, emission sources, and source streams

It is a basic philosophy in the UK ETS MRV system, that the biggest emissions should be monitored most accurately, while less ambitious methods may be applied for smaller emissions. By this method, cost effectiveness is considered, and unreasonable financial and administrative burden is avoided where the benefit of more efforts would be only marginal.

3.4.1 Installation categories

To identify the required 'ambition level' of monitoring (details are given in section 4.3), the operator must classify the installation according to the average annual emissions (Article 19(2) of the MRR):

- category A: Annual average emissions are equal to or less than 50,000 tonnes of CO_2 equivalent (CO_2e)
- category B: Annual average emissions are more than 50,000 tonnes of CO_2e and equal to or less than 500,000 tonnes of CO_2e
- category C: Annual average emissions are more than 500,000 tonnes of CO_2e.

The 'annual average emissions' here means the annual average verified emissions of the previous trading period. As for annual reporting, emissions from sustainable[22] biomass are excluded (i.e. zero-rated), but contrary to annual reporting, CO_2 transferred out of the installation, if any, is counted as emitted, to give a better indication of the size of the GHG amounts occurring at the installation.

Where the average annual verified emissions in the trading period immediately preceding the current trading period for the installation are not available or no longer representative for the used installation category, the operator shall use a conservative estimate, with the exclusion of CO_2 stemming from biomass and before subtraction of transferred CO_2, to determine the category of the installation (Article 19(5) of the MRR).

[22] This means that the biomass – if used for combustion – must comply with the sustainability and GHG savings criteria established by the RED to be "zero-rated". For further details on biomass see section 5.3.5 and 'UKETS03 MRR - Reporting biomass in installations'.

This is particularly the case where the installation boundaries change due to an extension of the scope of the UK ETS.

Example 7: the operator determines the installation's category via the following steps:

1. average annual verified emissions in 2013-2020, excluding biomass, were 349,000 tonnes CO_2e. The installation is category B and there was no transfer of CO_2.

2. in 2023, the installation starts up an additional CHP plant, which is designed to emit around 200,000tCO_2 per year. Therefore, the emissions of 349,000 tonnes CO_2e are no longer considered representative, and the operator must make a conservative estimate of future emissions. The new estimate for the annual emissions is 549,000tCO_2 per year, so the installation becomes category C. Consequently, the operator must revise the monitoring plan (higher tiers may be required) and submit an updated monitoring plan to the regulator for approval (see section 4.6).

3. in 2025, the installation starts a pilot project for CO_2 capture and transfers on average 100,000tCO_2 to an installation for the geological storage of CO_2. However, in this case the category of the installation does not change to B, because the transfer of CO_2 is not to be considered. However, due to the significant change of the installation's functioning, the monitoring plan must be revised and submitted to the regulator for approval.

The MRR allows for an installation that exceeds one of the mentioned thresholds only once in a six-year period to retain its categorisation. For example, a category A installation that emits 51,000tCO_2 in one year only does not have to change its category if the emissions were below 50,000tCO_2 in the five preceding years. What is more important, this also means that the applicable minimum tiers do not change due to this one year of higher emissions, and the operator does not have to submit an updated monitoring plan for approval. Instead, the operator only must provide evidence "*to the satisfaction of the regulator that this threshold has not already been exceeded within the past five reporting periods and will not be exceeded again in subsequent reporting periods*" (2^{nd} subparagraph of Article 19(2) of the MRR). On the other hand, if the threshold is exceeded a second time within the next five years, the monitoring plan must be modified to comply with the more stringent conditions of the higher category.

3.4.2 Installations with low emissions

Installations which on average emit less than 25,000tCO_2e per year can be classified as 'installations with low emissions' in accordance with Article 47 of the MRR. For these, special simplifications of the MRV system are applicable to reduce administrative costs (see the guidance 'UK Emissions Trading Scheme for installations: How to Comply').[23]

As for other installation categories, the annual average emissions are to be determined as average annual verified emissions of the previous trading period, with exclusion of CO_2 stemming from sustainable biomass and before subtraction of transferred CO_2. Where those average emissions are not available or are no longer applicable because of changes in the installation's boundaries or changes to the operating conditions of the installation, a conservative estimate is to be used concerning the projected emissions for the next five years.

A special situation then arises if the installation's emissions exceed the threshold of 25,000tCO_2 per year. In that case it is necessary to revise the monitoring plan and submit a new one to the regulator for approval because the simplifications for small installations are no longer applicable. However, the wording of Article 47(8) of the MRR allows that the operator may continue as an installation with low emissions provided that the operator can demonstrate to the regulator that the 25,000tCO_2 per year threshold has not been exceeded in the previous five years and will not be exceeded again (e.g. due to limitations in installation capacity). Thus, high emissions in one single year out of six years may be tolerable, but if the threshold is exceeded again in one of the following five years, that exception will not be applicable anymore.

Example 8: An older and less efficient reserve boiler must be used in only one year due to a longer maintenance shutdown of the main boiler. The emissions exceed the 25,000tCO_2/year threshold in this one year, but the operator can easily demonstrate to the regulator that after these maintenance works it will not happen again in the next 5 years.

3.4.3 Source streams

Within an installation, the greatest attention should be given to the bigger source streams. For minor source streams, lower tier requirements are applicable from the MRR (section 4.3). The operator must classify all source streams for which the operator will use calculation-based approaches. For this purpose, the operator must compare the emissions of the source stream with the 'total of all monitored items'. The following steps must be performed:

1. Determine the 'total of all monitored items', by adding up:

    a. the emissions (CO_2e) of all source streams which are determined using the standard methodology (see section 3.3.1)

[23] https://www.gov.uk/government/publications/uk-emissions-trading-scheme-for-installations-how-to-comply/uk-emissions-trading-scheme-for-installations-how-to-comply

b. the *absolute values* of all CO_2 streams in a mass balance (i.e. the outgoing streams (e.g. carbon contained in steel products) are also counted as positive! See section 3.3.2), and

c. the emissions of CO_2 and CO_2e of all emission sources which are determined using a measurement-based methodology (see section 3.3.3).

d. for this calculation, CO_2 from fossil sources as well as 'non-sustainable biomass' is taken into account.

e. transferred CO_2 is not subtracted from the total.

2. Thereafter the operator should list all source streams (including those which form a part of a mass balance, given in absolute numbers) sorted in descending order.

3. The operator may then select source streams which are to be classified 'minor', 'de minimis' or 'marginal' source streams, to apply reduced monitoring requirements to them. For this purpose, the thresholds given below must be complied with:

   a. The operator may select as **minor source streams**: source streams which jointly account for less than 5,000 tonnes of fossil CO_2 per year or to less than 10% of the 'total of all monitored items', up to a total maximum contribution of 100,000 tonnes of fossil CO_2 per year, whichever is greater in terms of absolute value.

   b. The operator may select as **de minimis source streams**: source streams which jointly correspond to less than 1,000 tonnes of fossil CO_2 per year or to less than 2% of the 'total of all monitored items', up to a total maximum contribution of 20,000 tonnes of fossil CO_2 per year, whichever is the highest in terms of absolute value. Note that the de minimis source streams are no longer part of the minor source streams.

   c. The operator may select as **marginal source streams**: source streams selected by the operator that jointly account for less than 10 tonnes of fossil CO_2 per year.[24]

   d. All other source streams are classified as **major source streams**.

Note: The MRR does not specify a reference time span for these classifications, such as the previous trading period in the case of installation categorisation. However, Article 14(1) requires the operator to regularly check "*if the monitoring plan reflects the nature and functioning of the installation*" and whether the monitoring methodology can be improved.

[24] Typically, these may include source streams such as, but not limited to, propane and acetylene cylinders.

This check should be performed *at least* once per year (e.g. when the annual emission report has been compiled, as it then becomes evident if source streams have exceeded the relevant thresholds). Best practice is to have a procedure which connects such checks to the regular performance of control activities such as monthly horizontal or vertical checks (see section 4.6). Furthermore, the check should be automatically triggered by any change of the capacity or operations of the installation.

The MRR allows an installation that exceeds one of the source stream thresholds only once in six years to retain its classification. This means that the applicable minimum tiers do not change due to this single year of higher emissions, and the operator does not have to submit an updated monitoring plan for approval. However, the operator must provide evidence 'to the satisfaction of the regulator that this threshold has not already been exceeded within the past five reporting periods and will not be exceeded again in subsequent reporting periods' (2^{nd} subparagraph of Article 19(3) of the MRR).

Example 9: The source streams of the fictitious installation described in Example 6 are classified using the approach outlined above. The result is shown in Table 1 below.

Table 1: Categorisation of source streams of a fictitious installation

Source stream / emission source	CO_2 equivalent	Absolute value	% of total	Source stream category allowed
coal fired boiler (CEMS)	400,000	400,000	71.6%	*(not a source stream, but an emission source)*
natural gas	100,000	100,000	17.9%	major
recycled material (fallback)	50,000	50,000	8.9%	minor
pig iron	5,000	5,000	0.9%	de minimis
alloying elements	2,000	2,000	0.4%	de minimis
iron scrap	1,000	1,000	0.2%	de minimis
steel products[25]	-1,000	1,000	0.2%	de minimis

3.4.4 Emission sources

The MRR provides for a categorisation of emissions sources for which a measurement-based methodology is applied (Article 19(4) of the MRR). Similar to source streams in the previous section, the operator may classify **minor emission sources** where the emission source emits less than 5,000 tonnes of fossil CO_2 per year or less than 10% of the 'total of all monitored items', up to a total maximum contribution of 100,000 tonnes

[25] This is a product stream, i.e. contributing to the mass balance as output. Therefore, the CO_2 equivalent is a negative number.

of fossil CO_2 per year, whichever is the highest in terms of absolute value. All other emission sources are **major emission sources**.

Note: If the installation does not use CEMS, this categorisation can be omitted.

3.5 The tier system

As mentioned earlier, the UK ETS system for monitoring and reporting provides for a building block system of monitoring methodologies. Each parameter needed for the determination of emissions can be determined applying different 'data quality levels'. These 'data quality levels' are called 'tiers'.[26] The building block idea is illustrated by Figure 6, which shows the tiers which can be selected for determining the emissions from a fuel under the calculation-based methodologies. The descriptions of the different tiers (i.e. the requirements for complying with those tiers) are presented in more detail in chapter 4.

In general, tiers with lower numbers represent methods with lower requirements that are less accurate than higher tiers. Tiers of the same number (e.g. tier 2a and 2b) are considered equivalent.

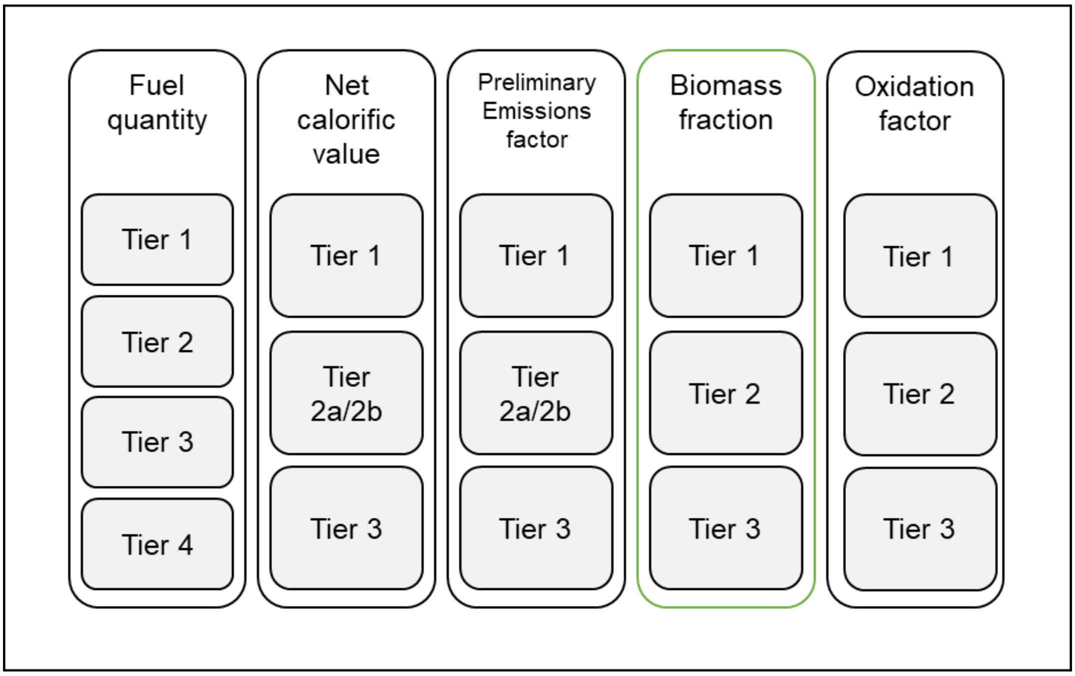

Figure 6: illustration of the tier system for calculation-based approaches (combustion emissions)

Higher tiers are generally considered more difficult and costly to meet than lower ones (e.g. due to more expensive measurements applied). Therefore, lower tiers are usually required for smaller quantities of emissions, i.e. for minor, de minimis and marginal

[26] Article 3(8) of the MRR defines: "*'tier' means a set requirement used for determining activity data, calculation factors, annual emission and annual average hourly emission, and payload*".

source streams (see section 3.4.3) and for smaller installations (for categorisation see section 3.4.1). A cost-effective approach is thus ensured.

Which tier an operator must select according to the requirements of the MRR is discussed in detail in section 4.3.

3.6 Reasons for derogation

Cost-effectiveness is an important concept for the MRR. It is generally possible for the operator to get permission from the regulator to derogate from a specific requirement of the MRR (such as the required tier level), if fully applying the requirement would lead to unreasonable costs or if a measure is technically not feasible.

3.6.1 Technical feasibility

Technical feasibility is not a question of cost benefit, but whether the operator is able to achieve a certain requirement at all. Article 17 of the MRR requires that an operator provides a justification where they claim something to be technically not feasible. This justification must demonstrate that the operator does not have the resources available to meet the specific requirement within the required time.

3.6.2 Unreasonable costs

When assessing whether costs for a specific measure are reasonable, the costs are compared with the benefit it would give. Costs are considered unreasonable where the costs exceed the benefit (Article 18 of the MRR).

The operator is responsible for providing a reasonable estimation of the costs involved. Only costs which are additional to those applicable for the alternative scenario should be considered i.e., higher costs compared to existing equipment or costs of a more expensive (but more accurate or reliable) equipment less the costs of equipment that would have been purchased, i.e. without monitoring obligations under the UK ETS.

The following type of costs can be considered relevant:

1. **investment costs**: Those costs must be based upon an appropriate depreciation period. Where appropriate, a suitable interest rate can be applied.

2. **operating & maintenance (O&M) costs**: Those costs include costs for any outsourced calibration or maintenance. It should also include, for the sake of equal treatment, any internal labour costs related to O&M. However, this only applies to those internal labour costs that the operator can demonstrate are clearly attributed to the improvement under consideration.

3. **costs related to changes in operations**: for example, if the installation of measurement equipment requires a temporary shutdown of operations. Again, this only applies to costs that the operator can demonstrate are clearly attributed to the installation of the new equipment. If a shutdown was planned anyway, the associated costs cannot be considered.

4. **any other costs**: Those costs may include, e.g. costs of sampling, costs for additional analyses, etc.

In some cases, certain costs, such as those related to maintenance shutdowns or instrument replacements, may not occur every year. For such cases those costs should be summed up over the whole depreciation period and divided by the number of years of this depreciation period.

Example 10: For assessing whether the acquisition of a measurement instrument incurs unreasonable costs, the operator wants to calculate the annual O&M costs. The depreciation period of this investment has been agreed to be 10 years. The manufacturer's specification of the instrument specifies that special maintenance is required every three years. Associated O&M costs are £3,000 each. What are the annual costs of this special maintenance?

The operator determines the annual costs to be £900/year since this special maintenance will be necessary three times over the whole depreciation period resulting in £9,000. Dividing by the depreciation period of ten years provides the result. Alternatively, simply dividing those £3,000 by three may also be an acceptable approach, where considered more appropriate, e.g. if the technical lifetime significantly deviates from the economic lifetime.

The MRR requires that the equipment costs are to be assessed using a depreciation period appropriate for the 'economic lifetime' of the equipment. Thus, the annual costs during the lifetime rather than the total equipment costs are to be used in the assessment.

Nevertheless, those values are not legally binding for the UK ETS but may be considered as reference values. The operator's justification for proposing a different depreciation period may be taken into account, e.g., where a measuring instrument is used in a corrosive environment.

Example 11: An old measuring instrument is found to not function properly anymore and is to be exchanged for a new one. The old instrument reached an uncertainty of 3% corresponding to tier 2 (±5%) for activity data (for tier definitions see section 6.1.1). Because the operator would have to apply a higher tier anyway, he considers whether a better instrument would incur unreasonable costs. Instrument A costs £40,000 and leads to an uncertainty of 2.8% (still tier 2), instrument B costs £70,000 but allows an uncertainty of 2.1% (tier 3, ±2.5%). Due to the rough environment in the installation, a depreciation period of 5 years is considered appropriate.

The costs to be taken into account for the assessment of unreasonable costs are £30,000 (i.e. the difference between the two meters) divided by 5 years, i.e.,

£6,000. No cost for the working time should be considered, as the same workload is assumed to be necessary independent from the type of the meter to be installed. Furthermore, the same maintenance costs can be assumed as an approximation.

Benefit: As the benefit of, for example, more precise metering is difficult to express in financial values, the MRR uses the cost of allowances as a proxy. The benefit is considered proportionate to a number of allowances in the order of magnitude of the reduced uncertainty. To make this estimation independent from daily price fluctuations, the MRR requires a constant allowance price of £20 to be applied. For determining the assumed benefit, this allowance price is to be multiplied by an 'improvement factor', which is the improvement of uncertainty multiplied by the average annual emissions caused by the respective source stream[27] over the three most recent years.[28] The improvement of uncertainty is the difference between the uncertainty currently achieved[29] and the uncertainty threshold of the tier which would be achieved after the improvement.

Where no direct improvement of the accuracy of emissions data is achieved by an improvement, the improvement factor is always 1%. Article 18(3) of the MRR lists some of such improvements, e.g. switching from default values to analyses, increasing the number of samples analysed, improving the data flow and control system, etc.

Please note the **minimum threshold** introduced by the MRR: accumulated improvement costs below £2,000 per scheme year are always considered reasonable, without assessing the benefit. For installations with low emissions (see section 3.4.2) this threshold is only £500.

Summarising the above by means of a formula, the costs are considered reasonable, if:

Equation 10:

$$C < P \times AEm \times (U_{curr} - U_{new\ tier})$$

Where:

C .... costs [£/year]

P .... specified allowance price = £20 / tCO_2e

[27] Where one measuring instrument is used for several source streams, such as a weighbridge, the sum of emissions of all related source streams should be used.
[28] Only the fossil emissions are considered. Transferred CO_2 is not subtracted. Where the average emissions of the most recent three years are not available or not applicable due to technical changes, a conservative estimate is to be used.
[29] Please note that the "real" uncertainty is meant here and not the uncertainty threshold of the tier.

AEm .... average emissions from related source stream(s) over the three most recent years [tCO_2e/year]

U_{curr} ...... current uncertainty (not the tier) [%]

$U_{new\ tier}$ ... uncertainty threshold of the new tier that can be reached [%]

Example 12: For the replacement of meters described above, the benefit of "improvement" for instrument A is zero, as it is a replacement that will maintain the current tier. It cannot be unreasonable, as the installation cannot be operated without at least this instrument.

In case of instrument B, tier 3 (threshold uncertainty = 2.5 %) can be reached. Thus, the uncertainty improvement is $U_{curr} - U_{new\ tier}$ = 2.8% – 2.5% = 0.3%.

The average annual emissions are AEm = 120,000tCO_2/year. Therefore, the assumed benefit is 0.003 x 120,000 x £80 = £28,800. This is higher than the assumed costs (see above). It is therefore not unreasonable to require instrument B to be installed.

To determine whether applying at least tier 1 for activity data incurs unreasonable costs the operator must assess whether the costs exceed the benefit. To calculate the benefit, the difference between the uncertainty currently achieved and the uncertainty threshold of the tier must be used as the improvement factor.

This approach is relevant regardless of whether the scenarios described in section 3.3.5.2 is the reason for deviation because both have a direct impact on the accuracy of activity data. The improvement factor of 1% in Article 18(3) of the MRR does not apply here. Therefore, the uncertainty related to the determination of activity data currently achieved must be assessed and used to calculate the improvement factor.

Note that the higher the uncertainty achieved by a fall-back approach, the more likely it is that the costs do not exceed the benefit, i.e. it will be more difficult to demonstrate unreasonable costs. This is the case because the improvement factor feeding into the calculation will be higher. Improving the monitoring methodology of a fall-back approach in terms of reducing its associated uncertainty (e.g. by applying a better estimation method) may lead to a lower uncertainty achieved. Consequently, costs for meeting at least tier 1 (using measurement equipment to determine the activity data) may more likely be unreasonable after such improvement.

For further information, as well as access to a UK ETS tool for determining unreasonable costs, please contact your regulator.

4 The monitoring plan

This chapter takes the concepts and approaches described so far to help operators develop a monitoring plan.

4.1 Developing a monitoring plan

When developing a monitoring plan, operators should follow some guiding principles:

1. Make the monitoring methodology as simple as possible. Operators know their own installation best. Wherever possible, use the most reliable data sources, robust metering instruments, short data flows, and effective control procedures.

2. Minimise administrative burden. Monitoring plans are living documents and are likely to undergo technical changes over the years. Operators should be mindful of which elements must be included in the monitoring plan itself, and what can be put into written procedures supplementing the monitoring plan.

3. Think about everyone who may need to understand your monitoring plan: is it clear to staff who need to follow it? Consider too the verifier's perspective. What would a verifier ask about how the data has been compiled? How can the data flow be made transparent? Which controls prevent errors, misrepresentations, or omissions?

(Note: for installations with small emissions and some other 'simple' installations, this chapter is only partly relevant. It is advisable to first consult chapter 6 of this document.)

The following step-by-step approach might be helpful.

4.2 A 13-step approach for creating a monitoring plan

1. Define the installation's boundaries, taking account of the provisions on the scope of each regulated activity, as defined in the Order

2. Determine the installation's category (see section 3.4.1) based on an estimate of the installation's annual GHG emissions. Where the boundaries of an incumbent installation are unchanged, the average verified annual emissions of the previous years can be used. In other situations, a conservative estimate is needed

3. List all emission sources and source streams (for definitions see section 3.2) to decide on a calculation or measurement-based approach. Classify the source streams as major, minor, de minimis and marginal as well as the emission sources as major or minor, as appropriate (see section 3.4.3 and 3.4.4).

4. Identify the tier requirements based on the installation category and the source stream/emission source category (see section 3.2).

5. List and assess potential sources of data:

    a. For calculation-based approaches, activity data (for detailed requirements see section 5.1):

        i. How can the amount of fuel or material be determined?

            - Are there instruments for continual metering, such as flow meters, weighing belts etc. which give direct results for material entering or leaving the process over time?

            - Or must the fuel or material quantity be based on batches purchased? In this case, how can the quantity on stockpiles or in tanks at the end of the year be determined?

        ii. Are measuring instruments owned/controlled by the operator available?

            - If yes - what is their uncertainty level? Are they difficult to calibrate? Are they subject to national legal metrological control?[30]

            - If no - can measuring instruments be used, which are under the control of the fuel supplier? (This is often the case for gas meters, and for many cases where quantities are determined based on invoices.)

        iii. Estimate uncertainty associated with those instruments and determine the achievable tier associated. Note that for uncertainty assessments several simplifications are applicable. For details see guidance document 'UKETS02 MRR/FAR - uncertainty assessments for installations'.

    b. Calculation factors (NCV, emission factor or carbon content, oxidation or conversion factor, biomass fraction): depending on the required tiers (which are determined based on installation category and source stream category):

        i. Are default values applicable? If yes, are values available? (Annex VI to the MRR, publications of the regulator, UK ETS Authority, national inventory values)?

[30] Some measuring instruments used for commercial transactions are subject to national legal metrological control. Special requirements (simplified approaches) are applicable to such instruments under the MRR. See guidance document 'UKETS02 MRR - Uncertainty assessments for installations' for details.

ii. If the highest tiers are to be applied, or if no default values are applicable, chemical analyses must be carried out for determining the missing calculation factors. In this case the operator must:

- Decide on the laboratory to be used. If no accredited laboratory[31] is available, establish evidence on the equivalence to accreditation (see section 5.2.2)
- Select the appropriate analytical method (and applicable standard)
- Design a sampling plan (see guidance document 'UKETS07 MRR – Sampling and analysis').

c. For measurement-based approaches, if applicable:

i. collect the necessary information (see section 7.1 and guidance document 'UKETS06 MRR - Use of continuous emissions measuring systems (CEMS)') on the measurement instruments involved, particularly the uncertainty levels achieved when carrying out the relevant Quality Assurance Level (QAL) tests

ii. Check whether the placement of the probes allows for representative measurements

iii. Select the method to determine the flue gas flow.

6. Can all required tiers be met for calculation-based approaches? If not, can a lower tier be met, if allowed in accordance with technical feasibility and unreasonable costs (see section 3.6)?

7. If measurement-based approaches (CEMS, see section 7) can or must be used,[32] can the relevant tiers and other requirements be complied with?

8. If the answers for steps 6 and 7 are negative, is there a way of using a fall-back methodology (see section 3.3.4)? A full uncertainty assessment for the installation will be required in this scenario.

9. The operator should define all data flows (who takes which data from where, does what with the data, hands over the results to whom, etc.) from the measuring instruments or invoices to the final annual report. The design of a flow diagram will be helpful. More details on data flow activities are found in section 4.6.

[31] "Accredited laboratory" is used here as short for "a laboratory which has been accredited pursuant to EN ISO/IEC 17025 for the analytical method required".
[32] CEMS must be used for N_2O emissions and may be used for CO_2 emissions. If the requirements for calculation-based methods for CO_2 cannot be reached, CEMS should be considered as equally valid alternative.

10. With this overview of the data sources and data flows, the operator can carry out a risk analysis (see section 4.6) which will determine where in the system errors might most easily occur.

11. Using the risk analysis, the operator should:

    a. If applicable, decide whether CEMS or calculation-based approaches are more suitable

    b. Assess which measuring instruments and data sources to use for activity data (see step 5a above). In case of several possibilities, the one with the lowest uncertainty and lowest risk should be used

    c. In all other cases which need decisions,[33] decide based on the lowest associated risk; and

    d. Define control activities for mitigating the identified risks (see section 4.6).

12. It may be necessary to repeat some of the steps 5 to 11, before finally writing down the monitoring plan and the related procedures. In particular, updating the risk analysis is likely to be required after having the control activities defined.

13. The operator will then create the monitoring plan along with the required supporting documents (Article 12(1) of the MRR):

    a. Evidence that all the tiers noted in the monitoring plan are complied with (this requires an uncertainty assessment, which can be very simple in most cases, see section 4.5)

    b. The result of the final risk analysis, showing that the defined control system is appropriately mitigating the identified risks

    c. Further documents (such as installation description and diagram) may need to be attached

    d. The written procedures referenced by the monitoring plan need to be developed, but do not need to be attached to the monitoring plan when submitting it to the regulator (see section 4.6 on procedures).

The operator should make sure that all versions of the monitoring plan, the related documents and procedures are clearly identifiable, and that the most recent versions are always used by all staff involved. A good document management system is advisable from the beginning.

[33] E.g., where several departments could handle the data, choose the most suitable with the lowest number of error possibilities.

4.3 Defining monitoring boundaries

Schedule 2 of the Order and Annex IV to the MRR set out the scope of activities covered by the UK ETS and greenhouse gases to be monitored. This section provides guidance on those situations that are less clearly defined.

4.3.1 Does the monitoring plan cover non-significant source streams and mobile sources?

Yes, all source streams must be included in the monitoring plan. There is no threshold laid down in the MRR with respect to the annual emissions stemming from each source stream.

Operators with multiple de minimis source streams can chose to group these emission sources into a combined source stream if they have the same fuel type, or as a marginal source stream.

Example 13: Natural gas is supplied to site via a main site gas meter; the gas is consumed by several emission sources including boilers, canteen equipment and laboratory units. In this case the emission sources can be grouped into one source stream and fuel consumption determined via the single gas meter.

Example 14: Several emergency generators are fuelled by gas oil; the generators may only be used for very small periods and so annual emissions are low. Gas oil for the generators is taken from a storage tank which is used to supply fuel to a number of other emission sources at the installation. Fuel consumption for reporting purposes can therefore be based on deliveries and/or stock tank measurements for this source stream.

In the case of small emission sources which cannot be grouped as they use unique fuel streams then the monitoring approach should be appropriate to the scale of emissions. It is likely that very small sources will fall into the de minimis category and therefore under MRR a 'no tier' approach may be applied using a conservative estimation method.

Example 15: An installation uses propane cylinders to supply small heating units, acetylene for welding and diesel to fuel generators. Emissions are determined using a conservative estimation method based on the number of cylinders and volume of diesel purchased each year. Total emissions are less than 10 tonnes of CO_2 per year. These fuel sources are grouped together as a marginal source stream. A procedure is in place to check each year whether consumption remains within this threshold.

4.3.2 Must process fuel from pressurised gas bottles be monitored and reported?

In principle, fuels stored in pressurised gas bottles (e.g. propane, acetylene, etc.) that are used for certain process steps within an installation must be monitored regardless of whether the fuel is stored in tanks, in pressurised gas-bottles, or is directly imported from an external fuel network (e.g. natural gas). It is only relevant in which technical unit those fuels are used and whether those units have a technical connection with the activities carried out on that site. If those units are stationary and have a technical connection with the activities carried out (e.g. laboratory units), they must be included in the greenhouse gas permit. Hence all fuels combusted in those units must be listed as source streams in the monitoring plan.

4.3.3 Should CO_2 from the purification of natural gas be monitored and reported?

CO_2 must be monitored and reported only if the CO_2 is released in a combustion process (by using either a standard combustion methodology or a mass balance methodology) where a calculation-based monitoring approach is applied or by using CEMS. This means that there is no monitoring and reporting requirement for CO_2 that is part of the imported raw natural gas but is at no point in the process fed into a combustion process. In the simplest case, CO_2 contained in any natural gas will be reported by including this CO_2 when determining the emission factor for applying it in a standard calculation method.

In upstream industries, the situation is slightly more complex. Natural gas (for the purposes of UK ETS) usually requires several purification steps after extraction to meet the specifications of the gas network operator. Those purification steps are normally done in a gas processing terminal. If the CO_2 or H_2S (hydrogen sulphide) concentration (acid gas) exceeds the thresholds of the gas network operator's specification, a removal of those impurities is also required. This is commonly achieved by separating those acidic gases from the main organic components in the natural gas by an amine treatment system. In subsequent steps the CO_2 and H_2S are separated from each other as well. H_2S will generally be converted into saleable products (e.g. to sulphur in a CLAUS unit)[34] and the gas flow containing very high CO_2 concentrations will be released to the air.

This gas flow containing CO_2 in high concentrations often contains some VOC (volatile organic carbon) impurities and therefore cannot be released directly to the atmosphere without a thermal conversion of those VOCs. Because this conversion is an oxidation of fuels, this conversion qualifies as combustion within the UK ETS, and the off-gas is regarded a fuel. Consequently, the CO_2 contained in this fuel is inherentCO_2 according to Article 48 of the MRR[35] and needs to be monitored and taken into account for the emission factor of this fuel.

It must be noted that gas processing terminals are normally covered by the UK ETS due to their combustion activities being above 20MW (e.g. steam production for the purification process) and there is no special activity unlike for liquid fuel refineries. However, section 1 of Annex IV to the MRR also provides the opportunity for combustion processes taking place in gas processing terminals to be monitored by a

[34] Note: The H2S enriched gas flow may still contain a significant concentration of CO_2. If this gas flow is also fed into a combustion unit (e.g. CLAUS unit), this CO_2 must be monitored and reported as well.
[35] Article 48 of the MRR: "*Inherent CO_2 that is transferred into an installation, including that contained in natural gas, a waste gas (including blast furnace gas or coke oven gas) or in process inputs (including synthesis gas), shall be included in the emission factor for that source stream*."

mass balance methodology in accordance with Article 25 of the MRR. In this case, the CO_2 emissions may simply be calculated as the difference between the amount of natural gas imported by the installation (multiplied by the corresponding carbon content), and the amount of natural gas exported from the installation (multiplied by the corresponding carbon content).

4.3.4 What is the difference between flares and post-combustion units?

Identifying relevant units correctly impacts the effort which is necessary to comply with the monitoring requirements in the MRR. Fuels combusted in post-combustion units, also commonly known as incinerators, must be monitored like all other fuels in combustion units, whereas for flares less stringent requirements apply.

The definition of safety flaring in Article 2(13) of the FAR can be used as a suitable starting point for this distinction. In this Article safety flaring is defined as '*the combustion of pilot fuels and highly fluctuating amounts of process or residual gases in a unit open to atmospheric disturbances which is explicitly required for safety reasons by relevant permits for the installation*'.

Therefore, flaring can be considered as safety flaring if all three of the following conditions are met:

1. The flaring is required for safety reasons (particularly if required by a relevant permit), and

2. The combustion takes place in a unit open to atmospheric disturbances (the combustion in other units is not covered), and

3. The amounts and/or composition of process or residual gases are highly fluctuating.[36]

This definition implies that the predictability of the combustion activity is a relevant parameter for the distinction. Flaring is often encountered for processes in which combustible gas flows are transported under high pressure through ducts for chemical reaction (e.g. production of polyethylene from pressurized ethylene gas) or purification (e.g. refineries).

However, the MRR does not distinguish between flaring and safety flaring. For flaring other than safety flaring the criterion of 'highly fluctuating' amounts of gas is not met. Therefore, as criteria 1 and 3 can only serve as indicators, the focus of the assessment should be on criterion 2.

All other post-combustion processes not meeting these specifications can be considered to be post-combustion units, in particular any combustion that does not take place in a unit open to atmospheric disturbances.[37] Post-combustion is often

[36] Note that flaring is currently under review as scope expansion occurs with the intention to better align with other initiatives.
[37] Note that this includes 'shrouded flares', i.e. flares where combustion is 'open to atmospheric disturbances' but a shroud is provided to hide the flame.

encountered in processes where the combustible gas is transported using a carrier gas (e.g. solvents for the production of fine organic chemicals, solvents in paint resins, etc.) in combustion units that are not open to atmospheric disturbances. Note that any unit equipped with a heat recovery steam generator is indicating that this unit is not open to atmospheric disturbances and is therefore considered to be a post-combustion unit.

4.4 Selecting the correct tier

The system of defining the minimum required tiers is laid down in Article 26 of the MRR for calculation-based approaches (i.e. for standard methodology and mass balances). **The overarching rule is that the operator should apply the highest tier defined for each parameter**. For major and minor source streams within category B and C installations this is mandatory.

In accordance with Article 26(1) of the MRR, the required tiers for major source streams are:

1. at least the tiers listed in Annex V for category A installations, or for a calculation factor for commercial standard fuels,[38]
2. the highest tier as defined in Annex II for all other cases.

Operators may deviate from applying those tiers if they demonstrate to the satisfaction of their regulator that they are technically not feasible (see section 3.6.1) or would incur unreasonable costs (see section 3.6.2), and can therefore apply the following:

- one tier lower in case of category C installations
- one or two tiers lower in case of category B and A installations

Where the required tier levels are still technically unfeasible or lead to unreasonable costs, the regulator may allow the operator to apply an even lower tier (with a minimum of tier 1) for an agreed transitional period to be agreed with the regulator, subject to the operator providing a suitable improvement plan within this period.

It is the tier that can be achieved that is documented in the monitoring plan.

Article 26(2) of the MRR specifies for minor source streams that the highest tier which is technically feasible and does not incur unreasonable costs shall be applied (with a

[38] Article 3(32) of the MRR defines: "*'commercial standard fuel' means the internationally standardised commercial fuels that exhibit a 95% confidence interval of not more than 1% for their specified calorific value, including gas oil, light fuel oil, gasoline, lamp oil, kerosene, ethane, propane, butane, jet kerosene (jet A1 or jet A), jet gasoline (jet B) and aviation gasoline (AvGas).*"
Commercial standard fuels are considered easy to monitor. Therefore Article 31(4) of the MRR allows the same treatment for other fuels that exhibit similar constant composition: "*Upon application by the operator, the regulator may allow that the net calorific value and emission factors of fuels are determined using the same tiers as required for commercial standard fuels provided that the operator submits, at least every three years, evidence that the 1 % interval for the specified calorific value has been met during the last three years*". See section 5.3.2.3 for further guidance on how this rule can be applied.

minimum of tier 1). Therefore, also for minor source streams the use of a tier lower than the required tier is allowed only if the operator demonstrates to the satisfaction of the regulator that the required tiers are technically not feasible or would incur in unreasonable cost. Please note that no reference is made here that there are any further derogations from paragraph 1. Therefore, for category A installations and commercial standard fuels tiers in Annex V are also to be considered as the required tiers for minor source streams.

Consequently, the main difference between the tier requirements for major and for minor source streams is that there is no threshold or time limit when deviating from the tier requirement. In any event this is true if at least tier 1 is applied and applying the required tiers is technically not feasible or would incur unreasonable costs (see examples below).

Example a: Category B or C installation, liquid fuel

	Tier required (highest tier in Annex II)	Minimum tier (technically not feasible or unreasonable costs)	Absolute minimum tier (transitional period to be agreed with the regulator)
Major	4	3 (for category C) 2 (for category B)	n/a
Minor	4	1	n/a

Example b: Category A installation, liquid fuel

	Tier required (highest tier in Annex V)	Minimum tier (technically not feasible or unreasonable costs)	Absolute minimum tier (transitional period to be agreed with the CA)
Major	2	1	n/a
Minor	2	1	n/a

Operators can apply a conservative[39] estimation to de minimis and marginal source streams, unless a tier equal to or higher than 1 can be achieved ‘without additional effort’ (see section 4.3.1). The operator should describe this method in the monitoring plan.

Special rules are applicable to calculation factors in some cases:

[39] “Conservative” means that the method shall not lead to underestimation of the emissions.

- tier 1 for oxidation and conversion factors, irrespective of the type of installations (i.e. setting the factor to a value of 100%).[40]

- for some methodologies, the net calorific value (NCV) of fuels is not required for the calculation but is reported for consistency reasons, and to provide information necessary for determining activity level values for free allocation purposes. According to Article 26(5) of the MRR this is the case for:

  - fuels where the regulator has allowed to use emission factors expressed as tCO_2 per tonne (or Nm^3) instead of tCO_2/TJ

  - fuels which are used as process input (if the emission factor is not expressed as per TJ)

  - fuels which are part of a mass balance as described in section 3.3.2.

  In these cases, the NCV may be determined by using conservative estimates instead of using tiers. However, the highest tier which does not involve additional effort should be applied.

The full system of tier selection requirements for calculation-based approaches is summarised in Table 2 below.

Note: If even tier 1 cannot be achieved for either activity data or a calculation factor of a major or minor source stream, the operator may consider applying a measurement-based approach (see section 7). Where this also cannot even reach tier 1, a fall-back methodology (see section 3.3.4) may be considered.

For measurement-based methodologies a similar hierarchy of approaches is laid down in Article 41 of the MRR. For major emission sources in category B and C installations, the highest tier must be applied. For category A installations, tier 2 may be used (see section 2 of Annex VIII to the MRR). Where the operator demonstrates unreasonable costs (see section 3.6.2) or that such a tier is technically not feasible, an even lower tier (minimum is tier 1) may be applied.

Again, if tier 1 is not possible, the operator may have to use a fall-back methodology.

Important note: The monitoring plan must always reflect the tier actually applied, not the minimum one required. The general principle is that operators should attempt to improve their monitoring systems wherever possible.

4.4.1 Concept of 'additional effort'

The MRR uses the term 'additional effort' three times:

[40] This is the "translation" of the text of Article 26(4) of the MRR, which requires "*the lowest tiers listed in Annex II, as a minimum*".

1. In Article 26(3): For de minimis source streams, the operator may determine activity data and each calculation factor by using conservative estimates instead of using tiers, unless a defined tier is achievable without additional effort.

2. In Article 26(5): Where the regulator has allowed the use of emission factors expressed as tCO_2/t or tCO_2/Nm^3 for fuels, and for fuels used as process input or in mass balances in accordance with Article 25 of the MRR, the net calorific value may be monitored using a conservative estimate instead of using tiers, unless a defined tier is achievable without additional effort.

3. In Article 47(6): By way of derogation from MRR Articles 26(1) and 41(1), the operator of an installation with low emissions may apply as a minimum tier 1 for the purposes of determining activity data and calculation factors for all source streams and for determining emissions by measurement-based methodologies, unless higher accuracy is achievable without additional effort for the operator, without providing evidence that applying higher tiers is technically not feasible or would incur unreasonable costs.

In all three cases, ‘additional effort’ means effort in addition to the monitoring systems or monitoring methodologies already in place. This usually refers to existing systems or methodologies before considering improvements, or, where appropriate, there were no prior UK ETS monitoring obligations. Therefore, it should not be considered to incur an additional effort to use available data for a second purpose (i.e. GHG emissions monitoring), including any associated administrative or bureaucratic effort (e.g. writing procedures or providing evidence).

Example 16: An installation with low emissions is covered by the UK ETS from 2021 onwards because of its production of bulk organic chemicals. For quality assurance and for commercial purposes the installation is analysing (indirectly) the carbon content of each source stream involved in the reaction in accordance with Articles 32 to 35 of the MRR, i.e. compliant with tier 3 for the determination of the carbon content. Although eligible to apply tier 1 under Article 47(6) of the MRR, compliance with tier 3 in effect requires no additional effort because it is already being met. The requirement to provide a sampling plan to the regulator may be caused only by the UK ETS monitoring obligations, but it should not be considered to cause additional effort because it requires only to lay down in writing what is already done.

Example 17: The customers of this same installation are now only requiring the main compound of the product to exhibit a purity of > 95 %. Due to the fluctuation of the production process, the impurities are not constant and not identified for quality assurance. In this case, the analytical results cannot be considered to comply with the requirements of Articles 32 to 35 of the MRR. Full compliance would require a more demanding analytical method and should therefore be considered as requiring additional effort. Consequently, the operator will not be required to apply tier 3 but to use available default values instead. However, note that the lower the purity the less appropriate it will be to assign this product to a certain material for which default values are available. If default values are not available, the operator will have to propose a fall-back approach demonstrating that improving their analytical method would otherwise incur unreasonable costs.

Table 2: Summary of tier requirements for calculation approaches

Installation category	Source stream category	Tier required**	Minimum tier***	Absolute minimum tier****	If at least tier 1 is not possible
category C* (> 500kt)	major	highest tier in Annexes II & IV	highest tier in Annexes II & IV minus 1 (minimum tier 1)	tier 1	fall-back approach
	minor	highest tier in Annexes II & IV	tier 1	N/A	
	de minimis / marginal	conservative estimates unless tier is achievable without additional effort			N/A
category B* (50kt < x ≤ 500kt)	major	highest tier in Annexes II & IV	highest tier in Annexes II & IV minus 2 (minimum tier 1)	tier 1	fall-back approach
	minor	highest tier in Annexes II & IV	tier 1	N/A	
	de minimis / marginal	conservative estimates unless tier is achievable without additional effort			N/A
category A (≤ 50kt)	major	tier in Annex V	tier in Annex V minus 2 (normally tier 1)	tier 1	Fall-back approach
	minor	tier in Annex V	tier 1	N/A	
	de minimis / marginal	conservative estimates unless tier is achievable without additional effort			N/A
Installation with low emissions (< 25kt)	major	tier 1 unless higher tier is achievable without additional effort			Fall-back approach
	minor	tier 1 unless higher tier is achievable without additional effort			
	de-minimis / marginal	conservative estimates unless tier is achievable without additional effort			N/A

* For calculation factors (emission factor, net calorific value) of source streams that are commercial standard fuels the same tier requirements for category A installations apply

** For oxidation and conversion factors the minimum requirement is to apply the lowest tier in Annexes II & IV (normally tier 1 = 100%)

*** If tier required technically not feasible or unreasonable costs

**** If technically not feasible or unreasonable costs for transitional period as agreed with the regulator

Table 3: Summary of tier requirements for measurement-based approaches

<table>
<tr><th>Installation category</th><th>Emission source category</th><th>Tier required</th><th>Minimum tier
(if tier required technically not feasible or unreasonable costs)</th><th>If at least tier 1 is not possible</th></tr>
<tr><td rowspan="2">category C
(> 500kt)</td><td>major</td><td>highest tier in Annex VIII</td><td>highest tier in Annex VIII minus 1 (minimum tier 1)</td><td rowspan="8">Fall-back approach</td></tr>
<tr><td>minor</td><td>highest tier in Annex VIII</td><td>tier 1</td></tr>
<tr><td rowspan="2">category B
(≤ 500kt > 50kt)</td><td>major</td><td>highest tier in Annex VIII</td><td>highest tier in Annex VIII minus 2 (minimum tier 1)</td></tr>
<tr><td>minor</td><td>highest tier in Annex VIII</td><td>tier 1</td></tr>
<tr><td rowspan="2">category A
(≤ 50kt)</td><td>major</td><td>tier 2</td><td>tier 1</td></tr>
<tr><td>minor</td><td>tier 2</td><td>tier 1</td></tr>
<tr><td rowspan="2">Installation with low emissions
(< 25kt)</td><td>major</td><td colspan="2" rowspan="2">tier 1 unless higher tier is achievable without additional effort (not applicable for N_2O)</td></tr>
<tr><td>minor</td></tr>
</table>

4.5 Uncertainty assessment as supporting documentation

When submitting a new or updated monitoring plan, the operator must demonstrate that the monitoring methodology (particularly the measuring instruments applied) complies with those uncertainty levels. Pursuant to Article 12(1) of the MRR, this is done by submitting an uncertainty assessment as supporting documentation together with the monitoring plan (note that installations with low emissions (see section 3.4.2) are exempt from submitting uncertainty assessments to their regulator).

This supporting document should contain the following information:

- evidence for compliance with uncertainty thresholds for activity data
- evidence for compliance with uncertainty required for calculation factors, if applicable[41]

[41] This is applicable only where the sampling frequency for analyses is determined based on the rule of 1/3 of the activity data uncertainty (Article 35(2) of the MRR). For more information see section 5.2.2.

- evidence for compliance with uncertainty requirements for measurement-based methodologies, if applicable
- if a fall-back methodology is applied for at least part of the installation, an uncertainty assessment for the total emissions of the installation is to be presented

It is advisable that at the same time the operator designs a pragmatic procedure for repeating this assessment regularly[42]

For activity data, the uncertainty assessment must cover (Article 28(2) of the MRR and by way of analogy also required by Article 29 of the MRR):

- the specified uncertainty of the applied measuring instruments,
- the uncertainty associated with the calibration, and
- any additional uncertainty connected to how the measuring instruments are used in practice.
- the influence of the uncertainty related to determination of stocks at the start/end of the year are to be included, if relevant. They are relevant if:
    - fuel or material quantities are determined based on batch measurements rather than continual metering, i.e. mostly when invoices are used
    - storage facilities are capable of containing at least 5% of the annually used quantity of the fuel or material considered, and
    - the installation is not an installation with low emissions (see section 3.4.2).

More detailed guidance on how to carry out an uncertainty assessment, including details on simplifications, national legal metrological control, and maximum permissible errors can be found in guidance document 'UKETS02 MRR/FAR - Uncertainty assessments for installations'.

4.6 Procedures and the monitoring plan

The MRR recognises that some monitoring activities can change quite frequently. To reduce the burden on operators and regulators by updating the monitoring plan every time,

[42] Such procedure is to be referenced in the monitoring plan in accordance with point 1(c)(ii), section 1 of Annex I to the MRR, and is needed for compliance with Articles 28(1) and Article 22 of the MRR (if applicable).

such monitoring activities may (or even must) be put into ‘written procedures’,[43] which are mentioned and described briefly in the monitoring plan but are not considered part of the monitoring plan. They must be described in the monitoring plan with enough level of detail that the regulator can understand the content of the procedure and can be assured that full documentation of the procedure is maintained and implemented by the operator. The operator must also make procedures available for the purposes of verification.[44] As a result, the operator has the full responsibility for the procedure. This gives the operator flexibility to make amendments to the procedure whenever needed, without requiring update of the monitoring plan, if the procedure’s content stays within the limitations of its description laid down in the monitoring plan.

The MRR contains several elements which are by default expected to be put into written procedures, such as:

- managing responsibilities and competency of personnel
- data flow and control procedures (see section 4.7)
- quality assurance measures
- estimation method for substitution data where data gaps have been found
- regular review of the monitoring plan for its appropriateness (including uncertainty assessment where relevant)
- a sampling plan,[45] if applicable (see section 5.2.2), and a procedure for revising the sampling plan, if relevant
- procedures for methods of analyses, if applicable
- procedure for demonstrating evidence for equivalence to EN ISO/IEC 17025 accreditation of laboratories, if relevant
- procedure for uncertainty assessment in case of fall-back methodologies (see section 3.3.4) applied
- procedures for use of measurement-based methodologies, including for corroborating calculations and for subtracting biomass emissions, if relevant.

[43] Article 11(1) of the MRR, 2nd sub-paragraph: “*The monitoring plan shall be supplemented by written procedures which the operator or aircraft operator establishes, documents, implements and maintains for activities under the monitoring plan, as appropriate.*”
[44] Point (g) of Article 10(1) of the VR
[45] Containing information on the methodologies for preparation of samples, including information on responsibilities, locations, frequencies and quantities and methodologies for the storage and transport of samples (Article 33 of the MRR).

The MRR furthermore outlines how the procedure must be described in the monitoring plan. Note that for simple installations the procedures will usually be very simple and straightforward. Where the procedure is very simple, it may be useful to use the procedure text immediately as "description" of the procedure as required for the monitoring plan.

Example 18 - a procedure

An operator might use different fractions of municipal or industrial waste as fuel. If every type of waste were to be considered as individual source stream, the operator would have to update the monitoring plan every time a new waste type is delivered. The regulator would be required to issue an approval of the monitoring plan each time. This situation cannot be considered practical, particularly if the monitoring method is always the same (e.g. same balance used, same sampling and methods of analysis applied).

(Note: This example is without prejudice to other legal requirements regarding burning of waste, such as requirements under the Environmental Permitting Regulations 2016. This example assumes that the different types of waste mentioned do not infringe any permit conditions or other legal requirements. The focus here lies solely on the UK ETS monitoring aspects).

Solution for monitoring: The operator uses a procedure for checking if the waste delivered fits into the boundaries of the defined source stream before applying the monitoring approach defined in the monitoring plan. The procedure could be outlined like this:

1. The shift personnel at the entrance gate are instructed to report every delivery of a waste material to the RSM (ETS Responsible Shift Manager).[46]

2. RSM checks if waste delivered complies with quality standard as defined by <procedure x.y.1>. That procedure defines that:

   a) only waste of certain waste catalogue numbers is permitted by the regulator

   b) only certain net calorific values, humidity and particle size can be used in the installation

   c) in case of doubt, the RSM will request the on-site laboratory to perform adequate analyses.

If the waste does not comply with <procedure x.y.1>, it must be put on storage until the calculation factors have been determined. In this case this waste is put on a list of

[46] Note that it is not the name of responsible staff, but rather the name of the post is to be used, to avoid necessary updates following staff changes.

new materials, which will be notified to the regulator every year in the first week of November.

Thereafter the waste can be used in the installation. The mass noted down on the delivery note, as well as the calculation factors are entered in the ETS data log, filename “E:\Raw data\SourceStreamData.xls”, sheet “WasteLog” by RSM. <End of procedure>

The two tables below outline the necessary elements of information required to be put into the monitoring plan for each procedure (Article 12(2) of the MRR) and provide examples.

Table 4: Example related to the management of staff: descriptions of a written procedure as required in the monitoring plan.

Item according to Article 12(2)	Possible content (examples)
Title of the procedure	ETS personnel management
Traceable and verifiable reference for identification of the procedure	ETS 01-P
Post or department responsible for implementing the procedure and the post or department responsible for the management of the related data (if different)	HSEQ deputy head of unit
Brief description of the procedure	• Responsible person maintains a list of personnel involved in ETS data management. • Responsible person holds at least one meeting per year with each involved person, at least 4 meetings with key staff as defined in the annex of the procedure; Aim: Identification of training needs. • Responsible person manages internal and external training according to identified needs.
Location of relevant records and information	Hardcopy: HSEQ Office, shelf 27/9, Folder identified “ETS 01-P”. Electronically: “P:\ETS_MRV\manag\ETS_01-P.xls”
Name of the computerised system used, where applicable	N.A. (Normal network drives)
List of EN standards or other standards applied, where relevant	N.A.

Table 5: QM-related example for a description of a written procedure in the monitoring plan

Item according to Article 12(2)	Possible content (examples)
Title of the procedure	QM for ETS instruments
Traceable and verifiable reference for identification of the procedure	QM 27-ETS
Post or department responsible for implementing the procedure and the post or department responsible for the management of the related data (if different)	Environmental officer / Business Unit 2
Brief description of the procedure	• Responsible person maintains a calendar of appropriate calibration and maintenance intervals for all instruments listed in table X.9 of the monitoring plan. • Responsible person checks weekly which QM activities are required according to the calendar within the next 4 weeks. As appropriate, he reserves resources required for these tasks in the weekly meetings with the plant manager. • Responsible person orders external experts (calibration institutes) when required. • Responsible person ensures that QM tasks are carried out on the agreed dates. • Responsible person keeps records of the above QM activities. • Responsible person reports back to plant manager on corrective action required. • Corrective action is handled under procedure QM 28-ETS.
Location of relevant records and information	Hardcopy: Office HS3/27, shelf 3, Folder identified “QM 27-ETS -nnnn”. (nnnn=year)
Name of the computerised system used, where applicable	MS Outlook calendar, also used for storing documents as attachments chronologically

List of EN standards or other standards applied, where relevant	In the instrument list (document ETSInstr-A1.xls) the applicable standards are listed. This document is made available to the regulator and verifier upon request.

4.7 Data flow and control system

Monitoring of emissions data is more than just reading instruments or carrying out chemical analyses. It is of utmost importance to ensure that data are produced, collected, processed, and stored in a controlled way. Therefore, the operator must define instructions for 'who takes data from where and does what with the data'. These 'data flow activities' (Article 58 of the MRR) form part of the monitoring plan (or are laid down in written procedures, where appropriate (see section 4.6). A data flow diagram is often a useful tool for analysing and/or setting up data flow procedures. Examples for data flow activities include reading from instruments, sending samples to the laboratory and receiving the results, aggregating data, calculating the emissions from various parameters, and storing all relevant information for later use.

As human beings (and often different information technology systems) are involved, mistakes in these activities can be expected. The MRR therefore requires the operator to establish an effective control system (Article 59 of the MRR). This consists of two elements:

1. a risk assessment
2. control activities for mitigating the risks identified.

'Risk' is a parameter which considers both, the probability of an incident and its impact. In terms of emission monitoring, the risk refers to the probability of a misstatement (omission, misrepresentation, or error) being made, a non-compliance with the rules or non-conformance with the monitoring plan or associated procedures and the impact in terms of annual emissions figure.

When the operator carries out a risk assessment, the operator analyses each point in the data flow needed for the whole installation's emission monitoring, whether there would be a risk of misstatements. Usually, this risk is expressed by qualitative parameters (low, medium, high) rather than by trying to assign exact figures. The operator furthermore assesses potential reasons for misstatements (such as paper copies being transported from one department to another, where delays may occur, or copy and paste errors may be introduced), and identifies which measures might reduce the found risks, e.g. sending data electronically and storing a paper copy in the first department; search for duplicates or data gaps in spreadsheets, control check by an independent person (the ‘four eyes principle’), etc.

Measures identified to reduce risks are then implemented. The risk assessment is then re-evaluated with the new (reduced) risks, until the operator considers that the remaining risks are sufficiently low to be able to produce an annual emissions report that is free from material misstatements).[47]

The control activities are laid down in written procedures and referenced in the monitoring plan. The results of the risk assessment (which take into account the control activities) are submitted as supporting documentation to the regulator when approval of the monitoring plan is requested by the operator.

Operators are required to establish and maintain written procedures related to control activities for at least (Article 59(3) of the MRR):

- quality assurance of the measurement equipment
- quality assurance of the information technology system used for data flow activities, including process control computer technology
- segregation of duties in the data flow activities and control activities and management of necessary competencies
- internal reviews and validation of data
- corrections and corrective action
- control of outsourced processes
- keeping records and documentation including the management of document versions.

Operators of installations with low emissions are exempt from submitting a risk analysis when submitting the monitoring plan for approval by the regulator (Article 47(3) of the MRR). However, operators should still find it useful to carry out a risk assessment for their own purposes. It has the advantage of reducing the risk of under-reporting of emissions, the under-surrender of allowances and consequential penalties; and conversely, the over-reporting of emissions and over-surrender of allowances.

[47] The operator should strive to produce “error-free” emission reports (Article 7 of the MRR: operators “*shall exercise due diligence to ensure that the calculation and measurement of emissions exhibit the highest achievable accuracy*”). However, verification cannot produce 100% assurance. Instead, verification aims at providing a reasonable level of assurance that the report is free from material misstatements.

More detailed guidance on this topic can be found in guidance document 'UKETS04 MRR - Data flow activities and control system'.

4.8 Keeping the monitoring plan up to date

The monitoring plan must always correspond to the current nature and functioning of the installation. Where the practical situation at the installation is modified, for example because technologies, processes, fuels, materials, measuring equipment, IT systems or organisation structures (such as staff assignments) are changed (where relevant for the monitoring of emissions), the monitoring plan must be updated (Article 14 of the MRR).[48] Depending on the nature of the changes, one of the following situations can occur:

- if an element of the monitoring plan itself needs updating, one of the following situations can apply:
    - the change to the monitoring plan is a significant one (see section 4.7.1). In case of doubt, the operator must assume that the change is significant.
    - the change to the monitoring plan is not significant (see section 4.7.2).
- an element of a written procedure is to be updated. If this doesn't affect the description of the procedure in the monitoring plan, the operator can update the procedure without notifying the regulator.

The same situations may occur because of the improvement principle (see section 4.8).

Article 16(3) of the MRR defines the requirements for record-keeping on any monitoring plan updates to maintain a complete history of changes to the monitoring plan. This allows for a fully transparent audit trail.

For this purpose, it is considered best practice for the operator to make use of a 'logbook', in which all non-significant changes to the monitoring plan and to procedures are recorded,

[48] Article 14(2) of the MRR lists a minimum of situations in which a monitoring plan update is mandatory:

a) *new emissions occur due to new activities being carried out or due to the use of new fuels or materials not yet contained in the monitoring plan;*
b) *a change in the availability of data, due to the use of new types of measuring instrument, sampling methods or analysis methods, or for other reasons, leads to higher accuracy in the determination of emissions;*
c) *data resulting from the monitoring methodology applied previously has been found to be incorrect;*
d) *changing the monitoring plan improves the accuracy of the reported data, unless this is technically not feasible or incurs unreasonable costs;*
e) *the monitoring plan is not in conformity with the requirements of this Regulation and the regulator requests the operator or aircraft operator to modify it;*
f) *it is necessary to respond to the suggestions for improvement of the monitoring plan contained in a verification report.*

as well as all versions of submitted and approved monitoring plans. This must be supplemented with a written procedure for regular assessment of whether the monitoring plan is up to date (Article 14(1) and point 1(c), section 1 of Annex I to the MRR).

Note: Any change of the monitoring plan under the MRR may have an impact on the monitoring methodology plan (MMP) required by the FAR. If the installation receives free allocation under the FAR, the operator is also responsible for keeping the MMP up to date.[49]

4.8.1 Significant modifications to the monitoring plan

Operators should be aware of and comply with the conditions in their permits, which include actions to take with respect to significant and non-significant changes to the monitoring plan and monitoring methodology plan.

Whenever a significant modification to the monitoring plan is necessary, the operator must notify the update to the regulator at least 14 days before making the modification or, where this is not possible, as soon as reasonably practicable. The regulator must assess whether the change is indeed a significant one. Article 15(3) of the MRR contains a non-exhaustive list of monitoring plan updates which are considered significant.[50] If the change is not significant, the procedure described under section 4.7.2 applies. For significant changes, the operators must apply for a variation to their monitoring plan, which will be reviewed and approved by the regulator.

The approval process may sometimes need longer than the physical change of the installation (for example where new source streams are introduced for monitoring). The regulator may find the operator's monitoring plan update incomplete or inappropriate and may require additional amendments of the monitoring plan. Thus, monitoring according to

[49] See the guidance document 'UKETS13 FAR - Monitoring and reporting in relation to the free allocation rules'

[50] Article 15(3) of the MRR: "*Significant modifications to the monitoring plan of an installation include:*
- *(a) changes to the category of the installation where such changes require a change to the monitoring methodology or lead to a change of the applicable materiality level pursuant to Article 23 of Implementing Regulation (EU) 2018/2067;*
- *(b) notwithstanding Article 47(8), changes regarding whether the installation is considered an 'installation with low emissions';*
- *(c) changes to emission sources;*
- *(d) a change from calculation-based to measurement-based methodologies, or vice versa, or from a fall-back methodology to a tier-based methodology for determining emissions or vice versa;*
- *(e) a change in the tier applied;*
- *(f) the introduction of new source streams;*
- *(g) a change in the categorisation of source streams – between major, minor, de minimis or marginal source streams where such a change requires a change to the monitoring methodology;*
- *(h) [….]*
- *(i) the introduction of new methods or changes to existing methods related to sampling, analysis or calibration, where this has a direct impact on the accuracy of emissions data;*
- *(j) the implementation or adaption of a quantification methodology for emissions from leakage at storage sites.*".

the old monitoring plan may be incomplete or lead to inaccurate results, while the operator is not sure whether the new monitoring plan will be approved as requested. The MRR provides for a pragmatic approach here:

According to Article 16(1) of the MRR, the operator shall immediately apply the new monitoring plan where they can reasonably assume that the updated monitoring plan will be approved as proposed. This may apply for example following the introduction of an additional fuel is that will be monitored using the same tiers as comparable fuels in that installation. Where the new monitoring plan is not yet applicable (i.e. where the situation in the installation will only change following approval of the monitoring plan by the regulator), monitoring is to be carried out in accordance with the old monitoring plan until the new one is approved.

Where the operator is unsure whether the regulator will approve the changes, the operator must carry out monitoring in parallel using both the modified and original monitoring plan (Article 16(1) of the MRR) and keep results from using both methods. Upon receiving the regulator's approval, the operator must only use the data obtained in accordance with the new monitoring plan as approved (Article 16(2) of the MRR).

4.8.2 Non-significant modifications of the monitoring plan

Non-significant modifications must be notified to the regulator in the year in which the change occurred.

The final decision on whether a change to the monitoring plan is significant is the responsibility of the regulator. However, an operator can reasonably anticipate that decision in many cases:

- where a change is comparable to one of the cases listed in Article 15(3) of the MRR, the change is significant.
- where the impact of the proposed monitoring plan changes the overall monitoring methodology or on the risks for error is small, it may be non-significant.
- in case of doubt, assume it is a significant change and follow section 4.7.1.

Non-significant changes do not need the approval of the regulator.

4.9 The improvement principle

While the previous section has dealt with monitoring plan updates which are mandated as consequence of factual changes at the installation, the MRR also requires the operator to explore possibilities to improve the monitoring methodology when the installation itself is unchanged. There are two requirements:

1. operators must take account of the recommendations included in the verification reports (Articles 9 and 69(4) of the MRR), and

2. operators must check regularly on their own initiative, whether the monitoring methodology can be improved (Article 14(1) and Article 69(1) - (3) of the MRR)

Operators must respond appropriately to any findings on possible improvements by the following steps:

1. sending an improvement report to the regulator for approval

2. updating the monitoring plan as appropriate (using the procedures outlined in sections 4.8.1 and 4.8.2)

3. implementing the improvements, if relevant, according to the timetable proposed in the approved improvement report.

As detailed above, operators are required to submit improvement reports to the regulator. There are two types of improvement report: the first relates to tiers and the fall-back methodology, while the second relates to verifier comments. The online guidance 'UK Emissions Trading Scheme for installations: how to comply' contains further details about these reports.

5 Calculation-based approaches

This chapter gives further details which must be considered when applying calculation-based monitoring methodologies. The principles of the methodology were outlined in section 3.3.1 (standard methodology) and 3.3.2 (mass balance). All calculation-based approaches have common elements which need to be defined in the monitoring plan. They will be discussed in this chapter as follows:

- for the monitoring of activity data, amounts of material or fuel need to be monitored, with tiers being defined according to the uncertainty of metering (see section 5.1).
- calculation factors must be determined either as default values (section 5.2.1) or must be determined by analyses (section 5.2.2)
- for calculation factors, a few specific requirements are found in the MRR. These are discussed in section 5.3.

5.1 Monitoring of activity data

5.1.1 Tier definitions

As discussed earlier, the tiers (see section 3.5) for activity data of a source stream are defined using thresholds for a maximum uncertainty allowed for the determination of the quantity of fuel or material over a scheme year. Unless it is an installation with low emissions (see section 3.4.2), the operator must demonstrate whether a tier is met by submitting an uncertainty assessment to the regulator together with the monitoring plan. Elements of this uncertainty assessment have been discussed in section 4.5. For illustration, Table 6 shows the tier definitions for combustion of fuels. A full list of the tier definitions of the MRR is given in section 1 of Annex II to the MRR.

Table 6: Typical definitions of tiers for activity data based on uncertainty, given for the combustion of fuels as example

Tier No.	Definition
1	Amount of fuel [t] or [Nm^3] over the scheme year[51] is determined with a maximum uncertainty of less than ± 7.5 %.
2	Amount of fuel [t] or [Nm^3] over the scheme year is determined with a maximum uncertainty of less than ± 5.0 %.
3	Amount of fuel [t] or [Nm^3] over the scheme year is determined with a maximum uncertainty of less than ± 2.5 %.

[51] The scheme year is the calendar year.

4	Amount of fuel [t] or [Nm^3] over the scheme year is determined with a maximum uncertainty of less than ± 1.5 %.

Note that the uncertainty applies as a total for all parts of the measurement instrumentation and refers to 'all sources of uncertainty, including uncertainty of instruments, of calibration, environmental impacts', unless some of the simplifications mentioned in guidance document 'UKETS02 MRR/FAR - Uncertainty assessments for installations' are applicable. The impact of the determination of stock changes at the beginning and end of the period must also be included, if applicable.

5.1.2 Relevant elements of the monitoring plan

When developing the monitoring plan, the operator must make several choices regarding the way activity data is determined. In the case of fuels, 'activity data' includes the component of the net calorific value. However, the **quantity of material or fuel** is discussed here specifically, to which the calculation factors are related. For simplicity purposes, the term 'activity data' is synonymous to 'quantity of material or fuel', and the net calorific value is discussed together with the other calculation factors in sections 5.2 and 5.3.2 below.

Continual vs. batch metering: in principle, there are two methods to determine activity (Article 27(1) of the MRR):

1. continual metering - based on continual metering at the process which causes the emissions

2. batch metering - based on aggregation of metering of quantities separately delivered (batch metering) taking into account relevant stock changes.

Continual metering: here the material or fuel is directly passing the measuring instrument before being fed to the GHG emitting process (or in some cases coming from there). This is the case for example with gas meters or belt weighers. Similarly, the metering may take place at the entrance to the installation, which is the more usual case for natural gas supplies. The quantity of fuel or material throughout the scheme year is read from the meter either as 'value at the end of the year minus value at the beginning of the year' (this is usually the case for gas meters), or by summing up (integrating) many readings (e.g. every minute, hour or day) over the whole scheme year. The uncertainty assessment will deal primarily with the uncertainty of this one instrument.

Note that cases may exist where part of the fuel or material entering the installation is not used within the installation but is instead exported to another installation or consumed within the installation for an activity which is not covered by the UK ETS. The metering of the amount of fuel or material exported must be considered in the uncertainty assessment and must be done using measurement instruments which allow the total quantity used within the UK ETS installation to be determined with an overall uncertainty below the allowed threshold of the applicable tier.

Batch metering: here the material quantity is determined using a material balance (Article 27(2) of the MRR):

Equation 11:

$$Q = P - E + (S_{begin} - S_{end})$$

Where:

Q .... quantity of fuel or material applied in the period

P .... purchased quantity

E .... exported quantity e.g. fuel delivered to parts of the installation or other installati that are not included in the UK ETS

S_{begin} ... stock of the material or fuel at the beginning of the reporting year

S_{end} ..... stock of the material or fuel at the end of the reporting year

This determination is usually applied where invoices are used as the main data source for parameter *P*. The operator should pay special attention to clarifying whether exports[52] occur at the installation. Furthermore, the operator must include in the monitoring plan a description how the stocks are determined at the beginning and end of the scheme year. Some simplifications are allowed in this regard, which are discussed below within this section.

Batch metering is often applied where the operator does not use their own measuring instruments. Therefore, the requirements for 'instruments not under the operator's control' are usually applicable for the uncertainty assessment. However, the operator must consider the uncertainties associated with the determination of the stock changes. Derogation is granted where the storage facilities are not capable of containing more than 5% of the annual used quantity of the fuel or material considered. In such case the uncertainty of stock changes may be omitted from the uncertainty assessment (Article 28(2) of the MRR).

[52] Typical "exports" include the use of fuels for mobile machinery such as forklifts, or where neighbouring installations are supplied with one common gas meter, while at least one of those installations does not fall within the scope of the UK ETS.

Simplifications to stock determination: Article 27(2) of the MRR allows two simplifications to the determination of stocks at the beginning and end of the scheme year:

1. Where it is technically not feasible or would incur unreasonable costs to determine quantities in stock by direct measurement, the operator may use an estimation method. Such situations may, for example, occur in tanks for heavy fuel oil, where some solid fraction on top of the liquid oil prevents the exact metering of the surface level. Methods allowed by the MRR are:

    - data from previous years correlated with output for the scheme year

    - documented procedures and respective data in audited financial statements for the scheme year.

2. Theoretically, the stocks would have to be determined at midnight of the 31 December every year, which may not be possible in practice. Therefore, the MRR allows[53] choosing the next most appropriate day to separate a scheme year from the following one. Data must be reconciled accordingly to the calendar year required. The deviations involved for one or more source streams shall be clearly recorded, form the basis of a value representative for the calendar year, and be considered consistently in relation to the next year.

    The closing stock must equal the opening stock of the following year and be reported as such within the annual emissions report.

Operator's instruments vs. supplier's instruments: the MRR does not require every operator to equip the installation with measuring instruments at any cost. That would contradict the MRR's approach regarding cost-effectiveness. Instead, instruments that are under the control of other parties (particularly fuel suppliers) may be used. In the context of commercial transactions such as fuel purchase, it is often the case that the metering is done by only one of the trade partners. The other partner may assume that the uncertainty associated with the measurement is reasonably low, because such measurements are often governed by legal metrological control. Alternatively, requirements on quality assurance for instruments, including maintenance and calibration can be included in the purchase contracts. However, the operator must seek confirmation on the uncertainty applicable for such meters to assess if the required tier can be met.

Thus, the operator may choose whether to use their own instruments or to rely on instruments used by the supplier. However, a slight preference is given by the MRR to the

[53] Under the condition that the exact time would be technically not feasible or would incur unreasonable costs the operator.

operator's own instruments: If the operator decides to use other instruments despite having their own instruments, the operator must provide evidence to the regulator that the supplier's instruments allow compliance with at least the same tier, give more reliable results and are less prone to control risks than the methodology based on his own instruments. This evidence must be accompanied with a simplified uncertainty assessment.

In many cases this uncertainty assessment will be very short and simple. If the operator has no alternative instrument available under their own control, the operator does not have to compare the tier applicable using their own instrument with the tier applicable to the supplier's instrument. For demonstrating the applicable tier for the supplier's instrument, suitable evidence should be added to the uncertainty assessment at the regulator's request (See 'UKETS02 MRR/FAR - Uncertainty assessments for installations' for further guidance).

Furthermore, the control risk may be low where invoices are subject to an accounting department's controls.[54]

In the case that invoices are used as primary data for determining the material or fuel quantity, the MRR requires the operator to demonstrate that the trade partners are independent. In principle, this should be considered a safeguard for ensuring that meaningful invoices exist. In many cases it will also be an indicator whether national legal metrological control is applicable.

Note that there is a 'hybrid' possibility allowed by the MRR: The instrument is outside the control of the operator, but the reading for monitoring is done by the operator. In such a case the owner of the instrument is responsible for maintenance, calibration and adjustment of the instrument, and ultimately for the applicable uncertainty value, but the data on material quantity can be directly checked by the operator. Again, this is a situation frequently found for natural gas meters.

5.2 Calculation factors – principles

Besides the activity data, the 'calculation factors' are important parts of any monitoring plan based on a calculation methodology. These factors, as outlined in the context of the calculation formulae in section 3.3.1 and section 3.3.2, are:

[54] Note that the existence of the accounting's controls does not automatically dispense the operator from including appropriate risk mitigation measures in the UK ETS related control system. The risk assessment according to Article 59(2) of the MRR must include this risk as appropriate.

- in the standard methodology for combustion of fuels, or fuels used as process input: emission factor, net calorific value (NCV), oxidation factor and biomass fraction
- in the standard methodology for process emissions (particularly for decomposition of carbonates): emission factor and conversion factor
- for mass balances: carbon content and (if applicable) biomass fraction and NCV.

According to Article 30(1) of the MRR, these factors can be determined by one of the following principles:

1. default values (see section 5.2.1)
2. by laboratory analyses (see section 5.2.2).

The applicable tier will determine which of these options is used. Lower tiers allow for default values, such as values which are kept constant throughout the years, and updated only when more accurate data becomes available. The highest tier defined for each parameter in the MRR is usually the laboratory analysis, which is more demanding but more accurate. The result of the analysis is valid for the very batch from which the sample has been taken, while a default value is usually an average or conservative value based on large quantities of that material (e.g. a UK-wide average as appears in the UK digest of energy statistics (DUKES)), while the analysis will be valid for only one batch of one coal type.

Important note: In all cases the operator must ensure that activity data and all calculation factors are used consistently. For example, where a fuel's quantity is determined in the wet state before entering the boiler, the calculation factors must also refer to the wet state. Where analyses are carried out in the laboratory from the dry sample, the moisture must be accounted for appropriately, to determine the calculation factors applicable for the wet material.

Operators must also be careful not to mix up parameters of inconsistent units. Where the amount of fuel is determined per volume, also the NCV and/or emission factor must refer to volume rather than mass.[55]

5.2.1 Default values

When an operator intends to use a default value for a calculation factor, the value of that factor must be documented in the monitoring plan. The only exception is where the default value or its information source changes on an annual basis. In principle, this is the case where the regulator regularly updates and publishes the standard factors used in the national GHG inventory. In such cases, the monitoring plan should contain the reference to

[55] See section 3.3.1, in which conditions are mentioned under which the operator may use emission factors expressed as tCO_2/t fuel instead of tCO_2/TJ.

the place (webpage, official journal, etc.) where these values are published, instead of the value itself (Article 31(2) of the MRR).

The applicable type of default values is determined by the applicable tier definition. Sections 2 to 4 of Annex II to the MRR give a general scheme for these definitions. The sector-specific monitoring methodologies in Annex IV further specify those tiers or sometimes overrule the tier definitions with more specific ones. A complete listing of all tier definitions would significantly exceed the scope of this guidance. However, a simplified overview of tier definitions given by Annex II is presented in Table 7 below.

Table 7: Overview of the most important tier definitions for calculation factors, based on Annex II to the MRR

Source stream type	Factor	Tier	Tier definition
combustion emissions	emission factor[56]	1	type I default values
		2a	type II default values
		2b	established proxies (if applicable)
		3	laboratory analyses or empirical correlations
combustion emissions	oxidation factor	1	default value OF=1
		2	type II default values
		3	laboratory analyses
combustion emissions and mass balance	net calorific value	1	type I default values
		2a	type II default values
		2b	purchasing records (if applicable)
		3	laboratory analyses
combustion emissions, process emissions and mass balance	biomass fraction	1	type I biomass fraction
		2	type II biomass fraction
		3	laboratory analyses
process emissions (method A: input-based)	emission factor	1	type I default values
		2	type II default values
		3	laboratory analyses and stoichiometric values
process emissions (method B: output-based)	emission factor	1	type I default values
		2	type II default values
		3	laboratory analyses & stoichiometric values
process emissions (methods A and B)	conversion factor	1	default value CF=1
		2	laboratory analyses & stoichiometric values

[56] According to section 2.1 of Annex II to the MRR, the tiers defined shall relate to the preliminary emission factor, where a biomass fraction is determined for a mixed fuel or material.

mass balance source stream	carbon content	1	type I default values
		2a	type II default values
		2b	established proxies (if applicable)
		3	laboratory analyses or empirical correlations or stoichiometric values for pure chemical substances

As can be seen from Table 7, the lowest tier usually applies an internationally applicable default value (IPCC standard factor or similar, as listed in Annex VI to the MRR). The second tier uses a national factor, which is in principle used for the national GHG inventory under the UNFCCC. However, further types of default values or proxy methods are allowed, which are deemed equivalent. The highest tier usually requires the factor to be determined by laboratory analyses.

The short descriptions of tier levels in Table 7 must be read in full text as follows:

- **type I default values**: Either standard factors listed in Annex VI (i.e. in principle IPCC values) or other constant values in accordance with point (e) of Article 31(1) of the MRR, i.e. analyses carried out in the past but still valid.[57]
- **type II default values**: Country specific emission factors in accordance with points (b), (c) and (d) of Article 31(1) of the MRR, i.e. values used for the national GHG inventory,[58] more values published by the regulator for more disaggregated fuel types, or other literature values which are agreed by the regulator,[59] or values guaranteed by the supplier.[60]
- **established proxies**: These are methods based on empirical correlations as determined at least once per year in accordance with the requirements applicable for laboratory analyses (see section 5.2.2). However, these rather complicated analyses are only carried out once per year, therefore this tier is considered a lower level than full analyses. The proxy correlations may be based on

[57] Article 31(1)(e) of the MRR: "*values based on analyses carried out in the past, where the operator can demonstrate to the satisfaction of the regulator that those values are representative for future batches of the same fuel or material*". This is a considerable simplification for operators, who do not have to carry out regular analyses as described in section 5.2.2.
[58] Article 31(1)(b) of the MRR: "*standard factors used by the UK for its national inventory submission to the Secretariat of the United Nations Framework Convention on Climate Change*".
[59] Article 31(1)(c) of the MRR: "*literature values agreed with the regulator, including standard factors published by the regulator, which are compatible with factors referred to in point (b), but representative of more disaggregated sources of fuel streams*".
[60] Article 31(1)(d) of the MRR (new as of 2021): "*values specified and guaranteed by the supplier of a fuel or material where the operator can demonstrate to the satisfaction of the regulator that the carbon content exhibits a 95% confidence interval of not more than 1%*" – this is a similar approach as for "commercial standard fuels" defined in Article 3(32) of the MRR.

  - density measurement of specific oils or gases, including those common to the refinery or steel industries, or
  - net calorific value for specific coal types.

- **purchasing records:** Only in case of commercially traded fuels, the net calorific value may be derived from the purchasing records provided by the fuel supplier, provided it has been derived based on accepted national or international standards.
- **laboratory analyses**: In this case, the requirements discussed in section 5.2.2 below are fully applicable. This also includes the use of the 'established proxies', if applicable and where the uncertainty of the empirical correlation does not exceed 1/3 of the uncertainty value associated with the applicable tier for activity data. Furthermore, the regulator may accept the use of the stoichiometric content of pure[61] chemical substances as meeting the tier that would otherwise require laboratory analyses.
- **type I biomass fraction**:[62] One of the following methods is applied, which are considered equivalent:
  - Use of values published by the UK ETS Authority.
  - Use of values in accordance with Article 31(1), i.e. a "Type I/II default value".
- **type II biomass fraction**: Use of a value determined in accordance with the second subparagraph of Article 39(2) of the MRR, i.e. use an estimation method approved by the regulator. For fuels or materials originating from a production process with defined and traceable input streams, the operator may base such estimation on a mass balance of fossil and biomass carbon entering and leaving the process.
- **stoichiometrical values**: In principle these are allowed in the same way as other literature values, i.e. they must be agreed with the regulator and can therefore be considered 'Type II default values'". However, under certain conditions (the substance must be pure, the use of that value would be conservative, and the otherwise required laboratory analyses would lead to unreasonable costs), the regulator may approve that those values suffice to comply with the highest tier. This

[61] The term pure is not defined in the MRR. It should however refer to best industry practices for identifying this state of purity of the substance, e.g. when sold on the market labelled as "purum".
[62] Note that it is not discussed here how to determine whether the relevant sustainability and GHG savings criteria are met (if applicable). A short overview is given in section 5.3.5. More information on the treatment of biomass issues in the UK ETS are given in guidance document 'UKETS03 MRR - Reporting biomass in installations'.

in turn reduces the cases where operators would have to submit an improvement report, as the higher tier thereby has been achieved.

5.2.2 Laboratory analyses

Where the MRR refers to determination ‘in accordance with Article 32 to 35’, this means that a parameter must be determined by (chemical) laboratory analyses. The MRR imposes relatively strict rules for such analyses, to ensure a high-quality level of the results. In particular, the following points need consideration:

1. The laboratory must demonstrate its competence. This is achieved by one of the following approaches:

    a. An accreditation in accordance with EN ISO/IEC 17025, where the analysis method required is within the accreditation scope; or

    b. Demonstrating that the criteria listed in Article 34(3) of the MRR are satisfied. This is considered reasonably equivalent to the requirements of EN ISO/IEC 17025. Note that this approach is allowed only where use of an accredited laboratory is shown to be technically not feasible or involving unreasonable costs (see section 3.6).

2. The way samples are taken from the material or fuel to be analysed is considered crucial for receiving representative results. Therefore, operators must develop sampling plans in the form of written procedures (see section 4.6) and get them approved by the regulator. Note that this also applies where the operator does not carry out the sampling but treats it as an outsourced process.

3. Analyses methods must usually follow international or national standards. Preference is given to EN standards.[63]

Note that laboratory analyses are usually related to the highest tiers for calculation factors. Therefore, these rather demanding requirements are rarely applicable to smaller installations. Operators of installations with low emissions (see section 3.4.2) may use ‘any laboratory that is technically competent and able to generate technically valid results using the relevant analytical procedures and provides evidence for quality assurance measures as referred to in Article 34(3)’. In fact, the minimum requirements would be that the laboratory demonstrates that it is technically competent and ‘capable of managing its

[63] For the use of standards, Article 32(1) of the MRR defines the following hierarchy: “*The operator shall ensure that any analyses, sampling, calibrations and validations for the determination of calculation factors are carried out by applying methods based on corresponding EN standards. Where such standards are not available, the methods shall be based on suitable ISO standards or national standards. Where no applicable published standards exist, suitable draft standards, industry best practice guidelines or other scientifically proven methodologies shall be used, limiting sampling and measurement bias.*”

personnel, procedures, documents and tasks in a reliable manner', and that it demonstrates quality assurance measures for calibration and test results.[64] However, it is in the operator's interest to receive reliable results from the laboratory. Therefore, operators should strive to comply with the requirements of Article 34 of the MRR to the highest degree feasible.

Furthermore, it is important to note that the MRR in the activity-specific requirements of Annex IV allows the use of 'industry best practice guidelines' for some lower tiers, where no default values are applicable. In such cases, where despite approval to apply lower tier methodology analyses are still required, it may not be appropriate or possible to apply Articles 32 to 35 of the MRR in full. However, the regulator should deem the following as minimum requirements:

- where the use of an accredited laboratory is technically not feasible or would lead to unreasonable costs, the operator may use any laboratory that is technically competent and able to generate technically valid results using the relevant analytical procedures and provides evidence for quality assurance measures as referred to in Article 34(3) of the MRR.
- the operator shall submit a sampling plan in accordance with Article 33 of the MRR.
- the operator shall determine the analysis of frequency in accordance with Article 35 of the MRR.

More detailed guidance on topics related to laboratory analyses, sampling, frequency of analyses, equivalence to accreditation etc. are given in guidance document 'UKETS12 MRR - Sampling and analysis'.

5.3 Calculation factors – specific requirements

In addition to the general approaches for determining calculation factors (default values or analyses) some specific rules for each factor are laid down in the MRR. These are discussed below. This section also includes some practical considerations for operators when developing their monitoring plans.

5.3.1 Emission factor

Article 3(13) of the MRR defines 'emission factor' as meaning 'the average emission rate of a greenhouse gas relative to the activity data of a source stream assuming complete oxidation for combustion and complete conversion for all other chemical reactions.' Furthermore Article 3(36) of the MRR is important for materials containing biomass:

[64] Examples for such measures are given in point (j) of Article 34(3) of the MRR: "*regular participation in proficiency testing schemes, applying analytical methods to certified reference materials, or inter-comparison with an accredited laboratory*".

'preliminary emission factor' means the assumed total emission factor of a fuel or material based on the carbon content of its biomass fraction and its fossil fraction before multiplying it by the fossil fraction to produce the emission factor.

Important note: According to section 2.1 of Annex II to the MRR, the tiers defined in the MRR must relate to the preliminary emission factor, where a biomass fraction is determined for a fuel or material. That is, tiers are applicable always to individual parameters.

The reporting of the preliminary emission factor is mandatory for all source streams whether the biomass source stream is 100% biomass or a biomass/fossil mixture.[65]

As reflected by the definition, the emission factor is the stoichiometry-based factor which converts the (fossil) carbon content of a material into the equivalent mass of (fossil) CO_2 assumed to be emitted. Adjustment for incomplete reactions is handled via the oxidation or conversion factor. However, as mentioned in Article 37(1) of the MRR, sometimes national inventories do not use oxidation or conversion factors (i.e. those factors are set to 100%) but instead have the adjustment for incomplete reaction included in the emission factor. Where such factors are used as default values in accordance with Article 31(1)(b) of the MRR, operators should consult with the regulator, if in case of doubt.

For combustion emissions, the emission factor is expressed in relation to the energy content (NCV) of the fuel rather than its mass or volume. However, under certain conditions (where the use of an emission factor expressed as tCO_2/TJ incurs unreasonable costs or where at least equivalent accuracy of the calculated emissions can be achieved) the regulator may allow the operator to use an emission factor expressed as tCO_2/t fuel or tCO_2/Nm^3 (Article 36(2) of the MRR).

Where the applicable tier requires the emission factor to be determined by analyses, the carbon content is to be analysed. Where a fuel or material contains organic as well as inorganic carbon,[66] usually the total carbon content is to be determined. Note that inorganic carbon is always considered fossil.

For fuels, the NCV must also be determined (depending on the tier, this may require another analysis of the same sample).

[65] This is not a large administrative burden, since pure biomass source streams are always de minims source streams, so that a low tier may be applied. Most appropriate will be the use of default values for the dry biomass, corrected for the moisture content. The latter may be estimated or measured. More guidance is found in 'UKETS03 MRR - Reporting biomass in installations', which also contains some typical preliminary emission factors.

[66] E.g. paper contains organic carbon (cellulose fibres, resins etc) as well as inorganic carbon (carbonate fillers).

If the emission factor of a fuel expressed as tCO_2/TJ is to be calculated from the carbon content, the following equation is used:

Equation 12:

$$EF = CC \times f / NCV$$

If the emission factor of a material or fuel expressed as tCO_2/t is to be calculated from the carbon content, the following equation is used:

Equation 13:

$$EF = CC \times f$$

The variable names used above are explained in section 3.3.1 and section 3.3.2.

5.3.2 Net calorific value (NCV)

Because activity data of fuels is to be reported as energy content (see section 3.3.1), the NCV is an important parameter to be reported. This allows emission reports to be compared with energy statistics and national GHG inventories under the UNFCCC.

Note: Although the activity data of fuels is 'NCV multiplied by the fuel quantity', the tier definitions for activity data refer to fuel quantity only, and the NCV is a separate parameter (calculation factor), for which individual tiers are applicable.

However, under certain conditions, the NCV is not indispensable for the emission calculation. This is the case:

- where emission factors of fuels are expressed as tCO_2/t fuel or tCO_2/Nm^3 (Article 36(2) of the MRR)[67]
- where fuels are used as process inputs, and
- fuels being part of a mass balance.

In those cases, the NCV may be determined using a conservative estimate instead of using tiers (Article 26(5) of the MRR). However, it should be noted that when the NCV is needed to determine energy values for the purposes of free allocation, accurate

[67] This may be allowed by the regulator if the use of an emission factor expressed as tCO_2/TJ would incur unreasonable costs, or where at least equivalent accuracy can be achieved with this method.

determination of NCV is required. This will avoid conservative estimates of NCVs leading to over-reporting of the HAL.

5.3.2.1 Mixing tiers: application of tier 2a for net calorific value and tier 2b for an emission factor (or vice versa) for the same fuel

It is not possible to apply 2a for one calculation factor and 2b for another, as the emission factor must be consistent with the use of NCV and the corresponding oxidation factor.

Tiers 2a and 2b are considered to be at the same accuracy level in the MRR, hence there is no preference to choose one or the other. Furthermore, there is no provision that the same tier (either tier 2a, 2b, or another tier) must be applied for NCV and EF for the same fuel.

However, Article 24(1) of the MRR states: ‘Under the standard methodology, the operator shall calculate combustion emissions per source stream by multiplying the activity data related to the amount of fuel combusted, expressed as terajoules based on net calorific value (NCV), with the corresponding emission factor, expressed as tonnes CO_2 per terajoule (tCO_2/TJ) consistent with the use of NCV, and with the corresponding oxidation factor.’

If the NCV or EF contradict this principle, this approach is not allowed. To avoid such inconsistency please contact your regulator regarding background information on certain default values (e.g. values from the National Inventory used for tier 2a) or the IPCC Guidelines (tier 1).

5.3.2.2 Calculation of emissions if EF and NCV are based on analyses per batch

The calculation is made according to the formula presented in section 5.3.3.1. Based on the figures used in the example in that section, the calculation of EF and NCV are done as follows. For simplicity reasons it is assumed that the oxidation factor is 1 (i.e. any carbon contained in ashes is not deducted).

Table 8: EF and NCV Values

Batch	FQ [t]	NCV[GJ/t]	Energy input (FQ x NCV) [TJ]	EF [tCO_2/TJ]
1	20,000	11.90	238.00	101.6
2	22,000	12.10	266.20	101.0
3	25,000	11.95	298.75	101.3
4	21,000	12.06	253.26	101.8
5	23,000	11.85	272.55	102.3
6	24,000	11.90	285.60	101.5
7	23,000	11.93	274.39	102.2
8	24,000	11.91	285.84	101.6
Sum/weighted average	182,000	11.95	2,174.59	101.66

The weighted average annual NCV, and subsequently the weighted average annual EF, can be calculated by the following equations:

Equation 14:

$$NCV = \frac{\sum_i NCV_i \times FQ_i}{\sum FQ}$$

$$= \frac{20{,}000t \times 11.90\ \frac{GJ}{t} + 22{,}000t \times 12.10\frac{GJ}{t} + \ldots 24{,}000t \times 11.91\frac{GJ}{t}}{182{,}000t}$$

$$= 11.95\ \frac{GJ}{t}$$

Equation 15:

$$EF = \frac{\sum_i EF_i \times NCV_i \times FQ_i}{\sum_i NCV_i \times FQ_i}$$

$$= \frac{101.6\ \frac{t\ CO2}{TJ} \times \frac{11.90\ \frac{GJ}{t}}{1{,}000} \times 20{,}000t + \ldots + 101.6\frac{tCO_2}{TJ} \times \frac{11.91\ \frac{GJ}{t}}{1{,}000} \times 24{,}000t}{2{,}174.59TJ}$$

$$= 101.66\frac{t\ CO2}{TJ}$$

5.3.2.3 How to apply the 1% rule - application of Article 31(4)

Article 31(4) of the MRR states that ‘upon application by the operator, the regulator may allow that the net calorific value and emission factors of fuels are determined using the same tiers as required for commercial standard fuels provided that the operator submits, at least every three years, evidence that the 1% interval for the specified calorific value has been met during the last three years.’

An operator may now demonstrate to the regulator that, based on past analyses, the NCV or EF of a specific fuel was determined to be within this 1% interval. This may be achieved by calculating twice the standard deviation (a 95% confidence interval) of those historic values and checking whether it is lower than 1%. However, as Article 31(4) of the MRR requires provision of evidence at least every three years, an operator will have to start sampling and analysing again for the following three years to demonstrate that the 1% interval is not exceeded. Note that such homogeneous fuels may only require lower frequencies of analyses than those listed in Annex VII due to application of the 1/3 rule or the incurrence of unreasonable costs.

5.3.3 Oxidation factor and conversion factors

These two factors are used to account for incomplete reaction. Thus, if they are to be determined based on laboratory analyses, the factor would be determined as follows (oxidation factor):

Equation 16:

$$OF = 1 - C_{ash} / C_{comb}$$

Where:

OF....... oxidation factor [dimensionless]

C_{ash}...... carbon contained in ash, soot and other non-oxidised forms of carbon (excluding carbon monoxide, which is considered as molar equivalent of CO_2 emissions)

C_{comb}.... (total) carbon combusted.

The two *C* variables are expressed as [tonnes C], i.e. quantity of material or fuel times the concentration of carbon in it. Therefore, not only does the carbon content of the ash need to be determined by analysis, but also the amount of ash must be determined for the period for which the oxidation factor is determined.

Further points to be considered in line with Article 37 of the MRR:

1. Unlike for other parameters, for all categories of installations and source streams, tier 1 is the minimum applicable tier. This is equivalent to OF = 1 or CF = 1, i.e. reflects a conservative assumption in any event.

2. Regulators are allowed to require an operator to use tier 1. As outlined in section 5.3.1, this may be required because in some cases the effect of incomplete reaction has been included in the emission factor.

3. Where several fuels are used in an installation and tier 3 (i.e. laboratory analyses) is required, the operator may choose one of two options:

    a. Determination of one average oxidation factor for the whole combustion process, to be applied to all involved source streams, or

b. Attribution of the incomplete oxidation to one major source stream (i.e. using an OF < 1), and use OF = 1 for the other source streams.

4. Where biomass or mixed fuels are used, the operator must provide evidence that an underestimation of emissions is avoided.

5.3.3.1 Determination of oxidation factors by accounting for the carbon content of ash

The annual emissions are calculated by:

Equation 17:

$$Emissions = FQ \times NCV \times EF \times OF$$

Where:

FQ...... quantity of fuel [t]

NCV.... net calorific value [TJ/t]

EF...... emission factor [tCO_2/TJ]

OF...... oxidation factor

There are two possible approaches to calculating those annual emissions:

1. Method A: emissions are calculated for each batch or delivery period that the analytical value is representing. The total emissions are obtained by adding up all emissions calculated, or
2. Method B: determine annual weighted averages for each calculation factor and calculate the annual emissions according to the formula above.

Where not all calculation factors represent the same batch or delivery period, method A will not be applicable. The following example gives guidance on the Method B calculation route.

Example 19 An operator is burning lignite. Each analytical value for NCV and EF determined in accordance with Articles 32 to 35 is representative for each batch of lignite. Note that the EF will be calculated from the carbon content (CC) and the NCV (f=3.664)[68] according to:

Equation 18:

[68] Article 36(3) of the MRR: "*For the conversion of the carbon content into the respective value of a CO_2 related emission factor or vice versa, the operator shall use the factor 3.664 tCO_2/tC.*"

$$EF = CC \times f \,/\, NCV$$

The OF is determined by analysis of the carbon content of the ash and by the amount of ash obtained upon combustion in accordance with Articles 32 to 35 of the MRR as well. The oxidation factor will be obtained by:

Equation 19:

$$OF = 1 - \frac{CC_{ash} \times Quantity_{ash}}{CC_{fuel} \times Quantity_{fuel}}$$

The batches of ash used for analysing their carbon content do not correspond necessarily with the fuel batches. Still, Annex VII requires to also analyse the OF at least six times per year. Therefore, the OF can be calculated as follows.

Batch	FQ [t]	NCV [GJ/t]	EF [tCO_2/TJ]	CC [tC/t]	FQ x CC [tC]
1	20,000	11.90	101.6	0.3300	6,600
2	22,000	12.10	101.0	0.3335	7,338
3	25,000	11.95	101.3	0.3304	8,260
4	21,000	12.06	101.8	0.3351	7,037
5	23,000	11.85	102.3	0.3309	7,610
6	24,000	11.90	101.5	0.3297	7,912
7	23,000	11.93	102.2	0.3328	7,654
8	24,000	11.91	101.6	0.3303	7,926
Sum (i.e. total amount of carbon in lignite)					60,335

Batch	Q_{ash} [t]	CC_{ash} [tC/t]	Q_{ash} x CC_{ash} [tC]
1	1,589	0.0207	32.9
2	1,900	0.0180	34.3
3	2,108	0.0193	40.7
4	1,573	0.0243	38.3
5	1,764	0.0203	35.8
6	2,073	0.0229	47.4
Sum (i.e. total amount of carbon in ash)			229.4

The weighted average annual NCV is calculated by:

Equation 20:

$$NCV = \frac{\sum_i NCV_i \times FQ_i}{\sum FQ} = 11.95\ \frac{GJ}{t}$$

The weighted average annual EF is calculated by:

Equation 21:

$$EF = \frac{\sum_i EF_i \times NCV_i \times FQ_i}{\sum NCV_i \times FQ_i} = 101.66\ \frac{tCO_2}{TJ}$$

The weighted average annual OF is calculated by:

Equation 22:

$$OF = 1 - \frac{CC_{ash} \times Quantity_{ash}}{CC_{fuel} \times Quantity_{fuel}} = 1 - \frac{229.4}{60{,}335} = 99.62\%$$

The annual emissions are calculated by:

Equation 23:

$$Emissions = 182{,}000 \times 11.95/1{,}000 \times 101.66 \times 99.62\% = 220{,}260 tCO_2$$

In principle, this approach for determining OF is based on a mass balance but not based on Article 25 of the MRR. Therefore, the quantity of ash is not considered a separate source stream and no dedicated uncertainty thresholds apply. However, operators should strive to apply an uncertainty level similar to the tier level that would be required if the ash were a source stream of its own. It must be noted that in most cases such an ‘ash source stream’ would be a de minimis source stream. The appropriate method for determining the ash amount, and therefore the associated uncertainty, will be taken from suitable standards. For sampling and analysing the Articles 32 to 35 of the MRR (requirements for analyses) apply.

Note that alternatively the oxidation factor can be determined using the carbon content of the ash and ash content of the fuel ($AC_{fuel}\%$) instead of determining the amount of ash. This alternative does not require the ash quantity to be measured, only the percentage ash content of the fuel and carbon content of the resultant ash.

Equation 24:

$$OF = 1 - \frac{CC_{ash} \times AC_{fuel}}{CC_{fuel}}$$

The ash content of a fuel is commonly obtained by a loss on ignition method where the fuel is burned until no more mass loss is observed. However, for this method burning of 0-+0

the fuel is done under laboratory conditions which may lead to different results than the fuel combustion in the boiler (e.g. due to different particle sizes and morphology as well as different retention times). On the other hand, accurate measurement of ash quantity can be problematic if water is used to convey (and cool) the ash. Therefore, preference should be given to the method giving higher accuracy and the operator must ensure that emissions are not underestimated.

5.3.4 Carbon content in case of mass balances

Due to the close relation between the emission factor in the standard methodology and the carbon content in case of the mass balance, the items discussed under section 5.3.1 (emission factor) apply as appropriate. Analyses are applicable in the same way, and default values given in Annex VI to the MRR can be converted into default values for the carbon content by using the formulae given in section 3.3.2. For

5.3.5 Biomass fraction

According to the MRR, "*biomass fraction means the ratio of carbon stemming from biomass to the total carbon content of a fuel or material, expressed as a fraction*". The biomass fraction only needs to be determined for mixed fuels or materials that contain biomass. To determine the biomass fraction of a fuel, the operator must apply the appropriate tier set out in section 2.4 of Annex II to the MRR and carry out calculations using a methodology approved by the regulator. An introduction to the topic is given in section 5.3.6, but further detail on biomass-related topics can be found in 'UKETS03 MRR - Reporting biomass in installations'.[69]

To determine the biomass fraction, an operator can use one of the following approaches, as set out in Article 39 of the MRR:

1. assume the absence of biomass and apply a default fossil fraction of 100%,

2. carry out analyses such as the sorting or 14C method, based on a relevant standard, provided that the use of that standard and analytical method is approved by the regulator.

[69] This guidance document covers: how to demonstrate compliance with sustainability criteria for bioliquids, analytical methods for determining the biomass content, preliminary emission factors, and a list of biomass materials

5.3.6 How do I report emissions from mixed (fossil-biomass) materials?

The following example explains how the fossil and biomass-related emissions of a mixed fuel should be determined and reported.

An installation produces mixed pellets before using them in a boiler that was formerly fired by coal. The Installation uses the following raw materials for producing the pellets:

- plastic waste (mostly polyethylene) – 25% of the total input by weight, fossil.
- imported forest residues (small cut branches from hard wood) – 40% of input by weight. The operator receives these residues from a cheap source in a third country without evidence whether the land-related sustainability criteria are met, so the operator must consider such residues as non-sustainable biomass.
- residues (bark) of locally harvested wood – 35% of input by weight; certified by a voluntary scheme, therefore counted as sustainable biomass and zero-rated.

The input materials have the following properties:

Raw material	Fossil or biomass?	Input to Mix	Moisture (H_2O content)	C content (dry) tC/t fuel	NCV (dry) GJ/t
polyethylene	fossil	25%	0%	86%	40.2
hard wood residues	non-sustainable biomass	40%	30%	50%	18
wood wastes (bark)	sustainable biomass	35%	45%	46%	17

During processing to pellets, the mixture is dried such that the wood components contain only 8% water in the end (the polyethylene is assumed to remain completely dry). The operator calculates the properties of the components in the final pellets as follows:

Dried mixture	Content in mix	Moisture	C content	NCV GJ/t	EF tCO_2/TJ
polyethylene	32.7%	0%	86.0%	40.2	78.4
hard wood residues	39.9%	8%	46.0%	16.4	102.8
wood wastes (bark)	27.4%	8%	42.3%	15.4	100.6

Note: For this calculation the total mass decrease due to drying is taken into account. Therefore, the relative quantities of the materials in the mix change. For calculating the NCV based on the moisture content, the following equation is used:

Equation 25:

$$NCV = NCV_{dry} \times (1 - w) - \Delta H_v \times w$$

Where:

NCV_{dry}... NCV of the absolute dry material

w.......... water content (mass fraction)

ΔH_v....... 2.4GJ / t H20 is the evaporation enthalpy of water.

Using the above individual components, the operator can calculate the emissions and energy input from 1,000t of these pellets; The percentage in the total emissions can be used to calculate the carbon content percentage attributed to each component:

Dried mixture	Fossil or biomass?	Emissions tCO_2	Energy TJ	% of emissions = % of C content
polyethylene	fossil	1030.4	13.1	48.4%
hard wood residues	non-sustainable biomass	672.5	6.5	31.6%
wood wastes (bark)	sustainable biomass	424.7	4.2	20.0%
total		**2127.6**	**23.8**	**100%**

In the annual emission report the operator may choose to report these three components separately, which has the advantage of transparency and avoiding the need to calculate with different moisture contents. Instead, the operator may directly use emission factor and NCV of the moist (as received) biomass.

Alternatively, there is also the possibility to calculate weighted carbon content / emission factor and NCV from the final pellets (particularly useful if e.g. the operator also sells part of the pellets and wants to inform the customers of their properties).

From the above, the operator may calculate (using *f* = 3.664 tCO_2/tC):

The weighted NCV = 23.8 GJ/t pellets

Carbon content: CC = 2127.6t / 1,000t / f = 58.1%

Weighted emission factor EF = CC × f / NCV = 89.39 tCO_2/TJ

Using these calculation factors and the percentages of the fossil and biomass fractions given in the previous table, the operator can fill the annual emissions report using one single source stream:

1	F1. Solid - Other solid fuels; Mixed plastic/Wood pellets		Combustion		CO2 fossil:	1.702,0	t CO2e
	Combustion: Solid fuels				CO2 bio:	425,5	t CO2e

	Tier	tier description	Unit		Value		error
iii. AD:	3	± 2,5%	t			1.000,00	
iv. (prelim) EF:	2a	Type II default values	tCO2/TJ			89,39	
v. NCV:	2a	Type II default values	GJ/t			23,8	
vi. OxF:	1	Default value OF=1	-		100,00%		
vii. ConvF:							
viii. CarbC:							
ix. BioC:	2	Type II biomass fraction	-			20,00%	
x. non-sust. BioC:	2	Type II biomass fraction	-			31,60%	

5.3.7 Special rules for mixed process materials

Most CO_2 process emissions stem from inorganic carbon, mostly carbonates however, in some cases elemental carbon (graphite) or even organic carbon can be contained in materials that lead to process emissions. A prominent example is the use of urea for flue gas cleaning (deNO$_X$). For pragmatic reasons, even if it is an oxidation which leads to the CO_2 emissions in those non-carbonate cases, the MRR allows emissions from such materials to be monitored as process emissions. The detailed requirements are given in section 4 of Annex II to the MRR. They apply to all process materials leading to CO_2 emissions, i.e.

- inorganic carbon (Carbonates, elemental carbon),
- organic carbon (e.g. urea) and biomass, and
- mixtures thereof.

Section 4 of Annex II to the MRR allows the following approaches:

- input-based (Method A): Since emissions are in a stoichiometric relation to the carbon content of the input materials, this approach is allowed for all process input materials
- output-based (Method B): This is allowed only if all the emissions stem from the decomposition of carbonates.

In case of mixed materials where more than one type of carbon is to be analysed, e.g. a clay that contains carbonates as well as an organic fraction, the MRR allows two general approaches:

- the total carbon contained in the input material may be determined, giving a mixed (preliminary) emission factor (if applicable, the biomass fraction is to be determined, too), or
- the source stream may be split formally into two streams for reporting purposes, so that one stream serves for the reporting of emissions from the inorganic carbon and the other for the emissions from the organic carbon.

Any applicable conversion factor must be determined using an approach consistent with the approach chosen for the emission factor.

Except for the above, in principle all rules mentioned in section 5.2 apply to process materials and their calculation factors. There is only one exception: NCV must be reported only ‘if relevant’. The MRR clarifies ‘NCV is considered not relevant for de-minimis source streams or where the material is not itself combustible without other fuels being added. If in doubt, the operator shall seek confirmation by the regulator on whether NCV must be monitored and reported.’

5.4 PFC emissions

Section 8 of Annex IV to the MRR describes the determination of PFC (Perfluorocarbon) emissions. PFC emissions are currently only covered by the ETS for the activity ‘production of primary aluminium’. The gases to be monitored are CF_4 and C_2F_6. Emissions from anode effects as well as fugitive emissions are to be included. PFC emissions not related to anode effects must be calculated based on estimation methods.

The MRR specifies that ‘the most recent version of the guidance mentioned under Tier 3 of section 4.4.2.4 of the 2006 IPCC Guidelines shall be used.’ That guidance is the ‘Aluminium sector greenhouse gas protocol’[70] published by the International Aluminium Institute (IAI). This uses a calculation-based approach which significantly deviates from the calculation-based approach outlined in section 3.3.1. Two different methods are allowed by the MRR: The ‘slope method’ and the ’overvoltage method’. Which method is to be applied depends on the installation’s process control equipment.

While the MRR describes the principal requirements and calculation formulae, other details on the applicable methods should be taken from the guidance mentioned above. Note that the IAI guidance is not applicable for CO_2 emissions from primary aluminium production and from anode production, as the MRR’s usual calculation methods are to be used instead.

[70] https://ghgprotocol.org/sites/default/files/2023-03/aluminium_1.pdf

For calculating CO_2e emissions from CF_4 and C_2F_6 emissions, the operator shall use the following formula:

Equation 26:

$$Em = Em(CF_4) \times GWP_{CF_4} + Em(C_2F_6) \times GWP_{C_2F_6}$$

Where:

Em.......... emissions expressed as tCO_2e

$Em(CF_4)$.... emissions of CF_4 in tonnes

GWP........ global warming potential as listed within Table 6 in section 3 of Annex VI to the MRR.

$Em(C_2F_6)$.. emissions of C_2F_6 in tonnes

6 Simplified approaches

6.1 Other 'simple' installations

The MRR aims to avoid unreasonable or disproportionate costs for installations, wherever possible. The concept of 'installations with low emissions' has been found useful, but not enough, while not all operators can make use of the simplifications offered to installations with low emissions.

Before we discuss further elements of the MRR, we must ask how a monitoring plan can be simplified in general, i.e. how can the administrative burden for operators (of simple installations) be reduced? In principle, there are three areas that must be covered in the monitoring plan (assuming that simple installations always use a calculation-based methodology for monitoring):

1. monitoring of activity data
2. determination of calculation factors, and
3. organisational issues, including data flow and control procedures.

When analysing the MRR's possibilities for simplification, it turns out that its requirements are largely proportionate anyway i.e. if an installation is very simple, the monitoring is also simple to perform. For monitoring of activity data, the most obvious simplification is the use of invoices. For calculation factors, only the highest tiers require more effort due to the laboratory analyses to be performed, while smaller emitters are usually entitled to use default values. The only remaining areas for simplification are the 'organisational' issues (of which many require written procedures). This is where Article 13 of the MRR comes in.

The MRR provides a flexible approach to allow simplifications where they are deemed appropriate by the regulator. Article 13(1) of the MRR gives regulators the possibility to allow operators to use standardised or simplified monitoring plans. In particular, the possibility that such templates include (standardised) descriptions of data flow and control procedures (see section 4.7).

6.1.1 Determining the scope for simplified approaches

The central tool for determining the appropriateness of simplifications is the risk assessment.[71] Regulators may allow any use of a standardised and simplified approach in the monitoring plan only where this does not lead to an undue risk of misstatements in the emission report. Because each installation is different, it does not seem appropriate to define one single way of broad simplification to a wide range of installations. Instead, the MRR offers flexibility to regulators, but requires that any simplification be justifiable based on a simplified risk assessment.

It is acknowledged that a detailed risk assessment may cause disproportionate effort for a regulator. This guidance therefore provides some indicators based on which regulators may decide whether simplifications can be allowed. It is proposed to classify installations into one of the three following groups:

- installation types which are considered too complex for allowing simplifications under Article 13 of the MRR
- installations which are considered eligible for simplified or standardised monitoring plans under Article 13 of the MRR, and
- installations where an assessment of the individual situation is required.

In the third scenario, regulators are encouraged to make use of the second sub-paragraph of Article 13(2) of the MRR, i.e. that it should be the operator who performs a risk assessment for his installation. In this case it may be most appropriate to apply only some of the simplifications offered in standardised monitoring plan templates.

6.1.2 Installations with potentially high risks

The following types of installations are considered too complex for allowing simplified monitoring plans:

- installations applying measurement-based approaches (CEMS)
- installations carrying out activities where PFC or N_2O as included in Table C of Schedule 2 to the UK ETS Order
- installations for capture, transport and geological storage of CO_2, as included in Table C of Schedule 2 to the UK ETS Order

[71] Article 13(2) of the MRR: "*Before the approval of any simplified monitoring plan, as referred to in paragraph 1, the regulator shall carry out a simplified risk assessment as to whether the proposed control activities and procedures for control activities are commensurate with the inherent risks and control risks identified, and justify the use of such a simplified monitoring plan. The regulator may require the operator or aircraft operator to carry out the risk assessment pursuant to the previous sub-paragraph itself, where appropriate*."

- installations applying a fall-back methodology in accordance with Article 22 of the MRR
- category C installations which apply other source streams than commercial standard fuels[72]
- category B or C installations which have at least one major source stream for which instruments are used which are not subject to national legal metrological control
- installations which must use laboratory analyses in accordance with Articles 32 to 35 of the MRR
- installations which have more than three major source streams to monitor, or which apply several different monitoring methodologies (e.g. batch metering as well as some continual measurements for activity data, several different sampling plans, etc.),

6.1.3 Installations eligible for simplified monitoring plans

The following types of installations are considered generally eligible for allowing simplified monitoring plans:

- installations of category A and B which have only natural gas as source stream
- installations that only use commercial standard fuels without process emissions
- installations which can
  - exclusively use invoices for monitoring activity data,
  - exclusively use default values for calculation factors, and
  - use a limited number[73] of source streams with fossil carbon.
- installations with low emissions, if
  - only minor and de minims source streams are not monitored using invoices and default values,
  - the installation does not use CEMS or fall-back approaches, and

[72] Regulators may consider treating fuels in the same way if they have been accepted eligible for using the same tiers as commercial standard fuels in line with Article 31(4) of the MRR.
[73] As guidance, the regulator should perform an individual assessment where the number of source streams exceeds 10.

  - the installation does not carry out PFC or N_2O emitting activities, nor the capture, transport or geological storage of CO_2.
- installations emitting fossil CO_2 only from minor and de minimis source streams.

This list also includes all installations that comply with the above criteria but in addition must monitor one or more biomass source streams. In other words, biomass source streams do not affect the eligibility for simplified approaches, as the following example shows:

Example 20: Assuming an installation of category A or B which only has natural gas as a source stream and in addition uses various types of solid biomass. This could be e.g. a biomass plant for district heating, which uses natural gas for covering peak load periods.

If ignoring the biomass, it complies with the first criterion presented above. It is therefore also eligible for simplified approaches as a whole.

7 Continuous emissions monitoring systems (CEMS)

7.1 General requirements

In addition to what has been outlined in section 3.3.4 about measurement-based methodologies, there are further considerations to account for:

1. CEMS are put on an equal footing with calculation-based approaches, i.e. it is not necessary to demonstrate to the regulator that using a CEMS achieves greater accuracy than the calculation approach using the most accurate tier approach. However, minimum tier (see section 4.3) requirements have been defined implying uncertainty levels comparable to those of calculation approaches are applicable. Thus, the operator must demonstrate to the regulators that those tiers can be met with the CEMS proposed. Table 9 below gives an overview on defined tiers for measurement-based approaches.

2. The measurement-based emissions must be corroborated using a calculation-based approach. However, no specific tiers are required for this calculation. Due to the non-stoichiometric nature of N_2O emissions from nitric acid production, no corroborating calculation is required for those emissions.

3. Carbon monoxide (CO) emitted to the atmosphere shall be treated as the molar equivalent amount of CO_2 (Article 43(1) of the MRR).

4. Concentration measurements may be difficult in gas streams of very high CO_2 concentrations. This is important for measurement of CO_2 transferred between installations for the capture, pipeline systems for the transport and installations for geological storage of CO_2. In such cases CO_2 concentrations may be determined indirectly, by determining the concentration of all other constituents of the gas and subtracting them from the total (Equation 3 in Annex VIII to the MRR).

5. Flue gas flow may be determined either by direct measurement, or by a mass balance[74] using only parameters which are easier to measure, namely input

[74] Article 43(5) of the MRR allows the use of "*a suitable mass balance, taking into account all significant parameters on the input side, including for CO_2 emissions at least input material loads, input airflow and process efficiency and on the output side including at least the product output and the concentration of oxygen (O_2), sulphur dioxide (SO_2) and nitrogen oxides (NO_X)*".

material flows, input airflow and concentration of O_2 and other gases which need to be measured also for other purposes.

6. The operator must ensure that the measurement equipment is suitable for the environment in which it is to be used, and regularly maintained and calibrated. Nevertheless, the operator must be aware that equipment may fail once in a while. Therefore Article 45 of the MRR outlines how data from missing hours are to be conservatively replaced. The operator must make provisions for such data substitution when developing the monitoring plan.[75]

7. Operators must apply EN 14181 ('Stationary source emissions – Quality assurance of automated measuring systems') for quality assurance. This standard requires several activities:

8. QAL 1: Testing whether the CEMS is meeting the specified requirements. For this purpose, EN ISO 14956 ('Air quality. Evaluation of the suitability of a measurement procedure by comparison with a required uncertainty measurement') is to be used.

    a. QAL 2: Calibration and validation of the CEM

    b. QAL 3: Ongoing quality assurance during operation

    c. AST: Annual surveillance test.

9. According to the standard, QAL 2 and AST are to be performed by accredited laboratories, QAL 3 is performed by the operator. Competence of the personnel carrying out the tests must be ensured

10. This standard does not cover quality assurance of any data collection or processing system (i.e. IT systems). For those the operator must ensure appropriate quality assurance by separate means

11. Another standard to be applied is EN 15259 ('Air quality – Measurement of stationary source emissions – Requirements for measurement sections and sites and for the measurement objective, plan and report')

12. Standard to be applied for measurements of the flue gas flow is EN ISO 16911-2 ('Stationary source emissions – Manual and automatic determination of velocity and volume flow rate in ducts')

13. All other methods applied in the context of the measurement-based approach should be based also on EN standards. Where such standards are not available,

[75] In accordance with point (4)(a)(ii) of section 1 of Annex I to the MRR, the monitoring plan must contain: "*the method for determining whether valid hours or shorter reference periods for each parameter can be calculated, and for substitution of missing data in accordance with Article 45*".

the methods must be based on suitable ISO standards or national standards. Where no applicable published standards exist, suitable draft standards, industry best practice guidelines or other scientifically proven methodologies shall be used, limiting sampling and measurement bias.

14. The operator must consider all relevant aspects of the continuous measurement system, including the location of the equipment, calibration, measurement, quality assurance and quality control.

15. The operator must ensure that laboratories carrying out measurements, calibrations and relevant equipment assessments for continuous emission measurement systems (CEMS) shall be accredited in accordance with EN ISO/IEC 17025 for the relevant analytical methods or calibration activities. Where the laboratory does not have such accreditation, the operator must ensure that equivalent requirements of Article 34(2) and (3) of the MRR are met.

Table 9: Tiers defined for CEMS (see section 1 of Annex VIII to the MRR), expressed using the maximum permissible uncertainties for the annual average hourly emissions

	Tier 1	Tier 2	Tier 3	Tier 4
CO_2 emission sources	± 10%	± 7.5%	± 5%	± 2.5%
N_2O emission sources	± 10%	± 7.5%	± 5%	N.A.
CO_2 transfer	± 10%	± 7.5%	± 5%	± 2.5%
N_2O transfer (new)	± 10%	± 7.5%	± 5%	N.A.

For determining biomass CO_2, the MRR allows for more flexibility. Article 43(4) of the MRR allows not only calculation-based approaches, but also:

- methods that use radiocarbon analyses of samples taken from the flue gas by continuous sampling. For this purpose, EN ISO 13833 ‘Stationary source emissions – Determination of the ratio of biomass (biogenic) and fossil-derived carbon 23 dioxide – Radiocarbon sampling and determination’
- the ‘balance method’ (based on ISO 18466 ‘Stationary source emissions – Determination of the biogenic fraction in CO_2 in stack gas using the balance method’)

7.2 N_2O emissions

Section 16 of Annex IV to the MRR deals with determining N_2O emissions from certain chemical production processes, which are set out in Schedule 2 of the UK ETS order (production of nitric acid, adipic acid, glyoxal and glyoxylic acid). N_2O emitted from the activity 'combustion of fuels' is not covered. N_2O emissions must be determined using a measurement-based approach, unless the highest tier is technically not feasible or incurs unreasonable costs (Article 50(3) and (4) of the MRR).

In addition to the points mentioned under sections 3.3.4 and 7.1, the following specific points should be noted:

- in subsection B.3 in section 16 of Annex IV to the MRR, specific requirements for determining the flue gas flow are given. Where needed, the oxygen concentration must be measured in accordance with subsection B.4.
- subsection B.5 specifies requirements for calculation of N_2O emissions in case of specific periods of unabated N_2O emissions (e.g. when the abatement system fails) and where measurement is technically not feasible.

For calculating CO_2e emissions from N_2O emissions, the operator shall use the following formula: (Equation 27):

$$Em = Em(N_2O) \times GWP_{N2O}$$

Where:

Em………… emissions expressed as tCO_2e

$Em(N_2O)$…. emissions of N_2O in tonnes

GWP_{N2O}…… global warming potential of N_2O as listed within Table 6 in section 3 of Annex VI to the MRR.

7.3 Transferred / inherent CO_2, N_2O and Carbon Capture and Storage (CCS)

7.3.1 Transferred CO_2 and Carbon Capture and Storage (CCS)

Where almost pure[76] fossil[77] CO_2 is not emitted, but transferred out of an installation, it may be subtracted from that installation's emissions only if the receiving installation is one of the following (Article 49(1) of the MRR):

- a capture installation for the purpose of transport and long-term geological storage in a storage site permitted in accordance with the CCS licensing regime
- a transport network with the purpose of long-term geological storage in a storage site permitted in accordance with the CCS licensing regime
- a storage site permitted in accordance with the CCS licensing regime for the purpose of long-term geological storage
- an installation where the CO_2 is used to produce precipitated calcium carbonate (PCC), in which the used CO_2 is chemically bound[78]

In all other cases, the CO_2 transferred out of the installation counts as emission of the originating installation.

7.3.1.1 Monitoring in case of PCC production

For the PCC case, the MRR requires explicitly that a calculation-based approach is to be used,[79] which can be simple, as discussed below. However, a difficulty results where the installation of the PCC production is not in the UK ETS. An outline of a monitoring approach could be as follows:

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[76] In contrast to "inherent CO_2" which is part of a source stream and therefore only one of several constituents of a gas flow, "transferred CO_2" is usually "overwhelmingly" composed of CO_2.
[77] In principle, also biomass CO_2 could be deducted if transferred out of the installation. However, as biomass CO_2 is zero-rated (if applicable, see section 5.3.5), the amount to be deducted would be zero, too.
[78] Article 49(1)(b) of the MRR can only apply if there is a transfer of CO_2 to another installation. However, there are cases where the CO_2 is chemically bound in PCC in the same installation and the bound CO_2 may be counted as not emitted by the installation. This is now allowed because the last sentence of section 10 of Annex IV to the MRR has been deleted - "*Where CO_2 is used in the plant or transferred to another plant for the production of PCC (precipitated calcium carbonate), that amount of CO_2 shall be considered emitted by the installation producing the CO_2.*"
For monitoring of CO_2 chemically bound in PCC, the most straightforward method would be the 'mass-balance methodology' in line with Article 25 of the MRR. If PCC is regarded as a "material leaving the boundaries of the mass balance", then the CO_2 bound in it is not reported as emitted. However, currently section 10 of Annex IV to the MRR does not mention the mass-balance approach as applicable. Therefore, even if the operator uses a mass balance in practice, it must be reported by assigning the emissions from limestone calcination an appropriate conversion factor under the standard methodology. In case purchased lime is used, so that the bound CO_2 would be more than what is emitted from actual lime burning, that CO_2 can be taken into account by assigning an appropriate conversion/oxidation factor to one or more other source streams, as necessary.
[79] This will usually be a mass balance, as the amount of CO_2 bound must be determined.

1. If the PCC producer is in the UK ETS and independent of the CO_2 transferring installation:

    a. The receiving and/or the transferring installation monitors the incoming CO_2 stream (e.g. using a CMS (see below) for gas stream and CO_2 concentration) – this quantity is to be shared and aligned between both installations (see last paragraph of this section).

    b. This continuous monitoring can be omitted if the complete CO_2 mass stream of the installation or of a clearly identifiable part thereof (e.g. the whole emissions of a single lime kiln) are transferred. In such case the CO_2 quantity can be calculated from the input source streams of that installation (part).

    c. The PCC producer monitors the quantity of CO_2 bound in PCC by monitoring the produced PCC quantity and calculating the amount of CO_2 bound using the appropriate stoichiometric factors.

    d. The emissions of the PCC producer are Em = incoming CO_2 – bound CO_2.

2. If the PCC producer is not under the UK ETS and has no own MRV obligation, the two connected installations will require some contractual agreement:

    a. Either the PCC producer monitors and reports the relevant CO_2 data to the UK ETS operator (in principle the quantity of produced PCC is sufficient information) and grants access to the verifier; or

    b. The PCC producer grants the UK ETS producers' personnel access to its installation so that they can carry out the relevant monitoring tasks, including access to the verifier.

The monitoring in this case is simpler: The total quantity of CO_2 transferred does not require monitoring. The operator of the UK ETS installation which transferred CO_2 to the PCC producer has only to determine (with the stoichiometric factor) the quantity of CO_2 bound and subtract it from its own installation's emissions.

7.3.1.2 Monitoring the capture process (CCS)

To make the calculation consistent in the case of a 'CCS chain' (i.e. several installations together performing the capture, transport and geological storage of CO_2), the receiving installation must add that CO_2 to its emissions (see sections 21 to 23 of Annex IV to the MRR) before it may again subtract the amount transferred to the next installation. Thus, CCS installations are monitored using a form of mass balance approach, where some of the CO_2 entering or leaving the installation (i.e. at the transfer points) is monitored using continuous measurement systems.

For these continuous measurement systems (CMS) the rules specified for CEMS (see section 7.1) can be applied. In particular, the provision of 'indirect' CO_2 measurement[80] is applicable. The highest tier (tier 4) must be used unless unreasonable costs or technical infeasibility are demonstrated. As a special provision, it is important to clearly identify the transferring and receiving installations in annual emissions report, using the unique identifiers which are also used in the UK Emissions Trading Registry.

For monitoring at the interface between installations, the operators may choose whether the measurement is carried out by the transferring or receiving installation (Article 48(3) of the MRR). Where both carry out measurements and where the results deviate, the arithmetic mean shall be used. If the deviation is higher than the uncertainty approved in the monitoring plan, a value with conservative adjustment is to be reported by the operators, which needs the approval by the regulator.

7.3.1.3 Monitoring CO_2 Transport

Currently under UK ETS rules, a transport network is a pipeline which includes all ancillary plant functionality connected to the pipeline, including booster stations and heaters (see section 22, Annex IV to the MRR).

The emissions from a CO_2 transport network are calculated as follows (equation 28):

$$Emissions[tCO2] = Emissions_{vented,leaked,fugitive} + Emissions_{transport\ activities}$$

Where:

$Emissions_{vented,leaked,fugitive}$ .... emissions from venting, leakage and fugitive emissions

$Emissions_{transport\ activities}$ ...... emissions from the transport network's own activities (emissions not stemming from the transported CO_2 which is intended for storage). These emissions include all emissions from any functionally connected ancillary facilities, such as booster stations and heaters. Emissions from fuels used in transport processes must be monitored separately from CO_2 losses (vented, leaked, fugitive sources) from the pipeline, applying the normal rules for either a calculation-based approach or a measurement-based approach.

[80] I.e. determining the concentration of all other constituents of the gas and subtracting them from the total (Equation 3 in Annex VIII to the MRR).

The operator can determine emissions from venting, leakage and fugitive sources using one of the two methods set out in section 22 of Annex IV to the MRR:

- method A - a mass balance between incoming CO_2 and outgoing CO_2 (transferred to another transport network or storage site), or
- method B – the monitoring of all individual emission sources by the operator.

Method A:

This is an overall mass balance of all input and output streams. The operator must apply a measurement-based approach (equation 29):

$$Emissions_{vented,leaked,fugitive} = \sum T_{IN,i} - \sum T_{OUT,i}$$

Where:

$T_{IN,i}$..... amount of CO_2 transferred to the transport network at entry point i

$T_{OUT,i}$... amount of CO_2 transferred out of the transport network at exit point i

Method B:

Emissions due to losses of transferred CO_2 are not monitored using a mass balance, but by monitoring all relevant sources from where the CO_2 is vented, leaked or released as fugitive emissions (from seals, valves and measurement devices). The operator must apply the rules set out in section 22 of Annex IV to the MRR (equation 29):

$$Emissions_{vented,leaked,fugitive} = E_{vented} + E_{leakage\ events} + E_{fugitive}$$

Where:

E_{vented}...........number of vented emissions (tCO_2) from CO_2 transported in the pipeline

$E_{leakage\ events}$... amount of CO_2 (tCO_2) transported in the pipeline which is emitted due to failure of one or more components of the transport network

$E_{fugitive}$......... number of fugitive emissions (tCO_2) from CO_2 transported in the pipeline, including from seals, valves and intermediate compressor stations and storage facilities.

Note that operators using Method B must demonstrate to the regulator that the overall uncertainty for CO_2 emitted from the transport network does not exceed 7.5%.

Additionally, when using Method B, the operator must not:

- add CO_2 received from another installation to its emissions total, and
- subtract from its emissions total any CO_2 transferred to another installation.

Each operator of a transport network shall use Method A to validate the results of Method B at least once annually. For the validation, the operator may use lower tiers to apply Method A.

7.3.1.4 Monitoring CO_2 storage

Emissions from the geological storage site include the following:

1. Emissions from the storage complex, the boundaries of which are defined in the permit under the CCS licensing regime, i.e. leakage from the storage site. Operators must monitor such emissions as per Section 23.B.3 of Annex IV to the MRR and include them as an emission source in their monitoring plan only when a leak is detected. Once the leak can no longer be detected, then the operator can remove the emission source related to the leak from the monitoring plan and no longer monitor and report such emissions.

2. Vented and fugitive emissions from injection: these are emissions from CO_2 intended to be stored underground. The monitoring rules are set out in Section 23.B.1 of Annex IV to the MRR and are similar to the rules for monitoring such emissions from a transport network (Method B).

3. Emissions from ancillary facilities functionally connected to the storage complex, such as CO_2 intermediate storage, booster, liquefaction, gasification, purification stations or heaters. These must be monitored as per any other UK ETS installation.

Note that storage sites can include sites at which enhanced oilfield recovery (EOR) operations take place. Section 23.B.2 of Annex IV to the MRR sets out the monitoring requirements for these sites.

7.3.2 Transferred N_2O

Article 50 of the MRR contains also specific rules for treatment of N_2O that is transferred to another installation. The pre-condition for subtracting the N_2O from the transferring installation's reported emissions is that the N_2O is received by an installation that monitors and reports emissions under the MRR. The latter installation must treat the N_2O as if it were generated within the receiving installation itself (i.e. monitor it by CEMS and report it).

If the N_2O is not used within the receiving installation, or where there is no evidence that the N_2O is destroyed by relevant abatement equipment, i.e. where the N_2O is sold and emitted later outside the installation, it shall be accounted for as emission of the installation where it originates.

7.3.3 Inherent CO_2

While 'transferred CO_2' in the MRR means 'more or less pure CO_2', the term 'inherent CO_2' in Article 48 of the MRR refers to CO_2 which results from a regulated activity[81] that is contained in a gas and used as a fuel, such as waste gases from a blast furnace or from some parts of mineral oil refineries, or a process input (such as synthesis gas). Note that inherent CO_2 could also be equally applicable to other industry sectors operating under the UK ETS.

To ensure a consistent reporting of both receiving and transmitting installation, the following approaches are applicable:

1. Where an UK ETS installation uses a source stream which contains inherent CO_2, the emission factor (or in case of mass balances, the carbon content) takes into account the inherent CO_2 (i.e. the CO_2 forms a part of the source stream, and the inherent CO_2 counts as emitted by the installation which indeed emits the CO_2 and is required to be reported).

2. The UK ETS installation which transfers the CO_2 to the other installation, subtracts the CO_2 from its emissions. Usually this is done using a mass balance. The inherent CO_2 is simply treated in the same way as any other carbon in that outgoing source stream. An exception is applicable where the inherent CO_2 is transferred to a non-ETS installation: In this case the inherent CO_2 must be counted as emission from the ETS installation which transfers the CO_2.

3. Emissions from the transport network also require to be monitored and reported. That being fugitives (calculated), vented CO_2 (measured) and any leaks (calculated). Leaks from the store will also require to be monitored and reported.

Regarding monitoring the point of transfer, the same approach as for transferred CO_2 is applicable, i.e. operators may choose whether the measurement is carried out by the transferring or receiving installation (Article 48(3) of the MRR, see section 7.3.1 above).

[81] See Table C of Schedule 2 to the UK ETS Order