2.0
version

Methodology for the Production and Verification of Quantified Emissions Tokens® (QETs) in Accordance with ISO 14064-3

This methodology establishes standardized processes for quantifying emissions factors, enabling verification while remaining agnostic to the measurement methodologies employed by producers of natural gas and other commodities.

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QET

Methodology for the Production and Verification of Quantified Emissions Tokens® (QETs) in Accordance with ISO 14064-3

This comprehensive methodology document outlines a verifiable framework for the production of Quantified Emissions Tokens® (QETs) that is aligned with ISO 14064-3 verification requirements. The methodology establishes standardized processes for quantifying emissions factors while remaining agnostic to specific measurement methodologies employed by producers of natural gas and other commodities.

Introduction and Scope

The Quantified Emissions Token (QET) serves as a digital container for verified environmental attributes and emissions data collected from real-world commodities. This methodology document provides the procedural framework for creating, validating, and verifying QETs that represent the environmental impacts of physical commodities, with particular focus on natural gas production, processing, transmission, and distribution.

This methodology is designed to be compatible with and verifiable under ISO 14064-3 standards for greenhouse gas assertions, while incorporating the principles of ISO 14067 for product carbon footprinting. It establishes the requirements for QET production regardless of the specific measurement technology or approach used by the producer, so long as the measurement methodology meets the minimum requirements for data quality, uncertainty management, and verification.

Contents

1. Key Objectives

1. Establish a standardized approach to emissions quantification that is measurement-methodology agnostic.
2. Define procedures for converting raw emissions data into standardized QET format.
3. Detail uncertainty assessment and management processes.
4. Document verification requirements aligned with ISO 14064-3.
5. Support the creation of verifiable environmental attribute certificates (EACs).

2. Normative References

This methodology references and incorporates elements from the following standards and documents:

1. ISO 14064-3:2019 - Greenhouse gases - Part 3: Specification with guidance for the verification and validation of greenhouse gas statements.
2. ISO 14067:2018 - Greenhouse gases - Carbon footprint of products - Requirements and guidelines for quantification.
3. EarnDLT Quantified Emissions Token (QET) Framework Protocol.
4. OGCI Reporting Framework for methane intensity quantification.
5. IPCC AR5 Global Warming Potential values.

6. Natural Gas Sustainability Initiative (NGSI) Protocol Version 2.0 for methane intensity quantification in transmission systems, and for quantification and allocation of methane intensity in natural gas processing operations.
7. ONE Future Methane Emissions Estimation Protocol, V6.2023
8. Pipeline and Hazardous Materials Safety Administration (PHMSA) reporting requirements for pipeline throughput data.
9. American Petroleum Institute's Manual of Petroleum Measurement Standards (API MPMS), Chapters 14.3, 14.5, 14.7, and the Gas Processors Suppliers Association (GPSA) Engineering Data Book - Standards for measurement, gas processing, and NGL product specification relevant to processing QETs.
10. Energy Emissions Modeling and Data Lab, The University of Texas at Austin. "A Protocol for Independent Verification of Methane Emissions of Crude Oil and Natural Gas Production Destined for the European Union Market." September 8, 2025. (EEMDL Protocol).

3. Terms and Definitions

3.1 Quantified Emissions Token (QET)

A digital asset, on the EarnDLT registry, acting as a data container for a set of independently verified environmental and other attributes compiled from primary and secondary data sources related to the production, processing, or transportation of a specific unit of physical product or commodity (e.g., one QET corresponds to one MMBtu of natural gas).

3.2 Methane Intensity (MI)

The ratio of methane emissions to natural gas throughput, typically expressed as a percentage or in units of kg CH_4/MMBtu.

3.3 QET Pollutant Intensity

The ratio of pollutant, e.g., carbon (CO_2), methane (CH_4), Nitrous Oxide (N_2O), etc., emissions to one unit of the physical product, e.g., natural gas, sold to the market, which is typically expressed as a percentage or in units of, in the case of natural gas production, mcf emitted/mcf sold.

3.4 Carbon Intensity (CI)

The amount of pollutant (greenhouse gas) emissions expressed as CO_2 equivalent (CO_2e) per unit of energy, typically measured in kg CO_2e/MMBtu and qualified with the appropriate GWP.

3.5 Measurement, Reporting, and Verification (MRV)

The process of collecting emissions data, reporting it in a standardized format, and having it verified by a qualified third party.

3.6 Primary Data

Quantified value of a process or activity obtained from direct measurement or calculation based on direct measurements.

3.7 Secondary Data

Data that does not fulfill the requirements for primary data, including data from databases, published literature, default emission factors, or estimates.

3.8 Uncertainty

Parameter associated with the result of quantification that characterizes the dispersion of values that could reasonably be attributed to the quantified amount.

3.9 Global Warming Potential (GWP)

Index measuring the radiative forcing of a greenhouse gas relative to that of carbon dioxide over a specified time horizon.

3.10 Path-Based Emissions

Emissions allocated or correlated to a specific transportation route between defined receipt and delivery locations, calculated using segment-level emissions data and flow allocation factors.

3.11 Segment Allocation Factor

The proportional factor used to allocate pipeline segment emissions to specific gas volumes based on throughput and flow proportion calculations.

3.12 Pipeline and Hazardous Materials Safety Administration (PHMSA)

United States Department of Transportation agency providing pipeline throughput data for accurate emission allocation calculations.

3.13 Delivery Location (DLVRY LOC)

The point where the transportation system operator delivers gas to the shipper or downstream party for a specific contractual agreement. That point marks the exit from the transmission system.

3.14 Receipt Location (RCPT LOC)

The point on the transportation system where the shipper (or supplier) injects gas into that pipeline system for a specific contractual agreement. That point marks the entry to the transmission system.

3.15 Natural Gas Processing

The treatment of raw natural gas to remove impurities, separate natural gas liquids, and prepare pipeline-quality gas that meets commercial specifications.

3.16 Processing Plant Boundary

The physical and operational boundary encompassing all equipment and processes from raw gas inlet to treated gas outlet, including all ancillary systems and utilities.

3.17 Natural Gas Liquids (NGL) Allocation

The methodology for allocating emissions between residue gas and extracted NGL products based on energy content or market value.

3.18 Processing Efficiency Factor

The ratio of treated gas output to raw gas input, accounting for fuel gas consumption and losses during processing operations.

3.19 EU Methane Regulation (EUMR)

Regulation (EU) 2024/1787 on methane emissions reduction in the energy sector, establishing monitoring, reporting, and verification requirements for methane emissions from crude oil and natural gas operations, including Article 28 compliance requirements for imports destined for EU markets.

3.20 Producer-Level Reporting

Emissions reporting at the level of the producer as defined in EUMR Article 28, encompassing "operational control of a business or operating unit...at the level of the producer" for crude oil and natural gas production facilities located outside the European Union where the crude oil or natural gas is destined for the EU market.

3.21 Reasonable Assurance for EU Compliance

High level of assurance verification required under EUMR Article 8, providing "high, though not absolute, level of confidence in historical data" through extensive evidence-gathering activities and comprehensive verification procedures.

4. General Requirements for QET Production

4.1 Principles

QET production shall adhere to the following principles:

1. **Relevance:** Data and methods shall be appropriate to the assessment of GHG emissions.
2. **Completeness:** All significant GHG emissions and removals shall be included.
3. **Consistency:** Assumptions, methods, and data shall be applied in the same way throughout the process.
4. **Accuracy:** Bias and uncertainties shall be reduced as far as is practical.
5. **Transparency:** All relevant information shall be disclosed in a factual and coherent manner.
6. **Conservatism:** When faced with uncertainty, conservative values shall be selected to avoid underestimation of emissions.
7. **Avoidance of Double-Counting:** Each unit of emissions shall be accounted for only once.

4.2 Impartiality

QET verification and validation activities shall be designed and executed to ensure objectivity and elimination of bias. The principle of impartiality in the QET framework requires:

1. **Organizational independence:** Verifiers and validators shall maintain structural separation from entities involved in QET production, trading, or retirement.
2. **Financial independence:** Compensation for verification services shall not be contingent upon verification outcomes or token values.
3. **Threat assessment:** Verification bodies shall implement and document a formal process to identify, evaluate, and mitigate threats to impartiality, including:
    - Self-interest threats (financial or other interests that influence judgment).
    - Self-review threats (reviewing one's own work).
    - Familiarity threats (close relationships with responsible parties).
    - Intimidation threats (pressure to reach predetermined conclusions).
4. **Rotation requirements:** Lead verifiers shall be rotated at least every three years for continuous verification engagements with the same QET producer.

5. **Documentation of independence:** Prior to each verification engagement, verification bodies shall document:
    - Written declarations from all verification team members regarding the absence of conflicts.
    - Assessment of any previous relationships with the QET producer.
    - Safeguards that are implemented to maintain independence where potential conflicts exist.
    - Confirmation of financial independence from verification outcomes.

4.3 Evidence-based Approach

QET verification and validation shall employ rational methods for reaching reliable and reproducible conclusions based on sufficient and appropriate evidence. This principle requires:

1. **Evidence sufficiency:** The quantity of evidence collected must be adequate to support verification conclusions. Sufficiency in the QET context requires:
    - Complete coverage of material emission sources within the defined boundary.
    - Representative sampling across temporal and operational variations.
    - Adequate testing of calculations and data transformations.
    - Corroboration of critical data points through multiple lines of evidence.
2. **Evidence appropriateness**: The quality of evidence must be relevant and reliable. Appropriate evidence in the QET context is characterized by:
    - Relevance: Information that logically relates to the verification objectives and criteria.
    - Reliability: Information from sources with appropriate technical expertise, independence, and quality controls.
    - Accuracy: Information verified for correctness through testing, recalculation, or observation.
    - Traceability: Clear data trails connecting raw measurements to final QET attributes.
3. **Evidence assessment**: Verifiers shall evaluate evidence against predefined criteria, including:
    - Consistency with available scientific knowledge and established methodologies.
    - Alignment with the measurement methodology specified in the QET data structure.
    - Compliance with uncertainty thresholds and data quality requirements.
    - Reasonableness when compared to industry benchmarks or historical performance.
4. **Evidence documentation:** Verifiers shall maintain records of:
    - Evidence collection methods and sampling approaches.
    - Assessment of evidence against verification criteria.
    - Identified gaps in evidence and steps taken to address them.
    - Rationale for conclusions based on the collected evidence.

4.4 System Boundaries

4.4.1 Boundary Definition

The system boundary for QET production shall be clearly defined and documented. For natural gas:

- **Standard Applications:** The upstream boundary typically includes the wellhead to the point of sale, consistent with the OGCI definition.
- **EU Market Compliance:** For QETs representing crude oil and natural gas destined for EU markets under EUMR Article 28, boundaries shall be defined at the producer level following EEMDL Protocol requirements, encompassing "operational control of a business or operating unit...at the level of the producer" as specified in the EU Methane Regulation.
- **Facility vs Producer Level:**
  - Standard QET production uses facility-level boundaries
  - EU compliance requires producer-level aggregation capabilities where multiple facilities operate under common producer control

4.4.2 Included Activities

The following activities may be included within the system boundaries when applicable:

Production Activities:

- Extraction and production
- Gathering and processing
- Compression and boosting
- Storage

Processing Activities:

- Acid gas removal (amine treating, membrane separation).
- Dehydration (glycol systems, molecular sieves).
- Natural gas liquids extraction and fractionation.
- Sulfur recovery and tail gas treatment.
- Gas compression and pressure regulation.
- Process heating and power generation.
- Flare and thermal oxidizer systems.
- Storage and loading operations for NGLs.

Transportation Activities:

- Midstream pipeline transportation
- Compressor stations (reciprocating and centrifugal)
- Meter/regulator stations
- Pipeline segments between receipt and delivery locations

Distribution Activities:

- Liquefaction (if applicable)
- Distribution

4.4.3 Emission Sources

All significant emissions sources within the defined boundary shall be included. These include, but are not limited to:

Non-combustion related emissions:

- Hydrocarbon storage tanks.
- Compressor seals.
- Pneumatic controls and pumps.
- Liquids unloading and storage.
- Fugitive leaks.
- Loss of primary containment.
- Gas dehydration.
- Venting (e.g., casing head, gas separation).
- Well completion.

Combustion-related emissions:

- Flaring.
- Stationary combustion sources (e.g., turbines).

Processing Non-combustion Emissions:

- Amine regeneration systems.
- Glycol dehydration units.
- Compressor seals and rod packing.
- Process unit fugitive emissions.
- NGL storage tanks and loading operations.
- Pressure relief devices.
- Molecular sieve regeneration.

Processing Combustion Emissions:

- Process heaters and reboilers.
- Flare systems and thermal oxidizers.
- Emergency generators and fire pumps.
- Sulfur recovery unit thermal reactors.

5. Quantification Methodology for QET Production

5.1 Emissions Data Acquisition

Emissions data for QET production shall be acquired through direct API connections with verified measurement systems that provide real-time or near real-time monitoring capabilities within the defined system boundaries. Additionally, producers measuring their emissions according to verifiable standards may submit data directly to the EarnDLT system via API connection or through Excel file upload, provided such data meets the minimum detection limits, monitoring frequency requirements, and data hierarchy standards outlined in sections 5.1.2 and 5.1.3 of this methodology.

5.1.1 Data Requirements

QET production requires the collection of:

- Methane emissions data (mass).
- Natural gas throughput (volume or energy).
- Activity data for associated processes.
- Supporting information for verification.

5.1.2 Data Hierarchy

The following data hierarchy shall be applied:

1. Site-specific primary data (preferred).
2. Process-specific primary data.
3. Secondary data from peer-reviewed sources.
4. Industry-average secondary data.

5.1.3 Minimum Detection Limits and Measurement Frequency

When monitoring is used by the producer, the QET shall include information about the minimum detection limit (MDL) of monitoring equipment and the frequency of monitoring to ensure data representativeness over time. This information affects the confidence level rating as described in Section 6.

5.2 Methane Intensity Calculation

Methane intensity shall be calculated according to the producer's stated measurement methodology. In the QET data structure, this is identified within the category of "`measurerData`".

5.2.1 QET Pollutant Intensity Calculation

To calculate the Pollutant (e.g., CH_4) Intensity for environmental attribute certificate (EAC) tokens, such as QETs, whereby each token represents one unit (MMBtu) of the natural gas sold to the market, the following formula should be used:

$$QET\ Methane\ Intensity = \frac{McfEmitted_i}{McfSold_i}$$

```
QET_Methane_Intensity = Mcf_Emitted_i / Mcf_Sold_i
```

Where:

- `Mcf_Emitted_i` is the Mcf emitted from the *i*-th well on the Pad, a variable known to the measurer as determined by the producer's measurement standard.
- `Mcf_sold_i` is the Mcf sold from the *i*-th well on the Pad, which is the volumetric for natural gas sold to the market as determined by converting the MMBtus sold (reported by the producer at batch production) to Mcf.

To convert the energy content of natural gas sold from the *i*-th well on the Pad from MMBtu (Million British Thermal Units) to its volume equivalent of Mcf (Thousand Cubic Feet), you need to know the heat content of the gas from the *i*-th well on the Pad, typically expressed as MMBtu per thousand cubic feet. The formula is:

$$McfSold_i = \frac{MMBtuSold_i}{Heat\ ValueMMBtuPerMcf_i}$$

```
Mcf_Sold_i = MMBtu_Sold_i / Heat_Value_MMbtu_per_Mcf_i
```

Where:

- `MMBtu_Sold_i` is the amount of MMBtus sold from the i-th well on the pad (as reported by the producer at batch submission).
- `Heat_Value_MMbtu_per_Mcf_i` is the heat value (in MMBtu per Mcf) of the gas produced from the i-th well on the Pad (as reported by the producer at batch submission).
  - MMBtu: The energy content of the gas in million BTUs
  - Heat Value: The heating value of the gas, typically measured in MMBtu per Mcf. For example:
    - If the heat value is 1.015 MMBtu/Mcf, then 1 Mcf contains 1.015 MMBtu of energy.
    - For a heat value of 1.038 MMBtu/Mcf (the U.S. average), this would be used instead.

Example Calculation:

If you sold 100 MMBtu of natural gas with a heat value of 1.015 MMBtu/Mcf:

$$McfSold = \frac{100}{1.015} \approx 98.52\ Mcf$$

```
Mcf_Sold = 100 / 1.015 = 98.52
```

For a different heat value, such as 1.038 MMBtu/Mcf:

$$McfSold = \frac{100}{1.038} \approx 96.35\ Mcf$$

```
Mcf_Sold = 100 / 1.038 = 96.35
```

This formula ensures accurate conversion by accounting for variations in the heating value of natural gas.

5.3 Conversion of Pollutant (CH_4) from Volume to Mass

When emissions are measured in volumetric units (MSCF), convert to mass units (kg) using the Ideal Gas Law approach:

$$MassKg = \frac{\left(\frac{VolumeMSCF \times MolecularWeight}{0.83662}\right)}{1000}$$

```
Mass_kg = (Volume_MSCF * Molecular_Weight_g_per_mol / 0.836213) / 1000
```

Where:

- Methane (CH_4) has a molecular weight of 16.04 g/mol.
- Carbon Dioxide (CO_2) has a molecular weight of 44.01 g/mol.
- Nitrous Oxide (N_2O) has a molecular weight of 44.02 g/mol.
- 0.83662 SCF/g-mol is the Ideal Gas Law conversion factor.

Example: 1,000 MSCF of methane converts to 19.19 kg.

5.4 QET Pollutant Mass Calculation

To calculate the Pollutant (e.g., CH_4) Mass for environmental attribute certificate (EAC) tokens, such as QETs, whereby each token represents one unit (MMBtu) of the natural gas **sold** to the market, you need to use the following formula:

$$QET\ Methane\ Mass = \frac{WellCH4MassKg_i}{MMBtuSold_i}$$

```
QET_Methane_Mass = Well_CH4_Mass_kg_i / MMBtu_Sold_i
```

Where:

- `Well_CH4_Mass_kg_i` is the total mass inventory of CH_4 emitted in kilograms from the *i*-th well on the Pad.
- `MMBtu_Sold_i` is the amount of MMBtus sold from the *i*-th well on the pad during the producer's batch production period (as reported by the producer at batch submission).

Note: Since emissions in the natural gas upstream production segment are calculated at a pad level, you should use the following methods to calculate the T*i* for each well on the pad.

Step 1 Identify the number of MMBtus sold for the pad during the batch period: Sum the total MMBtus reported as "sold" by the producer at batch submission for each well on the pad.

$$MMBtus\ Sold\ Pad\ = \sum_{i=1}^{n} MMBtuSold_i$$

```
MMBtu_Sold_Pad = Σ{i=1..n} MMBtu_Sold_i
```

Where:

- `MMBtu_Sold_`i is the amount of MMBtus sold from the i-th well on the pad, as reported by the producer.
- `n` is the total number of wells on the pad (n>0).

Step 2 Determine the production ratio for each well on the pad: Divide the total MMBtus reported as "sold" for each well on the pad by the total MMBtus sold from the pad.

$$Production\ Ratio_i\ = \frac{MMBtus_i}{MMBtus\ sold\ from\ Pad}$$

```
Production_Ratio_i = MMBtu_Sold_i / MMBtu_Sold_Pad
```

Where:

- `Production_Ratio_i` (in %) is the production ratio for the i-th well on the pad
- `MMBtu_Sold_i` is the amount of MMBtus sold from the i-th well on the pad.
- `MMBtu_Sold_Pad` is the amount of MMBtus sold from all wells on the pad.

Step 3 Determine the `Well_CH4_Mass_kg_i` for each well on the pad: Multiply the total pad-level emissions mass of CH_4 (as determined by the producer's verifiable measurement standard) by the Production Ratio of each well on the pad.

$$WellCH4Mass(kg)_i = PadCH4Mass\ (kg) \times Production\ Ratio_i(\%)$$

```
Well_CH4_Mass_kg_i = Pad_CH4_Mass_kg * Production_Ratio_i
```

Where:
- `Well_CH4_Mass_kg_i` is the total mass inventory of CH4 emitted in kilograms from the i-th well on the Pad.
- `Pad_CH4_Mass_kg` is a known variable by the measurer as determined by the producer's verifiable measurement standard.
- `Production_Ratio_i` is the production ratio for the i-th well on the pad.

5.5 Carbon Equivalent Intensity Calculation

Carbon equivalent intensity shall be calculated by converting mass of pollutant, e.g., methane, emissions to CO_2e using the appropriate 100-years Global Warming Potentials from IPCC AR5 (GWP100_CH4_AR5 = 28):

$$MethanEmissionsCO2e = Methane\ Emissions \times GWP100CH4AR5$$

```
Methane_Emissions_CO2e = Methane_Emissions * GWP100_CH4_AR5
```

5.6 Transportation-Specific Quantification Methods

5.6.1 Segment-Level Methane Intensity (NGSI Protocol)

For each pipeline segment `i`:

$$CH4IntensitySegment_i = \frac{TotalSegmentCH4Emissions_i}{SegmentThroughput_i}$$

```
CH4_Intensity_Segment_i = Total_Segment_CH4_Emissions_i /
(Total_Segment_Throughput_1)
```

Where:
- `i` is each pipeline segment.
- `Total_Segment_CH4_Emissions_i` are the sum of CH_4 emissions of all equipment installed on the segment `i` (in kg).
- `Segment_Throughput_i` is the throughput in MMBtu of segment `i`.

5.6.2 Segment-Level Allocation of Pipeline Emissions

For each pipeline segment `i`:

$$AllocatedCH4Emissions_i = \left(\frac{SegmentThroughput_i}{\sum_{i=1}^{n} SegmentThroughput_i} \right) \times PipelineCH4Emission$$

```
Allocated_CH4_Emissions_i = Segment_Throughput_i / (Σ{i=1..n} Segment_Throughput_i ) * Pipeline_CH4_Emission
```

Where:

- `i` is each pipeline segment.
- `Segment_Throughput_i` is the throughput in MMBtu of segment `i`.
- `Pipeline_CH4_Emission` is the CH_4 emission of the pipeline that cannot be allocated to a specific segment.

For each pipeline segment `i`:

$$CH4IntensityPipeline_i = \frac{AllocatedPipelineCH4Emissions_i}{SegmentThroughput_i}$$

```
CH4_Intensity_Pipeline_i = Allocated_Pipeline_CH4_Emissions_i / Segment_Throughput_i
```

Where:

- `Allocated_Pipeline_CH4_Emissions_`i is the allocated mass of the pipeline CH4 emissions in kg.
- `Segment_Throughput_i` is the throughput in MMBtu of segment `i`.

5.6.3 Total Segment-Level Methane Intensity Emissions

For each pipeline segment `i`:

$$TotalCH4Intensity_i = CH4IntensitySegment_i + CH4IntensityPipeline_i$$

```
Total_CH4_Intensity_i = CH4_Intensity_Segment_i + CH4_Intensity_Pipeline_i
```

Where:

- `i` is each pipeline segment.
- `CH4_Intensity_Segment_`i is the CH4 intensity of segment `i` in kg/MMBtu.
- `CH4_Intensity_Pipeline_`i is the allocated pipeline emission of segment `i` in kg/MMBtu.

5.6.4 Total Segment-Level Carbon Intensity

Use the same calculation methods from the chapter 5.6.1 to 5.6.3 for all segment-level [CO_2, CH_4, N_2O] intensities and calculate their corresponding CO_2e intensities using the GWP100(AR5) factors (note the CO_2 factor is 1). The total segment-level CO2e Carbon Intensity in Kg/MMBtu is the calculated as:

$$TotalCarbonIntensityCO2e_i = TotalCH4IntensityCO2e_i + TotalN2OIntensityCO2e_i + TotalCO2Intensity_i$$

```
Total_Carbon_Intensity_CO2e_i = Total_CH4_Intensity_CO2e_i +
  Total_N2O_Intensity_CO2e_i + Total_CO2_Intensity_CO2e_i
```

Where:

- `i` is each pipeline segment.
- `Total_CH4_Intensity_CO2e_i` is the total CH_4 intensity of segment `i` in kg/MMBtu.
- `Total_N2O_Intensity_CO2e_i` is the total N_2O intensity of segment `i` in kg/MMBtu.
- `Total_CO2_Intensity_i` is the total CO_2 intensity of segment `i` in kg/MMBtu.

5.6.5 Path-Based Emissions Calculation

Step 1: Identify Path Segments of Contract

For each `Contract_ID`:

$$ContractSegments_{ContractID} = \left\{Seg_{ID}, Seg_{Rec} \leq Seg_{ID} \leq Seg_{Del}\right\}$$

```
Contract_Segments_Contract_ID = {all Segment_IDs between
  Segment_Receipt_Location and Segment_Delivery_Location}
```

Where:

- Assumption: `Segment_IDs` can be ordered representing all segment that are “touched” by the `Contract_ID` representing the path that the gas takes through the pipeline.
- `Segment_Receipt_Location` is the segment in which the contract’s receipt location is located.

- Segment_Delivery_Location is the segment in which the contract's delivery location is located.
- Whole Segments are counted (no further sub-division).

Step 2: Calculate Emissions per Segment of Contract

For each Segment_IDs in Path_Segments (example: Total Carbon Intensity CO2e, method works exactly the same for all other intensities):

$$TotalContractSegmentCarbonIntensityCO2e_i = ContractVolume_{ID} \times TotalCarbonIntensityCO2e_i$$

```
Total_Contract_Segment_Carbon_Intensity_CO2e_i = Contract_Volumne_ID *
                    Total_Carbon_Intensity_CO2e_i
```

Where:

- Contract_Volumne_ID is the receipt volume of the contract with the specified Contract_ID.
- Total_Carbon_Intensity_CO2e_i is the total carbon intensity (CO2e) for that segment measured in kg per MMBtu.

Note:

- Note: This works the same for all other intensities.

Step 3: Sum Emissions per Segment of Contract

For each Contract_ID:

$$TotalContractCarbonIntensityCO2e_i = \sum_{i=1}^{n} TotalContractSegmentCarbonIntensityCO2e_i$$

Where:

- Total_Contract_Segment_Carbon_Intensity_CO2e_i is the total Carbon Intensity (CO2e) for segment i that is part of Contract_Segments_Contract_ID for that specific contract with the Contract_ID.

Note:

- Note: This works the same for all other intensities.

5.6.6 PHMSA Integration Requirements

Transportation segment calculations shall use PHMSA-reported throughput data to ensure accurate denominators and prevent double-counting issues. This methodology ensures compliance with NGSI protocol standards for transmission segment methane intensity calculations.

5.7 Processing-Specific Quantification Methods

5.7.1 Processing Plant Methane Intensity Calculation

For natural gas processing operations, methane intensity shall be calculated using the NGSI 2.0 processing methodology:

$$ProcessingMI = \frac{TotalProcessCH4Emissions}{ProcessedGasThroughput}$$

```
Processing_MI = Total_Processing_CH4_Emissions /
Processed_Gas_Throughput
```

Where:

- `Total_Processing_CH4_Emissions` includes all emission sources within the processing plant boundary.
- `Processed_Gas_Throughput` is measured as pipeline-quality gas output.

5.7.2 NGL Product Allocation Methodology

When processing operations produce both residue gas and NGL products, emissions shall be allocated using energy content allocation:

$$ResidueGasAllocationFactor = \frac{ResidueGasEnergyContent}{TotalFeedGasEnergyContent}$$

```
Residue_Gas_Allocation_Factor = Residue_Gas_Energy_Content /
(Total_Feed_Gas_Energy_Content)
```

$$NGLAllocationFactor = \frac{NGLEnergyContent}{TotalFeedGasEnergyContent}$$

```
NGL_Allocation_Factor = NGL_Energy_Content /
Total_Feed_Gas_Energy_Content
```

Where:

- `Residue_Gas_Energy_Content` is the energy content in MMBtu of the residue (processed) gas.
- `NGL_Gas_Energy_Content` is the energy content in MMBtu of the NGL products.
- `Total_Feed_Gas_Energy_Content` is the total input in MMBtu of the processing plant.

5.7.3 Processing Efficiency Calculation

Processing efficiency shall be calculated as:

$$ProcessingEfficiency = \frac{ResidueGasEnergyContent}{Total\_Feed\_Gas\_Energy\_Content}$$

```
Processing_Efficiency = Processed_Gas_Output_MMBtu /
Raw_Gas_Input_MMBtu
```

Where:

- `Residue_Gas_Energy_Content` is the energy content in MMBtu of the residue (processed) gas.
- `Total_Feed_Gas_Energy_Content` is the total input in MMBtu of the processing plant.

This factor shall be applied to account for fuel gas consumption and processing losses.

5.7.4 Multi-Product Processing Facilities

Develop and apply methodologies for natural gas processing facilities that receive raw gas from multiple input sources and produce several output products. The work involves creating allocation systems that accurately attribute emissions to each gas source and product stream, reflecting the operational complexity of integrated processing sites. This requires detailed analysis of process configurations, tracking of material and energy flows, and validation of data to ensure transparency and verifiability. All methodologies must meet the precision and assurance criteria for QET production and align with ISO 14064-3 verification requirements.

5.7.4.1 Facility Classification and Scope Definition

Identify multi-product processing facilities and set the operational boundaries that define when specialized allocation methodologies are required, based on the number of input streams, product outputs, and integration of process units.

Multi-Source Input Classification:

- **Multiple feed gas sources:** Processing facilities receiving raw gas from two or more distinct production areas, reservoir systems, or upstream operators, each potentially

having different compositional characteristics and emission profiles that require separate tracking and allocation.
- **Integrated gathering and processing systems:** Facilities where gathering operations from multiple production areas are integrated with processing operations under common operational control, requiring allocation of processing emissions back to specific production sources.
- **Third-party processing services:** Processing facilities that provide tolling or processing services to multiple upstream operators, necessitating allocation of facility emissions to specific customers or gas sources for accurate environmental attribute determination.

Multi-Product Output Classification:
- **Residue gas differentiation:** When processed natural gas from different input sources maintains separate identity through processing and is delivered to different pipeline systems or customers, requiring source-specific emission allocation.
- **NGL product allocation:** When natural gas liquids extracted during processing must be allocated to specific input gas sources based on feed gas composition and extraction efficiency, ensuring accurate environmental attribute assignment.
- **Integrated product streams:** When products from different input sources are blended during processing, requiring weighted allocation methodologies that maintain traceability to original sources while accounting for processing efficiency variations.

5.7.4.2 Multi-Source Allocation Methodology Framework

Establish a hierarchical approach for allocating emissions across multiple input gas sources, using systematic methods that ensure accurate attribution while maintaining alignment with ISO 14064-3 principles and QET verification requirements.

Step 1: Total Facility Emissions Inventory Development
- **Comprehensive boundary definition:** All emissions within the processing plant boundary shall be quantified following the boundary definition requirements established in Section 16.1, ensuring complete coverage of emission sources including combustion, vented, fugitive, and process-specific emissions from all processing units serving multiple input sources.
- **Temporal alignment:** Emissions inventory shall be developed for time periods that align with input gas processing periods, ensuring that emission attribution accurately reflects the specific gas sources being processed during each time interval and accounting for operational variations that affect emission rates.
- **Equipment-specific emissions tracking:** Processing facilities shall implement monitoring systems capable of tracking emissions from shared equipment and utilities to enable accurate allocation among multiple gas sources, including dedicated monitoring for equipment serving multiple input streams simultaneously.

Step 2: Input Gas Source Characterization and Allocation Factor Development

- **Source-specific throughput measurement:** Accurate measurement of volumetric and energy throughput for each input gas source shall be maintained using custody transfer quality meters at each input point, providing the basis for proportional allocation of facility emissions among different gas sources.
- **Compositional analysis by source:** Regular analysis of input gas composition from each source shall be conducted to determine heating values, identify compositional differences that affect processing requirements, and establish source-specific processing intensity factors that influence emission allocation.
- **Processing complexity assessment:** Each input gas source shall be evaluated for processing complexity requirements including acid gas content, water content, NGL content, and other factors that affect the processing energy and emissions intensity required for that specific gas stream.

Step 3: Source-Specific Allocation Factor Calculation

- Following **QET Section 5.7.2** and **NGSI 2.0 Processing Protocol** compliance requirements:

$$SourceAllocationFactor_i = \frac{\left(SourceEnergyContent_i \times ProcessingComplexityFactor_i\right)}{(TotalFacilityEnergyProcess \times WeightedComplexity)}$$

```
Source_Allocation_Factor_i = (Source_Energy_Content_i * Processing_Complexity_Factor_i) / (Total_Facility_Energy_Processing * Weighted_Complexity)
```

Where:

- `Source_Energy_Content_i` represents the total energy content of gas processed from source i during the reporting period.
- `Processing_Complexity_Factor_i` accounts for the relative processing intensity required for source i based on compositional analysis and processing requirements.
- `Total_Facility_Energy_Processing` represents the aggregate energy content of all gas processed during the reporting period.
- `Weighted_Complexity` represents the facility-wide average processing complexity weighted by throughput.

Step 4: Allocated Emissions Calculation and Source-Specific Methane Intensity Determination

- **Proportional emissions allocation:** Total facility emissions shall be allocated to each input gas source using the calculated allocation factors, ensuring that the sum of allocated emissions equals total facility emissions and maintaining mathematical consistency across all allocation calculations.
- **Source-specific intensity calculation:** For each input gas source i:

$$SourceMethaneIntensity_i = \frac{AllocatedCH4Emissions_i}{SourceEnergyContent_i}$$

```
Source_Methane_Intensity_i = Allocated_CH4_Emissions_i /
Source_Energy_Content_i
```

$$SourceCarbonIntensity_i = \frac{AllocatedTotalCO2eEmissions_i}{SourceEnergyContent_i}$$

```
Source_Carbon_Intensity_i = Allocated_Total_CO2e_Emissions_i /
Source_Energy_Content_i
```

Where:

- `Allocated_CH4_Emissions_i` is the proportional share of all facility CH4 emissions attributed to processing gas from source `i`.
- `Allocated_Total_CO2e_Emissions_i` is the proportional share of all facility CO2e emissions attributed to processing gas from source `i`
- `Source_Energy_Content_i` represents the total energy content of gas processed from source i during the reporting period.

5.7.4.3 Processing Complexity Assessment Methodology

Provide guidance for quantifying processing complexity factors that reflect differences in processing requirements among various input gas sources, ensuring that emission allocation corresponds to the relative processing intensity of each source.

Complexity Factor Components:

- **Acid gas processing intensity:** Sources with higher H_2S and CO_2 content require more intensive processing in amine treating systems, resulting in higher energy consumption and emissions per unit of gas processed, quantified through:
  - Amine circulation rates relative to baseline conditions
  - Regeneration energy requirements per unit of acid gas removed
  - Additional equipment operating hours for high-acid gas processing
- **Dehydration processing intensity:** Sources with higher water content require more intensive dehydration processing, affecting both energy consumption and emissions from dehydration units, quantified through:
  - Glycol circulation rates relative to baseline conditions
  - Regeneration energy requirements per unit of water removed
  - Molecular sieve regeneration frequency for high-water content gas
- **NGL extraction processing intensity:** Sources with higher NGL content require more intensive processing for efficient extraction, affecting refrigeration energy consumption and overall processing emissions, quantified through:
  - Refrigeration load relative to baseline extraction conditions

- Fractionation energy requirements per unit of NGL recovered
- Additional equipment utilization for high-NGL content processing

Complexity Factor Calculation:

$$ProcessingComplexityFactor_i = WeightedAvg \times (AcidGasFactor_i \times 0.4 + DehydrationFactor_i \times 0.3 + NGLFactor_i \times 0.3)$$

```
Processing_Complexity_Factor_i = Weighted_Average [(Acid_Gas_Factor_i * 0.4) + (Dehydration_Factor_i * 0.3) + (NGL_Factor_i * 0.3)]
```

Where:

- Each component factor is normalized to a baseline of 1.0 representing average processing conditions, with factors above 1.0 indicating higher processing intensity and factors below 1.0 indicating lower processing intensity relative to facility average.

5.7.4.4 Multi-Product Output Allocation Requirements

Allocate emissions in facilities that produce multiple products from each input source, using nested allocation methodologies that maintain traceability from inputs through processing to final products.

Hierarchical Allocation Approach:

- **Primary allocation by input source:** Following the methodology established in **Sections 5.7.4.2** and **5.7.4.3**, total facility emissions shall first be allocated among input gas sources based on throughput and processing complexity factors.
- Secondary allocation by output product: For each input source, allocated emissions shall be further allocated among output products (residue gas, ethane, propane, butanes, natural gasoline) using energy content methodology consistent with **QET Section 5.7.2** and **Section 4.2 of the LNG QET methodology**.
- **Cross-validation requirements:** The sum of all product-specific allocated emissions across all input sources shall equal total facility emissions, providing mathematical verification of allocation accuracy and completeness.

Product-Specific Allocation Calculation:

For each combination of input source `i` and output product `j`:

$$ProductEmissions_{i,j} = SourceAllocatedEmission_i \times ProductAllocationFactor_{i,j}$$

```
Product_Emissions_(i,j) = Source_Allocated_Emissions_i * Product_Allocation_Factor_(i,j)
```

Where:

$$ProductAllocationFactor_{i,j} = ProductEnergyContent_{i,j} \times TotalProductEnergyFromSource_i$$

```
Product_Allocation_Factor_(i,j) = Product_Energy_Content_(i,j) /
Total_Product_Energy_from_Source_i
```

5.7.4.5 Data Management and Quality Assurance Requirements

Implement data management protocols that ensure the accuracy and verifiability of complex allocation calculations, maintaining full compliance with ISO 14064-3 verification standards.

Source-Specific Data Collection:

- **Segregated measurement systems:** Multi-source processing facilities shall implement measurement systems capable of tracking throughput, composition, and operational parameters for each input gas source independently, ensuring data integrity and traceability throughout processing operations.
- **Automated data validation:** Real-time data validation systems shall verify material balance closure for each input source independently and in aggregate, providing immediate detection of measurement errors or allocation inconsistencies that could affect QET accuracy.
- **Historical data reconciliation:** Monthly reconciliation of input source data shall be conducted to verify allocation factor accuracy, identify trends in processing complexity, and validate the consistency of source-specific emission attribution over time.

Allocation Calculation Documentation:

- **Methodology documentation:** Complete documentation of allocation methodologies shall be maintained including mathematical formulas, data sources, calculation procedures, and quality assurance protocols applied to each allocation step.
- **Calculation audit trails:** All allocation calculations shall maintain complete audit trails showing input data, calculation steps, intermediate results, and final allocated emissions for each source and product combination, enabling independent verification of calculation accuracy.
- **Periodic methodology review:** Allocation methodologies shall be reviewed annually to assess accuracy, identify improvements, and ensure continued alignment with facility operations and processing optimization changes.

5.7.4.6 Verification Integration Requirements

Define verification requirements for multi-product processing facilities that address the added complexity and specific assurance needs of multi-source and multi-product allocation methodologies.

Enhanced Site Visit Requirements:

Following **Section 14 Site Visit Requirements**, verification of multi-product processing facilities shall include:

- **Source segregation verification:** Physical verification that input gas sources are properly measured and tracked through processing systems, confirming that allocation methodologies accurately reflect operational realities.
- **Processing equipment assessment:** Detailed evaluation of shared processing equipment to verify that allocation of equipment emissions among input sources accurately reflects operational utilization patterns and processing intensity requirements.
- **Product measurement verification:** Confirmation that output product measurement systems provide accurate data for allocation calculations and that product quality analysis supports source-specific allocation factors.

Allocation Methodology Verification:

- **Independent calculation verification:** Verifiers shall independently recalculate allocation factors using facility data to confirm mathematical accuracy and verify that allocation methodologies are correctly implemented.
- **Cross-validation testing**: Verifiers shall perform cross-validation of allocation results using alternative methodologies where possible, comparing energy-based allocation with mass-based allocation to assess reasonableness and identify potential systematic errors.
- **Sensitivity analysis:** Verifiers shall conduct sensitivity analysis to evaluate how changes in key allocation parameters affect final results, ensuring that allocation methodologies are sufficiently robust and that uncertainties are appropriately characterized.

Documentation Review Requirements:

- **Methodology compliance verification:** Verification that allocation methodologies comply with **QET Section 5.7.2**, **NGSI 2.0 Processing Protocol** requirements, and **Section 4.2 of the LNG QET methodology** to ensure consistency across QET applications.
- **Quality assurance assessment:** Evaluation of quality assurance procedures including data validation protocols, calculation verification procedures, and change management controls that ensure allocation accuracy throughout reporting periods.
- **Materiality assessment:** Application of materiality thresholds established in Section 8.3 to allocation calculations, ensuring that allocation errors do not exceed acceptable materiality limits for individual QET batches or aggregated portfolios.

6. Uncertainty Reporting Requirements

The assessment and management of uncertainty in emissions data represents an important aspect of environmental attribute quantification. However, within the QET framework, uncertainty data shall only be required to be communicated within the QET data structure when:

1. The producer's chosen measurement methodology and/or standard explicitly calls for an uncertainty rating (such as ISO 14067 for carbon footprinting);
2. The applicable regulatory program governing the emissions measurement requires uncertainty quantification and reporting; or
3. The QET producer voluntarily elects to include uncertainty data to enhance data transparency and confidence.

When uncertainty reporting is required based on the above criteria, the assessment shall follow the methodologies outlined in sections 6.1 through 6.4. When uncertainty reporting is not required by the chosen methodology or standard, the producer shall document the rationale for exclusion in the verification documentation but is not required to include uncertainty metrics in the QET data structure.

This approach allows flexibility for different measurement methodologies while ensuring that uncertainty is properly assessed when required by the applicable standard or when beneficial for data interpretation and quality assurance.
For measurement methodologies that do require uncertainty assessment, the following sections provide comprehensive guidance for quantification, evaluation, and reporting of uncertainty data within the QET framework.

6.1 Sources of Uncertainty

The QET methodology shall account for the following sources of uncertainty, each requiring specific quantification approaches:

6.1.1 Parameter Uncertainty

Parameter uncertainty encompasses variability in input parameters used for emissions calculations, including:

- **GHG emission factors:** Uncertainty in conversion factors used to translate activity data into emissions quantities.
- **Activity data:** Variability in operational data such as throughput or fuel consumption.
- **Physical constants:** Uncertainties in values such as global warming potentials or molecular weights.

For parameter uncertainty, the standard deviation (σ) shall be derived from:

- Published uncertainty ranges from authoritative sources for emission factors.
- Standard deviation calculations from multiple measurements for activity data.
- Manufacturer-specified accuracy ranges for measurement equipment.

6.1.2 Scenario Uncertainty

Scenario uncertainty addresses assumptions about conditions or hypothetical scenarios:

- **Use stage scenarios:** Variations in how products are used after production.
- **End-of-life scenarios:** Different potential disposal or recycling pathways.
- **Baseline scenarios:** Alternative reference cases for emissions reductions.

For scenario uncertainty, the standard deviation (σ) shall be derived through:

- Sensitivity analyses with different scenario assumptions.
- Standard deviation calculations across multiple plausible scenarios.
- Expert judgment to establish reasonable uncertainty bounds.

6.1.3 Model Uncertainty

Model uncertainty stems from simplifications or approximations in mathematical models:

- **Structural uncertainty:** How well the model represents the real-world system.
- **Parametric uncertainty:** How model parameters affect output uncertainty.
- **Algorithmic uncertainty:** Approximations used in calculations.

For model uncertainty, the standard deviation (σ) shall be derived through:

- Comparison of model outputs with empirical measurements.
- Model validation techniques to establish error distributions.
- Monte Carlo or other uncertainty propagation methods.

6.1.4 Measurement Uncertainty

Measurement uncertainty arises from equipment and methodological limitations:

- **Instrument precision:** Consistency of repeated measurements.
- **Instrument accuracy:** Closeness of measurements to true values.
- **Calibration uncertainty:** Errors in instrument calibration.
- **Minimum Detection Limits (MDL):** Lowest detectable emission quantity.

For measurement uncertainty, the standard deviation (σ) shall be derived from:

- Manufacturer specifications for instrument precision and accuracy.
- Standard deviation from repeated calibration measurements.
- Propagation of errors analysis for complex measurement systems.
- MDL adjustments for measurements below detection thresholds.

6.1.5 Temporal Uncertainty

Temporal uncertainty relates to how measurement frequency affects data representativeness over time. Based on comprehensive Monte Carlo simulation research, temporal uncertainty is significantly affected by:

- **Measurement frequency:** How often measurements are conducted (hourly to annually).

- **Emission event patterns:** Frequency, duration, and magnitude of routine and large emission events.
- **Measurement detection limits (MDL):** Minimum thresholds at which emissions can be detected.

For temporal uncertainty, the standard deviation (σ) shall be derived using the following approach:

1. Monte Carlo simulation methodology:

- Generate time series data for the site's emission rate over a year.
- Randomly sample from this time series at different frequencies.
- Calculate the median absolute percent error (MdAPE) between true and measured emission rates.

2. Quantification formula:

$$MdAPE = median\left(\frac{|ActualAnnualAvgEmissions_i - MeasuredAnnualAvgEmissions_i|}{ActualAnnualAvgEmssions_i}\right)$$

```
MdAPE = median{i=1..N} (|Actual_Annual_Avg_Emissions_i -
Measured_Annual_Avg_Emissions_i| / Actual_Annual_Avg_Emissions_i)
```

Where:

- `Actual_Annual_Avg_Emissions_i` is the actual annual average emission rate.
- `Measured_Annual_Avg_Emissions_i` is the measured annual average based on sampling frequency.
- `i`∈ [1, 1000]

3. Example uncertainty values based on detection limit of 5 kg/hr:

- Annual sampling: 95.5% uncertainty.
- Monthly sampling: 84.8% uncertainty.
- Weekly sampling: 52.4% uncertainty.
- Daily sampling: 25.9% uncertainty.
- Hourly sampling: 8.6% uncertainty.

4. Example uncertainty values based on daily sampling frequency:

- 500 kg/hr detection limit: 95.4% uncertainty.
- 100 kg/hr detection limit: 67.7% uncertainty.
- 50 kg/hr detection limit: 48.0% uncertainty.
- 10 kg/hr detection limit: 27.2% uncertainty.
- 1 kg/hr detection limit: 20.2% uncertainty.

5. Treatment of measurements below MDL:

- When measurements fall below detection limits, the value shall be imputed with the mean of the routine emission distribution.

6.1.6 Processing-Specific Uncertainty Sources

For QETs from processing operations, the following additional sources of uncertainty must be considered and, where material, quantified:

- **Multi-product allocation uncertainty:** Uncertainty arising from the allocation of emissions between residue gas and NGL products, especially where product composition or energy content varies.
- **Processing efficiency variation:** Uncertainty due to changes in plant efficiency, fuel use, or process upsets.
- **NGL composition analysis:** Uncertainty in laboratory analysis of NGL product streams, affecting allocation factors.
- **Process upset and maintenance events:** Uncertainty from unplanned events or maintenance that temporarily alter emissions or product allocation.

6.2 Uncertainty Calculation

The estimated uncertainty of emissions shall be calculated using the formula:

$$Uncertainty = \frac{StdDev}{\sqrt{nMeasurements}}$$

```
Uncertainty = StdDev / sqrt(n_Measurements)
```

Where:

- `StdDev` is the standard deviation derived from appropriate methods for each uncertainty source.
- `n_Measurements` is the number of measurements in the set.

For temporal uncertainty specifically, σ shall be derived from the MdAPE values based on the measurement technology's detection limit and frequency as outlined in Section 6.1.5.

The total uncertainty should not exceed ±10% of the mean value. When uncertainty exceeds this threshold, one or more of the following shall be implemented:

- Increased measurement frequency.
- Improved detection limits.
- Additional measurement points.
- Enhanced calibration procedures.

The target maximum uncertainty should not exceed ±10% of the mean value for measurement purposes, which is distinct from the materiality thresholds for verification (5% for individual batches, 2% for portfolios) established in Section 8.3.

6.3 Confidence Level Rating

Each QET must include a confidence level rating based on:

1. Minimum Detection Limit (MDL) in kg/hr.
2. Frequency of measurement (hourly, daily, weekly, monthly, quarterly, semi-annually, annual).
3. Calculated uncertainty percentage.

The confidence level shall be calculated as the inverse of uncertainty and expressed as a percentage. For example:

- A measurement with ±15% uncertainty would have an 85% confidence level.
- A measurement with ±35% uncertainty would have a 65% confidence level.

Based on the temporal uncertainty, confidence levels can be directly determined from the measurement frequency and detection limit matrix provided in Section 6.1.5, using the formula:

$$ConfidenceLevel = 1 - TemporalUncertainty$$

```
Confidence_Level = 1 - Temporal_Uncertainty
```

Note: This measurement-based confidence level rating is distinct from the "assurance level" concept discussed in Section 8.4, which refers to the depth and rigor of verification procedures.

6.4 Combining Uncertainties

When combining multiple sources of uncertainty, the following approaches shall be used.

For uncorrelated uncertainties (independent data) in a sum:

$$UTotalPercent = \frac{\sqrt{\sum_{i=1}^{n}\left(UPercent_i \times Quantity_i\right)^2}}{\sum_{i=1}^{n} Quantity_i}$$

```
U_Total_Percent = sqrt(Σ{i=1..n} ((U_Percent_i × Quantity_i)^2 )) / (
Σ{i=1..n} Quantity_i)
```

For uncorrelated uncertainties in a product:

$$UTotalPercent = \sqrt{\sum_{i=1}^{n} UPercent_i^{\,2}}$$

```
U_Total_Percent = sqrt(Σ{i=1..n} (U_Percent_i^2))
```

Where:

- `U_Total_Percent` is the total uncertainty as a percentage.
- `U_Percent_i` are the percentage uncertainties of the individual components.
- `Quantity_i` are the quantities being combined.

When combining measurement uncertainty with temporal uncertainty, both components shall be quantified separately using the methods described in Sections 6.1.4 and 6.1.5, then combined using the formulas above.

The overall uncertainty shall be clearly documented in the QET data structure to ensure transparency and appropriate interpretation of the emissions data.

7. QET Data Structure and Required Fields

7.1 Token Structure

Each QET shall include the following data components:

Core Identification Fields:

- Token asset type (e.g., NatGas: Production, Processing, Transportation, etc.)
- Token ID
- Defined boundary (including processing plant boundary for processing QETs)
- GPS location of Facility/pad/well/segments
- Basin (if applicable)
- Unit of measure, i.e., MMBtu
- Time stamps

Production-Specific Fields:

- Well/pad identification
- Production batch size

Processing-Specific Fields:

- Raw gas input specifications (volume, energy content, composition)
- Processed gas output specifications (residue gas volume, energy, heat content)
- NGL product data (total production, energy content, allocation method)
- Processing efficiency metrics
- Multi-product allocation methodology and factors
- Processing plant boundary description

Transportation-Specific Fields:

- Path segments array containing:
    - Segment ID
    - Receipt Location ID
    - Delivery Location ID
    - Contract ID
    - Scheduled volume
    - Segment-specific emissions data

Environmental Attribute Fields:

- Methane Intensity (kg CH_4/MMBtu)
- Carbon Intensity (kg CO_2e/MMBtu)
- CO_2 mass (kg CO_2/MMBtu)
- CH_4 mass (kg CH_4/MMBtu)
- N_2O mass (if applicable)

Verification Fields:

- Measurer (primary data provider) ID
- Validator/Auditor ID
- Producer ID
- Time of issuance
- Confidence level (when uncertainty reporting is required per Section 6)

7.2 Required Fields

- **MI:** Expressed as percentage (mcf/mcf) and energy-normalized (mcf/MMBtu).
- **CI:** kg CO2_22e/MMBtu using IPCC GWP.
- **Temporal Metadata:** Measurement timestamps and frequency.

For QETs from processing operations, the following data fields are required:

- **Raw gas input:** Volume (MMCF), energy content (MMBtu), heat content (MMBtu/MCF).
- **Processed gas output:** Residue gas volume (MMCF), energy (MMBtu), heat content.
- **NGL products:** Total production (bbls), total energy (MMBtu), allocation method (energy content basis).
- **Processing efficiency:** Input and output energy, calculated efficiency.
- **Multi-product allocation factors:** Calculated for each product stream.
- **Processing plant boundary:** Facility ID, boundary description, GPS location.
- **Methane and carbon intensities:** As per Section 5.7.
- **Verification and standards compliance:** As per Section 7.1.

7.3 Sample JSON Schema for Data Submission - Natural Gas Production

QET measured data shall be submitted using a JSON structure that aligns with the producer's specified measurement methodology(s)/standard(s). The structure shall include (note: all attribute values below are only for demonstration purposes):


```json
{
 "_id": "96ebfba9-1de0-4e23-99a3-d1ffa40072dc",
 "energy": {
   "type": "natural-gas",
   "quantity": {
     "amount": 15119,
     "uom": "MMBtu"
   },
   "stage": "upstream"
 },
 "periodStart": "2024-12-01T00:00:00Z",
 "periodEnd": "2024-12-31T23:59:59Z",
 "token": {
   "tokenType": "QET",
   "createdAt": "2025-07-25T16:27:22.521Z",
   "updatedAt": "2025-07-25T16:27:22.521Z"
 },
 "boundary": {
   "producer": {
     "id": "PROD-NAT-1045",
     "name": "NaturalGas Producers LLC"
   },
   "stage": "production",
   "basin": "Permian",
   "category": "well",
   "field": "Grand Valley",
   "identifier": {
     "format": "api",
     "id": "42-123-45678"
   },
   "location": {
     "latitude": 31.4229,
     "longitude": -103.4938
   },
   "name": "BJU B17 FED 23A-26-496",
```

```
    "number": "B17",
    "pad": "H17"
  },
  "productionBatchData": {
    "productionDays": 31,
    "btuFactor": 1026.77,
    "methaneConcentration": 0.897613,
    "name": "H17_-_December_2024-2-1753460841990"
  },
  "standards": [
    {
      "workflowId": "d97b0fe4-6a07-4135-9dbe-af67993dc3a2",
      "standard": {
        "name": "NGSI",
        "url": "https://www.ngsi.com/",
        "carbonIntensityFactor": "GWP100(AR5)"
      },
      "carbonIntensity": {
        "formula": "Attributed kgs of CO2e emitted represented as CO2e
per MMbtu sold",
        "label": "CO2e of Carbon Intensity",
        "uom": "kg CO2e/MMBtu",
        "value": 0.01951593614
      },
      "methaneIntensity": {
        "formula": "Attributed kgs of Methane emitted represented as
CO2e per MMbtu sold",
        "label": "CO2e of Methane Intensity",
        "uom": "kg CO2e/MMBtu",
        "value": 0.01757715809
      },
      "scope": [
        {
          "scopeNumber": 1,
          "carbonIntensity": {
            "uom": "kg CO2e/MMBtu",
            "value": 0.0190245343
          },
```

```
        "methaneIntensity": {
          "uom": "kg CO2e/MMBtu",
          "value": 0.01757715809
        },
        "emissions": [
          {
            "methodology": {
              "name": "NGSI Methane Emissions Intensity Protocol
Version 2.0: Emission Factor-Based Estimation",
              "type": "measured",
              "granularity": "pollutantSource",
              "measurement": {
                "frequency": {
                  "description": "Daily monitoring via fixed
sensors",
                  "uom": "hours",
                  "value": 24
                },
                "minimumDetectionLimit": {
                  "uom": "kg/hr",
                  "value": 0.25
                },
                "technology": "Optical Gas Imaging with
Quantification",
                "temporalUncertainty": {
                  "calculationMethod": "Monte Carlo simulation as per
Section 6.1.5",
                  "uom": "percentage",
                  "value": 25.9
                }
              }
            },
            "pollutant": "CH4",
            "measurerData": {
              "pollutantMassAbsolute": {
                "formula": "Attributed CH4 emissions based on energy
produced converted to kg",
                "label": "NGSI CH4 Mass",
```

```
                "uom": "kg",
                "value": 9.491037613
              },
              "pollutantMassPerUnit": {
                "formula": "Attributed CH4 emissions based on energy
sold converted to kgs per MMbtu sold",
                "label": "CH4 Mass per MMbtu sold",
                "uom": "kg/MMBtu",
                "value": 0.000627755646
              },
              "pollutantIntensity": {
                "formula": "kg of attributed CH4 emitted divided by
kg of methane produced represented as a percent",
                "label": "NGSI CH4 Intensity",
                "uom": "percentage",
                "value": 0.00002163679204
              },
              "carbonIntensity": {
                "uom": "kg CO2e/MMBtu",
                "value": 0.01757715809
              },
              "uncertainty": {
                "formula": "As outlined in QET methodology document",
                "label": "Uncertainty (in %)",
                "uom": "percentage",
                "value": 15
              },
              "confidenceLevel": {
                "applicabilityReason": "Producer voluntarily elected
to include uncertainty data",
                "uom": "percentage",
                "value": 85,
                "combinedUncertainty": 15,
                "measurementUncertainty": 5.2,
                "temporalUncertainty": 9.8
              }
            },
            "source": {
```

```
              "id": "PAD-23A-WELL-04",
              "monitoringEquipment": "QL-500 Continuous Methane
Monitor",
              "type": "wellhead"
            }
          },
          {
            "methodology": {
              "name": "NGSI Methane Emissions Intensity Protocol
Version 2.0",
              "type": "Emission Factor-Based Estimation"
            },
            "pollutant": "N2O",
            "measurerData": {
              "pollutantMass": {
                "formula": "Attributed N2O emissions based on energy
produced converted to kg",
                "label": "N2O Mass",
                "uom": "kg",
                "value": 0.0825769093
              },
              "pollutantMassPerUnit": {
                "formula": "Attributed N2O emissions based on energy
sold converted to kgs per MMbtu sold",
                "label": "N2O Mass per MMbtu sold",
                "uom": "kg/MMBtu",
                "value": 0.00000546179703
              },
              "carbonIntensity": {
                "uom": "kg CO2e/MMBtu",
                "value": 0.001447376213
              }
            }
          }
        ]
      }
    ],
    "verification": {
```

```
        "producer": {
          "id": "PROD-NAT-1045",
          "name": "NaturalGas Producers LLC",
          "user": "user@producer.com"
        },
        "measurer": {
          "accreditation": "ISO-14065-2024-015",
          "id": "MEAS-2023-097",
          "name": "EcoMonitors Inc.",
          "user": "user@measurer.com"
        },
        "validator": {
          "accreditation": "ANAB-VER-2024-078",
          "id": "VAL-ISO-4832",
          "name": "GreenCert Verification Services",
          "user": "user@validator.com"
        },
        "issuance": {
          "timestamp": "2025-01-15T14:23:56Z"
        },
        "statement": {
          "assuranceLevel": "limited",
          "opinionType": "unmodified",
          "reference": "VER-2025-01-00567",
          "timestamp": "2025-01-14T09:32:17Z",
          "url":
"https://registry.earndlt.com/verification/VER-2025-01-00567"
        }
      }
    },
    {
      "workflowId": "d97b0fe4-6a07-4135-9dbe-af67993dc3a2",
      "standard": {
        "name": "EPA eGrid",
        "url": "https://www.epa.gov/egrid",
        "carbonIntensityFactor": "GWP100(AR5)"
      },
      "scope": [
```

```
        {
          "scopeNumber": 2,
          "carbonIntensity": {
            "uom": "kg CO2e/MMBtu",
            "value": 0.0004914018387
          },
          "emissions": [
            {
              "methodology": {
                "name": "EPA eGrid CO2",
                "type": "measured"
              },
              "pollutant": "CO2",
              "measurerData": {
                "pollutantMass": {
                  "formula": "Attributed CO2 emissions based on energy
produced converted to kg",
                  "label": "CO2 Mass",
                  "uom": "kg",
                  "value": 7.429504399
                },
                "pollutantMassPerUnit": {
                  "formula": "Attributed CO2 emissions based on energy
sold converted to kgs per MMbtu sold",
                  "label": "CO2 Mass per MMbtu sold",
                  "uom": "kg/MMBtu",
                  "value": 0.0004914018387
                },
                "carbonIntensity": {
                  "uom": "kg CO2e/MMBtu",
                  "value": 0.0004914018387
                }
              }
            }
          ],
          "verification": {
            "confidenceLevel": {
```

```
            "applicabilityReason": "Producer voluntarily elected to
include uncertainty data",
            "uom": "percentage",
            "value": 85,
            "combinedUncertainty": 15,
            "measurementUncertainty": 5.2,
            "temporalUncertainty": 9.8
          }
        }
      }
    ],
    "verification": {
      "issuance": {
        "timestamp": "2025-01-15T14:23:56Z"
      },
      "measurer": {
        "accreditation": "ISO-14065-2024-015",
        "id": "MEAS-2023-097",
        "name": "EcoMonitors Inc."
      },
      "producer": {
        "id": "PROD-NAT-1045",
        "name": "NaturalGas Producers LLC"
      },
      "statement": {
        "assuranceLevel": "limited",
        "opinionType": "unmodified",
        "reference": "VER-2025-01-00567",
        "timestamp": "2025-01-14T09:32:17Z",
        "url":
"https://registry.earndlt.com/verification/VER-2025-01-00567"
      },
      "validator": {
        "accreditation": "ANAB-VER-2024-078",
        "id": "VAL-ISO-4832",
        "name": "GreenCert Verification Services"
      }
    }
```

```
    }
  ]
}
```

7.4 Sample JSON Schema for Data Submission - Natural Gas Transportation

QET transportation data shall be submitted using a JSON structure that focuses specifically on midstream pipeline transportation activities between defined receipt and delivery locations. The structure shall align with NGSI 2.0 protocols and include path-based emissions allocation methodology. Note: all attribute values below are only for demonstration purposes.


```json
{
  "_id": "8f2e9d4a-7c3b-4f1e-9a8b-3d5c6e7f8a9b",
  "energy": {
    "type": "natural-gas",
    "quantity": {
      "amount": 15119,
      "uom": "MMBtu"
    },
    "stage": "midstream"
  },
  "timeStamps": {
    "periodStart": "2024-11-01T00:00:00Z",
    "periodEnd": "2024-11-30T23:59:59Z"
  },
  "token": {
    "tokenType": "QET",
    "tokenAssetType": "NatGas-Transmission",
    "createdAt": "2025-07-25T16:27:22.521Z"
  },
  "verification": {
    "issuance": {
      "timestamp": "2025-01-20T11:45:32Z"
    },
    "measurer": {
      "accreditation": "ISO-14065-2024-015",
      "id": "MEAS-TRANS-097",
```

```
      "name": "Pipeline Emissions Monitoring Inc."
    },
    "producer": {
      "id": "PROD-TRANS-234",
      "name": "Interstate Pipeline Consortium"
    },
    "statement": {
      "assuranceLevel": "limited",
      "opinionType": "unmodified",
      "reference": "VER-TRANS-2025-00234",
      "timestamp": "2025-01-19T15:22:14Z",
      "url":
"https://registry.earndlt.com/verification/VER-TRANS-2025-00234"
    },
    "validator": {
      "accreditation": "ANAB-VER-2024-078",
      "id": "VAL-TRANS-489",
      "name": "Midstream Verification Services"
    }
  },
  "boundary": {
    "producer": {
      "id": "PROD-TRANS-234",
      "name": "Interstate Pipeline Consortium"
    },
    "stage": "Transmission",
    "serviceType": "Pipeline",
    "contractId": "CONTRACT-456",
    "receiptLocation": {
      "ID": "RCPT-LOC-LA-002",
      "Name": "DELHHUISJERA-E054GH",
      "Segment": 390
    },
    "deliveryLocation": {
      "ID": "DLVRY-LOC-TX-001",
      "Name": "MGH-BREA-MOULTRIE",
      "Segment": 380
    }
```

```
},
"standards": [
  {
    "scope": [
      {
        "scopeNumber": 1,
        "standard": {
          "name": "NGSI",
          "url": "https://www.ngsi.com/"
        },
        "calculationMethod": {
          "carbonIntensity": "path-based-allocation",
          "methaneIntensity": "path-based-allocation"
        },
        "emissions": [
          {
            "pollutant": "CO2",
            "measurerData": {
              "pollutantMassAbsolute": {
                "label": "NGSI CO2 Mass",
                "uom": "kg",
                "value": 1502.2816
              },
              "pollutantCO2eAbsolute": {
                "label": "NGSI CO2 CO2e",
                "uom": "kg",
                "value": 1502.2816
              }
            }
          },
          {
            "pollutant": "CH4",
            "measurerData": {
              "pollutantMassAbsolute": {
                "label": "NGSI CH4 Mass",
                "uom": "kg",
                "value": 5.097413
              },
```

```
        "pollutantCO2eAbsolute": {
          "label": "NGSI CH4 CO2e",
          "uom": "kg",
          "value": 142.727564
        }
      }
    },
    {
      "pollutant": "N2O",
      "measurerData": {
        "pollutantMassAbsolute": {
          "label": "NGSI N2O Mass",
          "uom": "kg",
          "value": 0.002816
        },
        "pollutantCO2eAbsolute": {
          "label": "NGSI N2O CO2e",
          "uom": "kg",
          "value": 0.74624
        }
      }
    }
  ],
  "emissionsCO2eWithoutPipelineAllocation": {
    "carbonIntensityAbsolute": {
      "label": "CO2e of Carbon Intensity (without allocated
pipeline emissions) per contract absolute",
      "uom": "kg CO2e",
      "value": 1645.755404
    },
    "carbonIntensityAllocation": {
      "label": "CO2e of Carbon Intensity (without allocated
pipeline emissions) per contract per MMBtu",
      "uom": "kg CO2e/MMBtu",
      "value": 0.6551574061
    },
    "methaneIntensityAbsolute": {
```

```
            "label": "CO2e of Methane Intensity (without allocated
pipeline emissions) per contract absolute",
            "uom": "kg CO2e",
            "value": 142.727564
          },
          "methaneIntensityAllocation": {
            "label": "CO2e of Methane Intensity (without allocated
pipeline emissions) per contract per MMBtu",
            "uom": "kg CO2e/MMBtu",
            "value": 0.056818298
          }
        },
        "emissionsCO2eWithPipelineAllocation": {
          "carbonIntensityAbsolute": {
            "label": "CO2e of Carbon Intensity (with allocated
pipeline emissions) per contract absolute",
            "uom": "kg CO2e",
            "value": 1645.756135374
          },
          "carbonIntensityAllocation": {
            "label": "CO2e of Carbon Intensity (with allocated
pipeline emissions) per contract per MMBtu",
            "uom": "kg CO2e/MMBtu",
            "value": 0.655157697203
          },
          "methaneIntensityAbsolute": {
            "label": "CO2e of Methane Intensity (with allocated
pipeline emissions) per contract absolute",
            "uom": "kg CO2e",
            "value": 142.72829462
          },
          "methaneIntensityAllocation": {
            "label": "CO2e of Methane Intensity (with allocated
pipeline emissions) per contract per MMBtu",
            "uom": "kg CO2e/MMBtu",
            "value": 0.056818589
          }
        },
```

```
"segments": [
  {
    "operatorID": "PHMSA-OP-12345",
    "operatorName": "ABC Pipeline Co.",
    "segmentId": 390,
    "standard": {
      "name": "NGSI",
      "url": "https://www.ngsi.com/"
    },
    "workflowId": "3c470178-9e31-4345-a62a-562591a080d3",
    "emissions": [
      {
        "pollutant": "CO2",
        "measurerData": {
          "pollutantMassAbsolute": {
            "label": "NGSI CO2 Mass",
            "uom": "kg",
            "value": 549.1
          },
          "pollutantCO2eAbsolute": {
            "label": "NGSI CO2 CO2e",
            "uom": "kg",
            "value": 549.1
          }
        }
      },
      {
        "pollutant": "CH4",
        "measurerData": {
          "pollutantMassAbsolute": {
            "label": "NGSI CH4 Mass",
            "uom": "kg",
            "value": 2.138649
          },
          "pollutantCO2eAbsolute": {
            "label": "NGSI CH4 CO2e",
            "uom": "kg",
            "value": 59.882172
```

```
          }
        }
      },
      {
        "pollutant": "N2O",
        "measurerData": {
          "pollutantMassAbsolute": {
            "label": "NGSI N2O Mass",
            "uom": "kg",
            "value": 0.00102
          },
          "pollutantCO2eAbsolute": {
            "label": "NGSI N2O CO2e",
            "uom": "kg",
            "value": 0.2703
          }
        }
      }
    ],
    "metadata": {
      "uncertaintyPercent": 15
    }
  },
  {
    "operatorID": "PHMSA-OP-12345",
    "operatorName": "ABC Pipeline Co.",
    "segmentId": 380,
    "standard": {
      "name": "NGSI",
      "url": "https://www.ngsi.com/"
    },
    "workflowId": "3c470178-9e31-4345-a62a-562591a080d3",
    "emissions": [
      {
        "pollutant": "CO2",
        "measurerData": {
          "pollutantMassAbsolute": {
            "label": "NGSI CO2 Mass",
```

```
        "uom": "kg",
        "value": 953.1816
      },
      "pollutantCO2eAbsolute": {
        "label": "NGSI CO2 CO2e",
        "uom": "kg",
        "value": 953.1816
      }
    }
  },
  {
    "pollutant": "CH4",
    "measurerData": {
      "pollutantMassAbsolute": {
        "label": "NGSI CH4 Mass",
        "uom": "kg",
        "value": 2.958764
      },
      "pollutantCO2eAbsolute": {
        "label": "NGSI CH4 CO2e",
        "uom": "kg",
        "value": 82.845392
      }
    }
  },
  {
    "pollutant": "N2O",
    "measurerData": {
      "pollutantMassAbsolute": {
        "label": "NGSI N2O Mass",
        "uom": "kg",
        "value": 0.001796
      },
      "pollutantCO2eAbsolute": {
        "label": "NGSI N2O CO2e",
        "uom": "kg",
        "value": 0.47594
      }
```

```
                }
              }
            ],
            "metadata": {
              "uncertaintyPercent": 15
            }
          }
        ],
        "measurerData": {
          "pHMSAIntegration": {
            "dataSource": "PHMSA Annual Report",
            "operatorDataAlignment": "verified",
            "reportingYear": 2024,
            "throughputVerification": "confirmed"
          },
          "uncertainty": {
            "components": {
              "combined": 15,
              "measurement": 6.2,
              "temporal": 8.8
            }
          },
          "confidenceLevel": {
            "uom": "percentage",
            "value": 85
          }
        },
        "methodology": {
          "granularity": "pathSegment",
          "measurement": {
            "calibration": {
              "lastCalibration": "2024-10-20T14:00:00Z",
              "nextCalibration": "2025-02-20T14:00:00Z",
              "standard": "NIST-traceable reference gas with
pipeline-specific corrections"
            },
            "frequency": {
```

```
              "description": "Twice-daily monitoring via distributed
fiber optic sensors",
              "uom": "hours",
              "value": 12
            },
            "minimumDetectionLimit": {
              "uom": "kg/hr",
              "value": 0.5
            },
            "technology": "Distributed Acoustic Sensing with
Quantification",
            "temporalUncertainty": {
              "calculationMethod": "Monte Carlo simulation as per
Section 6.1.5 adapted for transportation segments",
              "uom": "percentage",
              "value": 18.5
            }
          },
          "transportationSpecific": {
            "allocationFormula": "sum of segment emissions per
throughput MMBtu allocated to contract segments",
            "doubleCountingPrevention":
"segment-level-normalization",
            "pHMSAIntegration": true,
            "pathBasedCalculation": true,
            "segmentAllocation": "flow-proportional"
          },
          "type": "Path-Based Emissions Allocation"
        },
        "qualityAssurance": {
          "auditTrail": {
            "dataCollection": "2024-11-01T00:00:00Z",
            "dataProcessing": "2024-12-03T10:30:00Z",
            "finalApproval": "2024-12-12T14:20:00Z",
            "qualityReview": "2024-12-08T16:45:00Z"
          },
          "segmentVerification": {
            "allocationFactorValidation": "independently_calculated",
```

```
            "operatorDataAlignment": "confirmed",
            "pHMSAThroughputConfirmation": "verified"
          }
        },
        "confidenceLevel": {
          "applicabilityReason": "NGSI 2.0 methodology requires
uncertainty reporting for transportation segments",
          "uom": "percentage",
          "value": 85,
          "combinedUncertainty": 15,
          "measurementUncertainty": 6.2,
          "temporalUncertainty": 8.8
        },
        "metadata": {
          "co2eFactors": {
            "Methodology": "GWP100 (AR5)",
            "CO2": 1,
            "CH4": 28,
            "N2O": 265
          },
          "pipelineEmissionsAllocationsCO2ePerSegmentPerMMBtu": {
            "CO2": 0.0000000003,
            "CH4": 0.000000290852,
            "N2O": 0,
            "Total": 0.000000291152
          }
        }
      }
    ]
  }
]
}
```

7.5 Sample JSON Schema for Data Submission - Natural Gas Processing

QET processing data shall be submitted using a JSON structure that captures the complexity of natural gas processing operations while maintaining alignment with NGSI 2.0 processing protocols. The structure shall include raw gas inputs, processed gas outputs, NGL product allocations, and processing unit-specific emissions data.


```
{
 "update": {
   "items": [
     {
       "_id": "c4f8e2d1-9b7a-4e3c-8f2d-1a5b9c3e7f4d",
       "tokenAssetType": "NatGas-Processing",
       "timeStamps": {
         "periodStart": "2024-11-01T00:00:00Z",
         "periodEnd": "2024-11-30T23:59:59Z"
       },
       "boundary": {
         "facilityId": "PROC-PLANT-TX-005",
         "facilityName": "Eagle Ford Processing Complex",
         "gpsLocation": "28.7041° N, 97.3301° W",
         "basin": "Eagle Ford",
         "plantCapacity_MMCF/d": 500,
         "boundaryDescription": "Raw gas inlet to pipeline-quality gas
outlet, including NGL extraction"
       },
       "processingData": {
         "rawGasInput": {
           "volume_MMCF": 12500,
           "energy_MMBtu": 12875,
           "heatContent_MMBtu/MCF": 1.030
         },
         "processedGasOutput": {
           "residueGas": {
             "volume_MMCF": 11850,
             "energy_MMBtu": 12138,
             "heatContent_MMBtu/MCF": 1.024
           }
         },
         "nglProducts": {
           "totalProduction_bbls": 15420,
           "totalEnergy_MMBtu": 737,
           "allocationMethod": "energy_content_basis"
```

```
          },
          "processingEfficiency": {
            "inputEnergy_MMBtu": 12875,
            "outputEnergy_MMBtu": 12875,
            "efficiency": 0.943
          }
        },
        "verification": {
          "measurer": {
            "id": "MEAS-PROC-089",
            "name": "Process Emissions Analytics Inc.",
            "accreditation": "ISO-14065-2024-020"
          },
          "validator": {
            "id": "VAL-PROC-567",
            "name": "Industrial Verification Services",
            "accreditation": "ANAB-VER-2024-092"
          },
          "producer": {
            "id": "PROD-PROC-156",
            "name": "Midstream Processing Corporation"
          },
          "issuance": {
            "timestamp": "2025-01-25T09:30:45Z",
            "blockchainTxHash": "0x9f2e8d3a7b5c4e1f..."
          },
          "statement": {
            "reference": "VER-PROC-2025-00156",
            "timestamp": "2025-01-24T14:15:22Z",
            "url":
"https://registry.earndlt.com/verification/VER-PROC-2025-00156",
            "assuranceLevel": "limited",
            "opinionType": "unmodified"
          },
          "confidenceLevel": {
            "value": 88,
            "uom": "percentage",
```

```
          "applicabilityReason": "NGSI 2.0 processing methodology
requires uncertainty reporting for multi-product facilities"
        }
      },
      "standards": [
        {
          "standard": {
            "name": "NGSI",
            "version": "2.0",
            "url": "https://www.ngsi.com/",
            "alignment": "NGSI 2.0 Processing Plant Protocol"
          },
          "carbonIntensity": {
            "value": 0.4567,
            "uom": "kg CO2e/MMBtu",
            "factor": "GWP100(AR5)",
            "multiProductAllocation": true
          },
          "scope": 1,
          "emissions": [
            {
              "pollutant": "CH4",
              "pollutantIntensity": {
                "value": 0.0434,
                "uom": "percentage"
              },
              "pollutantMass": {
                "value": 0.5967,
                "uom": "kg/MMBtu"
              },
              "carbonIntensity": {
                "value": 1.6708,
                "uom": "kg CO2e/MMBtu",
                "factor": "GWP100(AR5)"
              },
              "measurerData": {
                "totalPlantEmissions_kg": 536.2,
                "residueGasAllocation": 0.943,
```

```
      "nglAllocation": 0.057,
      "uncertainty": {
        "value": 12.1,
        "uom": "percentage"
      }
    },
    "methodology": {
      "granularity": "processingPlant",
      "name": "NGSI Processing Plant Methane Intensity
Protocol Version 2.0",
      "type": "Multi-Product Processing Facility
Allocation",
      "processingSpecific": {
        "multiProductAllocation": true,
        "allocationMethod": "energy_content_basis",
        "processingEfficiencyCalculation": true
      },
      "measurement": {
        "technology": "Continuous Monitoring with Process
Integration",
        "minimumDetectionLimit": {
          "value": 0.1,
          "uom": "kg/hr"
        },
        "frequency": {
          "value": 1,
          "uom": "hours",
          "description": "Continuous monitoring via
integrated process control system"
        },
        "temporalUncertainty": {
          "value": 15.2,
          "uom": "percentage",
          "calculationMethod": "Monte Carlo simulation
adapted for processing operations"
        }
      }
    },
```

```
            "source": {
              "id": "PROCESSING-PLANT-TX-005",
              "type": "processing_facility",
              "monitoringEquipment": "Integrated Process Monitoring
System"
            }
          },
          {
            "pollutant": "CO2",
            "pollutantMass": {
              "value": 1.0234,
              "uom": "kg/MMBtu"
            },
            "carbonIntensity": {
              "value": 1.0234,
              "uom": "kg CO2e/MMBtu",
              "factor": "GWP100(AR5)"
            },
            "methodology": {
              "type": "Direct_Measurement_and_Calculation",
              "measurement": {
                "technology": "CEMS_and_Process_Calculations",
                "frequency": {
                  "value": 1,
                  "uom": "hours"
                }
              }
            }
          },
          {
            "pollutant": "N2O",
            "pollutantMass": {
              "value": 0.00134,
              "uom": "kg/MMBtu"
            },
            "carbonIntensity": {
              "value": 0.4002,
              "uom": "kg CO2e/MMBtu",
```

```
              "factor": "GWP100(AR5)"
            },
            "methodology": {
              "type": "Emission_Factor_Based_Estimation"
            }
          }
        ]
      }
    ],
    "metadata": {
      "batchSize": 1000,
      "unitOfMeasure": "MMBtu",
      "commodityType": "Natural Gas",
      "processingType": "Multi-Product NGL Extraction",
      "facilityClassification": "Major Processing Plant",
      "feedGasSource": "Eagle Ford Shale",
      "productDestination": {
        "residueGas": "Interstate Pipeline System",
        "nglProducts": "Petrochemical Markets"
      }
    }
  }
 ]
}
}
```


7.6 EU Methane Regulation Compliance Extension

This subsection establishes the data structure extensions required for QETs representing crude oil and natural gas production facilities located outside the European Union where the crude oil or natural gas is destined for the EU market, in compliance with EU Methane Regulation Article 28.

7.6.1 Extension Applicability and Scope

The EU Methane Regulation (EUMR) extension is **optional** for standard QET applications but **mandatory** for crude oil and natural gas destined for EU markets under EUMR Article 28.

7.6.2 EU Compliance Data Requirements

When the EUMR extension is applied, the following additional data fields shall be included in the QET JSON structure:

7.6.2.1 Producer-Level Reporting Fields

```
"eumr": {
 "producerLevel": {
   "producerEntity": {
     "legalName": "string",
     "entityId": "string",
     "operationalControl": {
       "boundaryDescription": "string",
       "licensedAreaDefinition": {
         "geographicUnit": "string",
         "regulatoryBasis": "string",
         "boundaryCoordinates": "string",
         "geographicClassification": "string"
       }
     },
     "producerThroughputData": {
       "reportingPeriod": {
         "annualReportingYear": "YYYY",
         "qetVintageMonth": "YYYY-MM",
         "temporalBoundaryAlignment": "string"
       },
       "monthlyThroughput": {
         "reportingMonth": "YYYY-MM",
         "crudeOilProduction": {
           "monthlyVolume": {
             "value": 0.0,
             "uom": "barrels/month"
           },
           "energyContent": {
             "value": 0.0,
             "uom": "MMBtu/month"
           }
         },
         "naturalGasProduction": {
```

```
        "monthlyVolume": {
          "value": 0.0,
          "uom": "MCF/month"
        },
        "energyContent": {
          "value": 0.0,
          "uom": "MMBtu/month"
        }
      }
    },
    "annualAggregatedThroughput": {
      "totalAnnualProduction": {
        "crudeOilAnnual": {
          "value": 0.0,
          "uom": "barrels/year"
        },
        "naturalGasAnnual": {
          "value": 0.0,
          "uom": "MCF/year"
        },
        "totalEnergyAnnual": {
          "value": 0.0,
          "uom": "MMBtu/year"
        }
      },
      "monthlyBreakdown": [
        {
          "month": "YYYY-MM",
          "monthlyContribution": {
            "value": 0.0,
            "uom": "percentage"
          }
        }
      ]
    },
    "eemdlReconciliation": {
      "annualToMonthlyReconciliation": {
        "annualTotalFromMonthlySum": {
```

```
          "value": 0.0,
          "uom": "MMBtu/year"
        },
        "reportedAnnualTotal": {
          "value": 0.0,
          "uom": "MMBtu/year"
        },
        "reconciliationVariance": {
          "value": 0.0,
          "uom": "percentage"
        },
        "varianceExplanation": "string"
      }
    }
   }
  }
 }
}
```

7.6.2.2 Verification and Assurance Requirements

```
"eumr": {
 "verification": {
   "assuranceLevel": "reasonable",
   "assuranceLevelJustification": "EU Methane Regulation Article 8
requirement",
   "eemdlProtocolCompliance": true,
   "verifierCompetence": {
     "methaneSpecificTraining": true,
     "oilGasProductionExpertise": true,
     "euRegulationKnowledge": true
   }
 }
}
```

7.6.2.3 Reconciliation and Quality Assurance

Verifiers shall implement EEMDL Protocol reconciliation requirements by applying "best-estimate-integration" methodology per EUMR Article 12.6, calculating percentage differences between source-level quantification and site-level measurements using the formula:

$$\left|\frac{(SourceLevelTotal - SiteLevelTotal)}{SourceLevelTotal}\right| \times 100$$

```
|(Source_Level_Total - Site_Level-Total) / Source-Level Total| × 100
```

applying a 5% materiality threshold to annual producer-level totals, and documenting EEMDL tiered threshold responses where detections ≥100 kg-CH4/hr require mandatory investigation and adjustment regardless of materiality ("must address"), detections 10-100 kg-CH4/hr require investigation only if material to the annual inventory ("should address"), and detections <10 kg-CH4/hr are generally considered within noise range ("may address").

The reconciliation status shall be documented as "completed" when all material discrepancies are resolved, "pending" for minor clarification issues, or "investigation-required" for unresolved material discrepancies, with the final integration approach selected from source-level-accepted, site-level-accepted, or best-estimate-integration based on the weight of evidence, and all outstanding discrepancies documented with impact assessment on the verification conclusion.


```
"eumr": {
 "reconciliation": {
   "eemdlComplianceFramework": {
 "protocolVersion": "[Verifier confirms: September 8, 2025]",
 "reconciliationDefinition": "[Verifier confirms:
best-estimate-integration]"
},
   "sourceSiteLevelReconciliation": {
     "discrepancyAnalysis": {
       "percentageDifference": {
         "value": 0.0,
         "uom": "percentage"
       },
       "eemdlTieredAssessment": {
         "mustAddressDetections": [
           {
             "detectionMagnitude": {
               "value": 0.0,
               "uom": "kg-CH4/hr"
             },
             "investigationRequired": true,
             "adjustmentMade": "string"
           }
```

```
        ],
        "shouldAddressDetections": [
          {
            "detectionMagnitude": {
              "value": 0.0,
              "uom": "kg-CH4/hr"
            },
            "materialityAssessment": "material|immaterial"
          }
        ]
      }
    },
    "reconciliationOutcome": {
      "reconciliationStatus":
"completed|pending|investigation-required",
      "finalIntegrationApproach":
"source-level-accepted|site-level-accepted|best-estimate-integration",
      "outstandingDiscrepancies": "string"
    }
  }
 }
}
```

7.6.3 Site Visit Risk-Based Determination

For EU compliance applications, site visit requirements follow EEMDL Protocol risk-based determination:

```
"eumr": {
 "siteVisit": {
   "riskBasedDetermination": {
     "riskAssessmentCompleted": true,
     "eemdlSpecificTriggers": {
       "sourceVsSiteLevelDiscrepancies": {
         "identified": false,
         "description": "string",
         "materiality": "low|medium|high"
       },
       "measurementMethodologyComplexity": {
```

```
          "complexityLevel": "standard|moderate|high",
          "novelTechnologies": false,
          "validationRequired": false
        },
        "operationalChanges": {
          "significantChanges": false,
          "changeDescription": "string",
          "impactAssessment": "string"
        },
        "qualityControlWeaknesses": {
          "identified": false,
          "description": "string",
          "remediationRequired": false
        }
      },
      "riskMatrix": {
        "inherentRisk": "low|medium|high",
        "controlRisk": "low|medium|high",
        "detectionRisk": "low|medium|high",
        "overallRisk": "low|medium|high"
      },
      "visitDecision": {
        "visitRequired": false,
        "visitType": "physical|remote|hybrid|not-required",
        "justification": "string",
        "alternativeProcedures": [
          {
            "procedure": "string",
            "rationale": "string",
            "adequacy":
"sufficient|insufficient|requires-supplementation"
          }
        ]
      }
    }
  }
}
```

8. Verification and Validation Requirements

8.1 Documentation Requirements

8.1.1 Overview and Purpose

Comprehensive documentation is essential for ensuring the integrity, transparency, and auditability of QET verification and validation processes. This section establishes mandatory requirements for the documentation, management, retention, and security of all records related to QET verification and validation activities in accordance with ISO 14064-3:2019.

8.1.2 Record Types and Content Requirements

8.1.2.1 Core Documentation Set

The following documentation shall be maintained for all QET verification and validation engagements:

1. **Pre-engagement documentation**:
    - Impartiality risk assessment.
    - Competence evaluations.
    - Engagement agreements and terms.
    - Selected level of assurance justification.
    - Materiality threshold determination.
2. **Planning documentation**:
    - Strategic analysis records.
    - Risk assessment outcomes.
    - Verification or validation plan.
    - Evidence-gathering plan.
    - Sampling approach justification.
3. **Execution documentation**:
    - Evidence collected and analyzed.
    - Data trails examined.
    - Calculations performed.
    - Test results and analytical outcomes.
    - Interview records and site visit findings.
    - Records of who performed evidence-gathering activities and when.
4. **Completion documentation**:
    - Requests for clarification.
    - Identified material misstatements and nonconformities.
    - Communications with the responsible party.

- Resolution of issues.
- Independent review findings.
- Final conclusions and opinions.
- Verification or validation report.

8.1.2.2 Additional Required Documentation

Beyond the core set, the following documentation shall also be maintained:

1. **Methodology documentation**:
   - Measurement methodologies assessed.
   - Emission factors and calculation approaches.
   - Uncertainty assessment calculations.
   - QA/QC procedures evaluation.
2. **Boundary documentation**:
   - System boundary definitions.
   - Organizational structure diagrams.
   - Process flow diagrams.
   - Source inclusion/exclusion justifications.
   - Cut-off criteria application.
3. **Professional judgment documentation**:
   - Rationale for significant decisions made.
   - Assessments of conflicting evidence.
   - Justifications for conclusions reached.

8.1.3 Record Retention Requirements

8.1.3.1 Retention Periods

1. **Minimum retention period**: All verification and validation documentation shall be retained for a minimum of seven (7) years from the date of verification opinion issuance.
2. **Extended retention**: When QETs are used for compliance with regulatory programs, documentation shall be retained for the longer of:
   - The seven-year minimum period.
   - Three years beyond the compliance period for which the QETs are used.
   - Any period specified by applicable regulations.
3. **QET lifecycle alignment**: Documentation shall be retained for the full lifecycle of associated QETs, including throughout any trading, retirement, or claim periods.

8.1.3.2 Retention Responsibility

1. **Primary responsibility**: The verification body shall retain complete documentation for the required retention period.

2. **Secondary documentation**: The QET producer shall maintain relevant documentation to support future verification activities.
3. **Registry documentation**: The QET registry administrator shall retain digital records of verification opinions and token status changes for the full retention period.

8.1.4 Documentation Format Specifications

8.1.4.1 Digital Documentation Standards

1. **File formats**: Documentation shall be maintained in the following formats:
   - Text documents: PDF/A format (ISO 19005)
   - Spreadsheets: Both native format (.xlsx, .ods) and PDF/A
   - Data exports: CSV or JSON with schema documentation
   - Multimedia evidence: Common formats (JPEG, PNG, MP4) with metadata
2. **Minimum metadata**: All digital files shall include:
   - Creation date
   - Author/responsible person
   - Version number
   - Engagement identifier
   - Document classification
3. **Organization structure**: Files shall be organized hierarchically by:
   - Engagement
   - Stage of verification
   - Document type
   - Date

8.1.4.2 Physical Documentation Standards

When physical documentation exists:

1. **Conversion requirement**: All physical documents shall be digitized according to the digital documentation standards.
2. **Original preservation**: Original physical documents shall be retained when:
   - Required by regulations.
   - Digital versions cannot capture essential attributes.
   - Documents contain original signatures.
3. **Storage conditions**: Physical documents shall be stored in controlled environments that prevent deterioration.

8.1.5 Chain of Custody Requirements for Evidence

8.1.5.1 Evidence Collection

1. **Collection documentation**: For each piece of evidence collected, the verifier shall document:
    - Date and time of collection.
    - Person collecting the evidence.
    - Source of the evidence.
    - Method of collection.
    - Confirmation of authenticity.
    - Chain of custody initiation.
2. **Sample identification**: Each sample or piece of evidence shall receive a unique identifier that:
    - Links to the verification engagement.
    - Identifies the specific source.
    - Contains a timestamp.
    - Includes a sequential identifier.

8.1.5.2 Evidence Transfer and Handling

1. **Transfer documentation**: Each transfer of evidence between responsible parties shall be documented with:
    - Date and time of transfer.
    - Name and role of the transferor and transferee.
    - Purpose of transfer.
    - Confirmation of evidence integrity.
2. **Evidence logs**: A master evidence log shall be maintained that tracks:
    - All evidence collected.
    - Current custodian.
    - All transfers.
    - Access records.
    - Final disposition.
3. **Digital evidence integrity**: Digital evidence shall maintain integrity through:
    - Hash values calculated at collection.
    - Digital signatures where applicable.
    - Version control for any processing.
    - Audit trails for access and modification.

8.1.6 Documentation Accessibility Requirements

8.1.6.1 Access Levels

Documentation shall be classified into the following access levels:

1. **Public access**: Verification opinions and summary reports.
2. **Client access**: Verification reports and findings.

3. **Regulator access**: Evidence supporting verification conclusions.
4. **Restricted access**: Internal verification body working papers.

8.1.6.2 Accessibility Provisions

1. **Timely access**: Documentation shall be made accessible to authorized parties:
   - Within 24 hours for digital records.
   - Within 5 business days for physical records.
2. **Usability requirements**: Documentation shall be:
   - Searchable (for digital text).
   - Clearly labeled and indexed.
   - Cross-referenced where applicable.
   - Readable in standard software.
3. **Long-term accessibility**: Documentation format and storage shall ensure:
   - Technology migration paths for older formats.
   - Hardware-independent access.
   - Periodic verification of accessibility.
4. **Accommodation provisions**: Documentation shall be available in alternative formats upon reasonable request to accommodate accessibility needs.

8.1.7 Security and Confidentiality Protocols

8.1.7.1 Information Classification

All verification documentation shall be classified according to sensitivity:

1. **Public information**: Can be freely disclosed.
2. **Business confidential**: Limited to authorized business parties.
3. **Commercially sensitive**: Subject to strict need-to-know access.
4. **Personal information**: Subject to privacy regulations.

8.1.7.2 Security Controls

The following security controls shall be implemented:

1. **Access controls**:
   - Role-based access permissions.
   - Multi-factor authentication for sensitive information.
   - Access logging and monitoring.
   - Periodic access review.
2. **Transmission security**:
   - Encryption for all electronic transmissions (minimum AES-256).
   - Secure file sharing platforms.

- Email transmission restrictions for sensitive information.
- Secure physical transfer for physical documentation.

3. **Storage security**:
    - Encryption at rest for digital documentation.
    - Secure physical storage with access controls.
    - Backup and recovery procedures.
    - Environmental controls for physical storage.
4. **Information handling procedures**:
    - Clean desk policy.
    - Secure disposal methods.
    - Screen privacy measures.
    - Mobile device restrictions.

8.1.7.3 Confidentiality Agreements

1. **Mandatory agreements**: All personnel with access to verification documentation shall sign confidentiality agreements.
2. **Third-party requirements**: All external parties receiving verification information shall be subject to confidentiality provisions that:
    - Survive the verification engagement.
    - Specify acceptable use of information.
    - Prohibit unauthorized disclosure.
    - Include enforcement mechanisms.
3. **Disclosure protocols**: Procedures for authorized disclosure shall include:
    - Authorization levels required.
    - Notification requirements to affected parties.
    - Recordkeeping of disclosures.
    - Minimization principles (disclosing only necessary information).

8.1.8 Documentation System Capabilities

The documentation system used shall provide:

1. **Version control** with:
    - Automatic versioning.
    - Change tracking.
    - Author identification.
    - Timestamp logging.
2. **Audit trail** capabilities including:
    - Access logs.
    - Modification history.
    - Export and printing records.
    - Administrative actions.
3. **Search and retrieval** functions with:

- Full-text search capability.
    - Metadata filtering.
    - Relationship mapping between documents.
    - Batch retrieval options.
4. **Integration capabilities** with:
    - QET registry systems.
    - Electronic signature platforms.
    - Secure communication channels.
    - Backup systems.

8.1.9 Compliance and Quality Assurance

8.1.9.1 Documentation Review Process

1. **Internal review**: All verification documentation shall undergo internal review for:
    - Completeness.
    - Accuracy.
    - Consistency.
    - Compliance with this section's requirements.
2. **Periodic audits**: The verification body shall conduct annual audits of documentation practices.
3. **Remediation process**: Deficiencies identified in documentation shall be:
    - Recorded in a findings log.
    - Assigned to responsible personnel.
    - Remediated within defined timeframes.
    - Subject to follow-up verification.

8.1.9.2 Training Requirements

Personnel responsible for documentation shall receive:

1. Initial training on documentation requirements.
2. Annual refresher training.
3. Updates when documentation standards change.
4. Performance evaluation that includes documentation quality.

8.1.10 Implementation Timeline

Verification bodies shall:

1. Implement these documentation requirements within six months of methodology adoption.
2. Conduct a gap analysis of existing systems within three months.

3. Provide a transition plan for legacy documentation within one month of gap analysis completion.
4. Achieve full compliance by the specified implementation deadline.

8.2 Risk Assessment Methodology for QET Verification

This section establishes a comprehensive risk assessment framework for QET verification in accordance with ISO 14064-3:2019. It provides structured guidance for identifying, evaluating, and documenting risks that could lead to material misstatements in QET emissions data.

8.2.1 Risk Assessment Principles

Risk assessment in QET verification shall adhere to the following principles:

1. **Systematic approach**: Risk assessment shall follow a structured, methodical process.
2. **Evidence-based evaluation**: Risk determinations shall be based on objective evidence rather than assumptions.
3. **Materiality focus**: Risk assessment shall prioritize factors that could lead to material misstatements.
4. **Conservatism**: When facing uncertainty in risk evaluation, verifiers shall apply professional skepticism and err on the side of higher risk ratings.
5. **Continuous reassessment**: Risks shall be reevaluated as new information becomes available during verification.

8.2.2 Types of Risks in QET Verification

In accordance with ISO 14064-3:2019, the risk assessment shall identify and evaluate three distinct risk categories:

a) Inherent Risk: The susceptibility of QET emissions data to material misstatement, assuming no related internal controls. Inherent risks are related to the nature of the emissions sources, measurement technologies, and calculation methodologies.

b) Control Risk: The risk that a material misstatement will not be prevented or detected and corrected by the QET producer's internal control systems.

c) Detection Risk: The risk that the verifier will not detect a material misstatement in the QET emissions data.

The relationship between these risk types shall be considered when planning verification activities, recognizing that:

- Verification risk = Inherent risk × Control risk × Detection risk

- Higher inherent and control risks require more extensive verification procedures to reduce detection risk and maintain acceptable overall verification risk.

8.2.3 QET-Specific Risk Factors

The verifier shall consider the following QET-specific risk factors when conducting risk assessment:

a) Measurement Technology Risks

1. **Technology reliability**: Risks associated with the accuracy, precision, and reliability of measurement technologies used to quantify emissions.
2. **Minimum detection limits**: Risks related to emission levels below measurement technology detection thresholds.
3. **Calibration practices**: Risks linked to inadequate or improper calibration of measurement equipment.
4. **Measurement frequency**: Risks of non-representative data due to insufficient temporal coverage of measurements.
5. **Technology integration**: Risks associated with integration of multiple measurement technologies or approaches.

b) Calculation Methodology Risks

1. **Conversion accuracy**: Risks related to errors in conversion factors or unit conversions in the calculations.
2. **Algorithm complexity**: Risks associated with complex calculation methodologies that increase error potential.
3. **Parameter uncertainty**: Risks related to uncertainty in input parameters for emission calculations.
4. **Methodology consistency**: Risks of inconsistent application of calculation methodologies across facilities or time periods.
5. **Secondary data quality**: Risks associated with the use of secondary data when primary data is unavailable.

c) Data Management and System Risks

1. **Data collection processes**: Risks related to manual data entry, transmission, or aggregation errors.
2. **System integration**: Risks associated with transferring data between different systems.
3. **Data validation controls**: Risks related to inadequate data quality controls.
4. **Information security**: Risks associated with unauthorized access or modification of emissions data.
5. **Boundary definition**: Risks related to incorrect or inconsistent system boundary application.

d) Token Generation and Blockchain Risks

1. **Data transformation**: Risks associated with transforming emissions data into the QET format.
2. **Smart contract execution**: Risks related to the execution of token generation protocols.
3. **Token metadata accuracy**: Risks of incorrect environmental attribute information in token metadata.
4. **Registry integrity**: Risks associated with the QET registry and blockchain implementation.
5. **Double-counting prevention**: Risks related to potential double-counting of environmental attributes.

e) Organizational and Personnel Risks

1. **Technical competence**: Risks linked to insufficient technical expertise of personnel involved in emissions measurement and reporting.
2. **Management oversight**: Risks associated with inadequate management review and responsibility.
3. **Incentive structures**: Risks related to incentives that might influence reporting outcomes.
4. **Organizational changes**: Risks associated with changes in personnel, ownership, or operational control.
5. **Resource allocation**: Risks related to insufficient resources allocated to emissions monitoring and reporting.

f) Transportation-Specific Risks

1. **Path definition accuracy**: Risks related to incorrect identification of pipeline segments between receipt and delivery points.
2. **Flow allocation errors**: Risks associated with inaccurate calculation of flow proportions across pipeline segments.
3. **PHMSA data quality**: Risks related to accuracy and timeliness of PHMSA throughput reporting.
6. **Multi-segment complexity:** Risks arising from complex transportation paths involving multiple pipeline operators.
7. **Contract volume verification:** Risks related to accurate reporting of scheduled versus actual transported volumes.

g) Processing-Specific Risks

1. Multi-product allocation risks: Risks related to incorrect allocation of emissions between residue gas and NGL products.
2. Process variability risks: Risks associated with varying feed gas compositions and processing conditions.

3. Equipment complexity risks: Risks related to complex processing equipment with multiple emission points.
4. Utility system risks: Risks associated with shared utilities serving multiple process units.
5. Product specification risks: Risks related to varying product quality requirements affecting processing intensity.
6. Turnaround and maintenance risks: Risks associated with planned and unplanned maintenance activities.

8.2.4 Risk Rating Methodology

The verifier shall implement a systematic risk rating methodology that:

1. Evaluates both the likelihood and potential impact of identified risks.
2. Applies consistent criteria for risk classification.
3. Prioritizes verification efforts based on risk levels.

a) Risk Likelihood Assessment

Each identified risk shall be assessed for likelihood using the following scale:

Level	Description	Criteria
1 - Low	Rare occurrence	Event occurs only in exceptional circumstances; strong controls exist
2 - Medium	Possible occurrence	Event might occur at some time; adequate controls with some weaknesses
3 - High	Probable occurrence	Event will likely occur in most circumstances; weak or minimal controls

b) Risk Impact Assessment

The potential impact of each risk shall be assessed using the following scale:

Level	Description	Criteria
1 - Low	Minor impact	Potential misstatement <1% of emissions; no effect on verification opinion
2 - Medium	Moderate impact	Potential misstatement 1-5% of emissions; may affect verification approach

Level	Description	Criteria
3 - High	Major impact	Potential misstatement >5% of emissions; likely to affect verification opinion

c) Risk Rating Matrix

The combined risk rating shall be determined using the following matrix:

Likelihood/Impact	Low Impact (1)	Medium Impact (2)	High Impact (3)
Low Likelihood (1)	Low Risk (1)	Low Risk (2)	Medium Risk (3)
Medium Likelihood (2)	Low Risk (2)	Medium Risk (4)	High Risk (6)
High Likelihood (3)	Medium Risk (3)	High Risk (6)	High Risk (9)

d) Risk Response Requirements

Verification activities shall be designed based on the following risk response requirements:

Risk Rating	Minimum Response Requirements
Low Risk (1-2)	Standard verification procedures; spot checks and analytical procedures may be sufficient
Medium Risk (3-4)	Enhanced verification procedures; increased sample sizes and more detailed testing required
High Risk (6-9)	Intensive verification procedures; extensive testing, recalculation, and corroboration from multiple sources required

8.2.5 Risk Assessment Process

The risk assessment process for QET verification shall include the following sequential steps:

a) Strategic Analysis

Before conducting the risk assessment, the verifier shall perform a strategic analysis as specified in section 6.1.1 of ISO 14064-3:20192, including:

1. Review of relevant sector information.
2. Analysis of the nature of operations and complexity.
3. Examination of requirements of applicable criteria.
4. Understanding of the scope and boundaries.

5. Assessment of data management systems and controls.

b) Risk Identification

Based on the strategic analysis, the verifier shall:

1. Identify potential sources of material misstatement within each risk category.
2. Consider both quantitative and qualitative materiality factors.
3. Document all identified risks in a risk register.

c) Risk Analysis and Evaluation

For each identified risk, the verifier shall:

1. Determine inherent risk level before considering controls.
2. Assess the design and implementation of relevant controls.
3. Evaluate the resulting control risk.
4. Determine the combined risk rating using the risk matrix.
5. Identify high-risk areas requiring special attention.

d) Risk Treatment Planning

Based on the risk evaluation, the verifier shall:

1. Design verification procedures that address the identified risks.
2. Allocate verification resources proportionate to risk levels.
3. Determine appropriate sample sizes and testing approaches.
4. Define the necessary level of evidence required for high-risk areas.
5. Document the risk treatment approach in the verification plan.

8.2.6 Risk-Based Verification Planning

The risk assessment shall directly inform the verification planning process as follows:

a) Evidence-Gathering Activities

The nature, timing, and extent of evidence-gathering activities shall be designed to address identified risks:

1. **High-risk areas**: More persuasive evidence shall be obtained, including:
    - Increased sample sizes
    - More precise analytical procedures
    - Corroboration through multiple evidence sources
    - Direct testing rather than analytical procedures
2. **Medium-risk areas**: Standard evidence-gathering procedures shall be applied with:
    - Representative sampling approaches

    - Balanced mix of tests of controls and substantive testing
    - Standard analytical procedures
3. **Low-risk areas**: Streamlined evidence-gathering procedures may be applied, including:
    - Reduced sample sizes
    - Greater reliance on analytical procedures
    - Reduced testing of controls

b) Site Visit Planning

Risk assessment shall inform site visit planning by:

1. Prioritizing facilities with higher risk ratings for in-person visits.
2. Determining the depth and scope of site inspection activities.
3. Identifying specific processes and equipment requiring on-site verification.
4. Determining which personnel should be interviewed during site visits.

c) Temporal Coverage

Risk assessment shall influence the temporal distribution of verification activities:

1. For emissions sources with high seasonality or variability, verification shall target periods of highest risk.
2. For high-risk processes, verification shall examine data from multiple time periods.
3. For lower-risk areas, verification may focus on representative time periods.

8.2.7 Risk Assessment Documentation Requirements

The verifier shall maintain comprehensive documentation of the risk assessment process, including:

a) Risk Register

A formal risk register shall be maintained that documents:

1. All identified risks categorized by type (inherent, control, detection).
2. Risk description and potential impact on the QET emissions data.
3. Risk likelihood and impact ratings with justification.
4. Overall risk rating according to the risk matrix.
5. Risk treatment approach and planned verification procedures.
6. Risk owner (verification team member responsible for addressing the risk).

b) Control Assessment Documentation

For control risks, the verifier shall document:

1. Description of relevant controls implemented by the QET producer.

2. Assessment of control design effectiveness.
3. Evidence of control implementation and operation.
4. Identified control weaknesses or deficiencies.
5. Conclusions about the level of reliance that can be placed on controls.

c) Risk Analysis Supporting Evidence

The verifier shall document the basis for risk assessments, including:

1. Information sources used in risk identification.
2. Calculation methods for quantitative risk assessments.
3. Benchmarking data or historical information used for comparison.
4. Expertise and professional judgment applied.
5. Changes in risk assessment from prior verifications (if applicable).

d) Risk Updates and Reassessment

The verifier shall document any changes to the risk assessment during verification, including:

1. New risks identified during verification activities.
2. Changes to risk ratings based on evidence obtained.
3. Justification for any modifications to the risk assessment.
4. Corresponding adjustments to verification procedures.
5. Impact on verification conclusions.

8.2.8 Example Risk Factors for QET Verification

The following table provides examples of common risk factors in QET verification and corresponding verification responses:

Risk Factor	Risk Category	Potential Impact	Example Verification Response
Intermittent emissions sampling rather than continuous monitoring	Inherent Risk	Non-representative data capturing only periodic conditions	Increase temporal sampling; compare with operational data to verify representativeness
Manual data transfer between measurement systems and reporting systems	Control Risk	Transcription errors or data manipulation	Trace data through entire information flow; perform recalculations; test controls over data transfer

Risk Factor	Risk Category	Potential Impact	Example Verification Response
Complex allocation of pad-level emissions to individual wells	Inherent Risk	Incorrect distribution of emissions among QETs	Examine allocation methodology; independently recalculate allocations; test for mathematical accuracy
New measurement technology with limited field validation	Inherent Risk	Systematic bias in measurements	Require cross-validation with established methods; increase uncertainty factors; review technology validation studies
Facilities with varied operational states (e.g., production fluctuations)	Inherent Risk	Non-representative emissions data if not correlated with operational variations	Stratify sampling by operational state; verify alignment between operations data and emissions data
High staff turnover in environmental monitoring roles	Control Risk	Inconsistent application of monitoring protocols	Review training records; interview current staff; test knowledge of procedures; review handover documentation
Aggregation of emissions data from multiple measurement methodologies	Control Risk	Inconsistent or incompatible data combined improperly	Review aggregation methodology; verify consistency of units and time periods; recalculate aggregated values
QET batches representing facilities across multiple regulatory jurisdictions	Inherent Risk	Inconsistent application of criteria across jurisdictions	Stratify verification by jurisdiction; verify compliance with all applicable requirements; test for consistency

8.2.9 EEMDL Protocol Reconciliation Requirements

For QETs representing crude oil and natural gas destined for EU markets under EUMR Article 28, the verifier shall implement the EEMDL Protocol's tiered reconciliation methodology for addressing discrepancies between source-level and site-level emissions observations.

8.2.9.1 Tiered Discrepancy Thresholds

The verifier shall classify and respond to reconciliation discrepancies according to the following mandatory thresholds:

Must Address Discrepancies (> 100 kg CH_4/hr)

- **Response Required:** Mandatory investigation and documentation
- **Actions:**
  - Conduct detailed root cause analysis
  - Perform enhanced data validation procedures
  - Document technical justification for discrepancy or implement corrective measures
  - Obtain independent technical review of reconciliation methodology
  - Report findings in verification statement with specific remediation measures

Should Address if Material Discrepancies (10-100 kg CH_4/hr)

- **Response Required:** Required when exceeding materiality thresholds established in Section 8.3
- **Actions:**
  - Assess quantitative impact relative to total facility emissions
  - Evaluate qualitative significance to data integrity
  - Document investigation approach and conclusions
  - Implement additional verification procedures if materiality threshold is exceeded
  - Consider impact on overall verification opinion

May Address Discrepancies (< 10 kg CH_4/hr)

- **Response Required:** Optional unless affecting overall materiality assessment
- **Actions:**
  - Document awareness of discrepancy in verification file
  - Monitor for patterns across multiple sources or time periods
  - Address if cumulative impact approaches materiality thresholds
  - Consider for future verification planning

8.2.9.2 Reconciliation Documentation Requirements

For each identified discrepancy, the verifier shall document:

1. Quantitative magnitude of the discrepancy (kg CH_4/hr)
2. Classification according to tiered thresholds
3. Investigation procedures conducted
4. Technical findings and root cause analysis
5. Impact assessment on overall emissions quantification
6. Resolution measures implemented or justification for non-resolution
7. Implications for verification opinion and assurance level

8.2.9.3 Integration with Risk Assessment

Reconciliation findings shall inform the overall risk assessment methodology established in Section 8.2, with persistent or systematic discrepancies elevating risk ratings and triggering enhanced verification procedures as specified in the risk response matrix.

8.3 Materiality Threshold

For QET verification, materiality thresholds shall be established:

- 5% for individual QET batches
- 2% for aggregated QET portfolios

Companies should seek completeness of reporting. Setting a materiality threshold is not recommended for data inclusion, but is needed for verification purposes.

For additional guidance, please reference the following:

8.3.1 Definition of Materiality Threshold

A materiality threshold is a predefined limit that determines whether an error, omission, or misstatement in greenhouse gas (GHG) emissions data is significant enough to impact the credibility of a GHG assertion. Under ISO 14064-3, materiality thresholds guide verifiers in:

1. Identifying discrepancies that could mislead stakeholders.
2. Prioritizing verification efforts on high-impact data.
3. Balancing rigor with practicality in audits.

Materiality has two components:

- **Quantitative**: Numerical limits (e.g., ±5% error tolerance).
- **Qualitative**: Non-numeric factors (e.g., misreporting a major emissions source).

8.3.2 Recommended Materiality Thresholds for QET Verification

The proposed thresholds align with ISO 14064-3's risk-based approach and EarnDLT's technical requirements:

Scope	Threshold	Rationale
Individual QET Batches	±5%	Allows for measurement uncertainty while maintaining batch-level integrity.

Scope	Threshold	Rationale
Aggregated QET Portfolios	±2%	Reflects cumulative risks across batches and stricter oversight for portfolios.

8.3.3 Application in Verification

8.3.3.1 Individual Batches (5% Threshold)

Verification Steps:

1. Calculate the absolute difference between reported and verified emissions.
2. Compute percentage error:

$$Error\ (\%) = 100 \times \left| \frac{Reported\ Emissions - Verified\ Emissions}{Verified\ Emissions} \right|$$

```
Batch_Error_Percent = 100 * (|Reported_Emissions -
Verified_Emissions| / Verified_Emissions)
```

3. If error ≤5%, the batch passes.
4. If error >5%, the batch requires correction or disqualification.

Example:

- `Reported_Emissions` = 100 kgCO2e/MMBtu
- `Verified_Emissions` = 95 kgCO2e/MMBtu
- `Batch_Error_Percent` = 100 * |100 − 95| / 95 = 5.26 % → **Material misstatement** (exceeds 5%).

8.3.3.2 Aggregated Portfolios (2% Threshold)

Verification Steps:

1. Sum errors across all batches in the portfolio.
2. Calculate total portfolio error:

$$Portfolio\ Error\ (\%) = 100 \times \frac{\sum_{i=1}^{n} \left| ReportedEmissions_i - VerifiedEmissions_i \right|}{\sum_{i=1}^{n} VerifiedEmissions_i}$$

$$Portfolio\_Error\_Percent = 100 * \Sigma\{i=1..n\} \mid Reported\_Emissions\_i - Verified\_Emissions\_i \mid / \Sigma\_\{i=1..n\} Verified\_Emissions\_i$$

3. If error ≤2%, the portfolio passes.
4. If error >2%, systemic issues require investigation.

Example:

- `Σ_i |Reported_Emissions_i - Verified_Emissions_i|` = 250 kgCO2e
- `Σ_i Verified_Emissions_i` = 10,000 kgCO2e
- `Portfolio_Error_Percent` = 100 * (250) / (10,000) = 2.50% → Fail (exceeds 2%)

8.4 Assurance Levels for QET Verification

This section establishes the requirements for assurance levels in QET verification activities, addressing the selection, application, and expression of verification opinions within the ISO 14064-3:2019 framework.

8.4.1 Definition of Assurance Levels

In accordance with ISO 14064-3:2019, two levels of assurance are recognized for greenhouse gas verification activities:

Reasonable Assurance: A high but not absolute level of assurance on historical data and information. Verification activities are designed and executed with sufficient depth and breadth to reduce verification risk to an acceptably low level, allowing the verifier to express a conclusion in a positive form (i.e., "the GHG statement is materially correct").

Limited Assurance: A reduced level of assurance where verification activities are less extensive in nature, timing, and extent. This level accepts a higher verification risk and allows the verifier to express a conclusion in a negative form (i.e., "nothing has come to the attention that causes belief that the GHG statement is not materially correct").

Note that these verification "assurance levels" are distinct from the measurement-based "confidence level rating" described in Section 6.3.

8.4.2 Default Assurance Level for QET Verification

For Quantified Emissions Tokens (QETs), limited assurance shall be the default level applied to verification activities unless:

1. The verifier/validator determines that reasonable assurance is necessary due to:

- The significance of financial or environmental claims associated with the QETs.
- Regulatory requirements applicable to the intended use of the QETs.
- Identified high risk factors that warrant deeper verification activities.
- **QETs representing crude oil and natural gas destined for EU markets under EU Methane Regulation Article 28, which REQUIRE reasonable assurance per EEMDL Protocol requirements.**

2. The QET producer specifically requests reasonable assurance.

EU Methane Regulation Compliance Requirement:
For QETs representing crude oil and natural gas production facilities located outside the European Union where the crude oil or natural gas is destined for the EU market, reasonable assurance verification is MANDATORY in accordance with EUMR Article 8 requirements. This requirement cannot be waived and supersedes the default limited assurance approach. The EU compliance flag in the QET data structure (Section 7.6) shall automatically trigger reasonable assurance requirements.

This approach balances efficiency and cost-effectiveness while maintaining appropriate verification rigor and ensuring full compliance with EU regulatory requirements. Limited assurance provides sufficient confidence for most QET applications while mandating higher assurance levels for EU market compliance.

Verification bodies shall explicitly state the level of assurance provided in their verification statements and opinions, including the rationale when reasonable assurance is selected.

8.4.3 Procedural Differences Between Assurance Levels

The verification procedures differ substantially between reasonable and limited assurance as follows:

8.4.3.1 Strategic Analysis

Reasonable Assurance: Requires detailed assessment of the design, existence, and effectiveness of controls for QET data management systems.

Limited Assurance: Permits less detailed assessment of controls based on the underlying assumption that the controls are reliable.

8.4.3.2 Risk Assessment

Reasonable Assurance: Requires identification and assessment of risks at both overall statement level and for specific types of emissions (occurrence, completeness, accuracy, cut-off, and classification).

Limited Assurance: Risk assessment performed on the statement as a whole, without the detailed categorization required for reasonable assurance.

8.4.3.3 Evidence-Gathering Activities

Reasonable Assurance:

- More extensive testing of controls
- Greater precision in analytical procedures
- Deeper tracing of data to primary sources
- More comprehensive site visits
- Development of independent estimates to evaluate the producer's estimates

Limited Assurance:

- Optional testing of controls
- Less precise analytical procedures
- Less extensive site visits based primarily on risk assessment
- Greater reliance on inquiry and analytical procedures than on detailed testing

8.4.3.4 Expression of Opinion

Reasonable Assurance: Opinion expressed in a positive form ("In our opinion, the QET GHG statement presents fairly, in all material respects, the GHG emissions...")

Limited Assurance: Opinion expressed in a negative form ("Based on the process and procedures conducted, there is no evidence that the QET GHG statement is not materially correct...")

8.4.4 Circumstances Where Reasonable Assurance May Be Appropriate

While limited assurance is the default for QET verification, reasonable assurance may be appropriate or required in specific circumstances:

1. **Financial Significance**: When QETs represent high monetary value or are used in transactions exceeding defined thresholds.
2. **Regulatory Compliance**: When QETs are used to fulfill regulatory obligations that specifically require reasonable assurance.
3. **High-Risk Factors**: When verification risk assessment identifies multiple high-risk factors that warrant deeper verification activities, including:
    - Complex measurement technologies with significant uncertainty.
    - Novel methodologies without established track records.

    - Systems with minimal internal controls.
    - Prior verification findings indicating systemic issues.
4. **Market Requirements**: When downstream markets or buyers specifically require reasonable assurance for their use cases.
5. **Producer Request**: When the QET producer specifically requests reasonable assurance to enhance market confidence in their environmental attributes.

8.4.5 Documentation Requirements for Assurance Level Selection

The verification body shall document:

1. The assurance level selected (limited or reasonable).
2. If reasonable assurance is selected, the specific rationale justifying the higher level of assurance, including:
    - Specific risk factors necessitating reasonable assurance.
    - Regulatory or market requirements mandating reasonable assurance.
    - Producer request for elevated assurance level.
3. How verification procedures were modified to align with the selected assurance level.
4. The implications of the selected assurance level on the verification process and conclusions.

8.4.6 Transition Between Assurance Levels

If a transition between assurance levels is necessary:

1. The verifier shall not change the level of assurance during an ongoing verification engagement.
2. A new verification engagement must be initiated with clearly defined parameters.
3. When transitioning from limited to reasonable assurance:
    - Additional evidence-gathering activities must be defined to meet the higher assurance requirements.
    - The scope of testing must be expanded as appropriate.
4. When transitioning from reasonable to limited assurance (which should be rare and carefully justified):
    - Clear documentation of the rationale for reducing the assurance level is required.
    - Potential impacts on data credibility must be assessed.
5. The client and verifier must explicitly agree to the new assurance level before commencing the new engagement.
6. The verification statement must clearly indicate any change in assurance level from previous verifications.

8.5 Verification and Validation Opinions

This section establishes the framework for opinions issued by verifiers and validators regarding QET emissions data and methodologies, in alignment with ISO 14064-3:2019 requirements.

8.5.1 Types of Opinions

In accordance with ISO 14064-3:2019, four distinct types of opinions may be issued regarding QET emissions data or methodologies:

Opinion Type	Description	Terminology Variants
Unmodified	Affirms the GHG statement is materially correct and conforms to criteria without qualification	Unqualified, Positive, Satisfactory
Modified	Affirms the GHG statement is materially correct overall, but with specific exceptions or qualifications	Qualified, Qualified positive, Satisfactory with comments
Adverse	States the GHG statement is not materially correct or does not conform to criteria	Adverse, Unsatisfactory, Negative
Disclaimer	Indicates the verifier/validator cannot form an opinion due to insufficient evidence	No opinion expressed

8.5.2 Criteria for Opinion Types

8.5.2.1 Unmodified Opinion

An unmodified opinion shall be issued when:

1. Sufficient and appropriate evidence supports material emissions, removals, or storage data contained in the QET
2. The verification/validation criteria have been appropriately applied
3. The effectiveness of controls has been adequately evaluated when relied upon
4. No material misstatements or nonconformities have been identified, or all identified issues have been adequately resolved
5. No scope limitations hindered the completion of verification/validation activities

8.5.2.2 Modified Opinion

A modified opinion shall be issued when:

1. There is no material misstatement at the level of the overall GHG statement, but there are specific issues that warrant disclosure.
2. There is a departure from the requirements of the criteria, but not of sufficient magnitude to warrant an adverse opinion.
3. There is a scope limitation that prevents the verifier/validator from obtaining sufficient evidence about specific aspects, but not the entire GHG statement.
4. The identified issues are:
    - Confined to specific elements or line items of the GHG statement.
    - Not representative of a substantial portion of the GHG statement.
    - Not fundamental to intended users' understanding of the GHG statement.

8.5.2.3 Adverse Opinion

An adverse opinion shall be issued when:

1. There is insufficient or inappropriate evidence to support an unmodified or modified opinion.
2. Criteria are not appropriately applied for material emissions, removals, or storage.
3. The effectiveness of controls cannot be determined when the verifier intends to rely on those controls.
4. The responsible party has not corrected material misstatements or nonconformities within an agreed timeframe.
5. The misstatements or nonconformities, individually or in aggregate, are both material and pervasive to the GHG statement.

8.5.2.4 Disclaimer of Opinion

A disclaimer of opinion shall be issued when:

1. The verifier/validator is unable to obtain sufficient appropriate evidence.
2. The possible effects of undetected material misstatements are both material and pervasive.
3. Circumstances impose significant limitations on the scope of verification/validation that cannot be removed.
4. There are significant uncertainties that cannot be reduced to an acceptable level.
5. Conflicts of interest or threats to independence cannot be mitigated to an acceptable level.

8.5.3 Mandatory Content Requirements for Opinions

All verification/validation opinions for QETs shall include:

1. An appropriate title clearly identifying it as a verification or validation opinion.
2. The addressee (typically the intended users of the QET).

3. Identification of the QET-related activity (production, processing, transmission, etc.).
4. Identification of the GHG statement, including date and period covered.
5. A statement that the responsible party is responsible for the preparation of the GHG statement.
6. Identification of the criteria used to assess the GHG statement.
7. A declaration that the verification/validation was conducted in accordance with ISO 14064-3:2019.
8. The verifier's/validator's conclusion, including the level of assurance (for verification)
9. The date of the opinion.
10. The verifier's/validator's location and signature.

8.5.3.1 Additional Content Requirements by Opinion Type

For Modified Opinions:

- A description of the reason for the modification placed before the conclusion.
- Clear delineation of the effects of the modification on the GHG statement.

For Adverse Opinions:

- Explicit statement of the reasons for the adverse opinion.
- Description of material misstatements or nonconformities identified.

For Disclaimers:

- Clear statement of the scope limitation or other circumstances that led to the disclaimer.
- Explanation of why sufficient appropriate evidence could not be obtained.

8.5.4 QET-Specific Opinion Requirements

Opinions on QETs shall additionally include:

1. Specific reference to the QET batch ID or range.
2. The boundary definition used (facility/pad/well/segment).
3. The specific pollutants and greenhouse gases covered.
4. Time period of emissions data represented by the QETs.
5. Measurement methodologies used and their alignment with the QET framework.
6. Statement regarding data quality and uncertainty levels.

8.5.5 Opinion Templates

8.5.5.1 Unmodified QET Verification Opinion (Limited Assurance)

INDEPENDENT VERIFICATION OPINION

To: [Intended User]

We have verified the greenhouse gas emissions data represented by Quantified Emissions Token batch [ID], produced by [Responsible Party] for [facility/pad/well/segment ID] located in [Basin/Location], covering the period from [Start Date] to [End Date].

Responsibility of the Responsible Party
[Responsible Party] is responsible for the preparation and fair presentation of the GHG statement in accordance with [specific criteria used, e.g., QET Methodology v1.0, ISO 14064-3:2019].

Our Responsibility
Our responsibility is to express a conclusion on the GHG statement based on our verification. We conducted our verification in accordance with ISO 14064-3:2019 for greenhouse gas statements. This standard requires that we comply with ethical requirements and plan and perform the verification to obtain limited assurance that the GHG statement is free from material misstatement.

Verification Procedures
Our verification procedures included [brief description of key procedures, including data testing, calculation verification, and site visits if applicable]. The procedures selected depend on our judgment, including the assessment of the risks of material misstatement of the GHG statement. The verification activities applied in a limited level of assurance verification are less extensive in nature, timing and extent than in a reasonable level of assurance verification.

Opinion
Based on the process and procedures conducted, nothing has come to our attention that causes us to believe that the GHG emissions data represented in QET batch [ID] is not materially correct in accordance with [criteria] at a limited level of assurance. The verified data indicates:

```
- Methane Intensity: [value] [unit]
- Carbon Intensity: [value] kg CO₂e/MMBtu
- CH₄ mass: [value] kg CH₄/MMBtu
- Data quality confidence level: [value]%

[Verifier's signature]
[Verifier's name and accreditation information]
[Date]
[Location]
```

8.5.5.2 Unmodified QET Verification Opinion (Reasonable Assurance)

```
INDEPENDENT VERIFICATION OPINION

[Same opening paragraphs as limited assurance template, with
"reasonable assurance" substituted for "limited assurance"]

Our Responsibility
Our responsibility is to express an opinion on the GHG statement based
on our verification. We conducted our verification in accordance with
ISO 14064-3:2019 for greenhouse gas statements. This standard requires
that we comply with ethical requirements and plan and perform the
verification to obtain reasonable assurance that the GHG statement is
free from material misstatement.

[Same verification procedures paragraph, noting more extensive
procedures for reasonable assurance]

Opinion
In our opinion, the GHG emissions data represented in QET batch [ID]
presents fairly, in all material respects, the greenhouse gas
emissions in accordance with [criteria] at a reasonable level of
assurance. The verified data indicates:

[Same data points as limited assurance template]

[Verifier's signature, etc.]
```

8.5.5.3 Unmodified QET Validation Opinion

```
INDEPENDENT VALIDATION OPINION

To: [Intended User]

We have validated the methodology and assumptions used to develop the
Quantified Emissions Token framework for [Responsible Party]'s
[measurement methodology name], designed for [facility/segment type].

Responsibility of the Responsible Party
[Responsible Party] is responsible for the development and
documentation of the methodology and the underlying assumptions on
which future QET emissions data will be based.

Our Responsibility
Our responsibility is to express an opinion on the reasonableness of
the assumptions, limitations, and methods that support the QET
methodology. We conducted our validation in accordance with ISO
14064-3:2019.

Validation Procedures
Our validation assessed the [list key characteristics evaluated, e.g.,
recognition, boundaries, quantification methodologies, secondary
effects, uncertainty, etc.].

Opinion
Based on our examination of the evidence, the assumptions provide a
reasonable basis for the QET methodology. In our opinion, the
methodology is properly prepared on the basis of the assumptions and
in accordance with [relevant criteria].

The methodology is suitable for [specific applications, e.g., upstream
natural gas emissions quantification] within the defined system
boundaries. Future emissions data generated using this methodology
will still require verification when used for QET creation.

[Validator's signature]
[Validator's name and accreditation information]
```

```
[Date]
[Location]
```

8.5.5.4 Modified Opinion

```
INDEPENDENT VERIFICATION OPINION

[Standard opening paragraphs as in unmodified opinion]

Basis for Modified Opinion
[Clearly describe the matter giving rise to the modification and its
effects on the GHG statement if they can be reasonably determined]

Modified Opinion
In our opinion, except for the effects of the matter described in the
Basis for Modified Opinion paragraph, the GHG emissions data
represented in QET batch [ID] presents fairly, in all material
respects, the greenhouse gas emissions in accordance with [criteria]
at a [reasonable/limited] level of assurance.

[Standard closing and signature]
```

8.5.5.5 Adverse Opinion

```
INDEPENDENT VERIFICATION OPINION

[Standard opening paragraphs as in unmodified opinion]

Basis for Adverse Opinion
[Clearly describe all significant matters giving rise to the adverse
opinion]

Adverse Opinion
In our opinion, because of the significance of the matters described
in the Basis for Adverse Opinion paragraph, the GHG emissions data
represented in QET batch [ID] does not present fairly the greenhouse
gas emissions in accordance with [criteria].

[Standard closing and signature]
```

8.5.5.6 Disclaimer of Opinion

```
DISCLAIMER OF VERIFICATION OPINION

[Standard opening paragraphs about responsibilities]

Basis for Disclaimer of Opinion
[Clearly describe the scope limitation or other circumstances leading
to the disclaimer]

Disclaimer of Opinion
Because of the significance of the matters described in the Basis for
Disclaimer of Opinion paragraph, we have not been able to obtain
sufficient appropriate evidence to provide a basis for a verification
opinion. Accordingly, we do not express an opinion on the GHG
emissions data represented in QET batch [ID].

[Standard closing and signature]
```

8.5.6 Combined Verification and Validation Opinions

When conducting mixed engagements as described in Section 11.4.3, the verifier/validator shall issue separate, clearly labeled sections for verification and validation opinions within a single report. Each section must adhere to the specific requirements for that type of opinion.

8.5.7 Facts Discovered After Opinion Issuance

For comprehensive procedures addressing facts discovered after verification completion, refer to Section 15 and QET-LNG Section 12, which establish detailed protocols for evaluation, disclosure, and corrective action when material information affecting QET attributes is identified subsequent to verification statement issuance.

If facts or new information that could materially affect the verification or validation opinion are discovered after issuance:

1. The verifier/validator shall take appropriate action including communicating the matter as soon as practicable to the responsible party, client, and appropriate QET registry administrators
2. If the original opinion is compromised, a revised opinion shall be issued with clear explanation of the changes and their basis
3. The QET registry shall be updated to reflect any changes to verification status

8.5.8 Opinion Registration Requirements

All verification and validation opinions for QETs shall be:

1. Digitally signed using cryptographic methods that ensure authenticity and integrity
2. Registered in the QET blockchain registry and linked to the relevant QET batch
3. Made available to authorized users through the QET platform's verification data access mechanisms
4. Retained for the full lifecycle of the associated QETs and for a minimum of 7 years

This comprehensive framework ensures that verification and validation opinions for QETs provide clear, consistent, and reliable information to users while maintaining alignment with ISO 14064-3:2019 requirements.

9. QET Lifecycle Management

9.1 Token Issuance

1. Data collection and validation.
2. Calculation of emissions intensities.
3. Creation of JSON submission.
4. Verification by approved verifier (and prior validation of methodologies when new measurement approaches are used).
5. Token minting on the EarnDLT blockchain registry.

9.2 Token Transfer

When QETs are transferred, the following shall be recorded:

1. Sender and recipient identifiers.
2. Transfer timestamp.
3. Batch information.
4. Emissions data retention.

9.3 Token Retirement

Upon retirement for claiming environmental attributes:

1. Retirement timestamp.
2. Retiring entity identifier.
3. Purpose of retirement.

4. Environmental claim being made.

10. Reporting and Communication

10.1 QET Batch Reporting

Each QET batch report shall include:

1. Batch identification.
2. Production period.
3. System boundary description.
4. Emissions intensities summary.
5. Measurement methodologies used.
6. Verification statement.

10.2 Environmental Attribute Claims

Valid environmental attribute claims based on QETs include:

Upstream (Scope 1) Claims:

- Methane intensity performance.
- Carbon intensity performance.
- Net zero tracking.

Downstream (Scope 3) Claims:

- Insetting calculations.
- Reduced carbon intensity of feedstock.
- Verified MRV commodity purchase.

10.3 Avoidance of Double-Counting

To prevent double-counting of environmental attributes:

1. Each QET shall have a unique identifier.
2. Retirement of QETs must be recorded on the blockchain registry.
3. Claims shall be specific to the entity retiring the QET.
4. Transparent chain of custody shall be maintained.

Post-Verification Discovery Management: To maintain the integrity of environmental attribute claims, QET holders and market participants shall follow the procedures established in Section

15 and QET-LNG Section 12 when material information affecting verified emissions data is discovered after token issuance. This ensures continued compliance with double-counting avoidance principles throughout the QET lifecycle.

11. Verification and Validation Distinction

11.1 Definitions and Fundamental Differences

In accordance with ISO 14064-3:2019, this methodology establishes clear distinctions between verification and validation processes as they apply to Quantified Emissions Tokens (QETs):

Verification: The process for evaluating a statement of historical data and information to determine if the statement is materially correct and conforms to criteria. For QETs, verification applies to emissions data that has already been measured and quantified.

Validation: The process for evaluating the reasonableness of the assumptions, limitations, and methods that support a statement about the outcome of future activities. For QETs, validation applies to methodological approaches, projections, and estimation techniques that will generate future emissions data.

11.1.1 Key Distinctions

Characteristic	Verification	Validation
Temporal focus	Historical data	Future projections
Subject matter	Measured emissions data	Assumptions, methodologies, models
Outcome	Opinion on accuracy of reported data	Opinion on reasonableness of methodology
Expression format	"The GHG statement is/is not materially correct"	"The assumptions provide/do not provide a reasonable basis"
Primary ISO section	ISO 14064-3:2019 Clause 6	ISO 14064-3:2019 Clause 7

11.2 Applicability to QET Framework

11.2.1 When Verification Applies

Verification shall be applied to QETs in the following circumstances:

1. Evaluation of historical emissions data collected through measurement or monitoring
2. Assessment of calculated methane intensity or carbon intensity values based on past operations
3. Review of data aggregation and unit conversion calculations
4. Examination of completeness and accuracy of QET emissions data records
5. Confirmation of QET token batches that represent historical commodity production

11.2.2 When Validation Applies

Validation shall be applied to QETs in the following circumstances:

1. Assessment of new measurement methodologies prior to implementation.
2. Evaluation of emissions modeling approaches that predict future emissions.
3. Review of assumptions and limitations in emissions estimation techniques.
4. Assessment of baseline scenario development for emissions reduction projects.
5. Examination of monitoring plans to be implemented in future QET data collection.

11.3 Distinct Procedures for Validation and Verification

11.3.1 Verification Procedures

The verification process for QET emissions data shall follow these steps in accordance with ISO 14064-3:2019 Clause 6:

1. **Strategic analysis** of the QET emissions data sources, scope boundaries, and quantification methods.
2. **Risk assessment** to identify potential material misstatements in reported emissions data.
3. **Evidence-gathering activities** focusing on:
    - Data trail examination from raw measurements to final QET token attributes.
    - Testing of calculations and conversions.
    - Assessment of historical data completeness.
4. **Evaluation of GHG statement** against the criteria in this methodology.
5. **Development of verification opinion** on whether the QET emissions data is materially correct.

11.3.2 Validation Procedures

The validation process for QET methodologies shall follow these steps in accordance with ISO 14064-3:2019 Clause 7:

1. **Strategic analysis** of the measurement methodology, estimation techniques, or modeling approaches.
2. **Assessment of GHG-related activity characteristics,** including:
   - Recognition of the methodology by intended users.
   - Appropriate boundary setting.
   - Baseline scenario selection (when applicable).
   - Quantification methodology assessment.
3. **Estimate testing** to evaluate:
   - Appropriateness of estimation methodology.
   - Applicability of assumptions.
   - Quality of input data.
4. **Sensitivity analysis** to identify assumptions with high potential for change.
5. **Development of a validation opinion** on the reasonableness of the methodology.

11.4 Integration of Validation and Verification in the QET Lifecycle

11.4.1 Sequential Application

For optimal assurance in the QET framework, validation and verification shall be applied sequentially:

1. **Validation first**: New measurement methodologies or modeling approaches shall undergo validation before being applied to generate emissions data.
2. **Verification second**: Once a validated methodology is implemented and generates emissions data, the resulting data shall undergo verification.

11.4.2 Connecting Validation to Verification

The validation and verification processes are connected through the following mechanisms:

1. **Validation outcomes inform verification planning**: Issues identified during validation (e.g., high uncertainty areas, sensitive assumptions) shall be considered priority focus areas during subsequent verification.
2. **Verification findings may trigger re-validation**: If verification identifies issues with the implementation of a methodology, the methodology may require re-validation with modified assumptions.
3. **Documentation linkage**: Validation reports shall be referenced in verification documentation to establish the methodological foundation for the verified data.

11.4.3 Mixed Engagements

In some cases, a mixed engagement combining validation and verification may be appropriate, as described in ISO 14064-3:2019 Annex D2. For QETs, mixed engagements apply when:

1. A methodology includes both historical calibration data and future projections.
2. A QET batch contains emissions data based on both measured historical values and estimated future values.
3. A new measurement technology is simultaneously being validated while its initial outputs are being verified.

In mixed engagements, the verification body shall clearly define and document which aspects of the QET data are subject to verification and which are subject to validation.

11.5 Documentation Requirements

11.5.1 Validation Report

A validation report for QET methodologies shall include:

1. Identification of the methodology being validated.
2. Description of the assumptions, limitations, and methods evaluated.
3. Validation criteria applied.
4. Evidence-gathering activities conducted.
5. Assessment of the methodology's reasonableness.
6. Validation opinion statement.
7. Limitations and qualifications to the opinion.

11.5.2 Verification Report

A verification report for QET emissions data shall include:

1. Description of the emissions data verified.
2. Verification criteria applied.
3. Evidence-gathering activities conducted.
4. Material findings and their resolution.
5. Verification opinion statement.
6. Limitations and qualifications to the opinion.

11.5.3 Opinion Statements

The validation and verification opinions shall be clearly distinguished:

Validation Opinion: "Based on our examination of the evidence, nothing has come to our attention which causes us to believe that these assumptions do not provide a reasonable basis for the [methodology/approach]. In our opinion, the [methodology/approach] is properly prepared on the basis of the assumptions and in accordance with [relevant standards and criteria]."

Verification Opinion: "In our opinion, the [QET emissions data] presents fairly, in all material respects, the GHG emissions in accordance with [relevant standards and criteria]."

11.6 Competence Requirements

Validators and verifiers shall possess competence appropriate to their roles as defined in ISO 14066. For QET validation and verification activities, the following specific competence areas are required:

1. Understanding of ISO 14064-3:2019 validation and verification processes.
2. Knowledge of emissions measurement technologies applicable to natural gas systems.
3. Expertise in uncertainty calculation and management.
4. Familiarity with the QET data structure and token lifecycle.
5. Experience with distributed ledger technology for environmental attributes.

When a single person or team conducts both validation and verification activities, they must demonstrate competence in both areas and maintain clear separation of the two processes.

12. Competence Requirements for QET Validators and Verifiers

12.1 General Competence Framework

Verification and validation of QETs shall be conducted by personnel with demonstrated competence in accordance with ISO 14066 "Greenhouse gases - Competence requirements for greenhouse gas validation teams and verification teams." The competence requirements outlined in this section ensure that validation and verification activities are conducted by qualified personnel who can deliver consistent, impartial, and technically sound opinions.

12.2 Core Competence Requirements

Validators and verifiers shall demonstrate and maintain proficiency in the following core competence areas:

1. **Technical competence**:
    - Understanding of GHG emission sources, sinks, and reservoirs in natural gas systems.

    - Knowledge of quantification methodologies for methane and other GHG emissions.
    - Expertise in data quality assurance and quality control procedures.
2. **Assessment processes**:
    - Proficiency in planning verification/validation activities.
    - Ability to conduct robust risk assessments.
    - Skill in evidence collection and evaluation.
    - Expertise in assessing uncertainty and materiality.
3. **Information systems and data management**:
    - Ability to evaluate data management systems.
    - Understanding of controls for ensuring data integrity.
    - Knowledge of information system security principles.
4. **Regulatory and program requirements**:
    - Knowledge of applicable GHG program requirements.
    - Understanding of relevant legal and regulatory frameworks.
    - Awareness of sector-specific compliance obligations.

12.3 QET-Specific Competence Requirements

In addition to the core competencies outlined in ISO 14066, validators and verifiers involved in QET verification shall demonstrate knowledge and expertise in:

1. **Distributed ledger technology**:
    - Understanding of blockchain fundamentals and environmental attribute tokenization.
    - Knowledge of cryptographic signing methods and security.
    - Ability to verify digital chain-of-custody for environmental attributes.
2. **QET measurement methodologies**:
    - Expertise in methane measurement technologies and performance characteristics.
    - Understanding of QET-specific calculation methodologies for methane intensity and carbon intensity.
    - Knowledge of uncertainty calculations specific to the QET framework.
3. **Industry-specific knowledge**:
    - Understanding of natural gas production, processing, and transportation operations.
    - Familiarity with industry standards for methane measurement and quantification.
    - Knowledge of typical emission sources and control technologies in natural gas systems.
4. **Data standardization and formats**:
    - Proficiency in evaluating JSON schema implementations for QET data.
    - Ability to trace data from source measurements to final QET attributes.
    - Understanding of data conversions between different units and formats.

Note: For QETs from processing operations, verifiers and validators must demonstrate:

- Knowledge of natural gas processing operations, including acid gas removal, dehydration, NGL extraction, and fractionation.
- Experience with multi-product allocation methodologies and energy-based allocation factors.
- Familiarity with NGSI 2.0 Processing Plant Protocol and relevant API/GPSA standards.
- Understanding of processing equipment emissions, uncertainty sources, and plant efficiency metrics.

12.4 Verification Team Composition Requirements

12.4.1 Team Structure

The verification/validation team shall include personnel with the combined expertise necessary to address all aspects of QET verification. The team shall be structured to include, at minimum:

1. **Lead verifier/validator**: Responsible for overall direction and quality of the engagement.
2. **Technical expert(s)**: Specialist(s) with detailed knowledge of measurement technologies, quantification methodologies, or industry operations relevant to the specific verification scope.
3. **Independent reviewer**: A competent person not involved in the verification activities who reviews the verification/validation process and conclusions prior to opinion issuance.

12.4.2 Team Balance

Verification teams shall be composed to ensure:

1. Impartiality through appropriate segregation of duties.
2. Collective competence covering all required expertise areas.
3. Appropriate level of supervision for team members with less experience.
4. Absence of conflicts of interest among all team members.

12.5 Qualifications for Lead Verifiers

12.5.1 Required Qualifications

Lead verifiers for QET verification/validation shall possess the following minimum qualifications:

1. **Education and training**:
    - Advanced degree in engineering, environmental science, or related field.

    - Completion of formal training in ISO 14064-3 verification and validation.
    - Demonstrated understanding of ISO 14064 series standards.
2. **Professional experience**:
    - Minimum five years of professional experience in GHG verification or related field.
    - Completion of at least ten GHG verification engagements as a team member.
    - Prior experience in leadership roles for at least five verification engagements.
3. **Professional certification**:
    - Current accreditation or certification from a recognized GHG verification program.
    - Examples include: ISO 14064 Lead Verifier certification, ANSI-accredited GHG Verification Body certification, or equivalent credentials.

12.5.2 Additional Qualifications for QET Lead Verifiers

QET Lead Verifiers shall additionally demonstrate:

1. Completion of specialized training in the QET methodology.
2. Experience with digital environmental attributes or carbon accounting.
3. Understanding of blockchain-based environmental attribute registries.
4. Knowledge of the specific QET data structure and verification requirements.

12.6 Competence Evaluation and Maintenance

12.6.1 Initial Competence Evaluation

Organizations providing verification services for QETs shall implement processes to:

1. Define competence criteria for each role within the verification/validation team.
2. Evaluate and document evidence of each team member's competence.
3. Assign verification/validation activities based on demonstrated competence.

12.6.2 Ongoing Competence Management

To maintain competence, verification personnel shall:

1. Regularly update their knowledge through continuing professional education.
2. Undergo periodic performance evaluations.
3. Participate in calibration activities to ensure consistent application of verification procedures.
4. Document relevant professional development activities.

12.7 Impartiality and Independence

All verification/validation personnel shall maintain strict impartiality and independence in accordance with ISO 14064-3:2019 principles. The verification body shall implement and document procedures to:

1. Identify and evaluate potential conflicts of interest.
2. Implement safeguards to maintain independence.
3. Obtain written declarations from all verification team members regarding potential conflicts.
4. Rotate lead verifiers periodically for repeated verifications with the same client.

12.8 Documentation of Competence

The verification body shall maintain documented information demonstrating that all verification/validation personnel meet the competence requirements specified in this section. Documentation shall include:

1. CV/resume with relevant qualifications and experience.
2. Training certificates and professional credentials.
3. Records of participation in prior verification activities.
4. Evidence of specialized knowledge in QET-specific requirements.
5. Results of performance evaluations and peer reviews.

This comprehensive framework for verifier/validator competence ensures that personnel conducting QET verification activities possess the necessary skills, knowledge, and experience to deliver high-quality, consistent verification services that meet the requirements of ISO 14064-3:2019 and the specific needs of the QET methodology.

12.9 EU Methane Regulation Specific Competence Requirements

For QETs with EUMR extension requiring Article 28 compliance, verification personnel shall demonstrate additional competence in:

12.9.1 Methane-Specific Technical Knowledge

- Understanding of methane emissions sources, controls, and measurement approaches across oil and gas production facilities
- Knowledge of source-level and site-level measurement integration methodologies
- Familiarity with reconciliation processes for complex measurement systems

12.9.2 EU Regulatory Framework

- Knowledge of EU Methane Regulation requirements and Article 28 provisions

- Understanding of EEMDL Protocol methodology and verification requirements
- Awareness of EU import verification standards and procedures

12.9.3 Producer-Level Reporting Expertise

- Experience with aggregation methodologies for multi-facility operations
- Understanding of operational control determinations for producer-level boundaries
- Knowledge of licensed area definitions and regulatory frameworks

12.9.4 Documentation Requirements

Verification bodies shall document EU-specific competence through:

1. **Training Records**: Evidence of completion of EU Methane Regulation training programs
2. **Experience Documentation**: Demonstrated experience with methane-focused verification activities
3. **Regulatory Knowledge Assessment**: Periodic evaluation of understanding of EU regulatory requirements
4. **EEMDL Protocol Familiarity**: Documentation of training on EEMDL Protocol methodology and requirements

12.9.5 Competence Maintenance

Personnel conducting EU compliance verifications shall:

1. **Annual Updates**: Complete annual training on EU Methane Regulation changes and updates
2. **Protocol Updates**: Stay current with EEMDL Protocol revisions and methodological improvements
3. **Peer Review**: Participate in peer review activities focused on EU compliance verification
4. **Regulatory Tracking**: Maintain awareness of EU regulatory developments affecting methane emissions verification

12.9.6 Mandatory Accreditation for EU Compliance

For QETs representing crude oil and natural gas destined for EU markets under EUMR Article 28, verification must be performed exclusively by verifiers meeting the following accreditation requirements aligned with EEMDL Protocol Section 3.1.1:

12.9.7 Acceptable Accreditation Bodies

Primary Accreditation Path:

- Verification Bodies accredited by EU National Accreditation Bodies (NABs) in accordance with Regulation (EC) No 765/2008
- Accreditation scope must explicitly cover greenhouse gas verification under ISO/IEC 17029:2019 and ISO 14065:2020
- Specific competence in oil and gas methane emissions verification must be demonstrated

Comparable Third-Country Accreditation Path:

Verification Bodies accredited by non-EU National Accreditation Bodies may be accepted when the accreditation body demonstrates:

- Full membership in International Accreditation Forum (IAF) and International Laboratory Accreditation Cooperation (ILAC)
- Application of ISO/IEC 17011 to its own accreditation processes
- Legal establishment as the national authority for accreditation operating on a non-profit basis
- Institutional safeguards for independence and impartiality equivalent to Regulation (EC) No 765/2008
- Regular peer evaluation and participation in multilateral recognition arrangements
- Transparent procedures for application, assessment, surveillance, and appeals

12.9.8 Enhanced Verifier Competence Requirements for EU Compliance

Beyond the baseline requirements established in Section 12 and the EU-specific requirements in Sections 12.9.1-12.9.5, EU compliance verifiers must demonstrate:

Enhanced Technical Competence:

- Specific training in methane emissions quantification methodologies for oil and gas production
- Demonstrated experience with source-level and site-level measurement reconciliation per EEMDL Protocol requirements
- Knowledge of EU Methane Regulation requirements, particularly Articles 8, 9, 12, and 28
- Familiarity with EEMDL Protocol verification procedures and tiered reconciliation thresholds

Operational Experience:

- Minimum three (3) years experience in oil and gas emissions verification
- Completion of at least five (5) reasonable assurance engagements in upstream oil and gas operations
- Demonstrated competence in reconciliation methodologies for complex measurement systems

- Experience with producer-level aggregation and reporting requirements

Regulatory Knowledge:

- Current knowledge of EU regulatory framework for methane emissions
- Understanding of producer-level reporting requirements under EUMR Article 12
- Familiarity with EU import compliance procedures and documentation requirements
- Knowledge of EEMDL Protocol reconciliation threshold applications

12.9.9 Documentation and Verification of Accreditation

Verifiers shall maintain and provide upon request:

1. Current accreditation certificates with explicit scope coverage for oil and gas methane verification
2. Evidence of ongoing competence maintenance and professional development specific to EU requirements
3. Documentation of team qualifications for EU compliance engagements
4. Quality management system procedures specific to EUMR verification requirements
5. Records of successful completion of EEMDL Protocol training or equivalent competence demonstration

12.9.10 Cross-Reference to EEMDL Protocol

This section implements the verifier accreditation requirements specified in EEMDL Protocol Section 3.1.1 and ensures alignment with Regulation (EC) No 765/2008 while enabling qualified non-EU verifiers to participate in EU compliance verification activities under appropriate oversight and quality assurance mechanisms. All requirements in this section are mandatory when the EU compliance flag is activated in the QET data structure (Section 7.6).

13. Independent Review Process

13.1 Definition and Purpose of Independent Review

Independent review is a critical quality assurance mechanism within the QET verification framework that provides an additional level of scrutiny before verification or validation opinions are issued. This review serves to ensure the accuracy, completeness, and integrity of the verification process and its conclusions.

For QET verification, independent review is defined as a documented evaluation performed by a competent individual who is separate from the verification/validation team, focusing on the adequacy and appropriateness of the verification or validation process and its outcome.

13.2 When Independent Review is Required

Independent review shall be required in the following circumstances:

1. **Large-volume QET batches**: For any verification of QET batches exceeding 100,000,000 MMBtu or equivalent.
2. **High materiality risk**: For verifications where the estimated monetary value of the QETs exceeds $500,000.
3. **Methodological complexity**: When verification involves novel measurement methodologies or combines multiple measurement approaches.
4. **Significant uncertainty**: When reported emissions data contains measurement uncertainties approaching the defined materiality threshold.
5. **Adverse or modified opinions**: Before issuing any adverse or modified verification opinion.
6. **High public visibility**: For projects with significant public interest or regulatory scrutiny.

The verifier shall document the applicability of these criteria and justify when independent review is deemed unnecessary in cases that would typically require it.

13.3 Independence Requirements for Reviewers

Independent reviewers shall meet the following independence requirements:

1. **Organizational separation**: The reviewer must not have participated in the verification/validation activities under review.
2. **Competence requirements**: The reviewer must demonstrate competence in accordance with Section 12 of this methodology and have expertise equal to or exceeding that of the verification team leader.
3. **Impartiality safeguards**:
    - The reviewer shall not have financial interests that could influence their judgment regarding the verification.
    - The reviewer shall not have provided consulting services to the QET producer within the past three years.
    - The reviewer shall document their independence from both the verification team and the QET producer.
4. **Rotation requirements**: An individual may not serve as independent reviewer for the same QET producer for more than three consecutive years.

13.4 Scope and Process of Independent Review

The independent review shall evaluate:

1. **Team competence**: The appropriateness of verification team competencies relative to the engagement requirements.
2. **Verification design**: Whether the verification has been properly designed to address relevant risks.
3. **Execution completeness**: Whether all required verification activities have been completed according to the verification plan.
4. **Decision rationale**: The appropriateness of significant decisions made during the verification process.
5. **Evidence sufficiency**: Whether sufficient and appropriate evidence was collected to support the verification opinion.
6. **Opinion alignment**: Whether the collected evidence supports the opinion proposed by the verification team.
7. **ISO compliance**: Whether the verification was performed in accordance with ISO 14064-3, including:
    - Alignment of risk assessment, verification plan, and evidence-gathering plan with objectives.
    - Establishment of appropriate data trails for material emissions.
    - Proper assessment of restatements if applicable.
    - Conformity of the GHG statement with criteria.
    - Appropriate identification, resolution, and documentation of significant issues.

The independent review shall be conducted before the opinion is issued, but may be performed during the verification process to allow significant issues to be addressed before conclusion.

13.5 Documentation Requirements

The independent review process shall be documented to include:

1. **Review plan**: Outline of the scope, timeline, and approach for the review.
2. **Reviewer qualifications**: Evidence of the independent reviewer's competence and independence.
3. **Review checklist**: Itemized evaluation of all required elements of the verification process,
4. **Issues log**: Documentation of all concerns identified during the review, including:
    - Description of each issue
    - Significance assessment
    - Classification (critical, major, minor)
    - Resolution path
5. **Review conclusion**: Overall assessment of the verification process and opinion, including:
    - Statement of whether the review supports the verification conclusion
    - Any remaining concerns or limitations
    - Date of review completion and reviewer's signature

All documentation shall be maintained alongside verification records for the full retention period specified in Section 8.5.8 of this methodology.

13.6 Addressing Review Findings

Review findings shall be addressed according to the following process:

1. **Communication of findings**: The independent reviewer shall communicate all concerns to the verification team as soon as they are identified.
2. **Response requirements**: The verification team shall respond to all concerns raised by the reviewer and document:
    - The nature of each concern
    - Actions taken to address the concern
    - Justification for any concerns not addressed
3. **Resolution hierarchy**:
    - **Critical findings**: Must be fully resolved before opinion issuance.
    - **Major findings**: Must be addressed with appropriate verification activities or reflected in the verification opinion.
    - **Minor findings**: Should be addressed where practical or noted for future improvement.
4. **Opinion modification**: If significant concerns cannot be adequately addressed, the verification team shall modify the verification opinion accordingly or disclaim the issuance of an opinion.
5. **Documentation of resolution**: The verification team shall document how each finding was addressed and obtain the reviewer's acknowledgment of satisfactory resolution.

13.7 Integration with the Verification Process

The independent review shall be integrated into the verification process as follows:

1. **Early engagement**: The independent reviewer should be identified at the planning stage of verification.
2. **Progressive review**: For complex verifications, the reviewer may conduct progressive reviews at key milestones:
    - After completion of risk assessment.
    - Following evidence gathering but before opinion drafting.
    - Before final opinion issuance.
3. **Final approval**: The verification body shall not issue any verification or validation opinion until the independent reviewer has confirmed that:
    - All significant concerns have been adequately addressed.
    - The verification process complies with ISO 14064-3 requirements.
    - The evidence supports the proposed opinion.

14. Site Visit Requirements for QET Verification

14.1 Purpose and Scope of Site Visits

Site visits are a critical component of the reasonable assurance level verification process that allows verifiers to gather evidence about GHG emissions data through direct observation, interviews, and examination of physical assets. In the context of QET verification, site visits provide essential opportunities to assess the completeness, accuracy, and reliability of emissions data in its operational context.

This section establishes requirements for planning, conducting, and documenting site visits to ensure they effectively support the verification objectives and provide sufficient evidence for issuing verification opinions on QET emissions data.

14.2 Criteria for Determining When Site Visits Are Required

The verifier shall determine the need for site visits based on a documented risk assessment that considers the following factors:

14.2.1 Mandatory Site Visits

The following site visit requirements reflect a risk-based approach appropriate for the default limited assurance level. While all criteria below remain applicable, the scope and depth of site visit activities should be adjusted based on the selected assurance level. For engagements conducted at a reasonable assurance level, more extensive site visits may be required.

A site visit shall be conducted under any of the following circumstances:

1. **Initial verification:** For first-time verification of a facility providing emissions data for QET production with reasonable assurance (not required for limited assurance), unless the producer submits substantiating documentation demonstrating that the environmental and economic effects of conducting the site visit would result in a net-negative impact to the environment or would be economically prohibitive to the production of QETs. In such cases, the validator shall have the authority to make the final determination on whether to conduct remote verification based on the evidence submitted by the producer.
2. **New ownership or operation**: When there has been a change in ownership or operational control of a facility since the previous verification, and the emissions are material to the QET statement.
3. **Identified material misstatements**: When the desk review phase identifies potential material misstatements that can only be resolved through on-site investigation.

4. **Material changes**: When there are unexplained material changes in emissions, removals, and storage compared to previously verified statements.
5. **Modified scope**: When there are material changes in reporting scope, boundary, or data management systems.
6. **High uncertainty measurements**: When measurement technologies with high uncertainty levels are deployed and require on-site assessment.
7. **Complex operations**: For facilities with multiple GHG sources that contribute significantly to the overall emissions profile.
8. **EU Methane Regulation Compliance Triggers**: When QETs are intended for EU market compliance under EUMR Article 28, site visits shall be conducted when any of the following EEMDL Protocol-specific triggers are identified:
    a. **Unexplained Discrepancies Between Source-Level and Site-Level Observations**:
        - When reconciliation between source-level quantification and site-level measurements reveals unexplained variances exceeding the tiered thresholds specified in Section 8.2.9.1
        - When site-level measurements consistently indicate higher or lower emissions than source-level calculations without adequate technical justification
        - When temporal patterns in source-level and site-level data are inconsistent without documented operational explanations
    b. **Missing or Contradictory Measurement Records**:
        - When source-level measurement data is incomplete for periods exceeding 10% of the reporting timeframe
        - When measurement equipment records show gaps, anomalies, or inconsistencies that cannot be resolved through desktop review
        - When calibration records are missing, expired, or show systematic drift patterns
        - When quality assurance documentation is inadequate or contradictory to reported emissions data
    c. **Use of Novel or Complex Methodologies Requiring On-Site Review**
        - When measurement technologies have been deployed for less than two full reporting cycles
        - When custom emission factors or facility-specific quantification approaches are used without established validation
        - When measurement methodologies combine multiple approaches requiring integration verification
        - When uncertainty assessments rely on novel statistical methods or modeling approaches
    d. **Requests from Competent Authorities or Substantiated Third-Party Concerns**
        - When EU Member State competent authorities request additional verification evidence

- When credible third-party observations (satellite data, independent monitoring, etc.) suggest potential discrepancies
- When regulatory compliance issues have been identified that could affect emissions data integrity
- When previous verification findings from other facilities operated by the same entity suggest systemic issues

For EU compliance scenarios, these triggers supplement but do not replace the existing mandatory site visit criteria. The verifier shall document the assessment of each trigger and justify decisions regarding site visit necessity.

14.2.2 Risk-Based Site Visit Determination

For situations not covered by mandatory requirements, the verifier shall assess the following risk factors to determine the need for site visits:

1. The complexity of operations and diversity of emission sources.
2. The materiality of emissions from specific facilities to the overall QET batch.
3. Quality and reliability of previous verification results.
4. Sophistication and reliability of monitoring systems and controls.
5. Experience and competence of facility personnel responsible for emissions data.
6. Results of previous site visits and identified issues.
7. Temporal variations in emissions that may require on-site observation.
8. Selected assurance level: Whether the engagement is conducted at limited assurance (default) or reasonable assurance. Reasonable assurance engagements typically require more extensive site visits than limited assurance engagements.

The verifier shall document the rationale for site visit decisions, including justification when site visits are deemed unnecessary for facilities that would typically require them.

14.3 Planning Requirements for Site Visits

14.3.1 Pre-Visit Planning

Prior to conducting a site visit, the verifier shall develop a comprehensive site visit plan that includes:

1. **Visit objectives**: Clear statement of verification objectives to be addressed through the site visit.
2. **Schedule and duration**: Appropriate timing and duration based on facility complexity and verification scope.
3. **Team composition**: Identification of verification team members participating in the visit and their roles.

4. **Focus areas**: Specific emissions sources, equipment, and data management systems to be examined.
5. **Interview schedule**: Key personnel to be interviewed and topics to be covered.
6. **Document requests**: List of specific documentation to be reviewed on-site.
7. **Testing activities**: Planned tests, such as data trail examination, equipment inspection, or recalculations.
8. **Logistics**: Travel arrangements, access requirements, safety protocols, and equipment needs.

14.3.2 Communication with Responsible Party

The verifier shall:

1. Provide the responsible party with sufficient advance notice of the site visit.
2. Communicate the site visit plan to the responsible party at least 14 days before the visit.
3. Ensure relevant personnel are notified and available during the site visit.
4. Coordinate access to restricted areas, equipment, and documentation.
5. Confirm safety requirements and protocols for the specific operational environment.

14.4 Activities to Perform During Site Visits

The verifier shall perform evidence-gathering activities at the site or facility to assess, as determined by the risk assessment:

14.4.1 Physical Infrastructure and Operations Assessment

Site visits shall include assessment of:

Production Facilities:
- Wellhead and gathering systems
- Processing equipment
- Storage facilities

Processing Facilities:

- Physical verification of processing plant boundaries and all included equipment.
- Review of raw gas input and processed gas output metering systems.
- Inspection of NGL product measurement and allocation systems.
- Assessment of process control and monitoring equipment used for emissions quantification.
- Review of records documenting process upsets, maintenance, and product quality.

Transportation Infrastructure:

- Compressor stations
- Meter and regulator stations
- Pipeline segment boundaries
- PHMSA reporting systems integration

14.4.2 Measurement Equipment Evaluation

1. **Equipment types and configuration**: Verification that installed equipment matches reported specifications.
2. **Calibration records**: Examination of calibration documentation and maintenance records.
3. **Monitoring practices**: Assessment of compliance with required monitoring procedures.
4. **Sampling methods**: Evaluation of sample collection and analysis techniques.

14.4.3 Data Management Assessment

1. **Data collection procedures**: Evaluation of how primary data is collected and recorded.
2. **Quality control measures**: Assessment of quality assurance and quality control procedures.
3. **Data trail verification**: Tracing data from measurement points to final reported values.
4. **Calculations**: Review of calculations and assumptions used in emissions quantification.

14.4.4 Personnel Interviews

1. **Operational personnel**: Interviews with staff responsible for emissions-generating activities.
2. **Data management personnel**: Discussions with staff responsible for data collection and reporting.
3. **Technical experts**: Consultation with facility experts on measurement technologies.
4. **Management**: Engagement with management on oversight processes and controls.

14.5 Documentation Requirements During Site Visits

The verifier shall maintain comprehensive documentation of site visit activities, including:

14.5.1 Required Documentation

1. **Site visit log**: Chronological record of all activities performed during the site visit.
2. **Observation records**: Documentation of physical observations, including:
    - Photographic evidence (where permitted).
    - Sketches or diagrams of equipment configurations.

    - Notes on operational conditions during the visit.
3. **Interview minutes**: Records of all interviews conducted, including:
    - Names and positions of interviewees.
    - Questions asked and responses provided.
    - Follow-up items identified.
4. **Evidence collection register**: Log of all evidence collected during the visit, including:
    - Documents obtained
    - Data samples collected
    - Measurements taken
    - Calculations performed
5. **Issues log**: Documentation of all potential issues identified during the site visit, including:
    - Description of each issue
    - Preliminary assessment of materiality
    - Proposed resolution approach
    - Follow-up requirements
6. **Data verification worksheets**: Records of data verification activities, including:
    - Source data examined
    - Cross-checks performed
    - Recalculations conducted
    - Tracing and retracing tests performed
7. **Site visit summary report**: Comprehensive summary of site visit findings, including:
    - Achievement of objectives
    - Material issues identified
    - Evidence gathered
    - Preliminary conclusions
    - Recommended follow-up actions

14.5.2 Documentation Standards

All site visit documentation shall:

1. Be dated and identify the author/verifier
2. Be organized and indexed for easy reference
3. Provide clear links to specific verification criteria
4. Be retained as part of the verification documentation package
5. Be protected to ensure confidentiality of sensitive information

14.6 Remote Verification Alternatives

14.6.1 Eligibility for Remote Verification

Remote verification techniques are particularly appropriate under limited assurance engagements (the default assurance level for QETs). For reasonable assurance engagements, a stronger justification for remote techniques and additional compensating procedures may be required.

Remote verification techniques may substitute for physical site visits only under the following circumstances:

1. **Follow-up verifications**: For subsequent verifications after a comprehensive initial site visit, when:
   - There have been no material changes to facilities or operations.
   - No significant issues were identified in previous verifications.
   - Adequate monitoring systems and controls are in place.
2. **Low materiality sites**: For facilities that contribute less than 5% to the total emissions in a QET batch.
3. **Advanced monitoring technology**: When facilities have continuous emissions monitoring systems (CEMS) or other advanced monitoring technology that provides reliable, real-time data accessible remotely.
4. **Force majeure**: When site access is impossible due to natural disasters, public health emergencies, or safety concerns.
5. **Regulatory alignment**: When applicable regulations or programs explicitly permit remote verification for the facility type.
6. Environmental/Economic Feasibility: When the producer provides substantiating documentation demonstrating that the combined environmental costs (e.g., carbon emissions from travel) and economic costs of conducting an in-person site visit would:
   - Result in a net negative environmental impact.
   - Impose financial hardship that would make QET production economically unviable.

The validator shall review the submitted evidence and make the final determination on whether remote verification is appropriate. The producer's documentation must include:

A. Quantified environmental impact assessment of the proposed site visit.
B. Detailed cost analysis relative to the expected value of the QETs.
C. Proposed alternative methods for providing equivalent verification evidence through remote means.
D. Enhanced documentation to support comprehensive remote assessment.

14.6.2 Remote Verification Requirements

When remote verification is deemed appropriate, the verifier shall:

1. **Document justification**: Provide explicit documentation of the rationale for conducting remote verification instead of a site visit.
2. **Enhanced planning**: Develop a detailed remote verification plan with:

    - Real-time video inspection requirements.
    - Data sharing protocols.
    - Interview schedules.
    - Contingency measures for technical difficulties.
3. **Technology requirements**: Ensure appropriate technology is available:
    - High-definition video capability for equipment inspection.
    - Secure data sharing platforms.
    - Real-time communication tools.
    - Screen sharing capability for data system review.
4. **Additional evidence**: Require supplementary evidence to compensate for the lack of physical presence:
    - Time-stamped photographs or videos of key equipment.
    - Continuous monitoring data for the verification period.
    - Increased sample sizes for data testing.
    - Third-party attestations where applicable.
5. **Risk mitigation**: Implement additional verification procedures to address increased risk:
    - More extensive data analytics.
    - Cross-verification with external data sources.
    - Increased focus on data consistency checks.
    - More comprehensive personnel interviews.

14.6.3 Limitations of Remote Verification

The verifier shall acknowledge the following limitations in remote verification reports:

1. Any aspects that could not be fully verified remotely.
2. Additional uncertainty introduced by the remote verification approach.
3. Any scope limitations that affect the assurance level.
4. Recommendations for future on-site verification activities.

14.7 Site Sampling Methodology for Multiple Facilities

14.7.1 Sampling Approach Development

When a QET batch includes data from multiple facilities, the verifier shall develop a site sampling approach that:

1. Is risk-based and statistically sound.
2. Provides representative coverage of the facility population.
3. Considers the relative contribution of each facility to total emissions.
4. Accounts for the complexity and variability across facilities.

14.7.2 Facility Categorization

Facilities shall be categorized based on:

1. **Materiality**: Contribution to total emissions in the QET batch.
2. **Complexity**: Number and types of emission sources.
3. **Measurement methodology**: Measurement approaches and technologies used.
4. **Performance history**: Results from previous verifications.
5. **Control environment**: Strength of data management and controls.

14.7.3 Minimum Sample Size Determination

The minimum number of facilities requiring site visits shall be determined using the following formula:

$$SampleSizeMinHomogenous = ceil\left(\sqrt{N\_Facilities}\right)$$
$$SampleSizeMinHeterogenous = ceil\left(0.6 \times \sqrt{N\_Facilities}\right)$$

```
Sample_Size_Min_Homogeneous = Ceil(sqrt(N_Facilities))
Sample_Size_Min_Heterogeneous = Ceil(0.6 * sqrt(N_Facilities))
```

Where:

- `N_Facilities` is the total number of facilities in the QET batch.
- `ceil()` rounds up to the nearest whole number.

This basic formula shall be adjusted based on risk factors:

1. **High-risk adjustment:** Increase sample size by 20% when:
   - Previous verifications identified material issues.
   - Significant changes have occurred in facilities or processes.
   - Complex measurement methodologies are employed.
   - High emission variability exists across facilities.
2. **Low-risk adjustment:** Decrease sample size by 10% (but never below √N/2) when:
   - Previous verifications found no material issues.
   - Standardized measurement and reporting systems are used across all facilities.
   - Strong central controls are demonstrated.
   - Continuous monitoring systems are deployed.

Note: For limited assurance engagements (the default for QET verification), the minimum sample size may be adjusted downward by applying a limited assurance factor of 0.8 to the calculated value of n, provided that the resulting sample size is never less than n = √N for homogeneous populations or n = 0.5√N for heterogeneous populations, and always includes sites with the highest risk ratings. For reasonable assurance engagements, the full sampling formula without this reduction factor shall be applied.

14.7.4 Facility Selection Criteria

The selection of specific facilities for site visits shall ensure:

1. **Materiality coverage:** Selected facilities represent at least 50% of total emissions.
2. **Mandatory sites:** All facilities meeting the mandatory site visit criteria are included.
3. **Risk representation:** Higher-risk facilities are preferentially selected.
4. **Geographical distribution:** Adequate coverage of different geographical regions.
5. **Operational diversity**: Representation of different operational types within the portfolio.
6. **Rotation strategy**: Systematic rotation through all facilities over multiple verification cycles.

14.7.5 Documentation of Sampling Approach

The verifier shall document:

1. The complete facility population and categorization.
2. The sampling methodology applied.
3. Sample size calculation with any adjustments.
4. Selection criteria and rationale for each selected facility.
5. Coverage achieved by the selected sample (percentage of total emissions).
6. Justification for facilities not selected.
7. Plan for rotating through all facilities over time.

14.8 Integration with Overall Verification Process

The site visit requirements shall be integrated with the broader verification process:

1. Site visit planning shall be incorporated into the verification plan.
2. Site visit findings shall inform the risk assessment and evidence-gathering activities.
3. Evidence from site visits shall be evaluated alongside other evidence sources.
4. Site visit documentation shall be included in the verification documentation package.
5. Material issues identified during site visits shall be communicated promptly to the responsible party.
6. Site visit results shall be considered in determining the appropriate verification opinion.
7. Site visit scope and intensity shall be appropriate to the selected assurance level, with limited assurance engagements (the default for QETs) generally requiring less extensive inspection and testing than reasonable assurance engagements.

15. Facts Discovered After Verification

This section establishes procedures and responsibilities for handling new information or facts discovered after QET verification has been completed and verification opinions have been issued.

15.1 Purpose and Scope

Post-verification discoveries may include new information, measurement data, calculation errors, or other facts that could materially affect the accuracy of QET emissions data or the validity of verification opinions. This framework ensures that such discoveries are properly evaluated, communicated, and reflected in QET records to maintain data integrity and market confidence.

15.2 Types of Post-Verification Discoveries

Post-verification discoveries may include, but are not limited to:

1. **Measurement errors:** Identification of errors in the original measurements or incorrect application of measurement methodologies.
2. **Calculation errors:** Discovery of mathematical errors, incorrect emission factors, or flawed algorithms.
3. **Omissions:** Detection of emission sources that were excluded from the original assessment.
4. **New scientific information**: Updates to Global Warming Potential values or measurement standards.
5. **Equipment calibration issues**: Discovery of faulty calibration that affects measurement accuracy.
6. **Boundary inconsistencies**: Identification of incorrect facility or operational boundaries.
7. **Data manipulation**: Evidence of intentional misrepresentation of emissions data.

15.3 Procedures for Evaluating New Information

15.3.1 Initial Assessment

When new facts or information are discovered that could affect a verification opinion, the following initial assessment shall be conducted:

1. **Documentation of discovery:** The party discovering the new information shall document:
    - Nature of the discovered information.
    - Source and date of discovery.
    - Potential impact on previously verified emissions data.
    - Supporting evidence.
2. **Materiality screening:** A preliminary assessment of whether the discovered information is likely to be material to the QET emissions data, considering:
    - Quantitative impact relative to materiality thresholds established in Section 8.3.
    - Qualitative significance to data integrity or market confidence.
    - Effect on environmental claims made using the QETs.
3. **Notification of relevant parties:** Prompt notification to affected parties, including:
    - The verifier/validator who issued the opinion.
    - The QET producer (responsible party).
    - The QET registry administrator (EarnDLT).

15.3.2 Comprehensive Evaluation

For information deemed potentially material, a comprehensive evaluation shall be conducted by the original verifier or, if unavailable, another qualified verification body:

1. **Evidence collection:** Gathering of sufficient and appropriate evidence related to the new information.
2. **Impact analysis:** Quantitative assessment of how the new information affects:
    - Methane intensity values
    - Carbon intensity values
    - Uncertainty levels
    - Material misstatements
3. **Root cause analysis:** Determination of how and why the issue was not identified during verification.
4. **Corrective action assessment:** Evaluation of actions needed to address systematic issues.

15.4 Responsibility for Disclosure

15.4.1 Verifier/Validator Responsibilities

The verifier or validator shall:

1. Take appropriate action when credible new information is brought to their attention, including:
    - Evaluating the significance of the information.
    - Communicating with the responsible party and QET registry within 5 business days.
    - Issuing updated opinions when warranted.
    - Maintaining documentation of all communications and decisions.
2. Communicate to other interested parties when reliance on the original opinion may be compromised.
3. Maintain confidentiality while balancing disclosure obligations for market integrity.

15.4.2 QET Producer Responsibilities

The QET producer (responsible party) shall:

1. Promptly disclose to the verifier and QET registry any material information discovered after verification.
2. Provide full access to relevant data and records needed to evaluate the impact.
3. Implement corrective actions to prevent similar issues in future verifications.
4. Bear the costs of re-verification when errors originated in producer-supplied information.

15.4.3 QET Registry Responsibilities

The QET registry administrator (EarnDLT) shall:

1. Facilitate communication between affected parties.
2. Implement any required updates to QET records based on verification determinations.
3. Maintain a public record of significant post-verification updates.
4. Notify current token holders of material changes.

15.5 Criteria for Reissuance of Verification Statements

15.5.1 Materiality Threshold for Reissuance

Verification statements shall be reissued when:

1. **Quantitative threshold:** The discovered information would change emissions values by more than:
   - 5% for individual QET batches.
   - 2% for aggregated QET portfolios.
   - Any change that crosses a regulatory compliance threshold.
2. **Qualitative threshold:** The discovered information:
   - Reveals significant control deficiencies not previously identified.
   - Changes the verification conclusion (e.g., from unmodified to modified opinion).
   - Affects the reliability of a substantial portion of the verification evidence.

15.5.2 Reissuance Process

When reissuance is determined necessary:

1. **Statement withdrawal:** The original verification statement shall be formally withdrawn.
2. **Supplementary verification:** A targeted verification of the affected aspects shall be conducted.
3. **New verification statement:** A new statement shall be issued that:
   - References the original statement and withdrawal.
   - Clearly indicates it is a replacement.
   - Explains the changes and their basis.
   - Includes the date of reissuance.
4. **Independent review:** The reissued verification statement shall undergo independent review as specified in Section 13.

15.6 Blockchain Record Updates

The immutable nature of blockchain records requires specific procedures for updating QET information after verification:

15.6.1 Update Mechanisms

QET blockchain records shall be updated through:

1. **Annotation transactions:** Additional transactions that reference the original token and contain:

    - Link to the original QET.
    - Updated emissions data values.
    - Reference to the new verification statement.
    - Timestamped record of the update reason.
2. **State change flags:** Status indicators within the registry that show:
    - Current validity status of each QET.
    - History of updates.
    - Link to current verification documentation.
3. **Token version control**: Implementation of versioning that maintains:
    - Original token data (immutable).
    - Current valid version indicator.
    - Complete audit trail of changes.

15.6.2 Token Holder Notifications

When material updates occur:

1. **Automated notifications:** The QET registry shall implement a system to notify all current token holders.
2. **Grace period:** A 30-day period during which token holders can:
    - Accept the updated values.
    - Reject the tokens with compensation options as defined in the QET platform terms.
3. **Update confirmation:** A requirement for token holders to acknowledge notification of material changes.

15.6.3 Public Transparency

To maintain market integrity:

1. **Public change log:** A publicly accessible record of all material post-verification updates shall be maintained.
2. **Disclosure requirements**: Any environmental claims based on updated QETs must disclose:
    - The fact that the data was updated post-verification.
    - The nature and magnitude of the changes.
    - The date of the update.

15.7 Preventive Measures

To minimize the need for post-verification updates, the following preventive measures shall be implemented:

1. **Enhanced QA/QC procedures:** Additional quality checks during initial verification.
2. **Continuous monitoring integration**: Where feasible, integration of continuous monitoring data to enable early detection of anomalies.

3. **Periodic data reviews**: Scheduled reviews of verified data against new information or methodologies.
4. **Learning system**: Documentation and sharing of lessons from post-verification discoveries to improve verification processes.

15.8 Documentation Requirements

All actions related to post-verification discoveries shall be thoroughly documented, including:

1. **Discovery records:** Initial identification and assessment of new information.
2. **Evaluation documentation**: Analysis of materiality and impact.
3. **Communication records**: All notifications and discussions among parties.
4. **Decision rationale**: Justification for decisions regarding reissuance or updates.
5. **Update implementation**: Documentation of blockchain record updates.
6. **Long-term retention**: All records shall be retained for the full lifecycle of the associated QETs and for a minimum of 7 years.

16. Processing Operations - QET Implementation Guidance

This section provides detailed implementation guidance for Quantified Emissions Tokens representing natural gas processing operations. Processing QETs present unique challenges due to multi-product outputs, complex allocation methodologies, and integration with upstream production and downstream transportation systems.

16.1 Processing Plant Boundary Definition

16.1.1 Fundamental Boundary Principles

Processing plant boundaries for QET purposes shall be defined using the following hierarchy of principles:

1. **Physical Control Boundary:** The boundary shall encompass all equipment and processes under the operational control of the processing facility operator.
2. **Material Flow Boundary**: The boundary shall include all activities from raw gas inlet to final product outlets, including:
    - Raw gas reception and inlet separation.
    - Gas treating and conditioning processes.
    - Natural gas liquids extraction and fractionation
    - Residue gas compression and delivery.
    - Product storage and loading operations.

3. **Shared Infrastructure Treatment**: When processing facilities share infrastructure with other operations, the boundary shall be defined at the point of operational control transfer.

16.1.2 Boundary Definition Requirements

Processing facility operators shall document the following boundary elements:

- **Inlet Boundary Definition**
    - Raw gas inlet meter or custody transfer point.
    - Feed gas composition measurement points.
    - Pre-processing separation equipment (if applicable).
    - Inlet pressure and temperature measurement locations.
- **Process Unit Boundaries**
    - Acid gas removal systems (amine, membrane, etc.).
    - Dehydration units (glycol, molecular sieve, etc.).
    - NGL extraction systems (refrigeration, absorption, etc.).
    - Fractionation towers and separation equipment.
    - Sulfur recovery units (if applicable).
    - Process heating and utility systems.
- **Outlet Boundary Definition**
    - Residue gas outlet meter or custody transfer point.
    - NGL product loading and measurement points.
    - Acid gas disposal or sales points.
    - Sulfur product loading points (if applicable).

16.1.3 Treatment of Shared Utilities and Interconnected Facilities

a) Shared Utility Systems

When processing plants share utility systems with other facilities:

1. **Dedicated Metering Required:** Shared utilities shall be separately metered for processing plant consumption, or allocation factors shall be developed based on:
    - Engineering calculations of demand.
    - Operational data correlation.
    - Time-weighted allocation factors.
2. **Utility Emission Allocation:** Emissions from shared utilities shall be allocated to processing operations using:
    - Energy consumption ratios.
    - Operating time proportions.
    - Process demand calculations.

b) Interconnected Processing Facilities

For processing plants that are physically or operationally interconnected:

1. **Individual Plant Boundaries:** Each processing plant shall maintain distinct boundaries even when interconnected.
2. **Transfer Point Definition:** Material transfers between plants shall be measured at clearly defined custody transfer points.
3. **Shared Infrastructure Allocation:** Shared infrastructure emissions shall be allocated based on:
   - Throughput proportions.
   - Capacity utilization factors.
   - Engineering design allocations.

16.1.4 Boundary Considerations for Integrated Facilities

a) Production-Processing Integration

For facilities where processing is integrated with production operations:

1. **Functional Separation:** Processing boundaries shall begin at the point where raw gas enters treating or conditioning processes.
2. **Allocation Requirements:** When production and processing share equipment or utilities, clear allocation methodologies shall be established.

b) Processing-Transportation Integration

For facilities where processing is integrated with transportation systems:

1. **Custody Transfer Points:** Processing boundaries shall end at pipeline inlet flanges or designated custody transfer meters.
2. **Compression Station Treatment:** Compression equipment serving both processing and transportation functions shall be allocated based on operational purpose.

16.1.5 Boundary Documentation Requirements

Processing facility operators shall maintain:

1. **Process Flow Diagrams:** Detailed P&IDs showing all equipment within the processing boundary.
2. **Boundary Description Document:** Written description identifying:
   - Inlet and outlet points.
   - Major process units included.
   - Shared infrastructure treatment.
   - Allocation methodologies used.
3. **Geographic Coordinates:** GPS coordinates for:
   - Processing plant boundaries.
   - Major equipment locations.
   - Inlet and outlet points.

16.2 NGSI 2.0 Processing Methodology Alignment

16.2.1 NGSI 2.0 Processing Protocol Compliance

QETs from Processing Operations using the Natural Gas Sustainability Initiative (NGSI) Version 2.0 processing protocols, should include:

a) Methane Intensity Calculation Requirements

- Use of energy-based denominators (MMBtu processed).
- Multi-product allocation using energy content.
- Processing efficiency factor application.
- Uncertainty reporting for complex facilities.

b) Emission Source Coverage

- All material emission sources within processing boundaries.
- Equipment-specific emission factors where available.
- Process-specific methodologies for unique operations.
- Quality assurance procedures for data collection.

16.2.2 Processing-Specific Emission Factor Applications

a) Process Unit Emission Factors

NGSI-aligned Processing facilities should apply NGSI 2.0 emission factors specific to:

1. **Acid Gas Removal Systems:**
    - Amine circulation pump seals.
    - Amine regeneration venting.
    - Acid gas flaring or incineration.
    - Solution makeup and storage.
2. **Dehydration Systems:**
    - Glycol circulation pump seals.
    - Glycol regeneration venting.
    - Molecular sieve regeneration.
    - Desiccant makeup and handling.
3. **NGL Extraction Systems:**
    - Refrigeration system leaks.
    - Turbo-expander systems.
    - Absorption systems.
    - Product separation equipment.
4. **Fractionation Systems:**
    - Distillation column venting.
    - Product storage and loading.
    - Pump and compressor seals.
    - Process heating requirements.

b) Emission Factor Hierarchy

Processing facilities shall apply emission factors in the following hierarchy:

1. Site-specific measurement data.
2. Process-specific emission factors from NGSI 2.0.
3. Equipment-specific factors from EPA/GRI studies.
4. Generic processing equipment factors.

16.2.3 Quality Assurance Requirements for Processing Data

a) Data Validation Procedures

Processing facilities shall implement:

1. **Mass Balance Reconciliation:** Monthly reconciliation of:
   - Feed gas input vs. product outputs.
   - Carbon balance across processing units.
   - Energy balance validation.
2. **Product Quality Verification:** Regular analysis of:
   - Residue gas composition and heating value.
   - NGL product purity and composition.
   - Process performance indicators.
3. **Operational Data Correlation:** Verification that:
   - Emissions data correlates with operational conditions.
   - Process upsets are properly documented.
   - Equipment maintenance impacts are captured.

b) Process Control System Integration

Processing facilities should integrate emissions monitoring with process control systems to ensure:

- Real-time data correlation.
- Automated data validation.
- Exception reporting for abnormal conditions.
- Historical data trending and analysis.

16.3 Processing Equipment Monitoring Requirements

16.3.1 Equipment-Specific Monitoring Protocols

a) Acid Gas Removal Equipment

1. **Amine Systems:**
   - Absorber and regenerator pressure monitoring.
   - Amine circulation rate measurement.
   - Acid gas flow rate monitoring.
   - Stack emissions monitoring (where applicable).
2. **Membrane Systems:**
   - Feed gas pressure and flow monitoring.

- Permeate and retentate composition analysis.
- Membrane integrity verification.
- Waste gas measurement.

b) Dehydration Equipment

1. **Glycol Systems:**
   - Glycol circulation rate monitoring.
   - Regenerator temperature monitoring.
   - Still column overhead monitoring.
   - Water content verification.
2. **Molecular Sieve Systems:**
   - Regeneration gas flow monitoring.
   - Bed switching cycle documentation.
   - Regeneration temperature monitoring.
   - Breakthrough analysis.

c) NGL Extraction Equipment

1. **Refrigeration Systems:**
   - Refrigerant inventory tracking.
   - Leak detection system monitoring.
   - Compressor performance monitoring.
   - Heat exchanger efficiency tracking.
2. **Fractionation Systems:**
   - Column operating pressure monitoring.
   - Reflux ratio optimization.
   - Product quality verification.
   - Reboiler duty measurement.

16.3.2 Performance-Based Monitoring Requirements for Processing Equipment

Tier 1 - Standard Processing Facilities (≤250 MMCF/d capacity):

- Detection limits aligned with existing EPA/state regulatory monitoring requirements.
- Quarterly leak detection and repair (LDAR) programs acceptable.
- Higher uncertainty factors applied with appropriate disclosure.

Tier 2 - Major Processing Facilities (>250 MMCF/d capacity):

- Enhanced detection limits for material emission sources.
- Monthly LDAR with continuous monitoring for major sources.
- Standard uncertainty factors applied.

Alternative Compliance Pathways:

1. **Regulatory Alignment Option:** Facilities meeting EPA Subpart W or state equivalent monitoring requirements may participate with appropriate uncertainty adjustments.

2. **Technology-Neutral Approach:** Any monitoring technology achieving equivalent uncertainty levels is acceptable.
3. **Graduated Implementation:** 3-year phase-in period allowing facilities to upgrade systems progressively.

Detection Limit Framework

Equipment Type	Tier 1 Facilities	Tier 2 Facilities	Frequency
Process Heaters	1.0 kg/hr	0.1 kg/hr	Continuous/Daily
Compressor Seals	0.5 kg/hr	0.05 kg/hr	Weekly/Daily
Storage Tanks	EPA Subpart W compliant	0.02 kg/hr	Monthly/Continuous
Process Vents	1.0 kg/hr	0.1 kg/hr	Monthly/Continuous
Equipment Leaks	10,000 ppm	1,000 ppm	Quarterly

16.3.3 Calibration Requirements for Processing Applications

a) General Calibration Standards
All processing monitoring equipment shall be calibrated according to:

- Equipment manufacturer specifications
- Industry standard practices (API, ASME, etc.)
- NIST-traceable reference standards
- Process-specific correction factors

b) Processing-Specific Calibration Requirements

1. **Composition-Dependent Calibrations:** Equipment measuring gas streams with variable composition shall be calibrated using:
    - Multi-component reference gas mixtures.
    - Composition-specific correction factors.
    - Regular span gas verification.
2. **Process Condition Corrections:** Monitoring equipment shall account for:
    - Temperature and pressure variations.
    - Process fluid composition changes.
    - Humidity and contamination effects.
3. **Calibration Frequency Requirements:**
    - Critical path equipment: Monthly calibration.
    - Safety-critical monitors: Bi-weekly calibration.
    - Standard process monitors: Quarterly calibration.
    - Portable survey equipment: Pre-use verification.

16.4 Processing Data Quality Management

16.4.1 Data Validation Procedures for Processing Operations

a) Real-Time Data Validation

Processing facilities shall implement automated data validation including:

1. **Range Checking:** Verification that all measurements fall within expected operational ranges.
2. **Rate-of-Change Limits:** Detection of unrealistic changes in measured parameters.
3. **Mass Balance Verification:** Continuous checking of material balance closure.
4. **Redundant Measurement Comparison:** Cross-validation using independent measurement systems.

b) Periodic Data Reconciliation

Processing facilities shall perform regular data reconciliation:

1. **Daily Reconciliation:**
   - Feed gas vs. product material balance.
   - Energy input vs. output balance.
   - Key performance indicator trending.
2. **Monthly Reconciliation:**
   - Comprehensive mass and energy balance.
   - Emission factor validation.
   - Process efficiency calculation.
   - Product quality verification.
3. **Annual Reconciliation:**
   - Full facility material balance.
   - Emission inventory verification.
   - Process optimization assessment.
   - Methodology improvement identification.

16.4.2 Process Control System Integration Requirements

a) Data Integration Architecture

Processing facilities should implement integrated data management systems that:

1. **Centralize Data Collection:** All emissions-related data should be collected in a central database.
2. **Provide Real-Time Access:** Process operators should have real-time access to emissions data.
3. **Enable Automated Reporting:** System should generate automated emissions reports.
4. **Maintain Data Integrity:** Include audit trails and change management controls.

b) System Integration Requirements

1. **Process Control Integration:**
    - Direct interfaces with DCS/SCADA systems.
    - Automated data transfer protocols.
    - Exception handling procedures.
    - Data validation at point of collection.
2. **Laboratory Integration:**
    - Automated transfer of analytical results.
    - Chain of custody documentation.
    - Quality control data validation.
    - Method detection limit tracking.
3. **Maintenance System Integration:**
    - Equipment maintenance schedule tracking.
    - Maintenance impact on emissions.
    - Calibration schedule management.
    - Equipment performance monitoring.

16.4.3 Handling of Process Upsets and Abnormal Operations

a) Process Upset Documentation Requirements

Processing facilities shall document:

1. **Upset Event Classification:**
    - Minor process deviations
    - Major process upsets
    - Emergency shutdown events
    - Planned maintenance activities
2. **Impact Assessment:**
    - Duration of upset condition
    - Affected process units
    - Emissions impact quantification
    - Recovery procedures implemented
3. **Data Treatment Protocols:**
    - Identification of affected data periods
    - Alternative calculation methodologies
    - Data quality flag assignments
    - Uncertainty impact assessment

b) Abnormal Operation Protocols

1. **Real-Time Response:**
    - Immediate notification systems
    - Emergency response procedures
    - Process isolation protocols
    - Environmental impact mitigation
2. **Data Management During Upsets:**

- Continued monitoring where safe
- Alternative measurement methods
- Engineering estimates when monitoring unavailable
- Documentation of all estimation methods

3. **Post-Upset Analysis:**
    - Root cause analysis
    - Process improvement identification
    - Data validation and reconciliation
    - Lessons learned documentation

16.4.4 Multi-Product Allocation Data Management

a) Allocation Methodology Documentation
Processing facilities shall maintain detailed documentation of:

1. **Energy Content Allocation:**
    - Product heating value determination
    - Allocation factor calculations
    - Periodic factor updates
    - Calculation verification procedures
2. **Production Data Management:**
    - Individual product flow measurement
    - Product quality analysis
    - Custody transfer documentation
    - Allocation factor validation

b) Allocation Data Quality Assurance

1. **Independent Calculation Verification:** Allocation factors shall be independently calculated and verified.
2. **Periodic Methodology Review:** Allocation methodologies shall be reviewed annually for accuracy.
3. **Cross-Validation:** Allocation results shall be cross-validated using alternative methodologies.
4. **Documentation Maintenance:** All allocation calculations shall be fully documented and auditable.

16.4.5 Verification Integration Requirements

a) Verifier Data Access
Processing facilities shall provide verifiers with:

- Real-time access to process control systems.
- Historical database access for data trending.
- Direct interface with laboratory information systems.
- Documentation management system access.

b) Audit Trail Requirements
Processing facilities shall maintain audit trails showing:

- Data collection timestamps and sources.
- Calculation methodology applications.
- Data validation and reconciliation steps.
- Manual data entry justifications.
- System modification logs.

17. Roles, Responsibilities, and Workflow in QET Production

This section outlines the sequential workflow and delineates the specific responsibilities of each party involved in the QET lifecycle. By understanding who does what and when, stakeholders can ensure proper coordination and compliance throughout the QET production process.

17.1 Overview of Key Participants

The QET production process involves four primary stakeholders, each with distinct roles:

- **EarnDLT:** Platform operator that maintains the blockchain registry, facilitates token issuance, and provides the technical infrastructure for QETs.
- **Producer:** Entity responsible for the physical commodity production (e.g., natural gas operator) who seeks to quantify and tokenize emissions data.
- **Measurement Partner:** Third-party entity that conducts emissions measurements using approved methodologies and provides primary emissions data.
- **Validator/Verifier:** Independent entity that assesses data quality, validates methodologies, and verifies emissions claims in accordance with ISO 14064-3.

17.2 Pre-Engagement Phase

17.2.1 Producer

1. Identifies facilities/assets for QET production.
2. Defines system boundaries as per Section 4.4.
3. Selects an appropriate Measurement Partner[1].
4. Establishes internal data management systems for production data.

17.2.2 Measurement Partner

[1] Alternatively, the producer can act as its own measurement partner if the producer has the ability to measure emissions in alignment with a verifiable measurement methodology.

1. Reviews and selects appropriate measurement methodologies aligned with the QET framework.
2. Documents minimum detection limits (MDL) and monitoring frequency capabilities.
3. Prepares measurement plans consistent with the Producer's defined boundaries.

17.2.3 EarnDLT

1. Provides guidance on QET methodology requirements.
2. Makes available technical documentation on JSON schema and data structure requirements.
3. Creates Producer and Measurement Partner accounts in the QET registry system.

17.2.4 Validator/Verifier

1. Conducts pre-engagement assessment as outlined in Section 8.1.2.1.
2. Evaluates independence and impartiality considerations per Section 8.2.
3. Documents team competence according to Section 12 requirements.

17.3 Measurement and Data Collection Phase

17.3.1 Producer

1. Provides access to facilities for emissions measurements.
2. Records accurate production data, including:
    - Throughput volumes by facility/pad/well.
    - MMBtus sold from each well.
    - Heat value of the gas produced.
3. Documents operational conditions and activities during measurement periods.

17.3.2 Measurement Partner

1. Deploys measurement equipment at defined facility boundaries.
2. Conducts emissions measurements according to the selected methodology.
3. Records and documents:
    - Raw emissions data collected.
    - Measurement timestamps and frequency.
    - Equipment calibration records.
    - Operational context of measurements.
    - Observed anomalies or special circumstances.
4. Documents all sources of uncertainty as defined in Section 6.1, including:
    - Parameter uncertainty.
    - Scenario uncertainty.
    - Model uncertainty.
    - Measurement uncertainty.

- Temporal uncertainty.

5. Records minimum detection limits (MDL) and measurement frequency to support temporal uncertainty calculations as specified in Section 6.1.5.
6. Prepares preliminary GHG statement for the batch period.

17.3.3 EarnDLT

1. Provides technical support on data formatting requirements.
2. Maintains data security protocols for incoming information.

17.4 Data Processing and QET Preparation Phase

17.4.1 Producer

1. Compiles production data in required format.
2. Calculates production ratios for each well on pads as specified in Section 5.4.
3. Provides facility identifiers and geographical information.

17.4.2 Measurement Partner

1. Processes raw emissions data according to approved methodologies.
2. Applies uncertainty calculation methodologies as specified in Section 6.2.
3. Determines confidence level ratings based on measurement equipment capabilities and frequency.

17.4.3 Producer and Measurement Partner (jointly)

1. Prepare the JSON data structure as defined in Section 7.3.
2. Ensure all required fields are populated accurately.
3. Apply appropriate emission factors and unit conversions.
4. Document all assumptions and calculation methodologies.
5. Calculate combined uncertainties following the methodology in Section 6.4.
6. Determine and document the confidence level rating according to Section 6.3.
7. Include uncertainty metrics in the QET data structure when required by the applicable measurement methodology or standard.

17.5 Verification and Validation Phase

17.5.1 Validator/Verifier

1. Designs verification procedures appropriate to limited assurance (the default level for QETs) unless circumstances warrant or the client requests reasonable assurance; document the rationale when reasonable assurance is selected.

2. Conducts strategic analysis of the QET emissions data as per Section 11.3.1.
3. Performs risk assessment following methodology in Section 8.2.2.
4. Develops and documents verification plan.
5. Determines need for site visits based on criteria in Section 14.2, including:
    - Application of the updated mandatory site visit criteria.
    - Implementation of risk-based site visit determination.
    - Documentation of the decision-making process for site visit determination.
6. When appropriate, implements remote verification alternatives according to Section 14.6, including:
    - Adherence to eligibility criteria.
    - Implementation of required technical safeguards.
    - Documentation of justification for remote verification.
7. When verifying multiple facilities, applies the site sampling methodology outlined in Section 14.7.
8. Conducts evidence-gathering activities:
    - Traces data from raw measurements to final QET values.
    - Tests calculations and conversions.
    - Assesses historical data completeness.
    - Interviews relevant personnel.
9. Evaluates GHG statement against established criteria.
10. Conducts independent review if required per Section 13.2.
11. Prepares verification or validation report according to Section 11.5.
12. Implements EEMDL Protocol reconciliation requirements when EU compliance flag is activated, including source-level versus site-level measurement reconciliation, application of tiered discrepancy thresholds per Section 8.2.9.1, and documentation of best-estimate-integration methodology per Section 7.6.2.3

17.5.2 Producer

1. Provides access to all necessary data and documentation.
2. Makes personnel available for interviews.
3. Understand the implications of the default limited assurance level and determine if specific circumstances require requesting reasonable assurance from the verifier.
4. Responds to verifier requests for clarification.
5. Addresses any material misstatements identified during verification.
6. Implements corrective actions as needed.
7. Facilitates site visits as required under Section 14.2 or prepares for remote verification alternatives when eligible under Section 14.6.
8. Provides access to equipment, facilities, and personnel needed for physical infrastructure assessment, measurement equipment evaluation, and data management assessment as specified in Section 14.4.

17.5.3 Measurement Partner

1. Provides detailed documentation of measurement methodologies.
2. Explains calculation procedures and assumptions when requested.
3. Clarifies technical aspects of emissions measurements.
4. Assists in resolving technical questions raised during verification.
5. Provides documentation of uncertainty calculations and supporting data as required by Section 6.

17.5.4 EarnDLT

1. Provides technical support on QET data structure and registry requirements.
2. Facilitates information exchange between parties as needed.
3. Ensure the QET registry system properly records and displays the assurance level (limited or reasonable) associated with each verified QET batch.

17.6 QET Issuance Phase

17.6.1 Validator/Verifier

1. Issues final verification or validation opinion as specified in Section 8.5.
2. Digitally signs the verification statement.
3. Submits verification documentation to the QET registry.

17.6.2 Producer

1. Reviews final verification report and opinion.
2. Approves QET issuance.

17.6.3 EarnDLT

1. Mints QETs on the blockchain registry based on verified data.
2. Associates verification statements with token batches.
3. Makes token information available to authorized parties.

17.7 Post-Issuance Management Phase

17.7.1 Producer

1. Manages QET inventory in the registry.
2. Initiates QET transfers when trading or retiring tokens.
3. Promptly discloses any material information discovered after verification.
4. Implements improvements for future measurement cycles based on verification findings.

17.7.2 EarnDLT

1. Maintains registry functionality and data integrity.
2. Processes token transfers and retirements.
3. Updates token status based on new information when necessary.
4. Provides transaction histories and audit trails.

17.7.3 Validator/Verifier

1. Takes appropriate action when new information is discovered post-verification, following the procedures outlined in Section 15.
2. Issues updated opinions when warranted.
3. Maintains documentation of all communications and decisions.

17.7.4 Measurement Partner

1. Provides technical support for any post-verification questions.
2. Assists in evaluating the impact of new information discovered after verification.
3. Documents lessons learned for future measurement campaigns.

17.8 Continuous Improvement Cycle

17.8.1 All Parties

1. Document lessons learned from each QET production cycle.
2. Identify opportunities for process improvement.
3. Update methodologies based on new scientific information.
4. Implement technological advancements in measurement, verification, and registry functions.

18. Conclusion and Implementation

This methodology establishes a standardized approach for QET production that is verifiable under ISO 14064-3. By following the procedures outlined in this document, validators can ensure that QETs accurately represent the environmental attributes of the underlying physical commodities.

Implementation of this methodology will enable the creation of verified environmental attribute certificates that are compliant with global reporting standards, while accommodating a variety of measurement methodologies employed by commodity producers.

Appendix A: Transportation QET Implementation Guidance

A.1 Transition from Production to Transportation Methodology

When implementing transportation-specific QET calculations, operators shall:

1. Validate path segment identification against PHMSA databases
2. Establish data sharing agreements for multi-operator transportation paths
3. Implement allocation factor calculation systems
4. Develop verification procedures for flow proportion accuracy

A.2 Integration with Existing Production QETs

Transportation QETs shall be designed to connect seamlessly with upstream production QETs to enable full supply chain tracking while avoiding double-counting of environmental attributes.

Appendix B: Processing Ops QET Implementation Guidance

B.1 Sample Processing Plant QET Calculation

This example demonstrates the complete QET calculation process for a natural gas processing facility producing both residue gas and NGL products.

B.1.1 Facility Overview

Example Facility: Permian Processing Complex
Location: West Texas
Capacity: 200 MMCF/d raw gas input
Products: Pipeline-quality natural gas and NGL products
Reporting Period: November 2024

B.1.2 Input Data Collection

Raw Gas Input Data:

- Total raw gas volume: 6,000 MMCF
- Total raw gas energy content: 6,180 MMBtu
- Average heat content: 1.030 MMBtu/MCF

Processed Gas Output Data:

- Residue gas volume: 5,700 MMCF
- Residue gas energy content: 5,814 MMBtu
- Heat content: 1.020 MMBtu/MCF

NGL Production Data:

- Total NGL production: 7,500 barrels
- Total NGL energy content: 366 MMBtu
- Energy allocation factor: 366 ÷ 6,180 = 0.059 (5.9%)

B.1.3 Emissions Data Summary

Total Plant Emissions (measured):

- CH_4 emissions: 285.6 kg
- CO_2 emissions: 4,250.8 kg
- N_2O emissions: 8.5 kg

B.1.4 Multi-Product Allocation Calculation

Step 1: Calculate Allocation Factors

- Residue gas allocation: 5,814 ÷ 6,180 = 0.941 (94.1%)
- NGL allocation: 366 ÷ 6,180 = 0.059 (5.9%)
- Verification: 0.941 + 0.059 = 1.000 ✓

Step 2: Allocate Emissions to Residue Gas

- CH_4 allocated to residue gas: 285.6 × 0.941 = 268.8 kg
- CO_2 allocated to residue gas: 4,250.8 × 0.941 = 4,000.0 kg
- N_2O allocated to residue gas: 8.5 × 0.941 = 8.0 kg

B.1.5 QET Intensity Calculations

Methane Intensity Calculation:

- CH_4 mass per MMBtu = 268.8 kg ÷ 5,814 MMBtu = 0.0462 kg CH_4/MMBtu
- Methane intensity = 0.0462 kg CH_4/MMBtu × 100% = 4.62% (if expressing as volume percentage equivalent)

Carbon Intensity Calculation:

- CH_4 CO_2e = 268.8 kg × 28 (GWP) = 7,526.4 kg CO_2e
- Total CO_2e = 7,526.4 + 4,000.0 + (8.0 × 298) = 13,910.4 kg CO_2e
- Carbon intensity = 13,910.4 kg CO_2e ÷ 5,814 MMBtu = 2.392 kg CO_2e/MMBtu

QET Batch Size Calculation:

- QET batch size = 1,000 MMBtu

- Number of QETs in batch = 5,814 ÷ 1,000 = 5.814 (round to 6 QET batches)
- Actual QET batch size = 5,814 ÷ 6 = 969 MMBtu per QET

B.2 Multi-Product Allocation Methodology Example

This example demonstrates the NGSI 2.0-compliant energy-based allocation methodology for complex processing facilities.

B.2.1 Complex Processing Scenario

Facility: Eagle Ford Fractionation Complex
Products: Residue gas, ethane, propane, butanes, natural gasoline

B.2.2 Product Energy Content Determination

Product	Volume	Energy Content per Unit	Total Energy (MMBtu)	Allocation Factor
Residue Gas	4,850 MCF	1.024 MMBtu/MCF	4,966.4	0.847
Ethane	3,200 bbl	0.0345 MMBtu/bbl	110.4	0.019
Propane	1,850 bbl	0.0615 MMBtu/bbl	113.8	0.019
Butanes	1,100 bbl	0.0620 MMBtu/bbl	68.2	0.012
Natural Gasoline	750 bbl	0.0720 MMBtu/bbl	54.0	0.009
Total	-	-	**5,312.8**	**1.000**

B.2.3 Emission Allocation Example

Total Plant CH_4 Emissions: 425.8 kg

Allocated Emissions by Product:

- Residue Gas: 425.8 × 0.847 = 360.6 kg CH_4
- Ethane: 425.8 × 0.019 = 8.1 kg CH_4
- Propane: 425.8 × 0.019 = 8.1 kg CH_4
- Butanes: 425.8 × 0.012 = 5.1 kg CH_4
- Natural Gasoline: 425.8 × 0.009 = 3.8 kg CH_4

QET Focus - Residue Gas Only:

- Methane intensity = 360.6 kg ÷ 4,966.4 MMBtu = 0.0726 kg CH_4/MMBtu

B.3 Processing Equipment Emission Quantification Examples

B.3.1 Amine Treating System Example

System: DEA (Diethanolamine) Acid Gas Removal
Throughput: 150 MMCF/d raw gas
H_2S Content: 1,200 ppm

Emission Sources and Calculations:

- **Amine Circulation Pump Seals:**
    - Pump count: 3 pumps
    - Emission factor: 0.8 kg CH_4/pump/month
    - Monthly emissions: 3 × 0.8 = 2.4 kg CH_4
- **Amine Regeneration Venting:**
    - Regenerator overhead: 15 MSCF/month
    - CH_4 content: 65%
    - CH_4 emissions: 15 × 0.65 × 19.19 kg/MSCF = 187.1 kg CH_4
- **Total Amine System Emissions:** 189.5 kg CH_4/month

B.3.2 Glycol Dehydration System Example

System: TEG (Triethylene Glycol) Dehydration
Throughput: 140 MMCF/d sweet gas
Water Removal: 250 lbs/MMCF to 7 lbs/MMCF

Emission Sources and Calculations:

- **Still Column Overhead:**
    - Vent gas rate: 8.5 MSCF/month
    - CH_4 content: 85%
    - CH_4 emissions: 8.5 × 0.85 × 19.19 kg/MSCF = 138.7 kg CH_4
- **Circulation Pump Seals:**
    - Pump count: 2 pumps
    - Emission factor: 0.6 kg CH_4/pump/month
    - Monthly emissions: 2 × 0.6 = 1.2 kg CH_4
- **Total Dehydration System Emissions:** 139.9 kg CH_4/month

B.3.3 NGL Extraction System Example

System: Turbo-expander with Propane Refrigeration
Throughput: 135 MMCF/d dry gas
NGL Recovery: 3.2 GPM

Emission Sources and Calculations:

- **Turbo-expander Seals:**
    - Equipment count: 1 unit
    - Emission factor: 12.5 kg CH_4/unit/month
    - Monthly emissions: 12.5 kg CH_4
- **Refrigeration System Leaks:**
    - Propane inventory: 15,000 kg
    - Leak rate: 0.15%/year
    - Monthly leakage: 15,000 × 0.0015 ÷ 12 = 1.9 kg propane (excluded from CH_4 inventory)
- **Cold Box Fugitives:**
    - Equipment pieces: 45
    - Average emission factor: 0.8 kg CH_4/piece/month
    - Monthly emissions: 45 × 0.8 = 36.0 kg CH_4
- **Total NGL Extraction Emissions:** 48.5 kg CH_4/month

B.3.4 Plant-Level Emission Summary

Processing Unit	Monthly CH_4 Emissions (kg)	Allocation to Residue Gas (94.1%)
Amine Treating	189.5	178.4
Dehydration	139.9	131.6
NGL Extraction	48.5	45.6
Total	**377.9**	**355.6**

Monthly Processing Volume: 4,200 MMCF ÷ 12 = 350 MMCF
Monthly Energy: 350 MMCF × 1.024 MMBtu/MCF = 358.4 MMBtu
Processing CH_4 Intensity: 355.6 kg ÷ 358.4 MMBtu = 0.992 kg CH_4/MMBtu

B.4 Processing Plant Verification Checklist

B.4.1 Pre-Verification Documentation Review

Boundary Definition Documents

- Process flow diagrams (P&IDs) current and accurate
- Plant boundary description document
- GPS coordinates for major equipment
- Utility system allocation methodologies

Multi-Product Allocation Documentation

- Energy content determination procedures

- Allocation factor calculations
- Independent verification of allocation methodology
- Product quality analysis records

Measurement and Monitoring Records
- Equipment calibration certificates
- Monitoring frequency documentation
- Data collection procedures
- Quality assurance protocols

B.4.2 Site Verification Activities

Physical Boundary Verification
- Walk plant boundaries and verify against documentation
- Confirm inlet and outlet measurement points
- Verify shared utility metering arrangements
- Document any boundary discrepancies

Process Unit Inspection
- Acid gas removal systems operational verification
- Dehydration equipment inspection
- NGL extraction and fractionation units
- Flare and thermal oxidizer systems

Monitoring Equipment Assessment
- Calibration status verification
- Equipment condition assessment
- Data transmission verification
- Backup and redundancy systems

B.4.3 Data Verification Procedures

Mass Balance Reconciliation
- Feed gas vs. product material balance (target: >98% closure)
- Energy balance verification (target: >98% closure)
- Carbon balance assessment
- Investigate and resolve significant imbalances

Calculation Verification
- Independent recalculation of allocation factors
- Emission intensity calculations verification
- Unit conversion accuracy
- Mathematical accuracy of aggregations

Quality Assurance Checks

- Data completeness assessment
- Temporal consistency verification
- Comparison with historical performance
- Outlier identification and investigation

B.4.4 Compliance Verification

NGSI 2.0 Alignment

- Methodology application verification
- Calculation procedure compliance
- Uncertainty reporting requirements
- Documentation standard compliance

Regulatory Compliance

- Environmental permit compliance
- PHMSA reporting alignment (if applicable)
- State regulatory requirement compliance
- Safety standard compliance verification

B.4.5 Final Verification Sign-off

Documentation Complete

- All verification activities documented
- Findings and resolutions recorded
- Supporting evidence collected
- Chain of custody maintained

Quality Review

- Independent review completed
- Technical review by senior verifier
- Client communication documented
- Final verification opinion prepared

Verification Team Sign-off:

Lead Verifier: __________________ Date: __________
Technical Specialist: __________________ Date: __________
Independent Reviewer: __________________ Date: __________

Note: This checklist should be customized based on facility-specific characteristics and complexity. Additional verification activities may be required based on risk assessment outcomes and the specific processing technologies employed.

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