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Methodology for the Production and Verification of Low Carbon Fuel Standard Quantified Emissions Tokens® (QET-LCFS) in Accordance with ISO 14064-3

This methodology defines procedures for producing and verifying QET-LCFS for California LCFS compliance, extending the core QET framework to incorporate LCFS-specific carbon intensity, fuel pathway, and CARB verification requirements.

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Methodology for the Production and Verification of Low Carbon Fuel Standard Quantified Emissions Tokens® (QET-LCFS) in Accordance with ISO 14064-3

Executive Summary

This methodology document establishes the standardized framework for producing and verifying Quantified Emissions Tokens® specifically designed for California's Low Carbon Fuel Standard (LCFS) compliance. The QET-LCFS methodology <u>extends</u> the core QET framework established in the primary methodology document to incorporate LCFS-specific requirements, including carbon intensity calculations, fuel pathway certification, and CARB verification protocols.

1. Key Objectives

1. **Establish LCFS-specific QET production processes** that align with CARB's Low Carbon Fuel Standard regulations and CA-GREET modeling requirements
2. **Define verification procedures** for QET-LCFS tokens that meet both ISO 14064-3 standards and CARB accreditation requirements
3. **Create standardized data structures** for LCFS fuel pathway codes, carbon intensity values, and credit generation mechanisms
4. **Enable seamless integration** with CARB's LRT-CBTS reporting system for quarterly fuel transaction reporting
5. **Support automated LCFS credit generation** through verifiable, blockchain-anchored emissions data

2. Normative References

This methodology incorporates and references the following standards and documents:

Primary Standards:

- **ISO 14064-3:2019** - Greenhouse gases - Part 3: Specification with guidance for the verification and validation of greenhouse gas statements
- **ISO 14067:2018** - Greenhouse gases - Carbon footprint of products - Requirements and guidelines for quantification

- **ISO 14065:2013** - Greenhouse gases - Requirements for greenhouse gas validation and verification bodies

California LCFS Regulatory Framework:

- **California Code of Regulations Title 17, Division 3, Chapter 1, Subchapter 10** - Low Carbon Fuel Standard regulations
- **CA-GREET4.0 Model** - California-modified GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation) model
- **CARB LCFS Pathway Application Requirements** (Section 95488.8)
- **LCFS Verification Requirements** and CARB-accredited verifier protocols

Core QET Framework:

- **Methodology for the Production and Verification of Quantified Emissions Tokens® (QETs) in Accordance with ISO 14064-3**
- **EarnDLT QET Technical Specifications** and JSON schema requirements

3. Terms and Definitions

3.1 Low Carbon Fuel Standard Quantified Emissions Token (QET-LCFS)

A specialized Quantified Emissions Token that contains verified carbon intensity data, fuel pathway information, and LCFS credit generation parameters specifically formatted for California LCFS compliance and credit generation.

3.2 Carbon Intensity (CI)

The lifecycle greenhouse gas emissions per unit of energy delivered, expressed in grams of CO_2 equivalent per megajoule (gCO_2e/MJ), calculated using the CA-GREET methodology.

3.3 Fuel Pathway

A specific combination of feedstock, production process, and transportation mode that defines the lifecycle carbon intensity of a fuel, as certified by CARB under the LCFS program.

3.4 Pathway Code

A unique identifier assigned by CARB to each certified fuel pathway, used for LCFS reporting and credit generation (e.g., "CA-GREET4.0-NG-001").

3.5 LCFS Credit

A tradeable compliance instrument representing one metric ton of CO_2 equivalent emission reduction below the applicable LCFS carbon intensity benchmark.

3.6 LRT-CBTS

CARB's LCFS Reporting Tool and Credit Bank & Transfer System, the official platform for LCFS fuel transaction reporting and credit management.

3.7 Book-and-Claim Accounting

An accounting methodology that allows environmental attributes to be claimed at a different location from where they were generated, provided proper documentation and verification requirements are met.

4. General Requirements for QET-LCFS Production

4.1 Foundational Compliance

QET-LCFS tokens shall comply with all requirements established in the primary QET methodology document while incorporating additional LCFS-specific elements as detailed in this methodology.

4.2 LCFS Regulatory Alignment

All QET-LCFS tokens shall be produced in accordance with:

- Current California LCFS regulations as amended (effective July 1, 2025)
- CARB fuel pathway certification requirements
- CA-GREET4.0 modeling standards
- CARB-accredited verification protocols

4.3 Fuel Pathway Integration

QET-LCFS tokens shall reference only CARB-certified fuel pathways through:

- **Lookup Table pathways** with predetermined CI values
- **Tier 1 pathways** using CARB-approved CI calculators
- **Tier 2 pathways** with custom CA-GREET modeling

5. LCFS-Specific Quantification Methodology

5.1 Carbon Intensity Calculation Requirements

5.1.1 CA-GREET Model Compliance

All carbon intensity calculations shall utilize the CA-GREET 4.0 model or associated Tier 1 CI Calculators, as specified by CARB. The carbon intensity value shall be calculated as:

```
CI = (Total Lifecycle GHG Emissions) / (Energy Content)
```

Where:

- Total Lifecycle GHG Emissions = Sum of all GHG emissions from feedstock production, fuel production, transportation, and distribution (in gCO_2e)
- Energy Content = Lower heating value of the fuel (in MJ)

5.1.2 Pathway-Specific Calculations

Carbon intensity calculations shall follow pathway-specific methodologies:

For Renewable Natural Gas (RNG) Pathways:

- Include methane emissions from anaerobic digestion processes
- Account for fugitive emissions from pipeline injection and distribution
- Apply appropriate global warming potential (GWP) factors as specified in CA-GREET4.0

For Renewable Diesel Pathways:

- Include emissions from feedstock preprocessing and hydrotreatment
- Account for co-product allocation using energy-based allocation factors
- Include transportation emissions based on actual delivery distances

5.2 Fuel Volume and Energy Content Determination

5.2.1 Volume Measurement Requirements

Fuel volumes shall be measured using calibrated flow meters with accuracy specifications meeting CARB requirements:

- **Natural Gas**: Standard cubic feet at standard conditions (14.73 psia, 60°F)

- **Liquid Fuels**: Gallons at 60°F temperature correction
- **Hydrogen**: Kilograms at dispensing conditions

5.2.2 Energy Content Calculation

Energy content shall be determined using:

- **Lower Heating Value (LHV)** for all fuel types
- **CARB-specified energy density factors** from LCFS regulations
- **Verified fuel quality analysis** when available

5.3 LCFS Credit Calculation Methodology

5.3.1 Credit Generation Formula

LCFS credits shall be calculated using the formula specified in CARB regulations :

```
Credits = (Benchmark CI - Fuel CI) × Energy Delivered × 0.001
```

Where:

- Benchmark CI = CARB-established carbon intensity benchmark for the compliance year (gCO_2e/MJ)
- Fuel CI = Verified carbon intensity of the fuel from the QET-LCFS token (gCO_2e/MJ)
- Energy Delivered = Total energy content of fuel delivered (MJ)
- 0.001 = Conversion factor to metric tons

5.3.2 Deficit Calculation

When fuel carbon intensity exceeds the benchmark, deficits shall be calculated using the same formula, resulting in negative credit values.

6. QET-LCFS Data Structure and Required Fields

6.1 LCFS Extension Schema

The QET-LCFS data structure shall include a dedicated "lcfs" object containing the following mandatory fields:

json

```
{
  "lcfs": {
    "pathwayCode": "CA-GREET4.0-RNG-DW-001",
    "ciScore": {
      "value": 22.5,
      "uom": "g CO2e/MJ",
      "methodology": "CA-GREET4.0"
    },
    "fuelType": "Renewable Natural Gas",
    "feedstock": "Dairy Manure",
    "lcaSource": "CARB Pathway Report ID-2025-001",
    "lcaVersion": "CA-GREET4.0",
    "volume": {
      "value": 10000,
      "uom": "MMBtu"
    },
    "creditEligibility": true,
    "verifier": {
      "name": "CARB-Accredited Verification Firm, Inc.",
      "accreditationId": "CARB-VER-2025-0078"
    },
    "emissionFactorSource": "CA-GREET4.0 Lookup Table",
    "lastUpdated": "2025-09-01"
  }
}
```

6.2 Mandatory LCFS Fields

Field	Description	Data Type	Required
pathwayCode	CARB-certified fuel pathway identifier	String	Yes
ciScore.value	Carbon intensity value	Number	Yes
ciScore.uom	Unit of measure (g CO2e/MJ)	String	Yes
fuelType	CARB-defined fuel type	String	Yes
feedstock	Primary feedstock source	String	Yes
volume.value	Fuel volume/quantity	Number	Yes

Field	Description	Data Type	Required
volume.uom	Volume unit of measure	String	Yes
creditEligibility	LCFS credit generation eligibility	Boolean	Yes
verifier.accreditationId	CARB verifier accreditation number	String	Yes

7. Verification and Validation Requirements for QET-LCFS

7.1 CARB Accreditation Requirements

All verifiers conducting QET-LCFS verification shall maintain current CARB accreditation under the LCFS verification program. Verifier qualifications shall include:

- **CARB-issued accreditation certificate** for LCFS verification
- **ISO 14065 accreditation** from an acceptable accreditation body
- **Technical competence** in CA-GREET modeling and fuel pathway analysis
- **Annual continuing education** requirements as specified by CARB

7.2 Dual Verification Framework

QET-LCFS tokens shall undergo dual verification covering:

7.2.1 ISO 14064-3 Verification

Standard QET verification procedures as defined in the primary methodology document, including:

- Risk assessment and materiality determination
- Evidence gathering and documentation review
- Site visits when required by risk assessment
- Independent review process for reasonable assurance engagements

7.2.2 LCFS-Specific Verification

Additional verification activities specific to LCFS compliance:

- **Pathway certification validation**: Confirmation that referenced pathway codes are current and applicable.

- **CA-GREET model compliance**: Verification of carbon intensity calculations using CA-GREET4.0
- **Fuel quality documentation**: Review of fuel analysis and energy content determinations
- **Chain of custody verification**: Confirmation of fuel delivery and consumption records

7.3 Documentation Requirements

QET-LCFS verification shall maintain documentation including:

- **CARB pathway application** and certification documents
- **CA-GREET model inputs** and calculation worksheets
- **Fuel quality analysis** reports and energy content determinations
- **Chain of custody documentation** from production to consumption
- **LRT-CBTS reporting records** when applicable

8. LCFS Credit Generation and Reporting

8.1 Credit Generation Process

QET-LCFS tokens enable LCFS credit generation through the following process:

1. **Token Creation**: Producer creates QET-LCFS with verified CI data
2. **Token Transfer**: Token transferred to fuel reporting entity
3. **Fuel Consumption**: Physical fuel consumed in an LCFS-eligible application
4. **LRT-CBTS Reporting**: Token data used for quarterly fuel transaction reporting
5. **Credit Issuance**: CARB calculates and issues credits based on reported data

8.2 LRT-CBTS Integration

QET-LCFS data shall be formatted for direct integration with CARB's LRT-CBTS system:

- **Automated data export** in CARB-specified formats
- **Quarterly reporting compatibility** with LCFS submission deadlines
- **Credit calculation support** using embedded CI and volume data
- **Audit trail maintenance** through blockchain verification

8.3 Book-and-Claim Compliance

For fuels utilizing book-and-claim accounting (RNG, low-CI hydrogen), QET-LCFS tokens shall:

- **Track injection and withdrawal points** with geographic and temporal data

- **Maintain environmental attribute ownership** documentation
- **Comply with matching timeframes** (quarterly for RNG, monthly for hydrogen)
- **Prevent double-counting** through unique token identifiers

9. Monitoring and Continuous Improvement

9.1 Regulatory Updates

The QET-LCFS methodology shall be updated to reflect:

- **CARB regulation amendments** and new pathway requirements
- **CA-GREET model updates** and revised emission factors
- **Verification protocol changes** and accreditation requirements

9.2 Performance Monitoring

Ongoing monitoring shall track:

- **Credit generation accuracy** compared to LRT-CBTS calculations
- **Verification consistency** across different verifiers and fuel types
- **Data quality metrics** and error rates in token production

10. Implementation Timeline and Compliance

10.1 Effective Date

This methodology shall be effective immediately for fuel transactions occurring on or after January 1, 2026, to align with LCFS reporting requirements.

10.2 Transition Provisions

Existing QET tokens may be enhanced with LCFS extensions through:

- **Supplemental verification** activities for LCFS-specific requirements
- **Data structure updates** to include mandatory LCFS fields
- **Re-issuance** with enhanced verification statements when required

10.3 QET-LCFS Extension Enhancement for Existing Tokens

This section discusses the conversion of standard QETs to QET-LCFS tokens via modular enhancement mechanisms. Here are the two primary conversion pathways:

10.3.1 API-Based Enhancement (PATCH Operations)

Standard QET tokens can be enhanced with LCFS extensions through dedicated API endpoints:

```
PATCH /api/qet/tokens/{tokenId}/lcfs
```

This enables:

- **Asynchronous compliance data addition,** where operations teams create base tokens first, and compliance teams add LCFS data later
- **Role-based accountability** with cleaner audit trails for different functional responsibilities
- **Backward compatibility** with existing token structures while adding LCFS functionality

10.3.2 Platform-Based Enhancement (EarnDLT Cloud Interface)

The EarnDLT platform provides a guided enhancement process:

- **Progressive disclosure interface** allowing users to add LCFS data to existing tokens
- **Wizard-style upgrade process** that maintains data integrity while adding compliance fields
- **Validation and preview capabilities** showing LCFS credit eligibility before finalizing enhancements

10.3.3 Modular Extension Architecture

The conversion system follows a **namespaced object approach** where:

- **Core QET structure remains unchanged** to maintain compatibility
- **LCFS extension is added as optional nested object** `{"lcfs": {...}}`
- **Conditional schema validation** applies only when LCFS fields are present
- **Metadata tracking** indicates which compliance modules have been activated

10.3.4 Verification Requirements for Enhanced Tokens

When converting standard QETs to QET-LCFS:

- **Supplemental verification activities** may be required for LCFS-specific data elements
- **Enhanced verification statements** must address both original QET data and new LCFS components
- **Chain of custody documentation** must be updated to reflect LCFS compliance requirements
- **Re-issuance protocols** may apply when enhancement significantly changes token attributes

This conversion capability is critical for the methodology because it enables **existing QET holders to upgrade their tokens** for LCFS compliance without losing the original verification integrity, while providing **flexible implementation pathways** that accommodate different organizational workflows and compliance timelines.

Conclusion

The QET-LCFS methodology provides a comprehensive framework for producing verifiable emissions tokens that support California's Low Carbon Fuel Standard compliance while maintaining alignment with ISO 14064-3 verification standards. This methodology enables the automated generation of LCFS credits through blockchain-verified carbon intensity data, streamlining compliance for fuel producers and reporting entities while ensuring regulatory compliance and audit readiness.

The integration of CARB's regulatory requirements with the established QET framework creates a robust system for tracking and verifying low-carbon fuel attributes, supporting California's climate goals through enhanced transparency and verification of fuel carbon intensity data.