45Q Carbon Oxide Utilization LCA Training Workshop: Toolkit Overview

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National Energy Technology Laboratory (NETL)
By the end of this session we hope you’ll be able to answer:

• What is LCA?
• What are the parts of the LCA development process?
  ◦ How do I define my goal and scope
  ◦ How do I perform an inventory analysis
  ◦ How do I perform an impact assessment?
• What is the NETL LCA 45Q Toolkit?
  ◦ What role does each part of the toolkit play in my LCA?
• What is required of my LCA for the 45Q LCA program?
• What additional tools and resources does NETL have for 45Q LCA?
• What are some common issues to look out for?
45Q LCA Background

Regulatory basis

• § 1.45Q-4 Utilization of Qualified Carbon Oxide:

• 26 CFR § 1.45Q-4 (hereby referred to as 45Q) requires a life cycle analysis (LCA) to be performed to document the amount of qualified carbon oxide for the utilization tax credit.

• Under the Internal Revenue Service’s (IRS) regulations, LCAs must be prepared and documented in conformance with certain ISO standards.

• The Treasury Department and the IRS noted in its final rule that the Department of Energy (DOE) National Energy Technology Laboratory (NETL) CO2 Utilization Guidance Toolkit is consistent with the ISO standards and directed taxpayers in the final rule to use such guidance when submitting LCAs under 45Q.

• LCAs only applicable to non-EOR utilization cases from 2018 on
§ 1.45Q-4 Utilization of Qualified Carbon Oxide.

(a) In general. For purposes of this section, utilization of qualified carbon oxide means -

1. The fixation of such qualified carbon oxide through photosynthesis or chemosynthesis, such as through the growing of algae or bacteria,
2. The chemical conversion of such qualified carbon oxide to a material or chemical compound in which such qualified carbon oxide is securely stored, or
3. The use of such qualified carbon oxide for any other purpose for which a commercial market exists (with the exception of use as a tertiary injectant in a qualified enhanced oil or natural gas recovery project), as described in paragraph (d) of this section.

From: https://www.ecfr.gov/current/title-26/chapter-I/subchapter-A/part-1/subject-group-ECFR321685e6a0496a0[section-1.45Q-4]
45Q LCA Background

• **Amount utilized —**
  
  • (1) *In general.* For purposes of §1.45Q-1(b)(ii) and (c)(2)(ii), the amount of qualified carbon oxide utilized by the taxpayer is equal to the metric tons of qualified carbon oxide which the taxpayer demonstrates, based upon an analysis of lifecycle greenhouse gas emissions (LCA), were—
    
    • (i) Captured and permanently isolated from the atmosphere through use of a process described in paragraph (a) of this section, or
    
    • (ii) Displaced from being emitted into the atmosphere through use of a process described in paragraph (a) of this section.
  
  • (2) **Limitation.** The amount determined under paragraph (b)(1) of this section cannot exceed the amount of qualified carbon oxide measured at the source of capture.

From: https://www.ecfr.gov/current/title-26/chapter-I/subchapter-A/part-1/subject-group-ECFR321685e6a0496a0/section-1.45Q-4
What is Life Cycle Assessment (LCA)?

LCA is a technique that helps people make better decisions to improve and protect the environment by accounting for the potential impacts from raw material acquisition through production, use, end-of-life treatment, recycling, and final disposal (i.e., cradle-to-grave).
CO2U LCA Guidance Document
NETL CO2U Guidance Toolkit

- First released in 2019
- Supports funding recipients with their LCA requirements
- Fosters better decision-making for the U.S. DOE Carbon Conversion Program by providing consistent and transparent analysis and reporting structure
- Provides LCA guidance, data, and tools to LCA practitioners in the area of carbon conversion
- Contributes to the global discussion on carbon conversion LCA and LCA methods
- Toolkit site: netl.doe.gov/LCA/CO2U
NETL refined the CO2U guidance for 45Q-specific purposes
- Technology Readiness Level (TRL) 8/9+
- Applicability to any conversion pathway, including any product in any market (e.g. food and beverage)
- Addition of regulatory-specific impact method to LCI database and documentation spreadsheet
- Updated Report Template with taxpayer-specific language
  Released Feb, 2022
- All products reviewed and approved by DOE and IRS
# 45Q Addendum

- Shared tools highlighted in green
- CO2U Guidance Document and 45Q addendum to be read together
## LCA Methods Comparison

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<th>CO2U</th>
<th>45Q</th>
<th>UPGrants</th>
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<tr>
<td><strong>Program Origination</strong></td>
<td>U.S. DOE Carbon Conversion Program FOAs</td>
<td>26 CFR § 1.45Q-4</td>
<td>Section 40302 of the Bipartisan Infrastructure Law</td>
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<td><strong>Terminology for LCA Submitter</strong></td>
<td>Principal Investigator (PI)</td>
<td>Applicant</td>
<td>Vendor</td>
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<tr>
<td><strong>LCA Submitter</strong></td>
<td>DOE FOA recipient working on carbon conversion project</td>
<td>Owner of carbon capture equipment selling carbon oxide for utilization applying for 45Q tax credit</td>
<td>Carbon conversion product manufacturer intending to be available to Grant Applicants</td>
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<tr>
<td><strong>Species Utilized</strong></td>
<td>Carbon Dioxide</td>
<td>Carbon Oxide</td>
<td>Carbon Oxide</td>
</tr>
<tr>
<td><strong>Expected TRL</strong></td>
<td>1-9</td>
<td>8-9</td>
<td>7-9</td>
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<tr>
<td><strong>Review Scope</strong></td>
<td>NETL provides critical and conformance review</td>
<td>NETL provides conformance review, third-party permitted to perform critical review (NETL provides if not)</td>
<td>NETL provides critical and conformance review</td>
</tr>
<tr>
<td><strong>Approval</strong></td>
<td>NETL works with PIs to bring LCA to sufficient quality</td>
<td>NETL provides conformance/critical review to IRS. IRS makes final decisions</td>
<td>NETL provides conformance/critical review to Carbon Conversion Program. Program makes final decisions</td>
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*Expected based on general industry information, not an eligibility requirement
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<td><strong>CO2U</strong></td>
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<tr>
<td>Technological Scope</td>
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<tr>
<td>Temporal Scope</td>
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<td>Geographical Scope</td>
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<td>NETL data usage</td>
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<td>Downstream System Boundary</td>
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<td>Carbon Oxide Source</td>
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<td>Sensitivity Analysis</td>
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<td>Uncertainty Analysis</td>
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## LCA Comparison

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<tr>
<td><strong>Email address for support</strong></td>
<td><strong><a href="mailto:LCA@netl.doe.gov">LCA@netl.doe.gov</a></strong></td>
<td>General, including eligibility questions: <a href="mailto:LBI.EEF.45QLCA@irs.gov">LBI.EEF.45QLCA@irs.gov</a></td>
<td>FOA Questions must be submitted through the FedConnect Portal: <a href="http://www.fedconnect.net/FedConnect/?doc=DE-FOA-0002829&amp;agency=DOE">http://www.fedconnect.net/FedConnect/?doc=DE-FOA-0002829&amp;agency=DOE</a></td>
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<tr>
<td></td>
<td>Or your NETL project manager</td>
<td>LCA-specific: <a href="mailto:lca45q@hq.doe.gov">lca45q@hq.doe.gov</a></td>
<td>Vendor Questions: <a href="mailto:UPGrants-Vendors@netl.doe.gov">UPGrants-Vendors@netl.doe.gov</a></td>
</tr>
</tbody>
</table>
| **Helpful links** | • [https://netl.doe.gov/LCA](https://netl.doe.gov/LCA) | • Regulatory Text (eCFR)  
• IRS Final Rule (including preamble)  
• ISO 14040:2006  
• ISO 14044:2006 | • [UPGrants Program General Information](https://netl.doe.gov/LCA/UPgrants)  
• [Information for Eligible Entities](https://netl.doe.gov/LCA/UPgrants)  
• [Funding Opportunity Announcement DE-FOA-0002829](https://netl.doe.gov/LCA/UPgrants)  
• ISO 14040:2006  
• ISO 14044:2006 |
The LCA Development Process

- Goal and Scope Definition
- Inventory Analysis
- Impact Assessment
- Interpretation
Inventory Analysis

GOAL AND SCOPE DEFINITION

INVENTORY ANALYSIS

IMPACT ASSESSMENT

INTERPRETATION
1. **Intended application** - to find the metric tons of qualified carbon oxide that the applicants demonstrate were captured and permanently isolated from the atmosphere or displaced from being emitted into the atmosphere through use in a qualified utilization process.

2. **Reasons for carrying out the study** - to determine the amount of qualified carbon oxide utilized by the applicants under paragraph (2)(B)(ii) or (4)(B)(ii) of subsection (a) of 26 CFR § 1.45Q-4.

3. **Intended audience** - the U.S. IRS and DOE.

4. **Public disclosure** – the LCAs conducted as a requirement of qualification for the 45Q tax credit will not be published by DOE/NETL.
Proposed Product System

Upstream Process(es) → Material and Energy Inputs → Power or Industrial Plant → Carbon Dioxide Product → CO2U Process → Main Product → Downstream Process(es), When Required

1.0 (units) Primary Product of Interest, intermediate or final

X (units) Co-Product A, intermediate or final

Y (units) Co-Product B

Multiproduct functional unit of 1.0 (unit) Primary Product of Interest, X (units) Co-Product A, and Y (units) Co-Product B
Proposed Product System

Upstream Process(es) → Material and Energy Inputs → Power or Industrial Plant

Material and Energy Inputs → CO2U Process

Carbon Oxide Product → Co-Product → Downstream Process(es), When Required

Main Product

1.0 (units) Primary Product of Interest, intermediate or final

X (units) Co-Product A, intermediate or final

Y (units) Co-Product B

Multiproduct functional unit of 1.0 (unit) Primary Product of Interest, X (units) Co-Product A, and Y (units) Co-Product B
Comparison Product System

- **UPSTREAM PROCESS(ES)**
- **COMPARISON PROCESS FOR PRODUCT B**
- **COMPARISON PROCESS FOR THE MAIN PRODUCT**
- **DOWNSTREAM PROCESS(ES), WHEN REQUIRED**

Material and Energy Inputs

Co-Product

1.0 (unit) Primary Product of Interest, Intermediate or final

X (units) Co-Product A, Intermediate or final

Y (units) Co-Product B

Multiproduct functional unit of 1.0 (unit) Primary Product of Interest, X (units) Co-Product A, and Y (units) Co-Product B
U.S. average GHG technology: The production weighted average of all U.S. facilities that produce the product of interest - i.e., the production weighted-average is the total GHG emissions across all U.S. facilities divided by total production from all U.S. facilities.

U.S. average GHG technology: If there is not enough information to construct a top-down GHG average, but technology- or production-route-specific LCIs exist, a production mix of the different types and routes can be constructed as a proxy for the true GHG average.

Industry standard practice technology: The method(s) of production that represents the industry standard practice for U.S. production. The industry standard practice technology contributes the highest percentage of production relative to the suite of technologies for a product or function.
NEW! NETL U.S. Average Baseline Datasets
NETL U.S. Average Baseline Datasets

• Based on publicly available data
• Includes existing capture rates in industries
• Representing years 2018 – 2022
  ◦ Will be updated as new data is available
• Documentation in complete report + supplemental data spreadsheet
• Data available in .zolca file compatible with CO2U LCI database
• Summary impact results will be available in next CO2U update
Inventory Analysis
Unit Process Development

Galatia Mine
Springfield 5/Illinois 6
Bituminous Coal
7 million tons annual production
60 yr life

• 4.25E-4 tons CO₂
• 1.05E-4 tons CH₄

Electricity
Fuel

1 ton coal
Unit Process Sources

Key:

- Applicant Process
- NETL, PI, or Third Party

Diagram:
- E.g., Power Plant → CO2U Process → Downstream process(es), when required → Primary Product of Interest & Co-Products
- Co-Product
- Materials, energy, transportation, & construction

Primary:
- E.g., Power Plant

Secondary:
- E.g., coal mining, col transport, power plant construction

Tertiary:
- E.g., electricity and fuels for coal mining

Materials, energy, transportation, & construction

Materials, energy, transportation, & construction

Materials, energy, transportation, & construction
Software Options

• openLCA
  ◦ Free, opensource LCA development tool for data management and LCA calculations
  ◦ Developed by GreenDelta in 2006
  ◦ Version 1.9 released with many feature improvements

• Spreadsheet Models
  ◦ May have to be built from scratch
  ◦ Can be very flexible

• Other third Party LCA software
  ◦ Often incorporate data management and LCA calculations
  ◦ Often come with datasets
Documentation Requirements

• openLCA Software
  ◦ NETL CO2U openLCA LCI Database
  ◦ NETL CO2U openLCA Results Contribution Tool
  ◦ NETL 45Q LCA Report Template

• PI Spreadsheet Model
  ◦ Spreadsheet model and supporting material
  ◦ NETL CO2U LCA Documentation Spreadsheet
  ◦ NETL 45Q LCA Report Template

• Other Software
  ◦ Final LCA model database file and supporting materials OR
  ◦ NETL CO2U LCA Documentation Spreadsheet
  ◦ NETL 45Q LCA Report Template
Impact Assessment

GOAL AND SCOPE DEFINITION

INVENTORY ANALYSIS

INTERPRETATION

IMPACT ASSESSMENT
Required Global Warming Potential

• Use of the GWPs in Table A-1 of 40 CFR Part 98, Subpart A is required by 26 CFR 1.45Q-4(c)(1). 40 CFR Part 98 are the EPA’s regulatory requirements for the Greenhouse Gas Reporting Program

• Version of table available in NETL CO2U LCI database as “GHGRP GWP”

Results Calculations

Calculated using GWP impact values scaled to 1 metric ton carbon oxide captured and utilized:

\[
LC_{45Q\ DF} = \frac{\text{Proposed Product System GWP Impact} - \text{Comparison Product System GWP Impact}}{1 \text{ metric ton carbon oxide captured and utilized}} \times -1
\]

OR

Calculated using GWP impact values scaled to the functional unit:

\[
LC_{45Q\ DF} = \frac{\text{Proposed Product System GWP Impact} - \text{Comparison Product System GWP Impact}}{\text{Amount of carbon oxide captured and utilized per functional unit}} \times -1
\]

Calculated using GWP impact values scaled to 1 metric ton carbon oxide captured and utilized:
Results Visualization

![Bar chart comparing CO2 emissions for proposed and comparison product systems]
Sensitivity Analysis

• Vary each model parameter by one increment (e.g. +10%) and record results to compare sensitivity of model to changes in parameters
• When using black box models, energy and material inputs must be used as parameters
• “one-at-a-time” sensitivity analysis required
• Break-even required for especially sensitive parameters
Contribution tree tool

<table>
<thead>
<tr>
<th>Cases to be compared:</th>
<th>Sheet name:</th>
<th>High (sheet name)</th>
<th>Low (sheet name)</th>
</tr>
</thead>
</table>

Impact Categories:
12. Global Warming Potential (AR5, 100-yr)
Results Reporting

LCA REPORT TITLE
Company Name and Relevant Tax Year
SUBMISSION DATE

Author List
NEW! Review Checklist

• Provides quick summary of key checkpoints

• Includes summary for each report section and what is expected

• Gives some context to typical NETL critical review
Toolkit Updates and Schedule

• The NETL 45Q LCA Guidance Toolkit will be updated as needed with additional tools and data, or revisions to guidance.

• The applicant must use the most current revision of this guidance as of the beginning of the year in which the LCA is to be submitted for review.

• This version of the guidance, Version 2.0, is optional for the remainder of 2024 and becomes required at the beginning of 2025.

• A detailed description of the revisions incorporated in this version of the guidance can be found in the Toolkit Changelog
Common Pitfalls

• Assuming the CPS is just “yourself minus carbon capture” instead of US GHG Average

• Providing insufficient documentation

• Using inappropriate pre-existing data or data with insufficient documentation to determine appropriateness

• Using inconsistent or inappropriate co-product management techniques

• Missing or insufficient sensitivity analysis
Questions?

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