

# Overview of Carbon Conversion Life Cycle Analysis at NETL

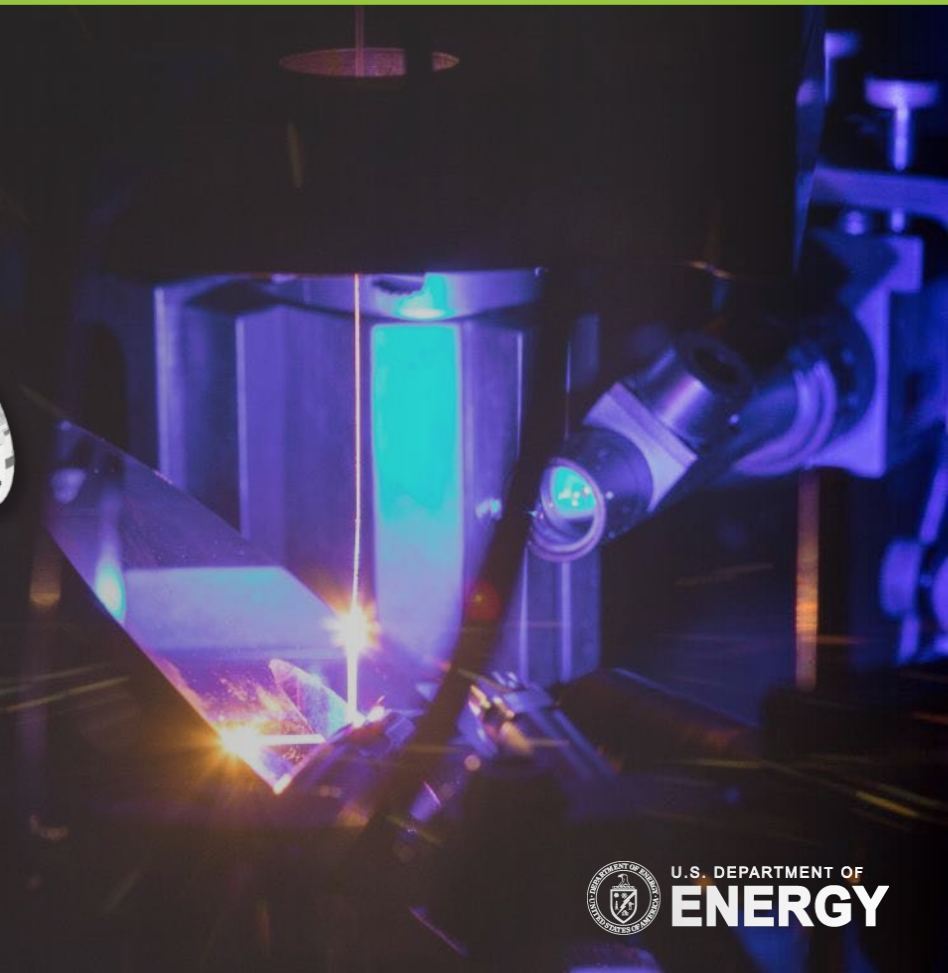
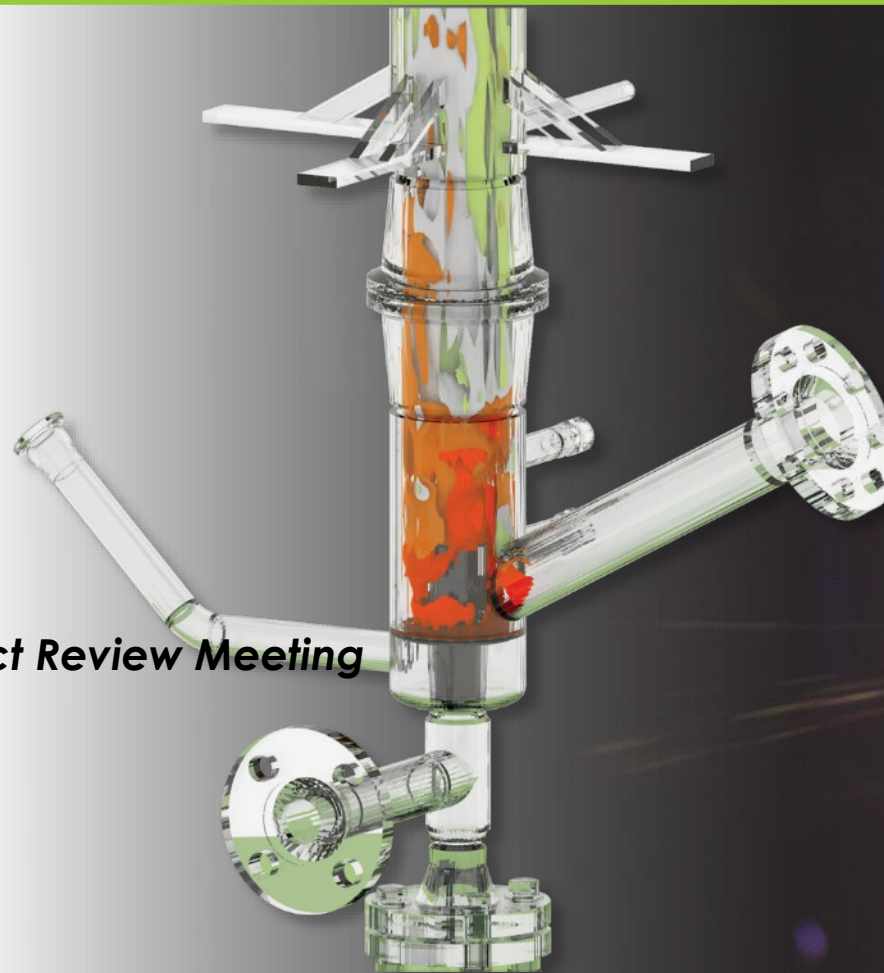


**Solutions for Today | Options for Tomorrow**

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*<sup>1</sup>National Energy Technology Laboratory (NETL)*

*<sup>2</sup>NETL Support Contractor*



**2022 Carbon Management Project Review Meeting**  
**August 15, 2022**

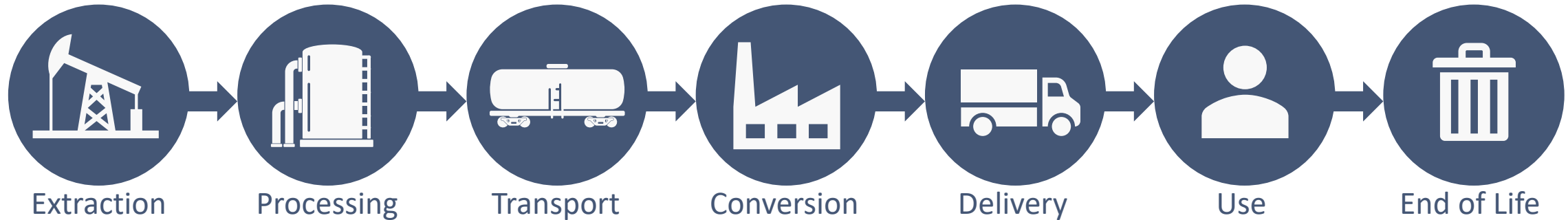
# Disclaimer



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# Energy Life Cycle Analysis (LCA)

## Cradle-to-Grave Environmental Footprint of Energy Systems



## What is Life Cycle Assessment/Analysis (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).

# Why LCA?

## Inform Business Decisions: R&D to Commercialization

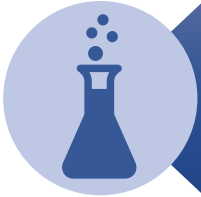
- **Guide research and development investment.**  
We want to invest in emerging technologies that are better than existing technologies.
- **Evaluate existing systems to identify opportunities for improvement.**  
Where should we invest to obtain the greatest return on investment?
- **Identify data gaps and validation needs to improve decision-making.**  
Inform and guide environmental field monitoring activities (data collection).
- **Assess potential benefits from commercializing technologies.**  
Quantify the environmental value at various levels of commercial adoption (at what scale will our technology make a measurable difference?).

# How Do We Use LCA?

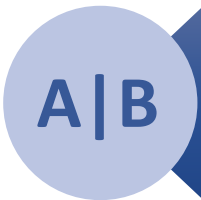
Depends on the Question of Interest....



Establish National Baselines



Assess Emerging and Existing Technologies



Compare Technology and Scenario Tradeoffs



Plan for the Future and Look Ahead



## NETL LCA team assessments (results currently internal)

- **Microalgae-to-biofuels LCA**
  - Compared NREL-based algae models to petroleum-derived diesel
- **Electrochemical catalyst LCA**
  - Screening tool to compare parameterizable ECC model
  - Multiple products produced and compared to business-as-usual environmental profiles
- **Direct carbonation of concrete products LCA**
  - Compared to non-carbonated concrete of the same type and mix
- **Building aggregates production from CO<sub>2</sub> and waste materials**
  - Steel slag carbonated to form aggregates used in concrete products
  - Compared to non-carbonated concrete of the same type and mix
- **Microwave-assisted conversion LCA**
  - Model of conversion of CO<sub>2</sub> to syngas
  - Compared to steam methane reforming and autothermal reforming of methane



## CO2U LCA Guidance Toolkit

- 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](http://netl.doe.gov/LCA/CO2U)

<p><b>CO2U LCA GUIDANCE DOCUMENT FOR THE U.S. DOE OFFICE OF FECM, VERSION 2.0</b></p> <p>Analysis requirements and instructions for using the supporting data and tools</p>	<p><b>NETL CO2U LCA DOCUMENTATION SPREADSHEET</b></p> <p>Excel file that can be used to document data when not using openLCA</p>	<p><b>TRAINING RESOURCES</b></p> <p>Provided to funding recipients to aid in modeling an LCA</p>	
<p><b>NETL CO2U OPENLCA LCI DATABASE VERSION 2</b></p> <p>openLCA database that includes NETL unit process data and an example CO2U LCA</p>	<p><b>LCA</b> Life Cycle Analysis</p>		<p><b>45Q ADDENDUM AND TOOLS</b></p> <p>Information pertaining to the use of this toolkit in performing life cycle analyses in support of the 26 CFR § 1.45Q tax credit, including an addendum to the Guidance Document.</p>
<p><b>OPENLCA CONTRIBUTION TOOL</b></p> <p>Excel template that translates openLCA results into required charts</p>	<p><b>NETL CO2U LCA REPORT TEMPLATE</b></p> <p>Word report template for summarizing data and results</p>	<p><b>NETL ADDITIONAL DOWNLOADS</b></p> <p> <a href="#">Download Full Toolkit</a></p> <p> <a href="#">Patches, Archives, and Version History</a></p>	

Developed to Provide Operational “How To” Guidance for CO2U Projects

## Developed specialized CO2U LCA guidance to address the following needs of the carbon conversion community:

- Improving clarity and specificity of existing ISO guidance.
- Ensuring accuracy of LCAs developed by technical personnel who are new to the framework.
- Minimizing PI effort needed to complete LCAs.



## Comparative LCA

Goal is to compare the CO2U system to the long-run marginal competitor in the market (comparison system).

## Multiproduct functional unit with system expansion

Improve comparability and results interpretation.

## Default scenarios for CO<sub>2</sub> sources

Applicants permitted to use any upstream source, but default scenarios are provided.

## Guidance for comparison processes and system

Data quality and representativeness: Expectations based on TRL.

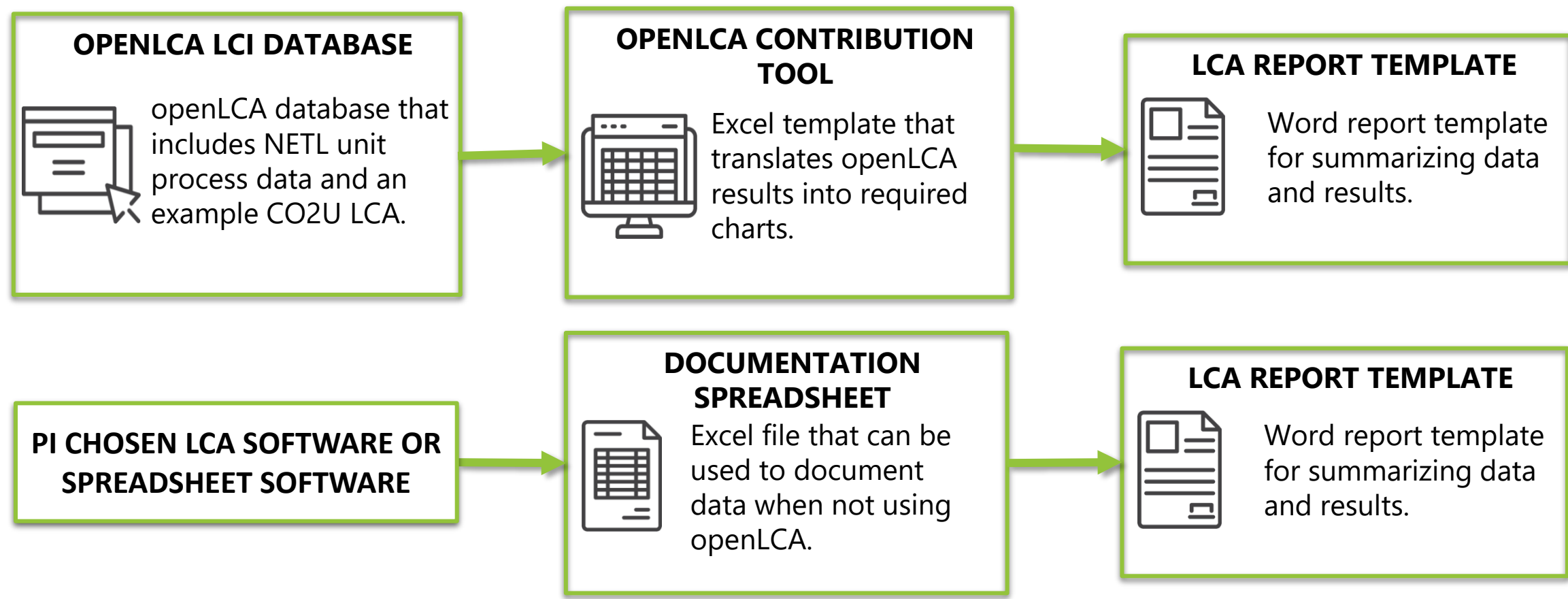
## Three modeling options

1. openLCA with provided data.
2. Excel-based documentation sheet.
3. Other commercial LCA modeling software.

## Interpretation requirements

Specific data/figures to provide consistency to study comparisons.

# The NETL CO2U LCA Guidance Toolkit



[netl.doe.gov/LCA/CO2U](http://netl.doe.gov/LCA/CO2U)

# The NETL CO2U LCA Guidance Toolkit

## GUIDANCE DOCUMENT



Analysis requirements and instructions for using the supporting data and tools.

Starting point for understanding LCA requirements

## OPENLCA MODEL TRAINING



Provided to funding recipients to aid in modeling an LCA in openLCA.

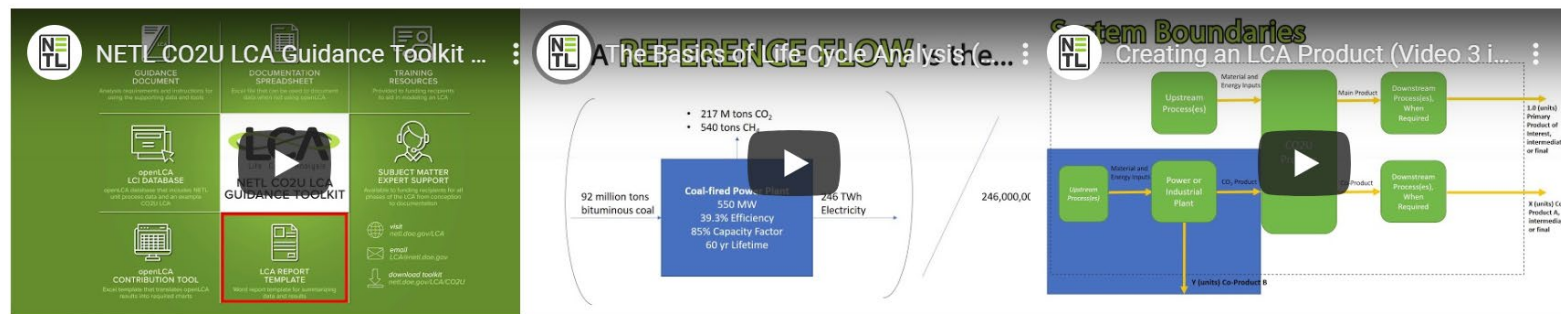
Training videos and live webinars will be available as developed at [www.netl.doe.gov/LCA/CO2U](http://www.netl.doe.gov/LCA/CO2U)

## SUBJECT MATTER EXPERT SUPPORT



Available to funding recipients for all phases of the LCA, from conception to documentation.

Contact us with questions at [LCA@netl.doe.gov](mailto:LCA@netl.doe.gov) (for NETL Project Recipients)



1. Overview

2. The Basics of Life Cycle Analysis

3. Creating an LCA Product



[netl.doe.gov/LCA/CO2U](http://netl.doe.gov/LCA/CO2U)

# The NETL CO2U LCA Guidance Toolkit

Version 2.0.0 and 2.1.0












- **Version 2.0.0 released in February 2022**
  - Coordination with 45Q addendum (to support 45Q tax credit calculations)
- **Version 2.1.0 released in June 2022**
  - Additional data sets added (biomass focus) to assist with new carbon capture-related FOA
- **Toolkit site:**  
[netl.doe.gov/LCA/CO2U](https://netl.doe.gov/LCA/CO2U)

<p><b>CO2U LCA GUIDANCE DOCUMENT FOR THE U.S. DOE OFFICE OF FECM, VERSION 2.0</b></p> <p>Analysis requirements and instructions for using the supporting data and tools</p>	<p><b>NETL CO2U LCA DOCUMENTATION SPREADSHEET</b></p> <p>Excel file that can be used to document data when not using openLCA</p>	<p><b>TRAINING RESOURCES</b></p> <p>Provided to funding recipients to aid in modelling an LCA</p>
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# 45Q Addendum to the Toolkit

- **Modifies existing language from CO2U Guidance Document**
- **Shares existing tools from the CO2U toolkit**
- **Changes scope to fit new purpose**
  - No longer focused on early development technologies
  - Focus on verifiability
- **Addendum site:**  
[netl.doe.gov/LCA/CO2U/45Q](https://netl.doe.gov/LCA/CO2U/45Q)

 <p><b>45Q ADDENDUM TO THE CO2U LCA GUIDANCE DOCUMENT</b></p> <p>Summary of modifications to the CO2U Guidance Document to be used to meet 26 CFR part 1, Section 1.45Q-4 carbon oxide tax credit</p>	 <p><b>NETL CO2U LCA DOCUMENTATION SPREADSHEET</b></p> <p>Excel file that can be used to document data when not using openLCA</p>	 <p><b>FREQUENTLY ASKED QUESTIONS</b></p>
 <p><b>NETL CO2U OPENLCA LCI DATABASE VERSION 2</b></p> <p>openLCA database that includes NETL unit process data and an example 45Q LCA</p>		 <p><b>ADDITIONAL QUESTIONS?</b></p> <p>Additional Questions should be directed to <a href="mailto:LCA45Q@hq.doe.gov">LCA45Q@hq.doe.gov</a></p>
 <p><b>OPENLCA CONTRIBUTION TOOL</b></p> <p>Excel template that translates openLCA results into required charts</p>	 <p><b>NETL 45Q LCA REPORT TEMPLATE</b></p> <p>Word report template for summarizing data and results</p>	<p><b>NETL ADDITIONAL DOWNLOADS</b></p> <p> <i>Patches, Archives, and Version History</i></p>

# Contribute to Global Discussion

## International Carbon Capture and Utilization (CCU) Assessment Harmonization Group

- The collaboration with the International CCU Assessment Harmonization Group will enable the development of consistent guidelines for LCA and TEA of CO<sub>2</sub> utilization technologies.
- The NETL LCA team co-lead and participated in multiple task force teams tackling distinct challenges for harmonization.
- Findings from this collaborative effort were presented in a series of mini webinars in May 2021.
- Recent GCI 2022 Workshop discussed updates and future work on May 19-20

### International CCU Assessment Harmonization Group Participants



# Contribute to Global Discussion

## SETAC-ACLCA Working Group: LCA Recommendations for Emerging Technologies

- The NETL LCA Team is collaborating with a diverse group of LCA experts to develop recommendations for LCA of emerging technologies as part of the SETAC-ACLCA LCA Working Group (<https://www.setac.org/group/SNAIGLCA>).
- This collaborative effort will enable LCA practitioners to:
  - Understand the state-of-the-art in LCA for emerging technologies.
  - Identify limitations and gaps in current LCA techniques.
  - Develop a roadmap to enable LCA of emerging technologies to better serve decision-making.
- Recently, NETL participated in the “Emerging Technologies” special session at the ACLCA 2021 conference, and co-presented findings from the SETAC-ACLCA LCA Working Group’s LCA effort.



**CALL FOR VOLUNTEERS!**  
COME JOIN US!  
<https://www.setac.org/group/SNAIGLCA>

**SETAC/ACLCA JOINT INTEREST GROUP LCA**

**CIRCULARITY & LCA**  
Chaired by: Michael Saidani, University of Illinois  
Ashley Kreuzer, Ramboll

**INDIRECT EMISSIONS & LCA**  
Chaired by: Sarah Cashman, ERG  
Ashley Kreuzer, Ramboll

**SDGs & LCA**  
Chaired by: Tom Gloria, Industrial Ecology Consultants/  
Harvard University  
\*Your name here\*

**MARINE LITTER IN LCA**  
Chaired by: Briana Niblick, U.S. EPA  
Amelia Abeynayaka, Tokyo City University

**ENVIRONMENTALLY-EXTENDED IO**  
Chaired by: Julie Chen, Carnegie Mellon  
Kushuang Fang, University of Maryland  
Joe Bergesen, Amazon

**LCA OF EMERGING TECHNOLOGIES**  
Chaired by: Mik Carbajales Oute, Clemson University  
Jocile Bergerson, University of Calgary

**REGIONALIZED LCIA**  
Chaired by: David Meyer, U.S. EPA  
Chris Tessum, University of Illinois

**NEW TECHNOLOGIES IN LCA**  
Chaired by: Ray Smith, U.S. EPA  
\*Your name here\*

Updates  
[https://youtu.be/By1\\_ucWh6Z4](https://youtu.be/By1_ucWh6Z4)  
<https://youtu.be/JdbvrRsmnRY>

# NETL RESOURCES

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VISIT US AT: [www.NETL.DOE.gov](http://www.NETL.DOE.gov)



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**ENERGY**



## How do we improve clarity and specificity of existing guidance?

- Guidance included in the NETL CO2U LCA Toolkit is ISO\* compliant.
- Additional guidance is provided specific to CO2U systems to:
  - 1. Understand feedstocks and technology pathways.**

Knowledge of application enables more specific focus and guidance depending on methodological choices.
  - 2. Ensure methodological consistency in applying the ISO standards.**

ISO standards provide a broad framework for applying LCA to a wide range of applications, which can lead to inconsistency.
  - 3. Define study goal and scope based on project Technology Readiness Level (TRL).**

This guidance aims to assist principal investigators in completing their comparative LCAs at different stages of technology development.

\*International Standards Organization, "ISO 14040:2006: Environmental management -- Life cycle assessment -- Principles and framework," 2006. Available: <https://www.iso.org/standard/37456.html>.  
International Standards Organization, "ISO 14044:2006: Environmental management -- Life cycle assessment -- Requirements and guidelines," 2006. Available: <https://www.iso.org/standard/38498.html>.

## How do we ensure accuracy of LCAs developed by technical personnel who are new to the framework?

- NETL LCA team provides videos, webinars, and one-on-one support throughout the LCA development process
- NETL LCA team completes a technical review of all PI LCAs
- Guidance and data ensure consistency and repeatability:
  1. **Consistent data for common inputs.**
  2. **LCA instruction for novices.**
  3. **Scenario development.**
  4. **Methodological decisions.**

## How do we minimize the effort needed for PIs to complete LCAs?

- Want to avoid burdensome requirements while providing useful and actionable results for decision-makers
- Diverse set of technologies, but there are many commonalities such as feedstock
- Structure the toolkit to provide guidance for all stages of the LCA
  1. **Goal and scope identification.**
  2. **LCI data.**
  3. **Modeling.**
  4. **Results interpretation.**
  5. **Reporting.**