

Life Cycle Analysis (LCA) and CCUS

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Energy & Environmental Research Center

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Tuesday, December 8, 2020

Bush Convention Center

Midland, Texas



Overview


- CCUS is a system with more than one product (e.g., oil & electricity). This creates accounting challenges.
- LCA requires accounting for flows within the system and proper treatment of the coproduct (electricity) to assign greenhouse gas (GHG) emissions to the primary product (oil).
- EOR field performance, system boundaries, and assumptions about coproduct displacement generally affect the LCA results far more than other inputs.
- Consequently, LCA applied to CCUS is wrought with potential for errors and omissions and needs a standard methodology.

CO₂ EOR Performance Drives LCA for CCUS

A Statistical Analysis of a Large Set of Individual CO₂ EOR Projects with an Emphasis on CO₂ Retention and Storage

Nicholas A. Azzolina and David V. Nakles (*The CETER Group, Inc.*)
 Charles D. Gorecki, Scott C. Ayash, and Wesley D. Peck (*EERC*)
 L. Stephen Melzer (*Melzer Consulting*)
 and L. Sumon Chatterjee (*Carnegie Mellon*)

Presented at the
 20th Annual CO₂ Flooding Conference
 December 11-12, 2014
 Midland, Texas



December 2014

March 2015

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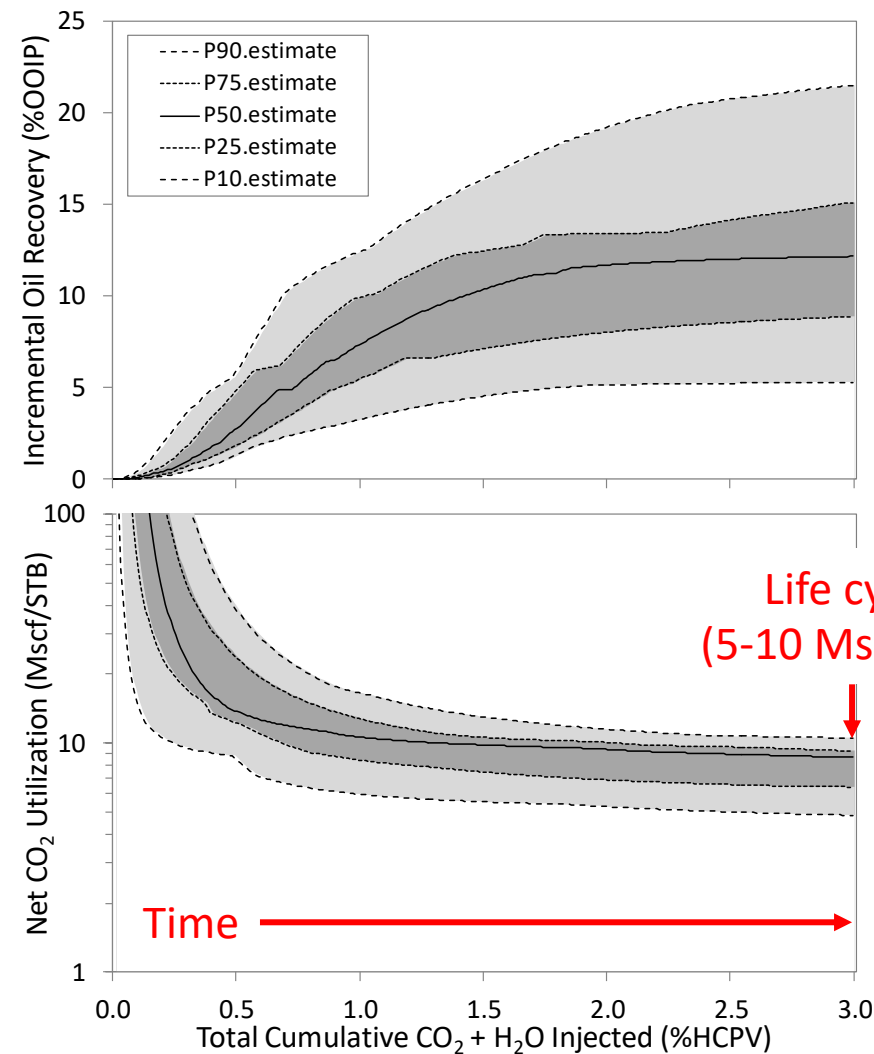
International Journal of Greenhouse Gas Control

journal homepage: www.elsevier.com/locate/ijggc

CO₂ storage associated with CO₂ enhanced oil recovery: A statistical analysis of historical operations

Nicholas A. Azzolina^{a,d,*}, David V. Nakles^{a,d}, Charles D. Gorecki^b, Wesley D. Peck^b,
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What the Heck is "Green Oil"?!

**How Green is My Oil?
A Detailed Look at Carbon Accounting
for CO₂ EOR Sites**

PCOR Partnership Annual Membership Meeting and Workshop
Chicago, Illinois
September 15, 2015

Nicholas A. Azzolina and Wesley D. Peck

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September 2015



Industry audience



Academic audience

Life Cycle Analysis Results – Case Specific

ENVIRONMENTAL Science & Technology May 2015 Article
pubs.acs.org/est

~6% reduction SCPC

Evaluating the Climate Benefits of CO₂-Enhanced Oil Recovery Using Life Cycle Analysis

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International Journal of Greenhouse Gas Control 51 (2016) 369–379

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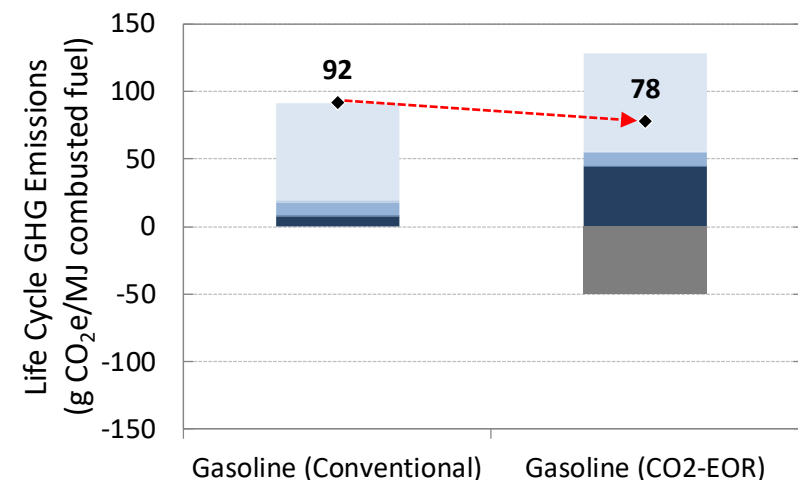
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How green is my oil? A detailed look at greenhouse gas accounting for CO₂-enhanced oil recovery (CO₂-EOR) sites

Nicholas A. Azzolina^{a,*}, Wesley D. Peck^b, John A. Hamling^b, Charles D. Gorecki^b, Scott C. Ayash^b, Thomas E. Doll^c, David V. Nakles^d, L. Stephen Melzer^e

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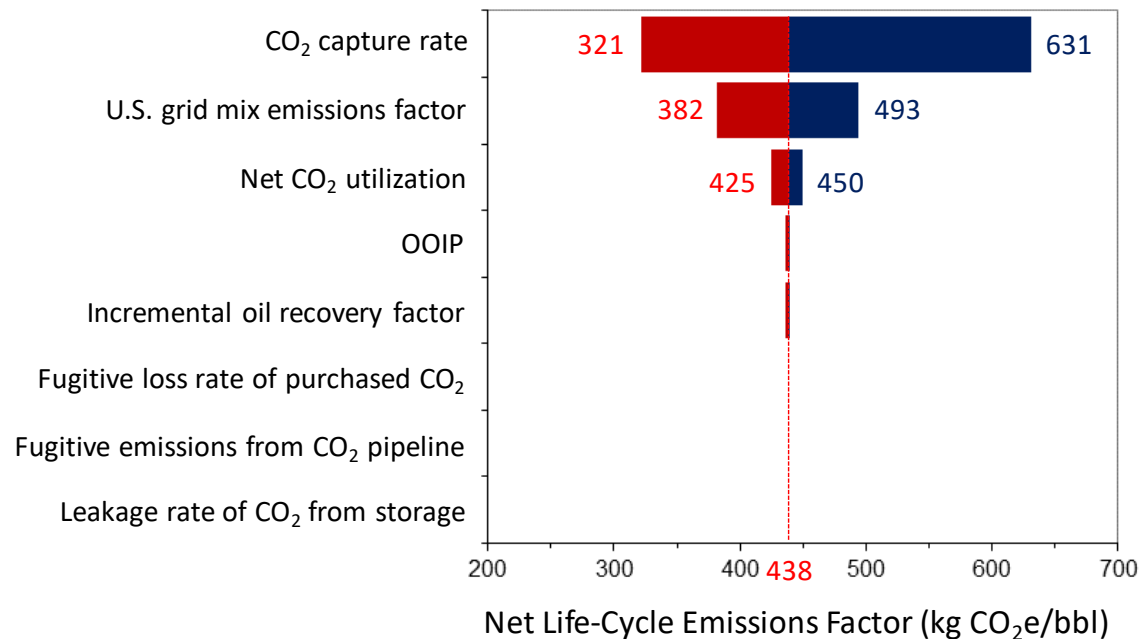
June 2016 ~15% reduction



Approximately 15% reduction in life cycle GHG emissions for incremental oil produced via CO₂ EOR as compared to conventional oil production (artificial lift/waterflood) when the CO₂ is captured from a coal-fired power plant and EOR performance is consistent with historical performance observed in the Permian Basin circa 1980-2007.

Optimization scenarios suggested up to 40% reduction in life cycle GHG emissions was possible.

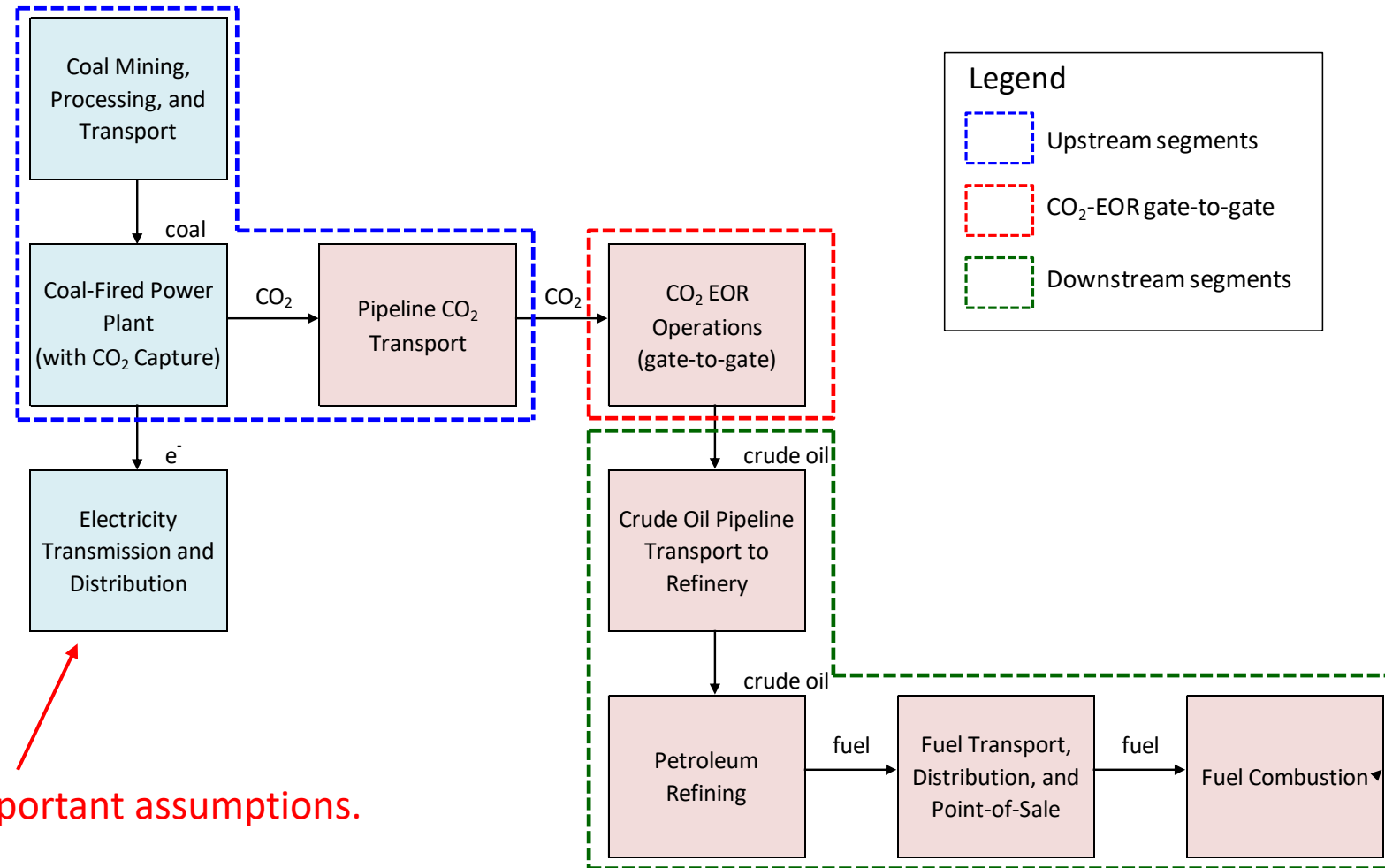
“Optimization” Depends on Perspective



Azzolina et al. (2016) International Journal of Greenhouse Gas Control 51 (2016) 369–379

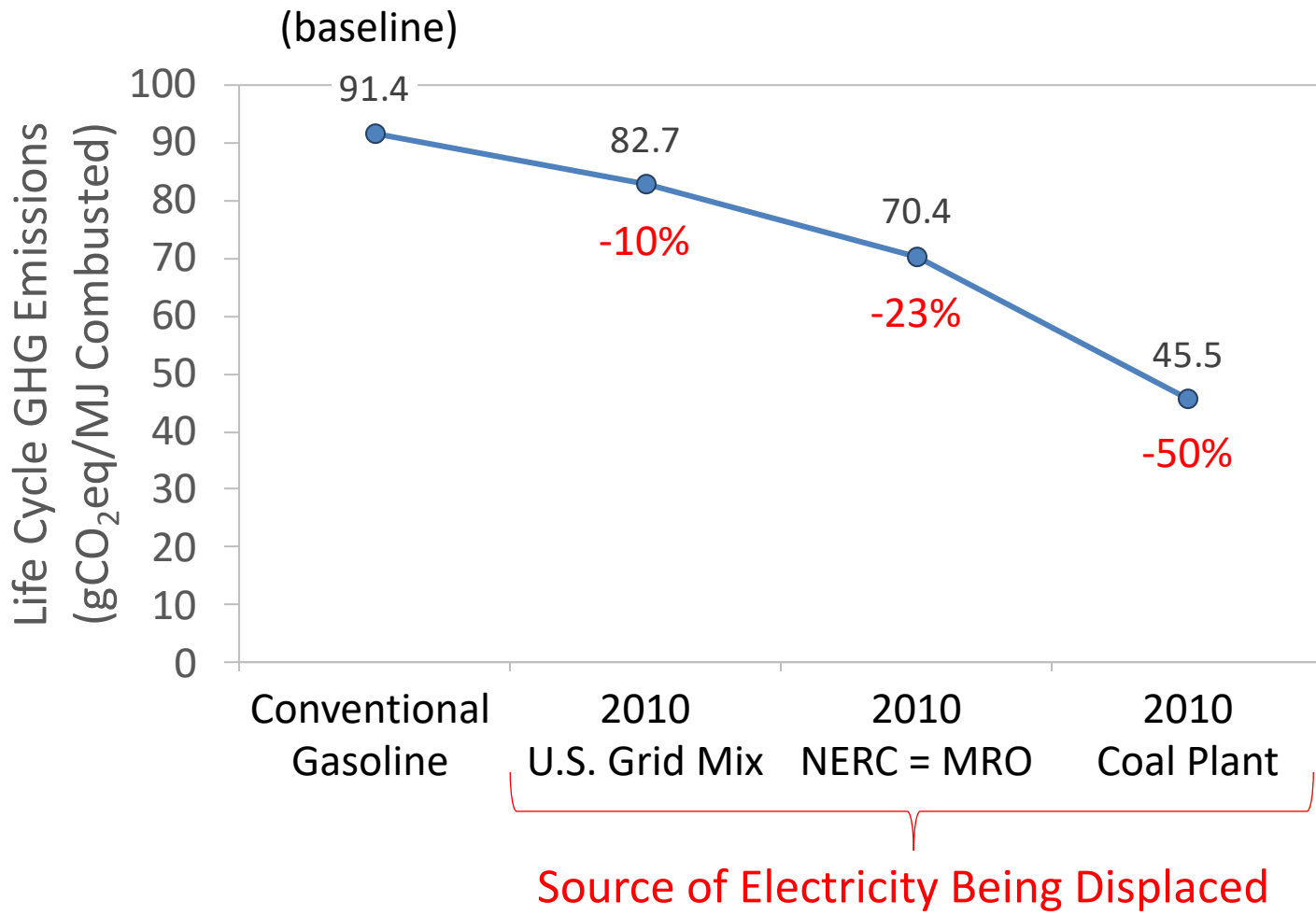
- CO₂ capture rate is by far the most important variable.
- Assumptions about displacement of electricity is very important (see next slides)
- Net CO₂ utilization was less important but still significant.
- “Optimization” depends on the objective function used.

CCUS System Boundaries and Material Flows

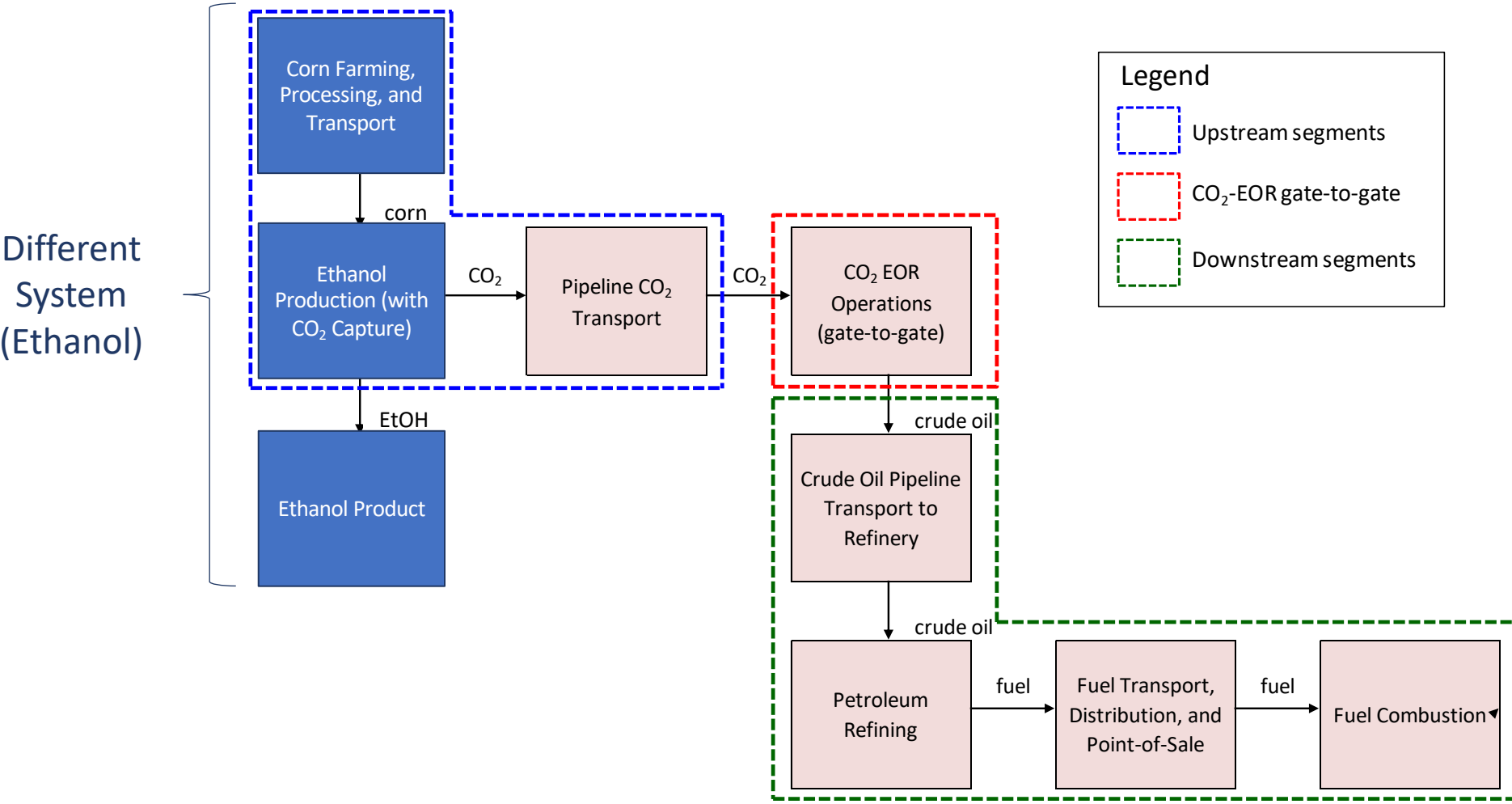


One of the most important assumptions.

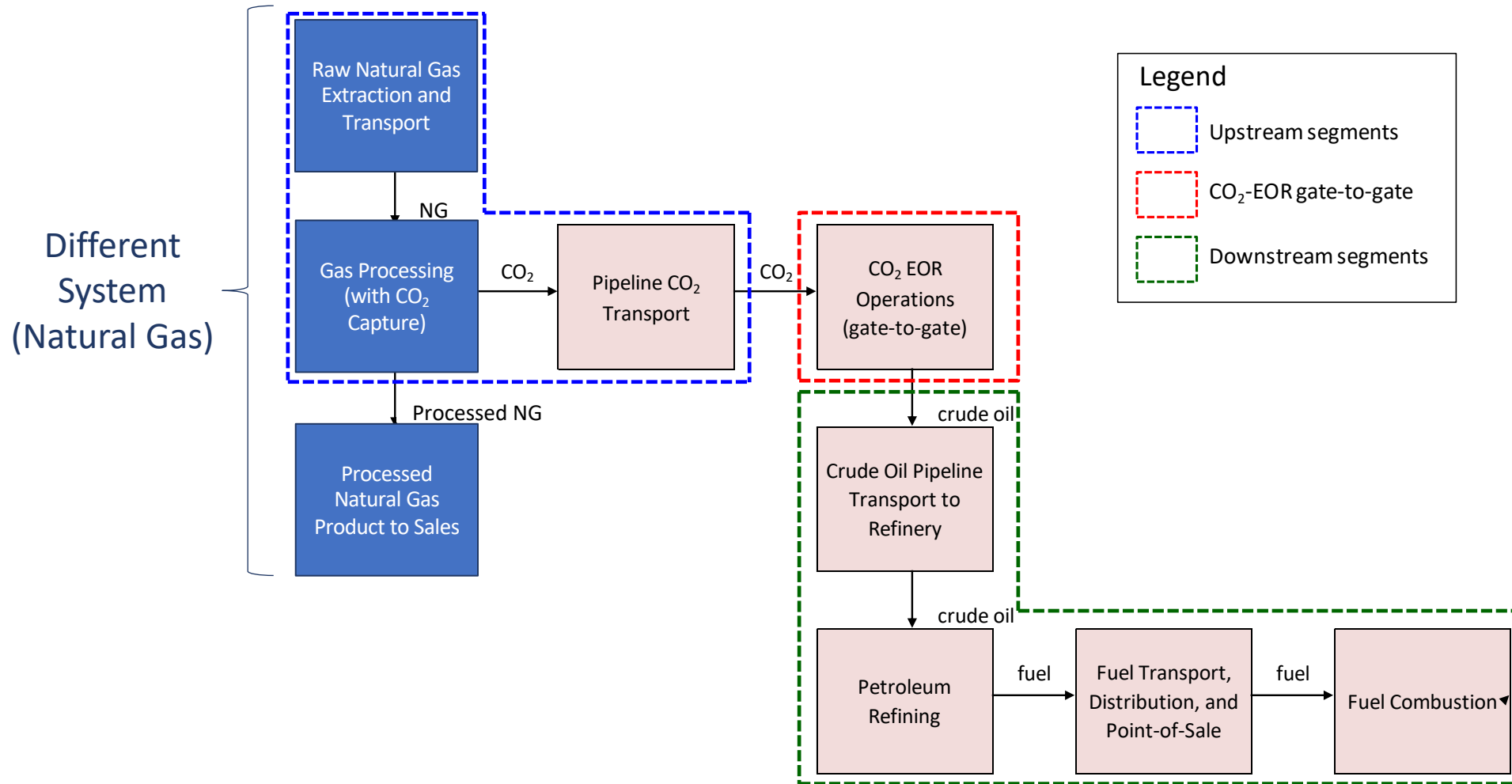
Displacement Has a Significant Effect



Other CO₂ Sources are Different Systems



Other CO₂ Sources are Different Systems



A Call for Harmonization

Energy Technology

Generation, Conversion, Storage, Distribution

Full Paper

The Need for and Path to Harmonized Life Cycle Assessment and Techno-Economic Assessment for Carbon Dioxide Capture and Utilization

Volker Sick , Katy Armstrong, Gregory Cooney, Lorenzo Cremonese, Alexandra Eggleston, Grant Faber, Gregory Hackett, Arne Kästelhön, Greg Keoleian, John Marano, Joseph Marriott, Stephen McCord, Shelie A. Miller, Michele Mutchek, Barbara Olfe-Kräutlein, Dwarakanath Ravikumar, Louise Kjellerup Roper, Joshua Schaidle, Timothy Skone, Lorraine Smith, Till Strunge, Peter Styring, Ling Tao, Simon Völker, Arno Zimmermann ... [See fewer authors](#) ^

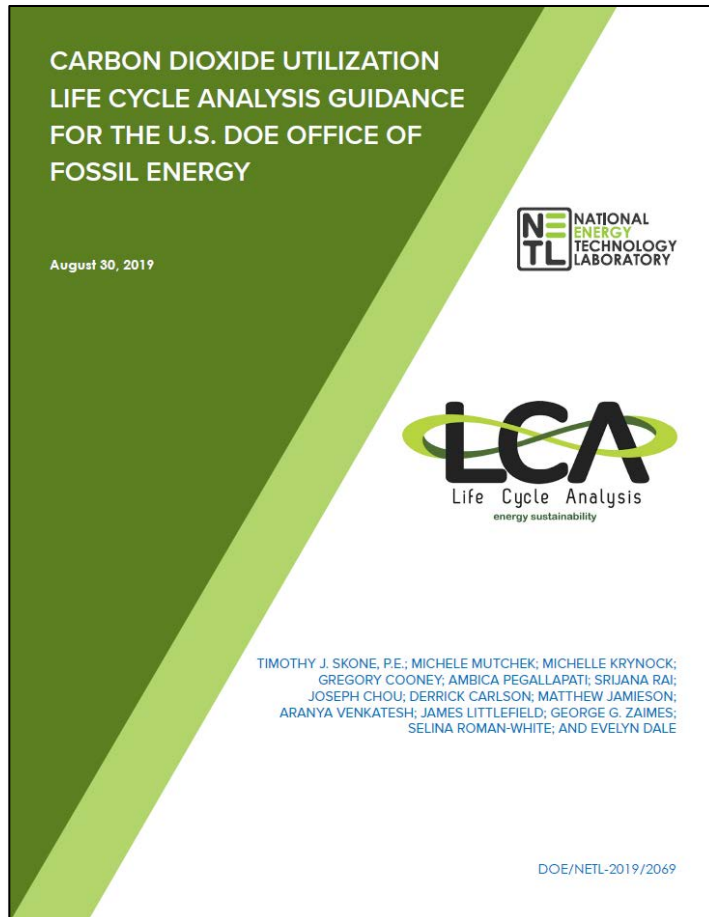
First published: 22 October 2019 | <https://doi.org/10.1002/ente.201901034> | Citations: 5

- The need for a standardized methodology was recognized several years ago and there have been recent articles on this topic.
- Sick et al. (2019) made the case for a “harmonized” approach to LCAs and techno-economic assessments (TEAs) for CCUS.
- Two key related documents.

Two Critical References for LCA and CCUS

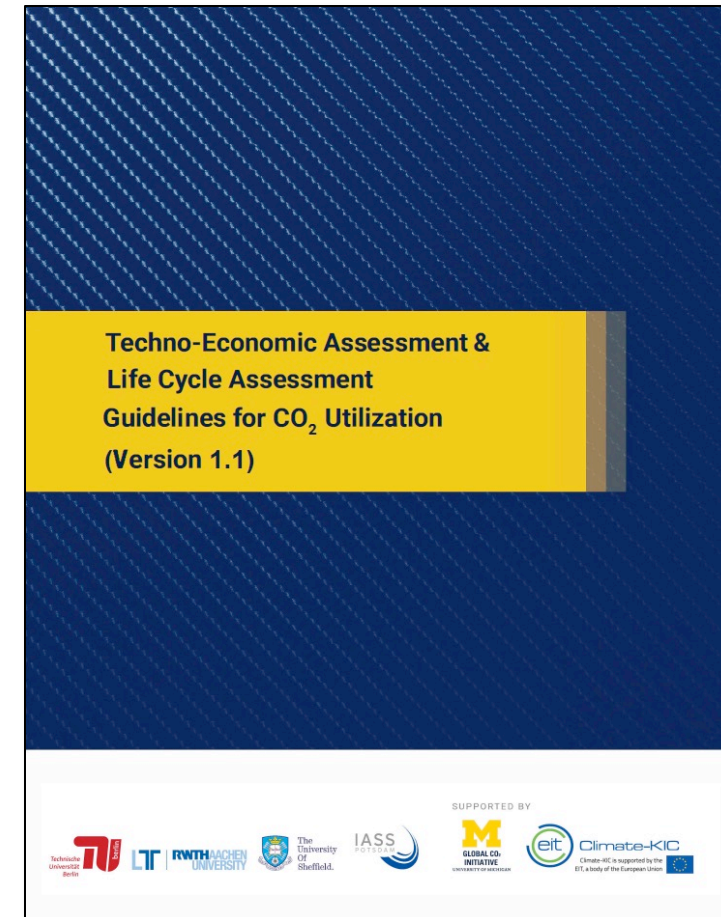
August 2019

https://www.netl.doe.gov/projects/files/NETLCO2ULCAGuidanceDocument_092019.pdf



September 2020

<https://deepblue.lib.umich.edu/handle/2027.42/162573>



Open-Source Tools from NETL

<https://netl.doe.gov/LCA/CO2U>

CARBON DIOXIDE UTILIZATION

LCA CO2U Quick Start: [NETL LCA Homepage](#) [NETL CO2U LCA Toolkit](#) [NETL CO2U LCA Training Resources](#) [NETL CO2U LCA Publications](#)

NETL CO2U LCA GUIDANCE TOOLKIT

Version 1.0.1
Released 08/07/20

<p>GUIDANCE DOCUMENT</p> <p>Analysis requirements and instructions for using the supporting data and tools</p>	<p>DOCUMENTATION SPREADSHEET</p> <p>Excel file that can be used to document data when not using openLCA</p>	<p>TRAINING RESOURCES</p> <p>Provided to funding recipients to aid in modeling an LCA</p>
<p>OPENLCA DATABASE</p> <p>openLCA database that includes NETL unit process data and an example CO2U LCA</p>	<p>LCA Life Cycle Analysis</p>	<p>SUBJECT MATTER EXPERT SUPPORT</p> <p>Available to funding recipients for all phases of the LCA from conception to documentation. Email lead@netl.doe.gov for support</p>
<p>OPENLCA CONTRIBUTION TOOL</p> <p>Excel template that translates openLCA results into required charts</p>	<p>NETL CO2U LCA REPORT TEMPLATE</p> <p>Word report template for summarizing data and results</p>	<p>NETL ADDITIONAL DOWNLOADS</p> <p>Download Full Toolkit</p> <p>Patches, Archives, and Version History</p>

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Summary

- CCUS is a system with more than one product (e.g., oil & electricity). This creates accounting challenges.
- LCA requires accounting for flows within the system and proper treatment of the coproduct (electricity) to assign GHG emissions to the primary product (oil).
- A standard methodology is needed to ensure consistency with system boundaries and assumptions about coproduct displacement.
- Recent guidance from NETL (2019) and associated tools like the “NETL CO₂U LCA Guidance Toolkit” provide a standard methodology.