CO2 Utilization Life Cycle Analysis (LCA) Guidance at the U.S. Department of Energy

Greg Cooney, NETL LCA Team

Carbon Dioxide Utilization Summit: February 27-28th, 2019

Disclaimer and Attribution

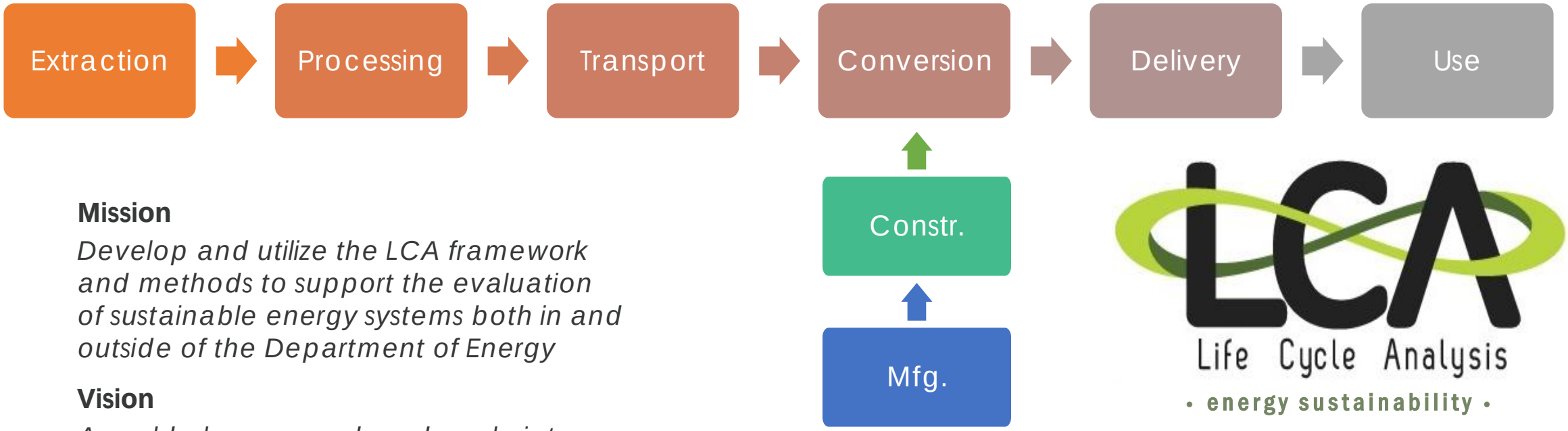
Attribution

KeyLogic Systems, Inc.'s contributions to this work were funded by the National Energy Technology Laboratory under the Mission Execution and Strategic Analysis contract (DE-FE0025912) for support services.

Outline

- **Life Cycle Analysis (LCA) at U.S. DOE NETL**
- **CO2U LCA in U.S. Federal Programs and Policy**
  - FOAs and 45Q
- **CO2U LCA Guidance Document Project**
  - Who, What, Why?
- **CO2U LCA Methods**
  - Carbon Accounting vs. LCA – Why do we include the source of CO_2?
  - System Definition
  - Upstream CO_2 and Electricity Co-Product Determination

Energy Life Cycle Analysis at NETL



Mission

Develop and utilize the LCA framework and methods to support the evaluation of sustainable energy systems both in and outside of the Department of Energy

Vision

A world-class research and analysis team that integrates results which inform and recommend sustainable energy strategy and technology development

LCA
Life Cycle Analysis
• energy sustainability •

Life Cycle Analysis Team

Tim Skone – 20 years
Federal Team Lead
BS Chem Engr | P.E. Env. Engr

Greg Cooney – 10 years
Contractor Team Lead
MS Env Engr | BS Chem Engr

James Littlefield – 17 years
Natural gas, system & process design
BS Chemical Engineering

Matt Jamieson – 9 years
Power systems, CO_2-EOR
BS Mechanical Engineering

Michele Mutchek – 6 years
Loan program office, CO2U
MS Civil/Env/Sust Engr | BS Env Sci

Michelle Krynock – 4 years
Natural gas, fuel cells, coal
BS Civil/Env Engr & Public Policy

Derrick Carlson – 7 years
I/O LCA, Energy efficiency
PhD/MS Civ/Env Engr | BS Chem

Greg Zaimes – 4 years
Energy analysis; fuels
PhD Civ/Env Eng; BS Physics

Selina Roman-White – 1 year
Energy/environment
BS Chem. Engr.

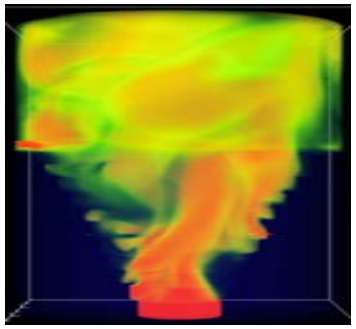
Joseph Chou – 1 year
Energy/environment
MS Civil & Env Engr

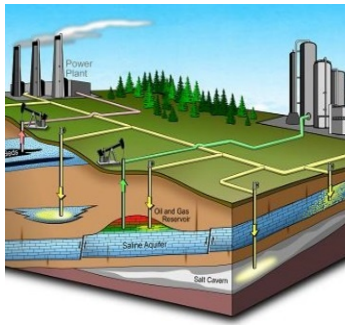
Srijana Rai– 1 year
Energy/environment
MS Civil & Env Engr

Joe Marriott – 12 years
Senior Advisor
PhD Env Engr & Public Policy

LCA is Well Suited for Energy Analysis

- Draws a more complete picture than one focused solely on stack or tailpipe emissions
- Allows direct comparison of dramatically different options based on function or service
- Includes methods for evaluating a wide variety of emissions and impacts on a common basis
- Brings clarity to results through systematic definition of goals and boundaries







CO2U LCA Requirements in U.S. Federal Programs and Policy

- **DOE Funding Opportunity Announcements (FOAs)**
  - LCA (GHG analysis) required for funding recipients under the Carbon Use and Reuse Program
  - "The FOA objective is to secure applications that will support the Carbon Storage program's efforts to **develop technologies that utilize CO_2 from coal-fired power plants as a reactant to produce useful products without generating additional CO_2 or greenhouse gas (GHG) emissions validated via a product life cycle analysis (LCA).** Awards made from this FOA will validate the concept, estimate the technology cost, and demonstrate that the carbon lifecycle of the products offer a true carbon reduction."

CO2U LCA Requirements in U.S. Federal Programs and Policy

- **26 USC 45Q: Credit for carbon oxide sequestration (aka, 45Q)**
  - LCA (GHG analysis) required for tax credit (non-EOR utilization)
  - "(B) Measurement
    - (i) In general For purposes of determining the amount of qualified carbon oxide utilized by the taxpayer under paragraph (2)(B)(ii) or (4)(B)(ii) of subsection (a), such amount shall be equal to the metric tons of qualified carbon oxide which the taxpayer demonstrates, **based upon an analysis of lifecycle greenhouse gas emissions** and subject to such requirements as the Secretary, in consultation with the Secretary of Energy and the Administrator of the Environmental Protection Agency, determines appropriate, were—
    - (I) captured and permanently isolated from the atmosphere, or
    - (II) displaced from being emitted into the atmosphere,
      - through use of a process described in subparagraph (A)."

The “Who?” “What?” and “Why?” of the U.S. DOE CO2U LCA Guidance Project

Who?

- The LCA team at the National Energy Technology Laboratory at the U.S. DOE
- In collaboration with other researchers and Office of Fossil Energy at the DOE

www.netl.doe.gov/lca

The “Who?” “What?” and “Why?” of the U.S. DOE CO2U LCA Guidance Project

NATIONAL ENERGY TECHNOLOGY LABORATORY

What?

- Guidance
- Tools
  - openLCA template
  - Excel template
- NETL Data
  - Unit process database
  - Algae pathway example

1. Introduction – Goals and How-to
2. Overview of LCA
3. Using openLCA
4. Using graph generating Excel tool
5. Using the GHG analysis documentation Excel template
6. Reporting structure

The “Who?” “What?” and “Why?” of the U.S. DOE CO2U LCA Guidance Project

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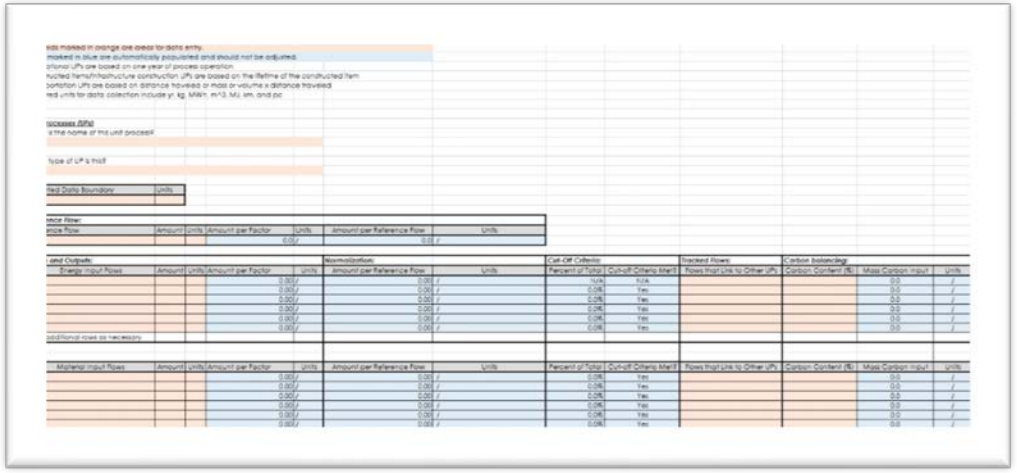
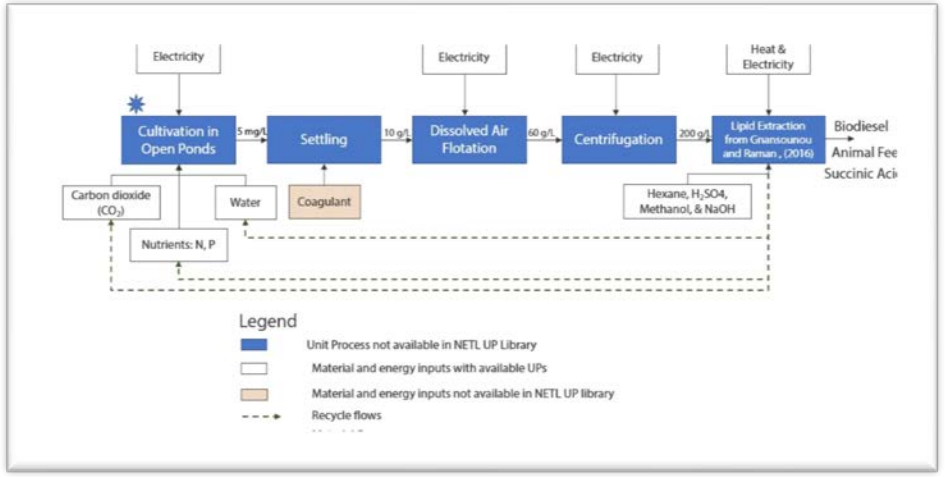
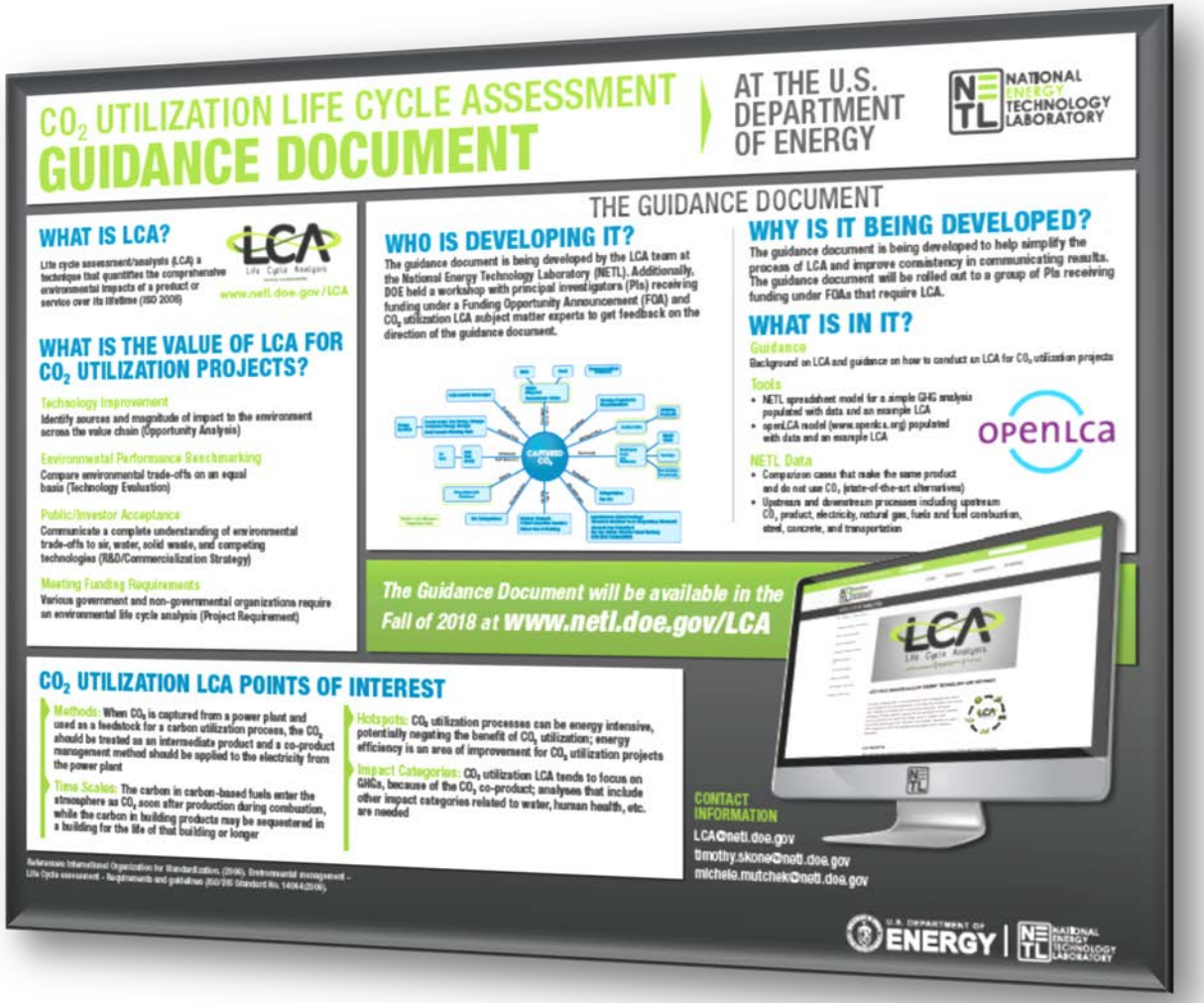




The "Who?" "What?" and "Why?" of the U.S. DOE CO2U LCA Guidance Project

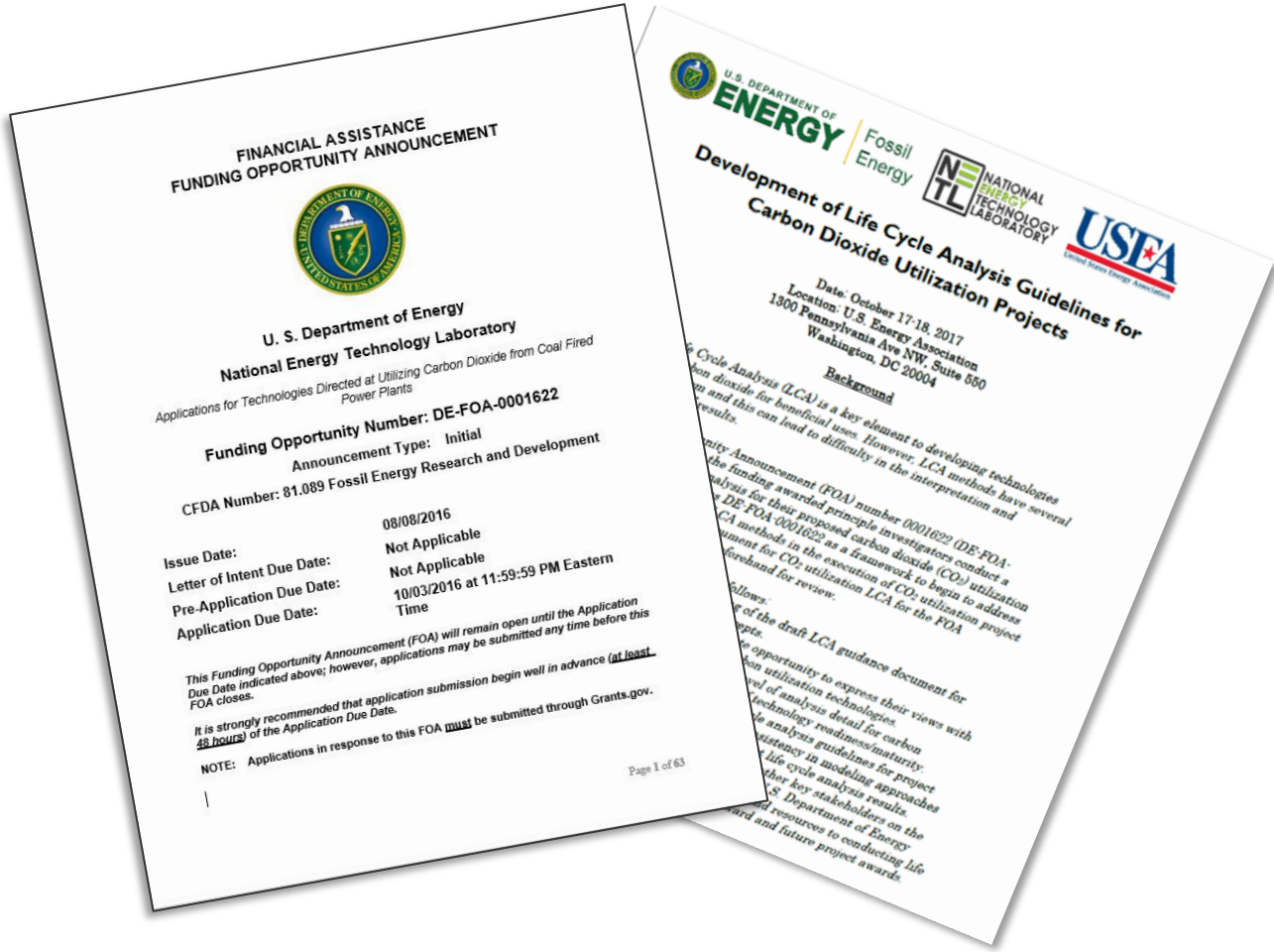
Why?

- To provide technical support to U.S. federal funding recipients
- To influence the development of consistent, robust analyses for policy decisions
- To provide value to the LCA community



This Project Responds to Funding Requirements and Will Be Released Soon

- 2016
  - Funding Opportunity Announcement for CO2U projects establishes requirement for life cycle greenhouse gas (GHG) analysis
- 2017
  - **August** - First exploratory draft of the guidance document is completed
  - **October** - A workshop was held in D.C. with subject matter experts and CO2U project principal investigators
- 2018
  - Second draft of guidance document is finalized based on stakeholder feedback
- 2019
  - **March** - Guidance document will be released to the public


FINANCIAL ASSISTANCE
FUNDING OPPORTUNITY ANNOUNCEMENT

U. S. Department of Energy
National Energy Technology Laboratory

Applications for Technologies Directed at Utilizing Carbon Dioxide from Coal Fired Power Plants

Funding Opportunity Number: DE-FOA-0001622
Announcement Type: Initial

CFDA Number: 81.089 Fossil Energy Research and Development

Issue Date: 08/08/2016
Letter of Intent Due Date: Not Applicable
Pre-Application Due Date: Not Applicable
Application Due Date: 10/03/2016 at 11:59:59 PM Eastern Time

This Funding Opportunity Announcement (FOA) will remain open until the Application Due Date indicated above; however, applications may be submitted any time before this FOA closes.

It is strongly recommended that application submission begin well in advance (at least 48 hours) of the Application Due Date.

NOTE: Applications in response to this FOA must be submitted through Grants.gov.

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U.S. DEPARTMENT OF ENERGY / Fossil Energy
NATIONAL ENERGY TECHNOLOGY LABORATORY
USEA

Development of Life Cycle Analysis Guidelines for Carbon Dioxide Utilization Projects

Date: October 17-18, 2017
Location: U.S. Energy Association
1300 Pennsylvania Ave NW, Suite 550
Washington, DC 20004

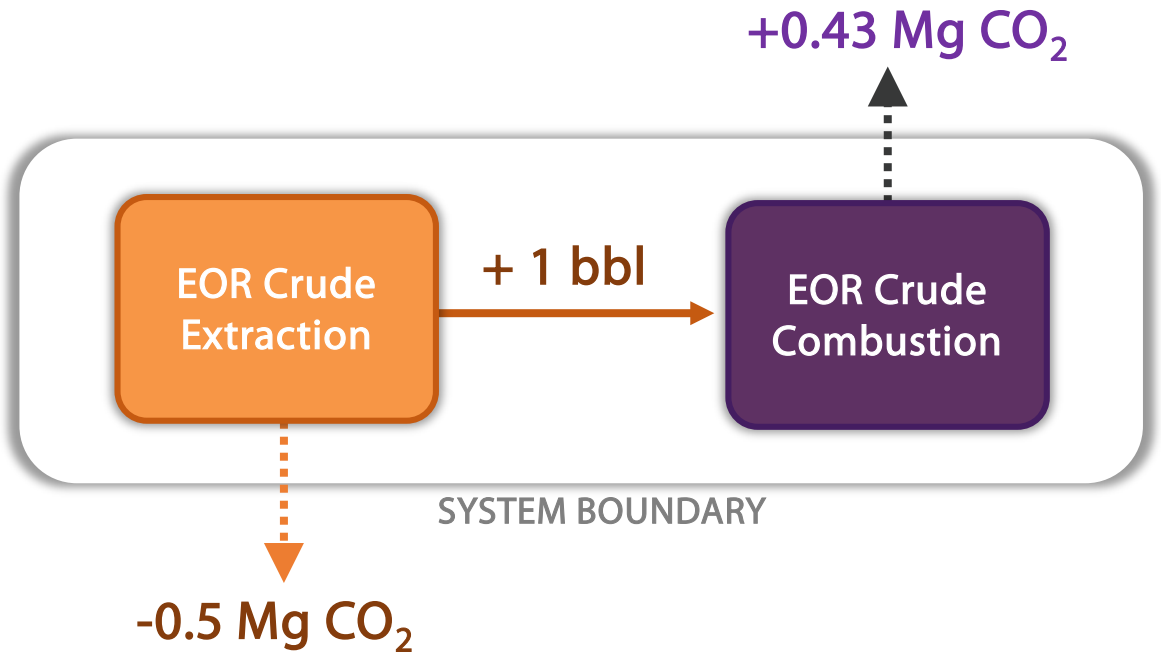
Background

Carbon Accounting vs. LCA – Why do we include the source of CO_2?

- We are not directly reducing the amount of CO_2 in the atmosphere, rather, we are relying on an indirect reduction in those emissions
  - Reduction is a consequence of choosing one option over another
  - If a captured power plant is deployed, it will displace (retire from the existing market or be built in lieu of) some other method of generating electricity (most likely one that is more GHG intensive)
- Capturing CO_2 alone yields an improvement in a comparative context relative to another technology option
- In the near-term, this line of thinking is important to quantifying the size of the benefit

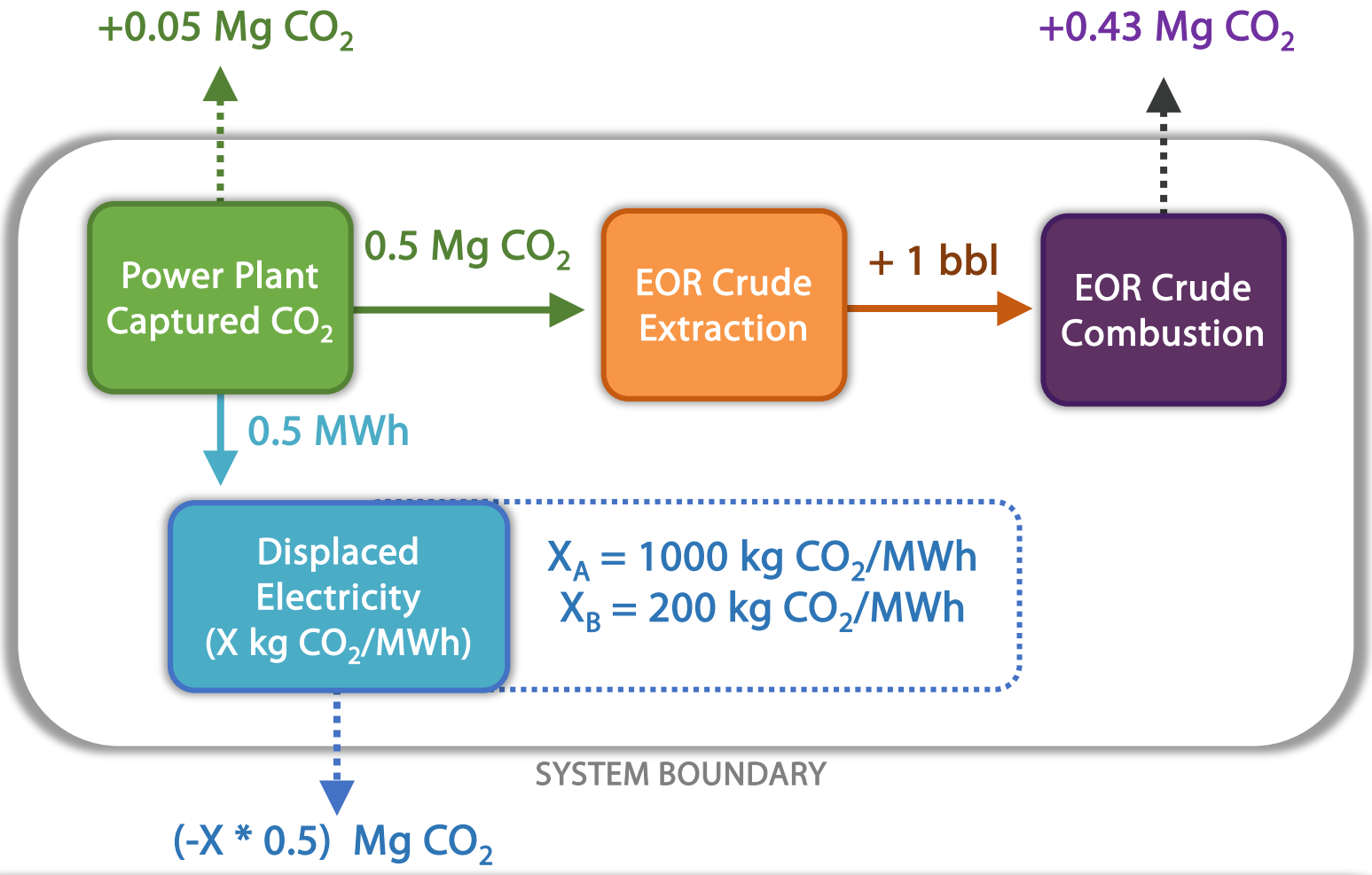
CARBON BALANCE ACCOUNTING

APPROACH



Net CO_2 = -0.5 + 0.43 = - 0.07 Mg CO_2

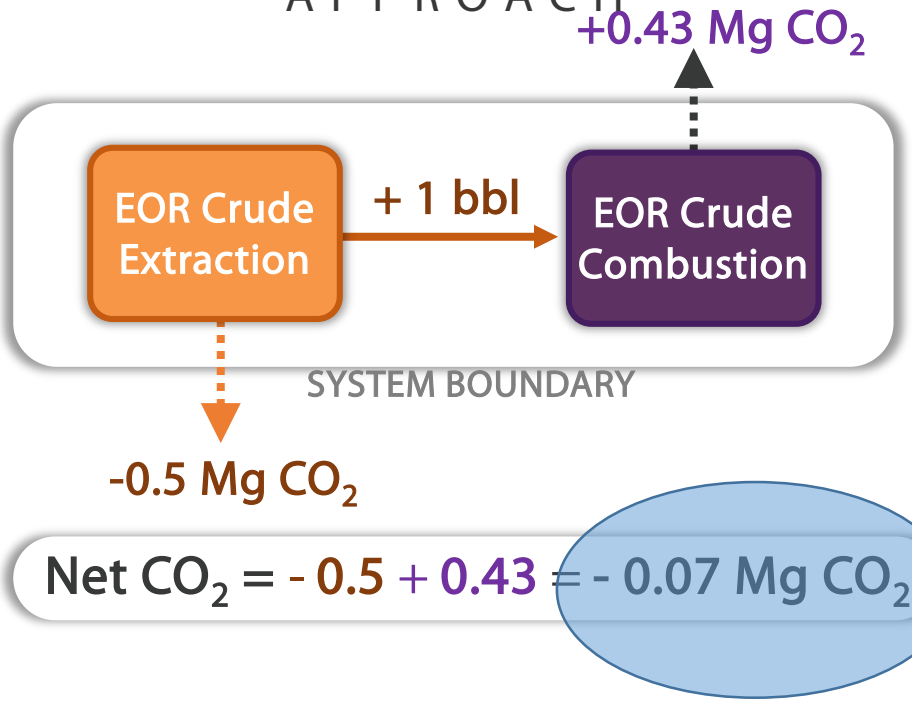
LCA ACCOUNTING
APPROACH



Net CO_2 [A] = + 0.43 + 0.05 – ([0.5] x 1.0) = - 0.02 Mg

Net CO_2 [B] = + 0.43 + 0.05 – ([0.5] x 0.2) = + 0.38 Mg

CARBON BALANCE ACCOUNTING APPROACH



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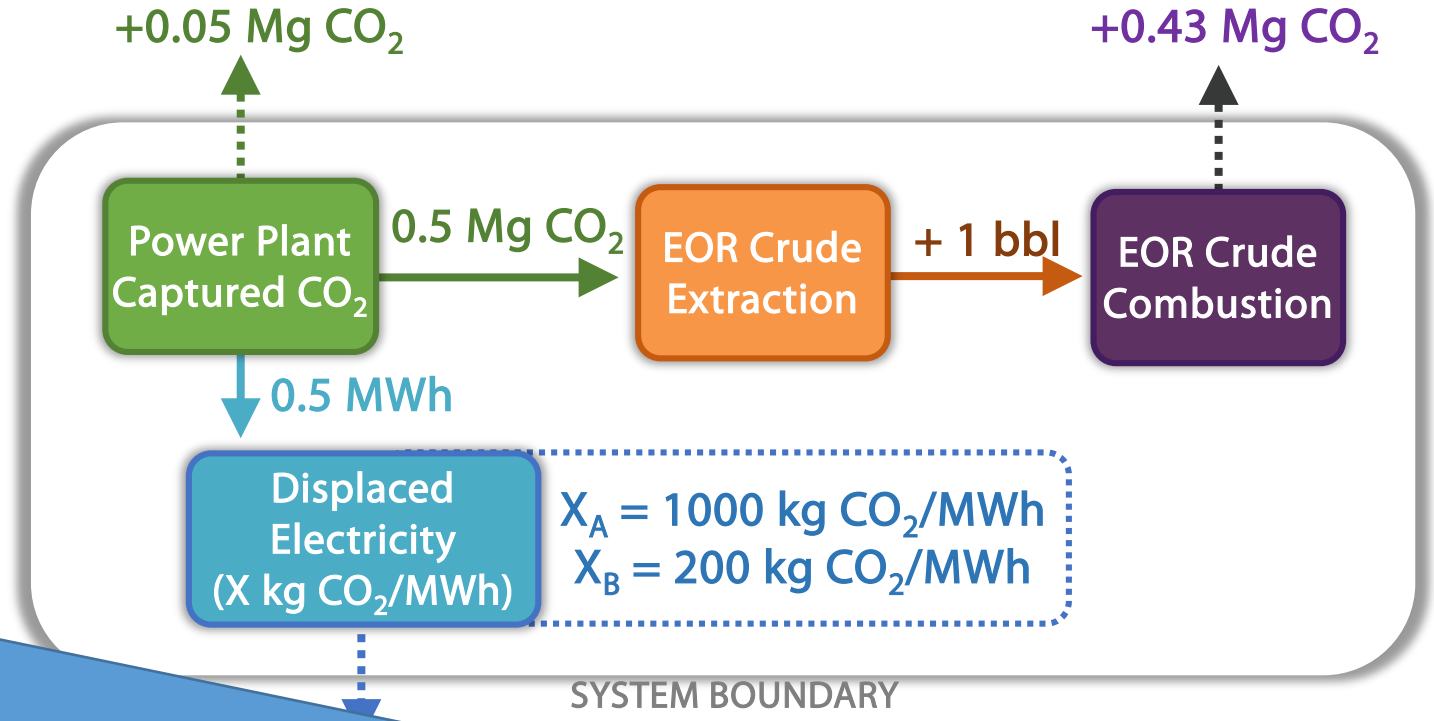
LCA ACCOUNTING APPROACH



Net CO_2 [A] = + 0.05 – ([0.5] x 0.2) + 0.43 = - 0.02 Mg

Net CO_2 [B] = + 0.05 – ([0.5] x 0.2) + 0.43 = + 0.38 Mg

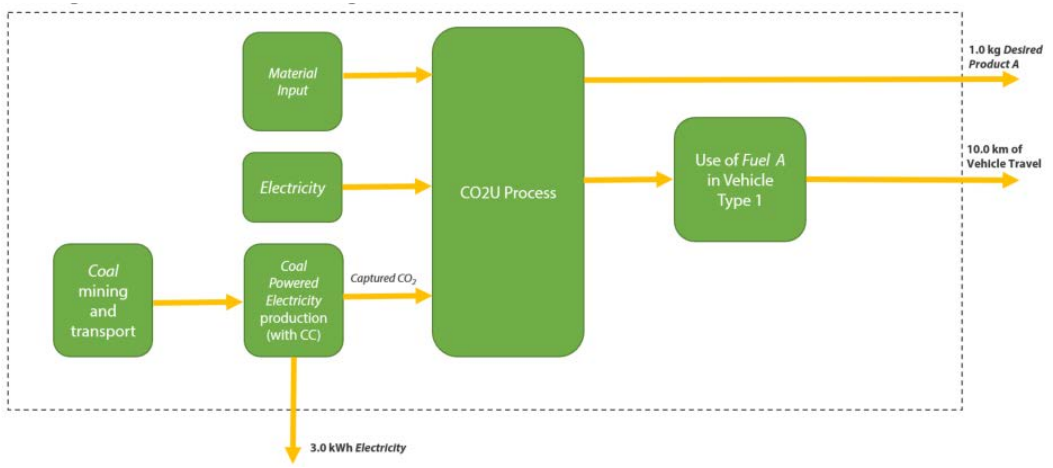
For reference, the GHG emissions for the extraction and combustion U.S. average crude, based on a characterization of the various technologies composing the mix are 0.49 Mg CO_2/bbl.

The LCA Guidance Makes Recommendations Related to Methods, Data, and Tools

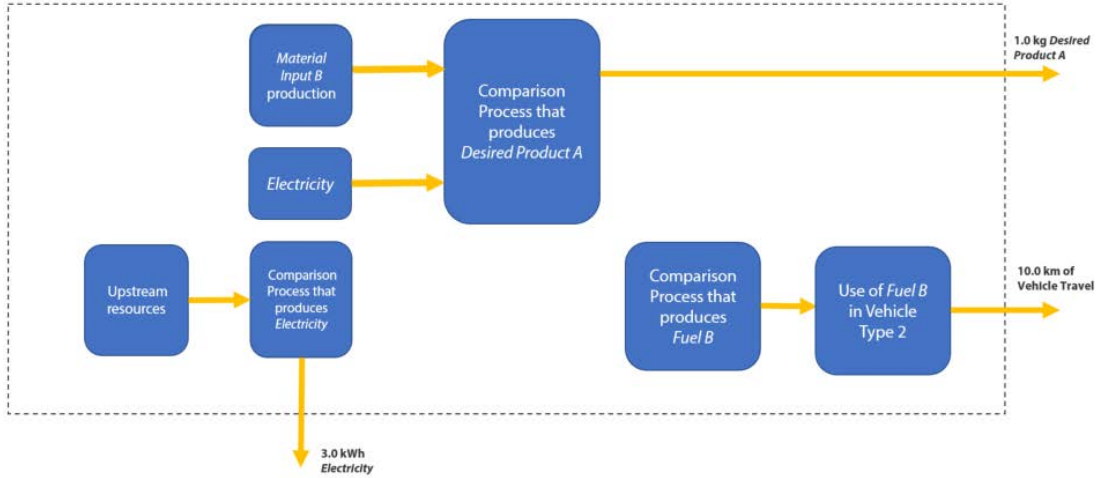
Recommendations on:

- Determining the comparison system
- Establishing the system boundaries
- What modeling/reporting platform(s) to use
- What upstream CO_2 profiles to use
- And more…

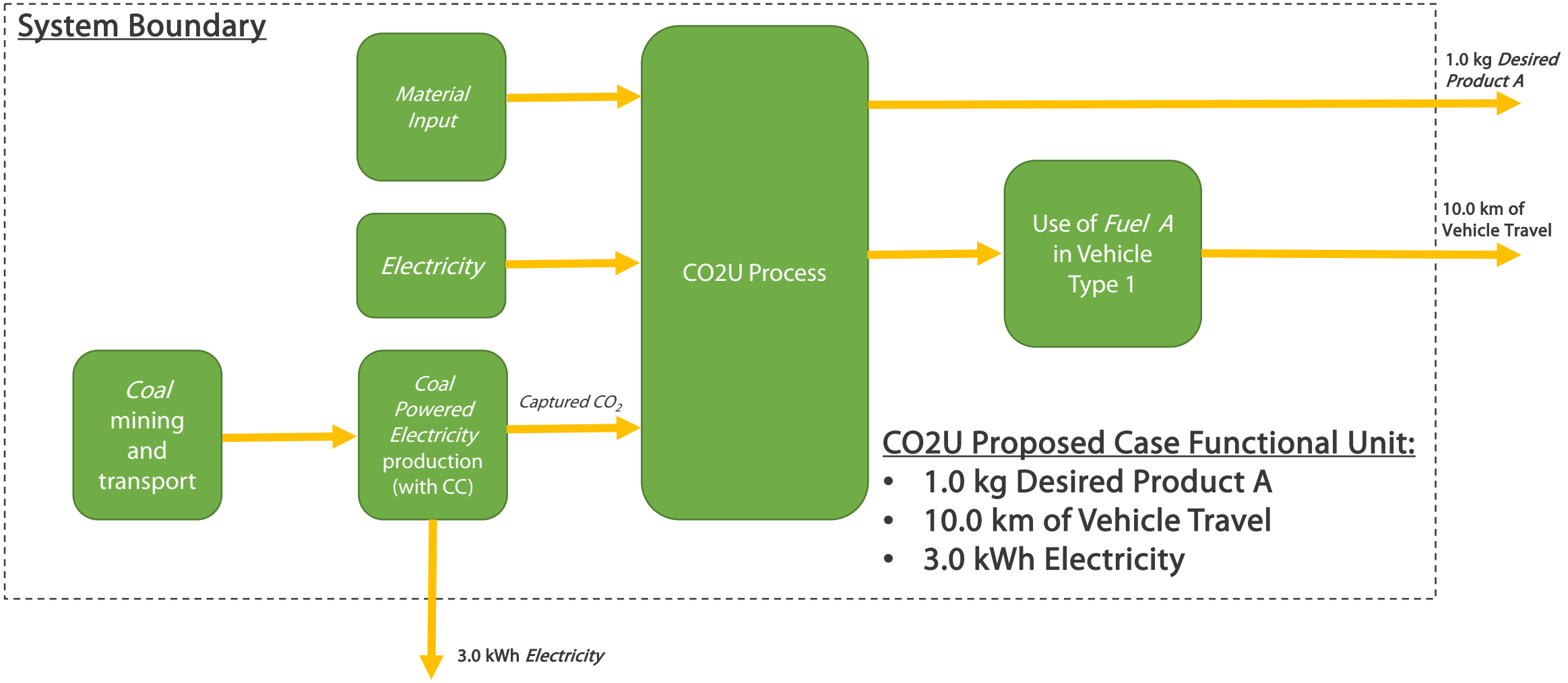
Proposed Case



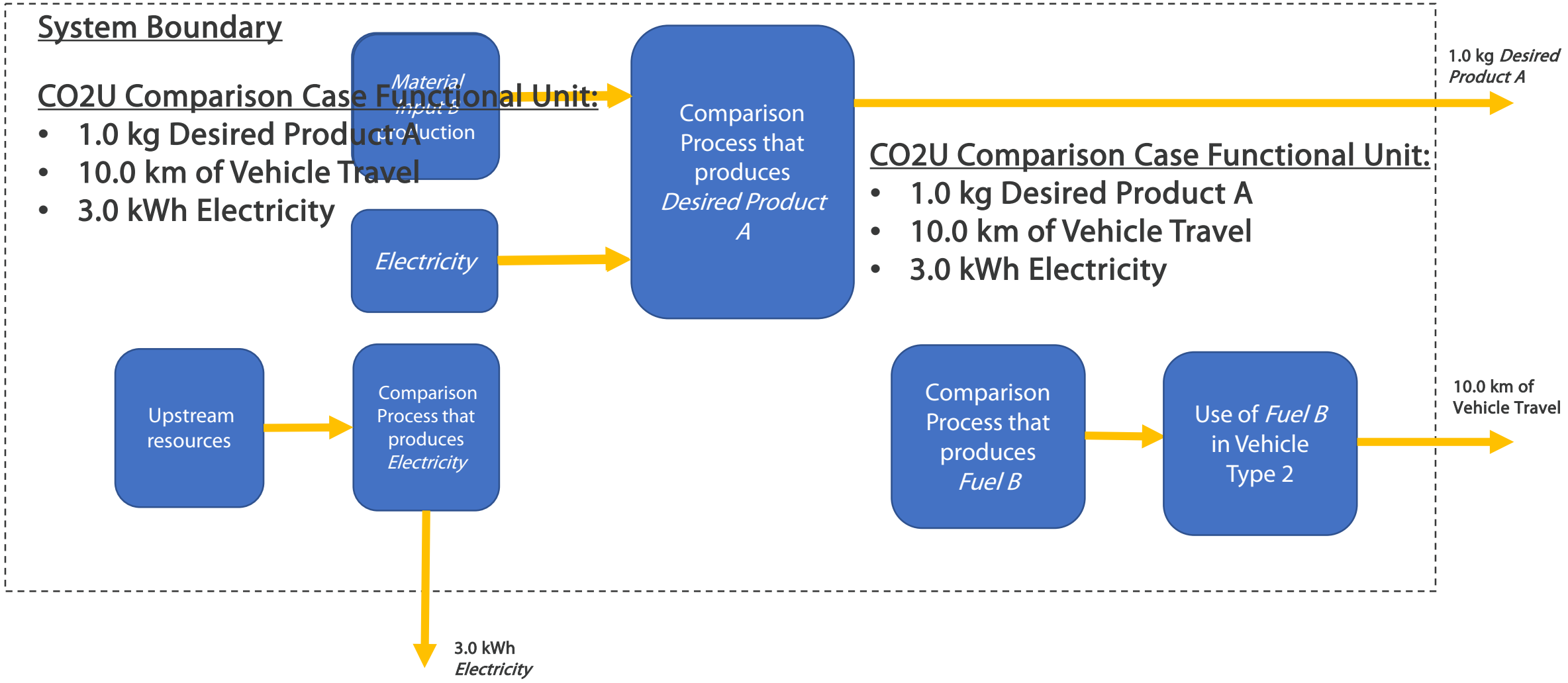
Comparison Case



Example CO2U Proposed Case



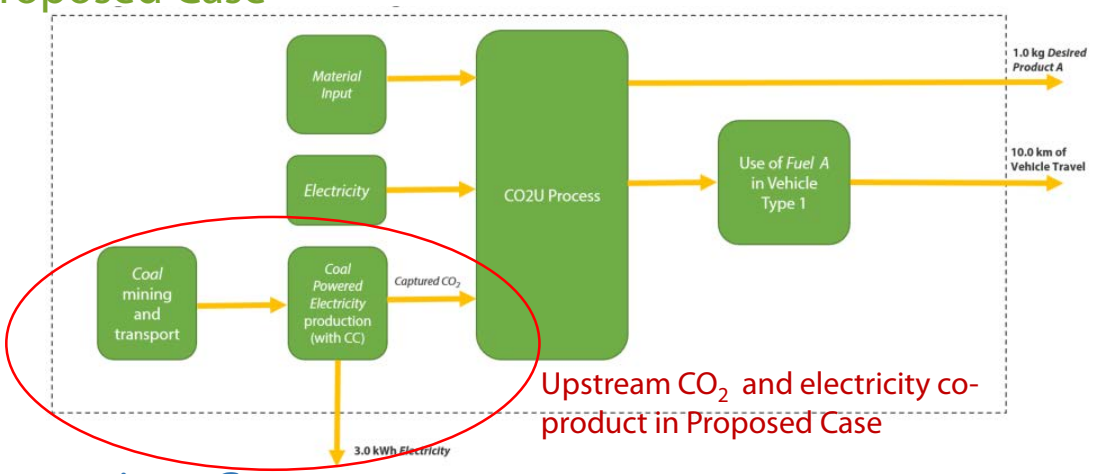
Example CO2U Comparison Case



One Area of Method Development is Upstream CO_2 and Electricity Co-Product Determination

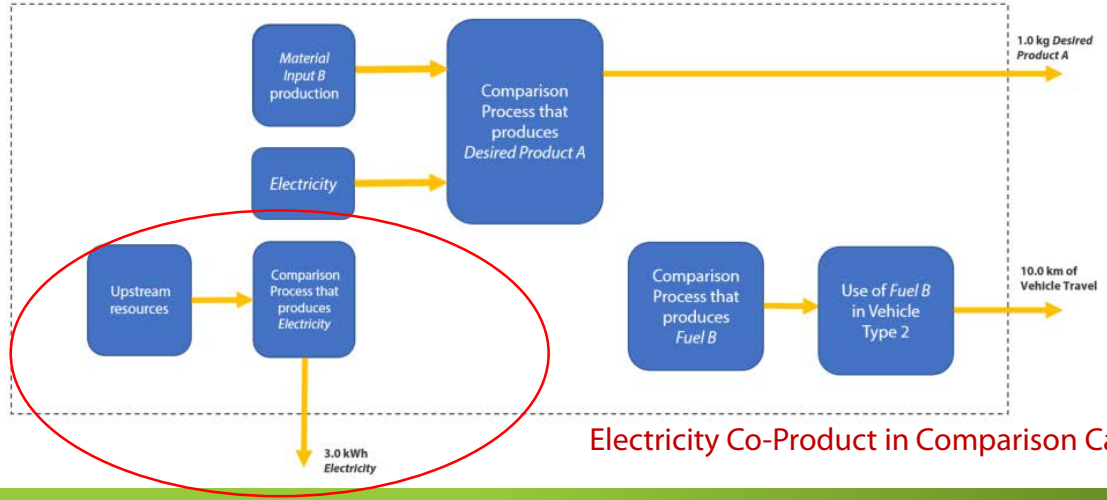
- Including upstream CO_2 in the boundary – results in an electricity co-product in the system boundary
- What should be the source of the electricity in the comparison case?
- How do we maintain functional equivalence between the cases?

Proposed Case



Upstream CO_2 and electricity co-product in Proposed Case

Comparison Case



Electricity Co-Product in Comparison Case

One Area of Method Development is Upstream CO_2 and Electricity Co-Product Determination

- Including upstream CO_2 in the boundary – results in an electricity co-product in the system boundary
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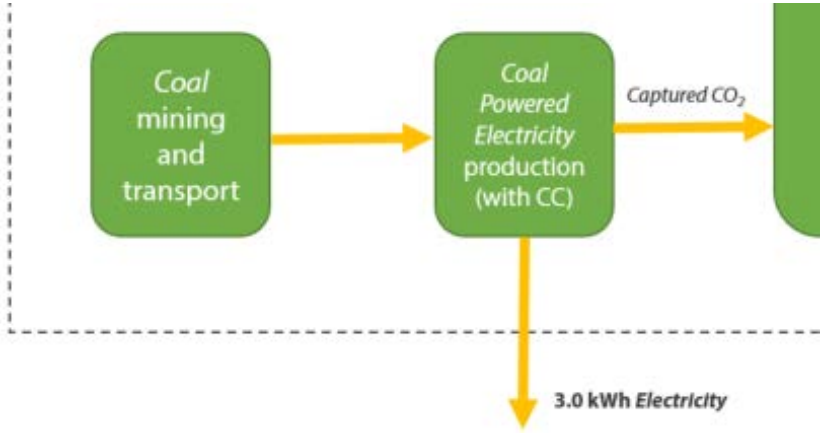
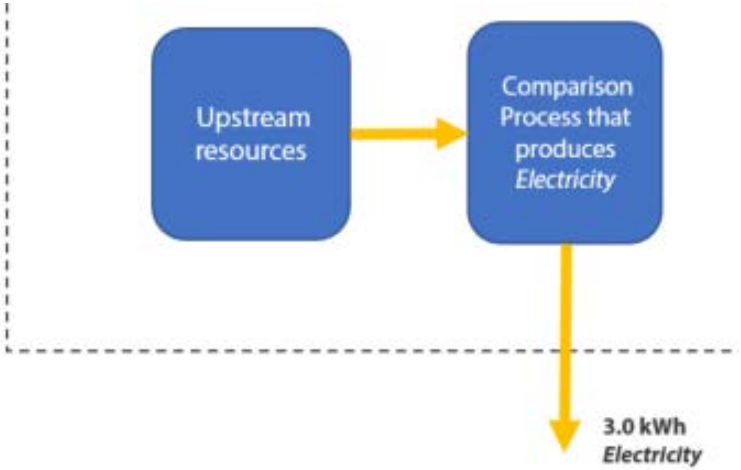
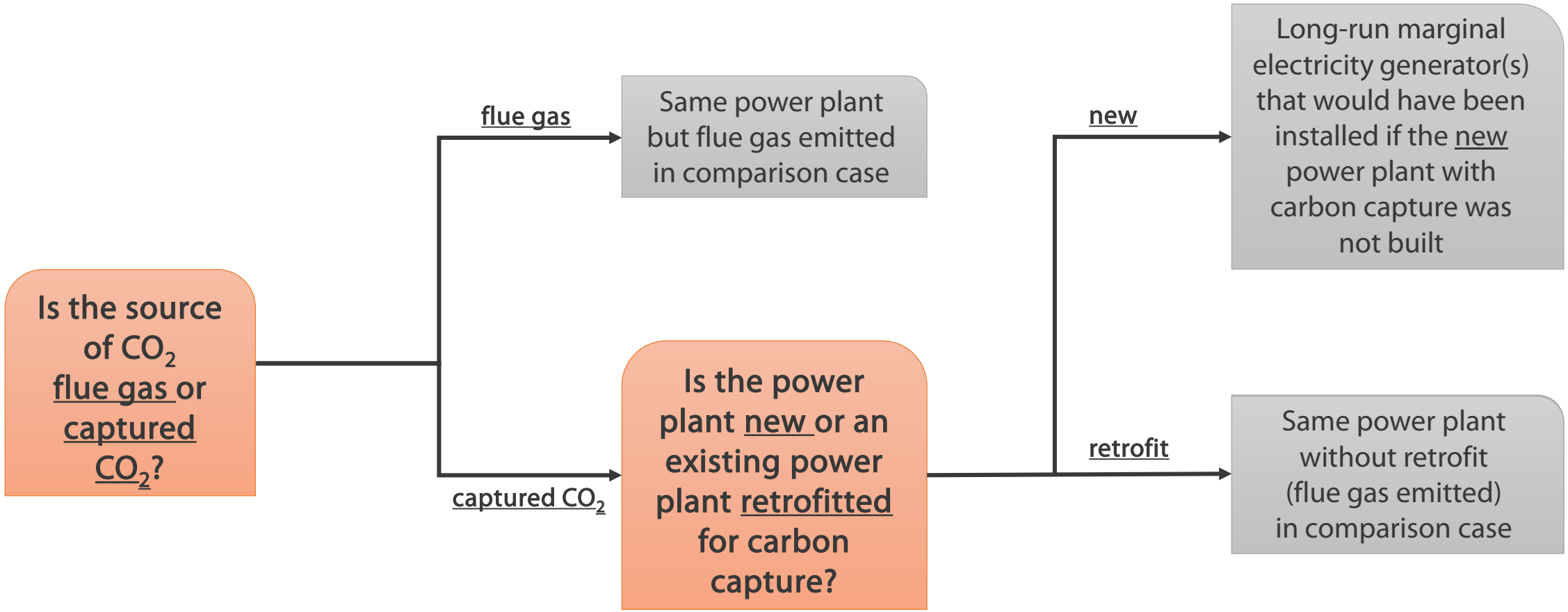
Proposed Case



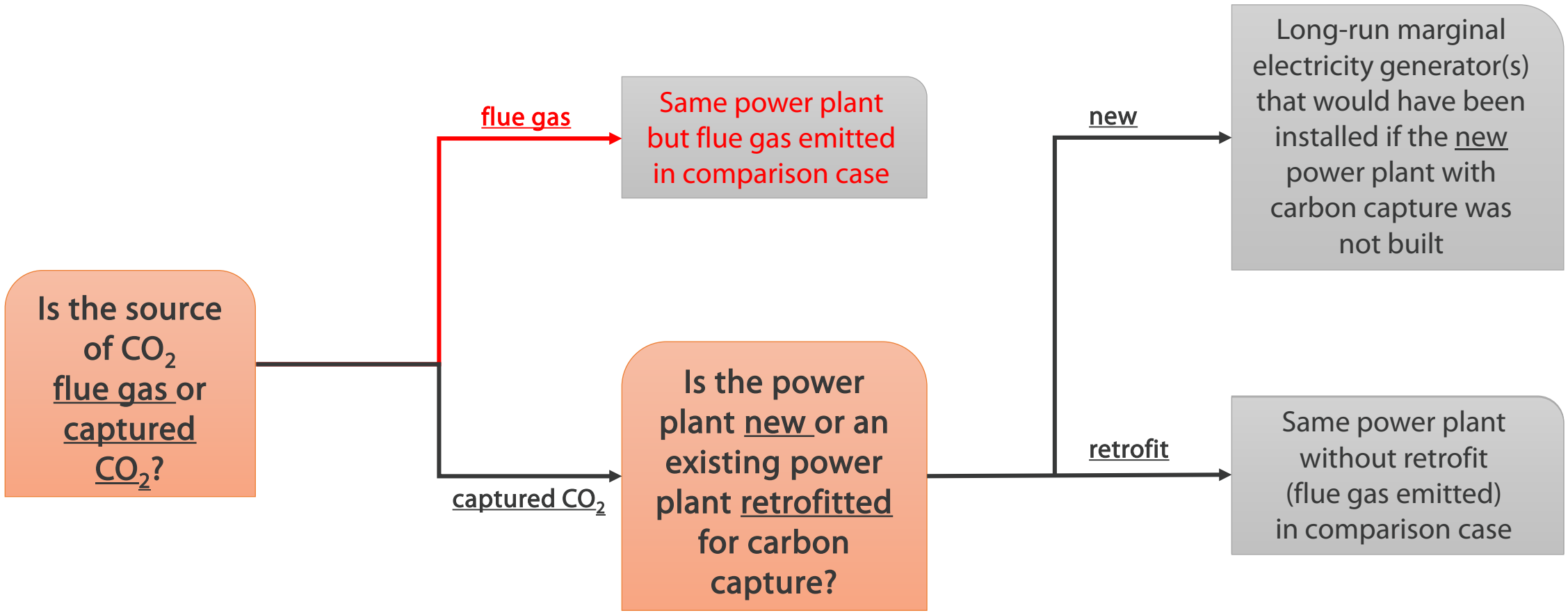
Comparison Case



The Electricity in the Comparison Case Depends on How the CO_2 Is Procured for CO2U

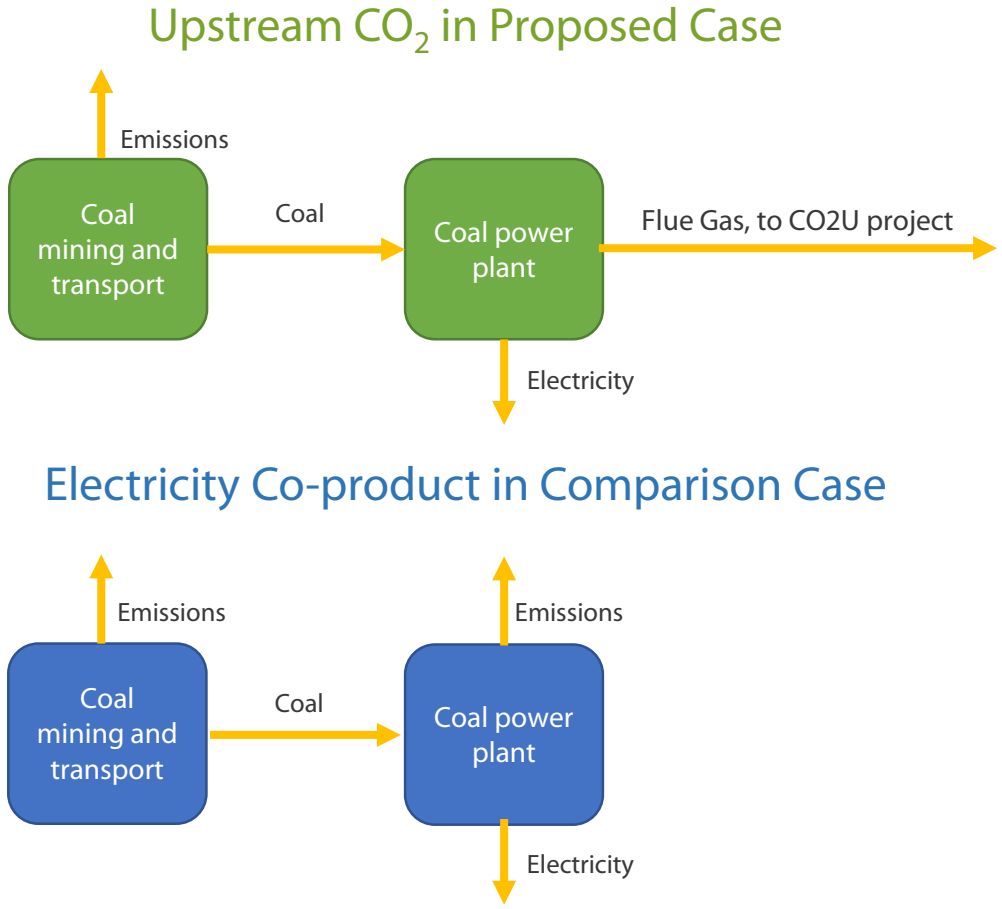


What If the Source of the CO_2 Is Flue Gas?

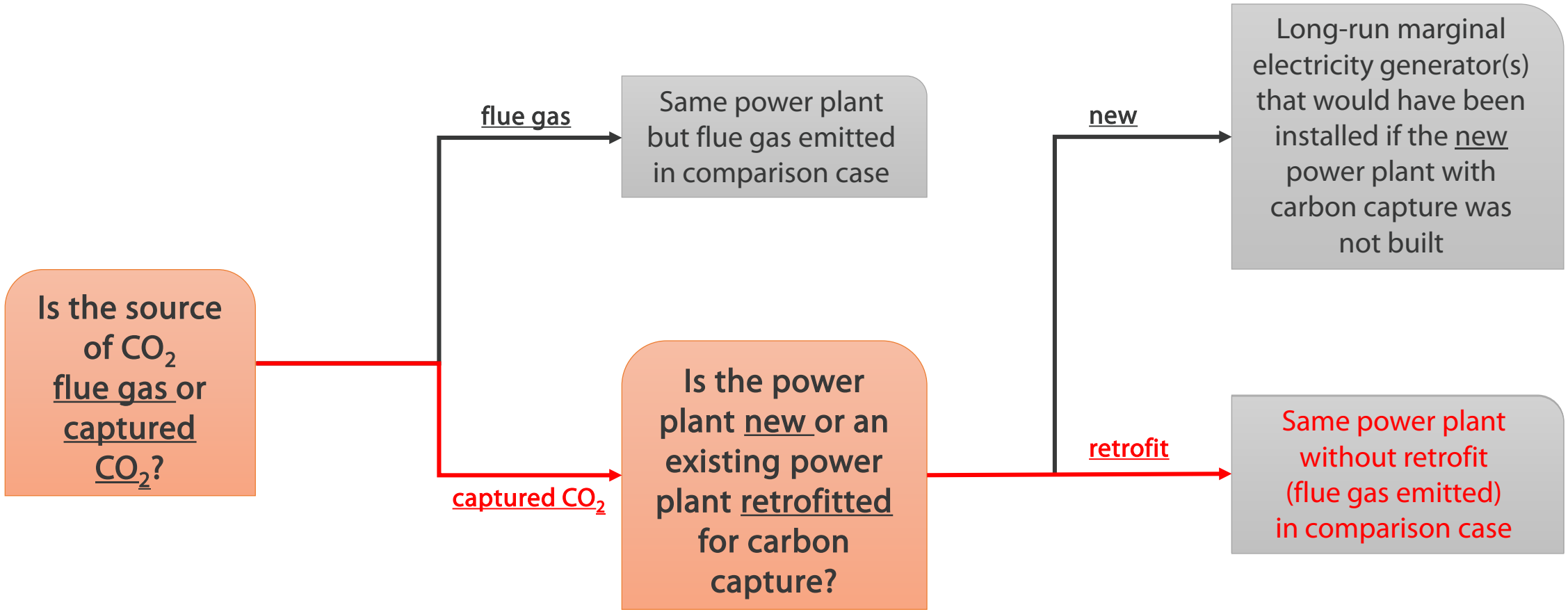


What If the Source of the CO_2 Is Flue Gas?

- Assume diversion of flue gas for alternative use does not affect the net electricity output the power plant prior to diversion of the flue gas
- Comparison case is the same power plant with the CO_2 being emitted rather than used

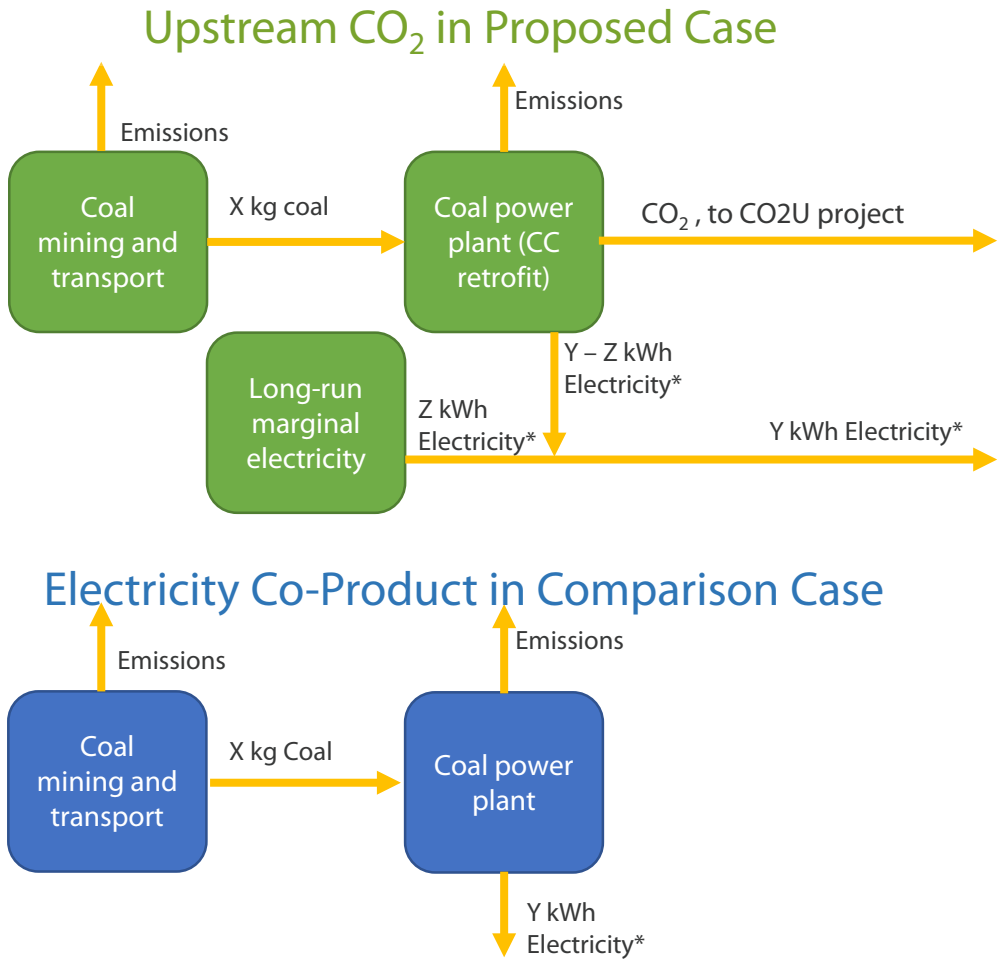


What If the Source of the CO_2 Is Captured CO_2 From a Retrofitted Power Plant?



What If the Source of the CO_2 Is Captured CO_2 From a Retrofitted Power Plant?

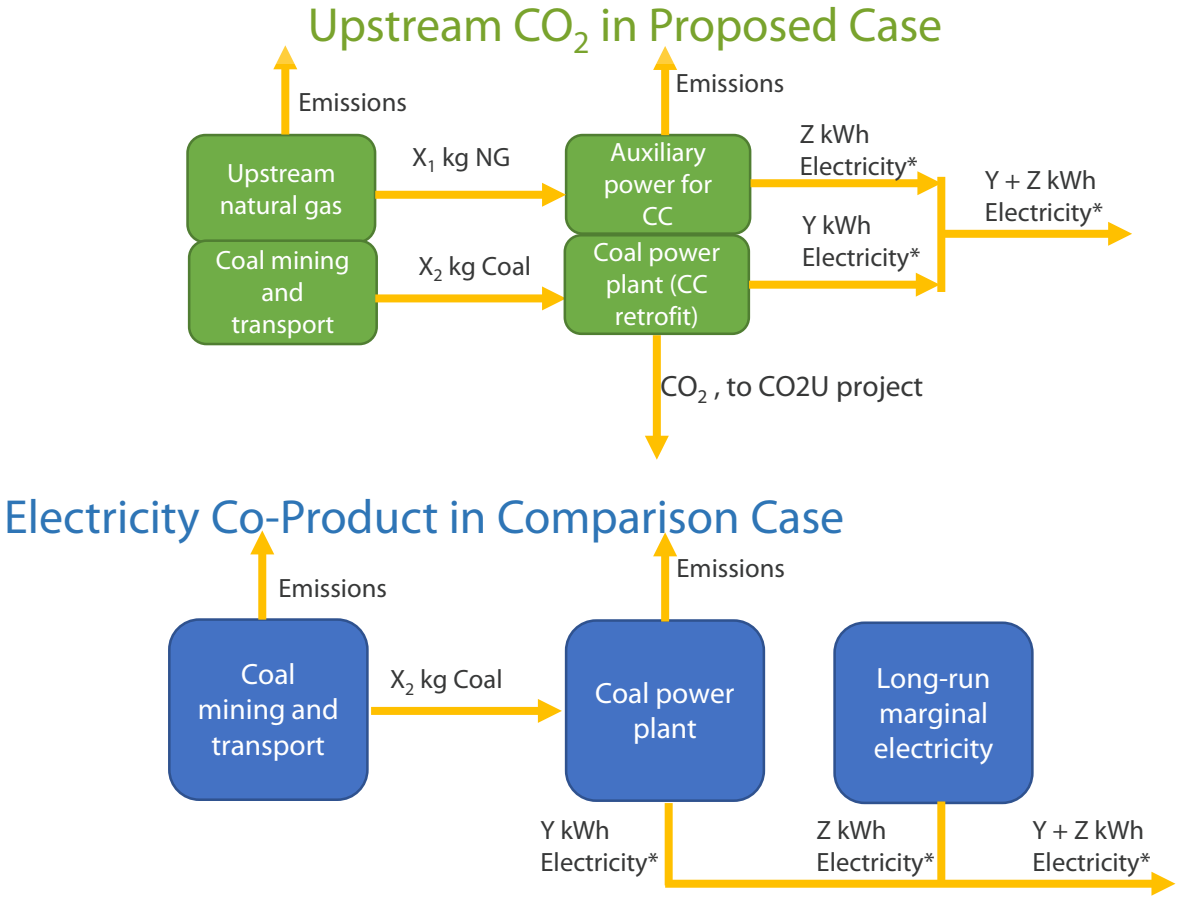
- IF, retrofitting the power plant results in a decrease in the net power output, then the "Proposed CO2U Case" will require "make-up" electricity
- "Make-up" electricity shall be equal to the electricity consumption mix (marginal supplier) in the geographical area defined in the study scope



*The carbon capture plant loses some of its capacity to run the carbon capture equipment, so make-up electricity in the proposed case is required to have the same amount of electricity output.

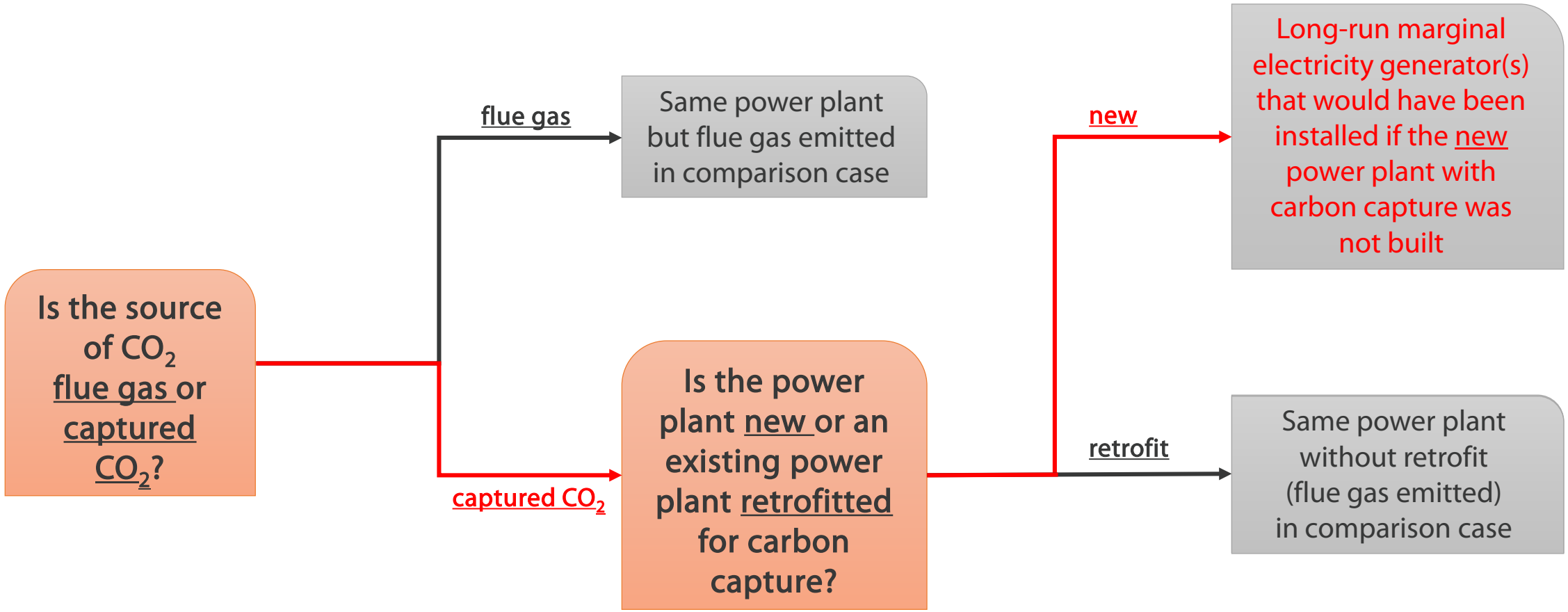
What If the Source of the CO_2 Is Captured CO_2 From a Retrofitted Power Plant?

- IF, retrofitting the power plant DOES NOT result in a change in the net power output, then assume external source of heat and power to operate the carbon capture and compression system (e.g., Petra Nova)
- IF, the auxiliary power system produces excess electricity, in turn increasing the net power output of the "Proposed CO2U Case", then additional "make-up" electricity has to be added to the "Comparison Case" to ensure system equivalence



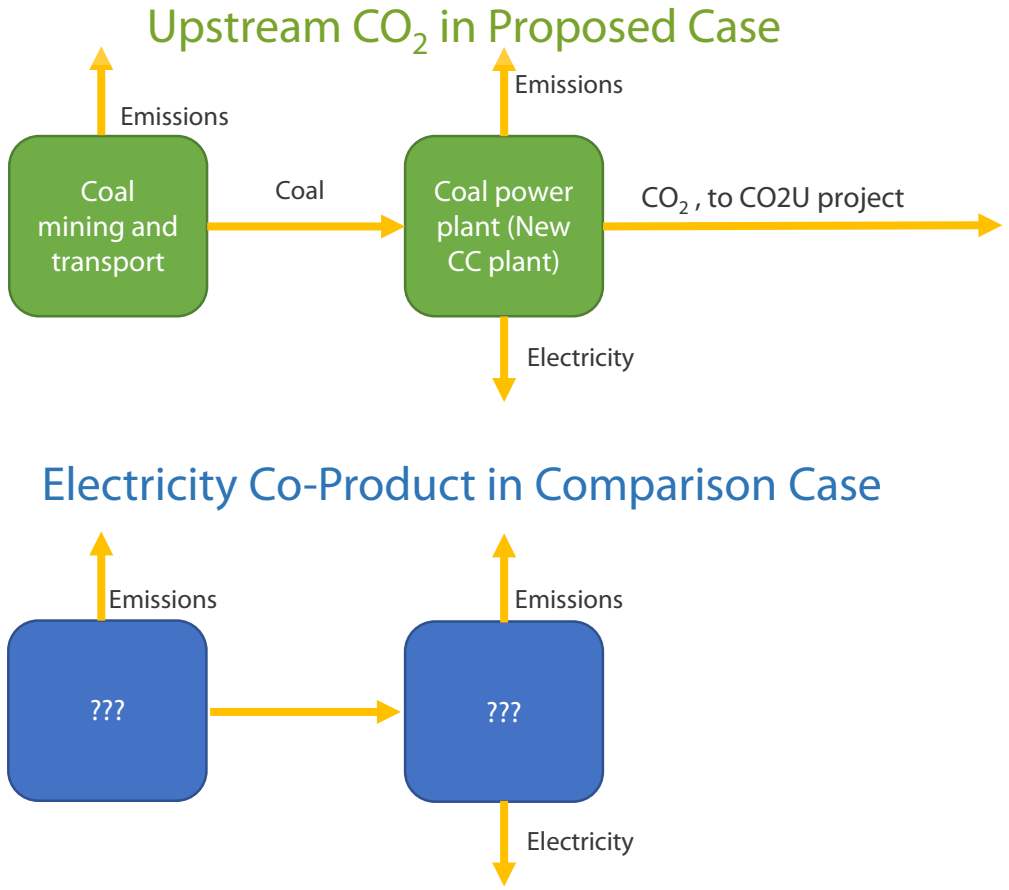
*The carbon capture plant gains capacity by installing auxiliary power to run the carbon capture equipment, so make-up electricity in the comparison case is required to have the same amount of electricity output.

What If the Source of the CO_2 Is Captured CO_2 From a New Power Plant?



What If the Source of the CO_2 Is Captured CO_2 From a New Power Plant?

- The comparison case is determined based on the long-run marginal electricity generator(s) that would have been installed if the new power plant with carbon capture was not built
- The electricity generator(s) are determined using capacity expansion modelling for the on-line (start) year of the power plant for the stated geographical scope of the study



What If the Source of the CO_2 Is Captured CO_2 From a New Power Plant?

1. Determine year of proposed CO2U project deployment (same as power plant on-line [start] year)
2. Compile mix of technologies composing capacity additions for that year
3. Develop weighted emission factors

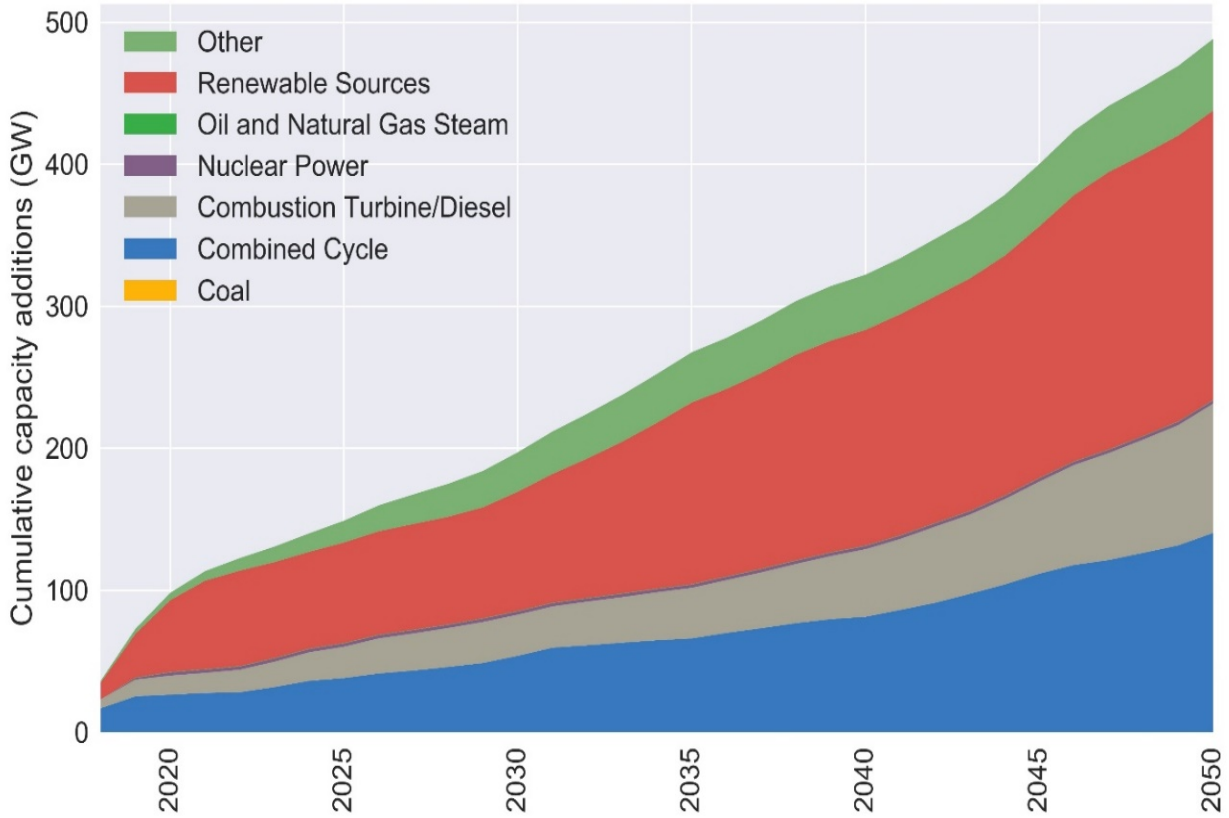


Figure 1. Cumulative capacity additions in the U.S. electric sector, based on the U.S. EIA's Annual Energy Outlook 2018, reference scenario. Source: EIA Annual Energy Outlook 2018, Electricity Generating Capacity

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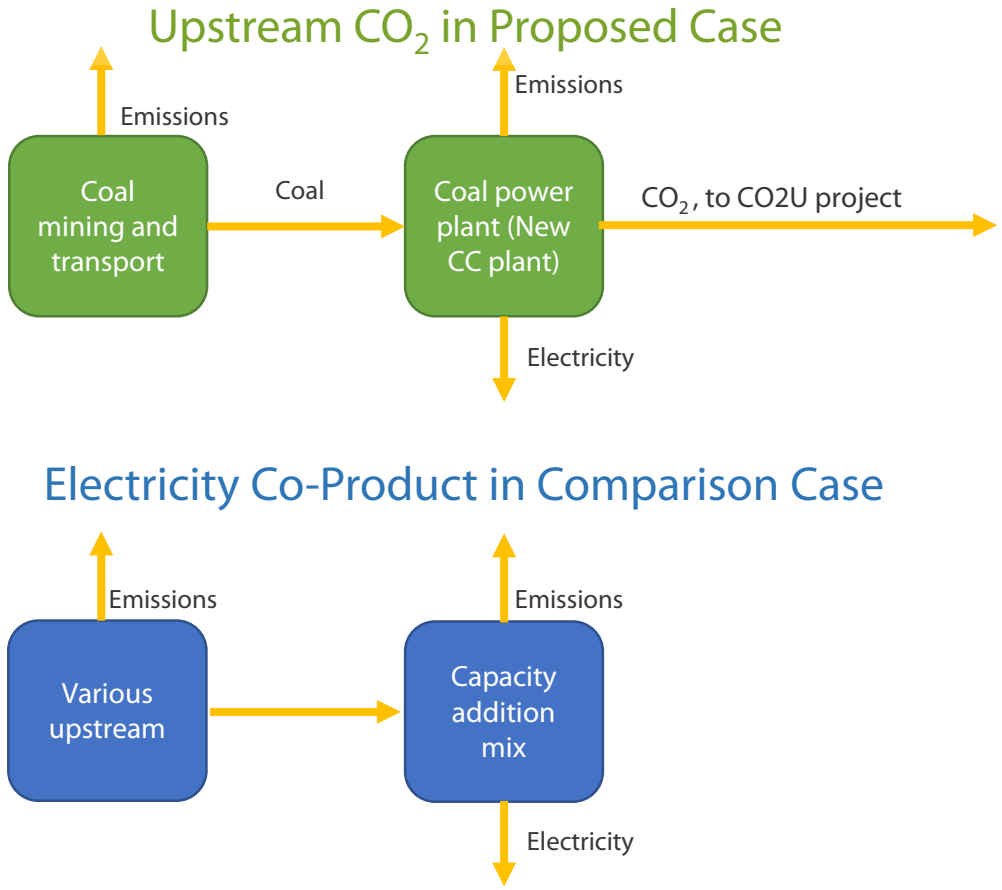

Conclusions

- CO2U systems are unique in that they combine two sectors (electricity and CO2U product)
- Consistent LCA approaches are necessary to ensure comparability and fairness
- The goal of the NETL CO2U Guidance is to determine the environmental preferability of utilizing captured carbon to produce products – this necessitates a consequential LCA approach

Contact Information

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LCA
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energy sustainability

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