NETL LCA Update

US DOE Special Session, ACLCA 2024

September 24, 2024

Matt Jamieson

Senior Life Cycle Analyst, Strategic Systems Analysis & Engineering

NETL LCA Team

Robert James – 18 yr
PhD Mech Eng
LCA quality control leader

Matt Jamieson – 13 yr
BS Mech Eng
Power systems analysis

Michelle Krynock – 9 yr
BS Civil Environ Eng & Public Policy
Carbon, critical minerals, tools and modeling, standards and guidance

Joe Marriott – 19 yr
PhD Environ Eng & Public Policy
LCA subject matter expert

Scott Matthews – 26 yr
PhD Economics
Data-driven modeling, environmental systems

Mission: *Evaluate existing and emerging energy systems to guide R&D and protect the environment for future generations*

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

Derrick Carlson – 14 yr
PhD Civil Environ Eng
I/O LCA, carbon capture

Tyler Davis – 13 yr
PhD Civil Eng
Environ modeling, geospatial data science

Michael Whiston – 10 yr
PhD Mech Eng
Energy analysis, fuel cells

Jorge Izar-Tenorio – 11 yr
PhD Eng & Public Policy
Food-energy-water nexus

Roksana Mahmud – 9 yr
PhD Env Engr
LCA, TEA, process design

Sheikh Moni – 8 yr
PhD Environ Eng & Earth Sci
LCA-emerging tech, carbon capture and utilization

Ashley Cutshaw - 7 yr
PhD Biosyst Agric Eng & Environ Sci Policy
Biomass, environmental science

Joseph Chou – 6 yr
MS Civil Environ Eng
Power and water systems

Updated 7.10.2024

NETL LCA Team (Cont'd)

Josh Redublo – 6 yr
MS Eng
Chemical & biological engineering

Nick Willems – 5 yr
PhD Mech Eng
Natural gas markets & economics

Harshvardhan Khutal – 4 yr
MS Energy, Sci, Technol & Policy
Energy, emissions analysis, natural gas

Shirley Sam – 4 yr
BS Environ Sci
Environmental science, sustainability, critical minerals

Marisol Contreras – 3 yr
MS Chem & Biochem Eng
Emerging technology TEA in chemical synthesis and energy conversion

Megan Henriksen – 3 yr
BS CEE & Public Policy
Air quality, energy analysis, hydrogen production

James Clarke – 3 yr
MS Chem Biomol Eng
Electrochemistry, carbon capture, water management

Priyadarshini – 3 yr
MS Civil Environ Eng
Sea-level rise and coastal adaptation, environmental modeling, energy analysis

Gianni Guglielmi – 3 yr
MS Civ, Envi, and Sust Eng
LCA modeling and visualization, water treatment

Kavya Chivukula – 2 yr
MS Civil Environ Eng
Natural gas

Juniper Deitering – 2 yr
BA Physics
Energy and Data Analysis, Environmental Studies

Xinyao Shen – 2 yr
MS Civil Environ Eng
Environmental engineering, water

John White – 2 yr
BS Chem Eng
Power plants, H_2, data analysis

Hydrogen and Hydrogen Carriers

Comparison of Commercial, SOA, Fossil-Based NH_3 Production Technologies

Objective

- Publish a peer-reviewed study titled "Comparison of Commercial, State-of-the-Art, Fossil-Based NH_3 Production Technologies"

Rationale

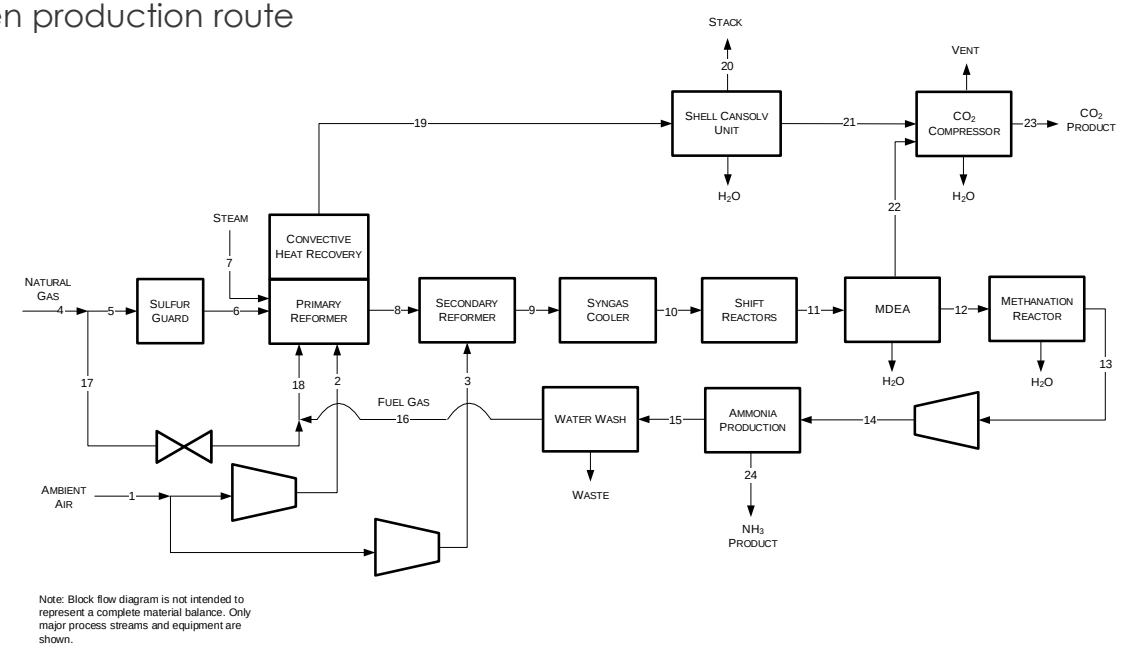
- Production of ammonia from clean hydrogen is currently viewed as a leading approach toward overcoming inherent challenges of transporting clean hydrogen to domestic and international markets
- The cost and carbon intensity of ammonia depends on the underlying hydrogen production route
- Reference/baseline cost and performance estimates are needed for current, commercial-scale, SOA, fossil-based ammonia production facilities with CCS

Approach

- Literature review and information gathering (building upon past SSAE efforts) to inform process modeling
- Establish Design Bases and Case Matric (expanded from past SSAE efforts)
- Perform process modeling and TEA/LCA evaluation in accordance with SSAE QGESS methodology
- Include sensitivity analyses of key process variables

Outcome

- Provide an important reference for policy and decision-makers within DOE as well as the external R&D community
- Platform for follow-on analyses that may include establishment of R&D goals and advanced NH_3 production concept assessments



Block Flow Diagram of Ammonia Production via SMR with CCS Source: NETL

Hydrogen and Hydrogen Carriers

NG Pyrolysis LCA

Objective

- Conduct life cycle analyses to coincide with TEAs for NG pyrolysis

Rationale

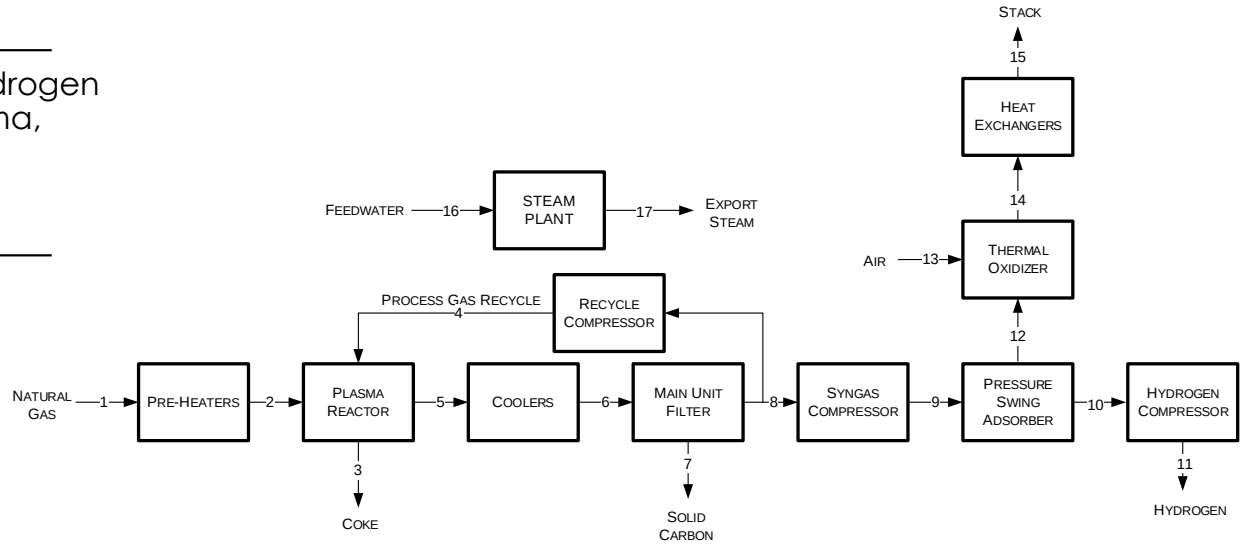
- In June 2021, DOE launched the Hydrogen Shot with a goal to reduce the cost of clean hydrogen production to $1/kg within one decade
- SSAE subsequently completed an integrated pathway screening analysis to identify potential technology and non-technology routes to achieving the Hydrogen Shot goal—NG pyrolysis concepts were identified as promising
- This project will provide valuable insight on plasma and catalytic-based pyrolysis pathways for DOE FECM Program Management and DOE's Hydrogen and Fuel Cells Technology Office (HFTO)

Approach

- Develop contemporary references for commercial and emerging hydrogen production technologies featuring different pyrolysis types (e.g., plasma, catalytic) using the LCOH (2018 $/kg) and life cycle carbon intensity (kg CO_2e/kg H_2) as the figure of merit

Outcome

- Valuable technical reference(s) for use in external modeling efforts (e.g., H2A, H2ALite, R&D GREET, 45VH2-GREET)
- Valuable technical reference(s) for potential follow-on analysis to assess R&D impacts to LCOH



Source: NETL

Hydrogen and Hydrogen Carriers

Net-Zero H_2 Production via Gasification

Objective

- Complete reference cost and performance models for gasification systems fed with biomass, MSW, and waste plastics

Rationale

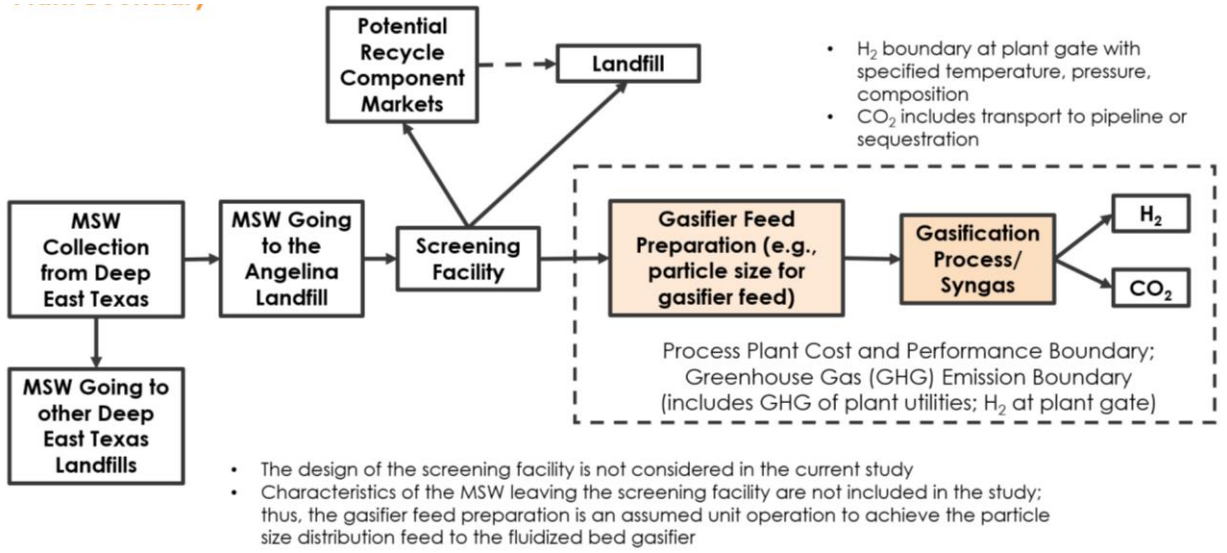
- Reference performance, cost, and greenhouse gas footprints are necessary to assess how DOE's Hydrogen Shot goal might be achieved using gasification systems fed with biomass, MSW, and waste plastics

Approach

- Develop design basis assumptions, steady-state thermodynamic modeling, and levelized cost of hydrogen estimates for each system
- Develop attributional life cycle GHG characterizations of feedstocks to be considered in the system design bases and life cycle profiles of each system

Outcome

- NETL lacks benchmark cost and performance information for gasification-based H_2 production systems fed with alternative feedstocks. Completion of this study will provide the following benefits:
  - Reference for R&D decision-making
  - Publicly available reference for external R&D community



MSW Gasification System Boundary

Using Waste Materials & Energy, September 24, 8:30-10a

Source: NETL

Hydrogen and Hydrogen Carriers

Publish Combined TEA/LCA Study on Net-Zero GHG Hydrogen pathways

Objective

- Show the TEAs and LCAs for multiple hydrogen production pathways using renewable natural gas in lieu of fossil natural gas

Rationale

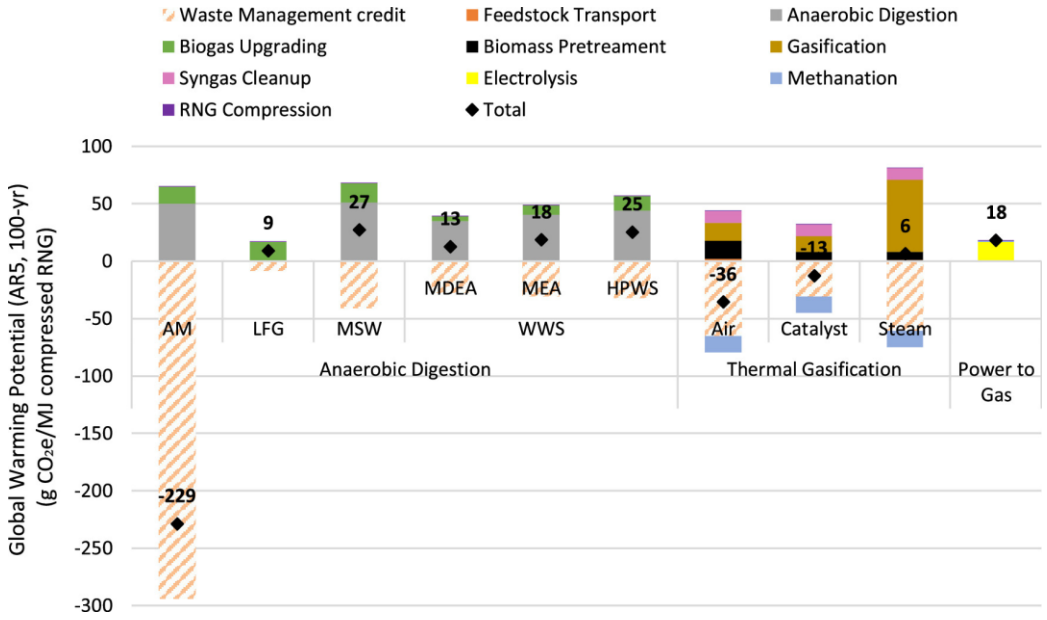
- For hydrogen fuels to be an environmental benefit, the life cycle GHG emissions associated with its production need to be less than alternative fuels at a minimum and ideally less than or equal to zero GHG emissions. This study will highlight RNG production and hydrogen production pathways that meet that criterion

Approach

- This is a multi-year, multi-competency effort. In the first year of the MYRP, the ESAT team will update the RNG production pathways to evaluate their GHG emissions on a strictly attributional basis (i.e., no credits for avoided emissions), using different approaches to account for the use (and presumably storage) of biogenic CO_2

Outcome

- Publicly available study informing stakeholder community of technical and economic characterization of net-zero H2 production from blended CH_4 sources



Published RNG Analysis Providing a Credit for Avoided Emissions

Source: NETL (Srijana Rai, Danny Hage, James Littlefield, Gabrielle Yanai, and Timothy J. Skone, "Comparative Life Cycle Evaluation of the Global Warming Potential (GWP) Impacts of Renewable Natural Gas Production Pathways," Environmental Science & Technology, 2022, 56, 12, 8581–8589)

LCA Reviews and Guidance

Program Extramural Project LCA Reviews

Objective

- Support programs by conducted as-needed technical review of extramural LCA products

Rationale

- As needed, support for DOE-FECM to evaluate external LCAs submitted as deliverables to recently completed and/or forthcoming FOA deliverables.

Approach

- Provide critical reviews for the LCAs and the associated life cycle model to ensure they are performed according to the FOA requirements

Outcome

- NETL Technology Development Center will leverage SSAE expertise, requesting support for extramural TEA review on a case-by-case basis. The NETL team will assess each LCA and provide written feedback to TDC in the form of a memo summarizing relevant comments
- Follow-up with TDC project managers/TEA performers as needed to clarify SSAE comments

Technology	Prime Performer Name	Prime Performer State	Award Number	Project Title	Start Date	Completion Date
Biological Uptake / Algae	MicroBio Engineering	CA	FE0031717	Beneficial use of CO2 from Coal-Fired Power Plants for Production of Animal Feeds	01/01/2019	06/30/2022
Biological Uptake / Algae	Helios-NRG, LLC	NY	FE0031710	Novel Algae Technology to Utilize Carbon Dioxide for Value-Added Products	05/01/2019	07/31/2023
Biological Uptake / Algae	University of Maryland Center for Environmental Science	MD	FE0031914	A Highly Efficient Microalgae-Based Carbon Sequestration System to Reduce Carbon Dioxide Emission from Power Plant Flue Gases	10/01/2020	09/30/2023
Biological Uptake / Algae	University of Kentucky	KY	FE0031921	NH4OH Looping with Membrane Absorber and Distributed Stripper for Enhanced Algae Growth	10/01/2020	09/30/2023
Biological Uptake / Algae	Global Algae Innovations, Inc.	CA	FE0032104	Carbon Capture and Utilization for Protein and Fatty Acids	09/01/2021	09/30/2024
Biological Uptake / Algae	University of Illinois	IL	FE0032098	Improving the Cost-Effectiveness of Algal CO2 Utilization by Synergistic Integration with Power Plant and Wastewater Treatment Operations	10/01/2021	03/31/2025
Biological Uptake / Algae	Texas A&M Agrilife Research	TX	FE0032108	Continuous Algae-Based Carbon Capture and Utilization to Tr... Economics and Environ... Impacts		
Biological Uptake / Algae	Helios-NRG, LLC	NY	FE0032103	Engineering-Scal... Algae Carbon D... and Bioproduc...		
Catalytic Pathway / Catalytic Pathway - Other	Advanced Cooling Technologies, Inc.	PA	SC0019664	Plasma-Assis... Utilization		
Catalytic Pathway / Catalytic Pathway - Other	Media and Process Technology, Inc.	PA	SC0019556	Inorganic Mem... Separation and ... Direct Synthesis ... Carbonate		

Source: FECM

energy.gov/fecm/fecm-solicitations-and-business-opportunities

LCA Reviews and Guidance

45Q Carbon Oxide Utilization Tax Credit LCA Support

Objective

- Provide environmental LCA modeling and technical review support to the Internal Review Support (IRS) for 45Q tax credit applications

Rationale

- The 45Q tax credit incentivizes implementation of carbon capture, utilization, and storage (CCUS) technologies by providing taxpayers a dollar amount per ton of qualified carbon oxide stored or utilized
- IRC Section 45Q-4 requires an LCA to be performed to document amount of qualified carbon oxide for the utilization tax credit

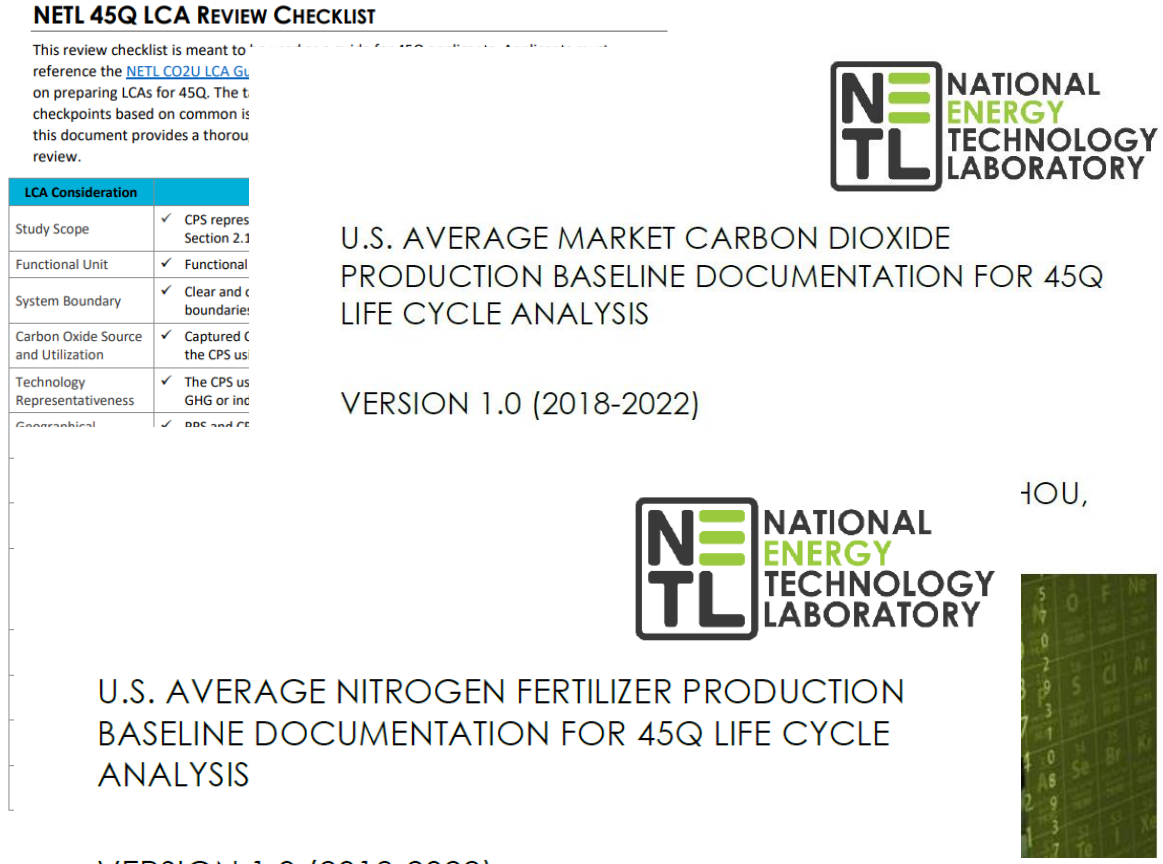
Approach

- Review applicant LCAs to ensure they conform to applicable ISO 14040 and 14044 standards and NETL CO2U LCA standards of practice, and model and data are a fair and reasonable estimate of the life cycle greenhouse gas emissions of proposed and comparison systems
- Update and maintain 45Q Addendum to the NETL CO2U LCA Guidance Toolkit, including additional tools and materials relevant to 45Q effort

Outcome

- Consistent, accurate LCAs for determining qualification for 45Q tax credit

netl.doe.gov/LCA/CO2U/45Q



LCA Reviews and Guidance

Bipartisan Infrastructure Law – Utilization Procurement Grants (UPGrants)

Objective

- Provide environmental LCA/assessment modeling and technical review support for the Utilization Procurement Grants (UPGrants) program

Rationale

- The commercial or industrial products to be procured and used under the UPGrants program will need to demonstrate significant net reductions in life cycle greenhouse gas emissions compared to incumbent technologies, processes, and products
- Vendors must complete LCAs to determine qualification for the program

Approach

- NETL will provide support to vendors navigating the UPGrants Addendum to the NETL CO2U LCA Guidance Toolkit to develop their own LCAs for the UPGrants program
- NETL will provide a critical review summary to HQ for each UPGrants LCA to aid in deciding qualification for the program
- Critical reviews will include a review of appropriateness of documentation, conformance to the program's LCA guidelines, and technical accuracy

Outcome

- Consistent and accurate LCAs necessary to determine qualification for the UPGrants program
- A list of vendors qualified to sell carbon conversion products to eligible entities (states, local governments, public utilities or agencies) under UPGrants program

netl.doe.gov/upgrants

Using Carbon, September 24, 10:30a-12p

Eligible Entities

Local Governments

States

Public Utilities/Agencies

Source: NETL

Carbon Conversion

Comparative LCA of CO_2 Utilization in Concrete

Objective

- Compare the environmental impacts of various concretes produced with and without CO2 utilization processes

Rationale

- CO2 utilization in concrete has been one of the most visible ways to use CO2 largely through the use of CO2 during the curing process. However, that's only one pathway at one specific point in the process of making concrete. This study seeks to compare combinations of the other points in concrete production that can be targeted for CO2 utilization.

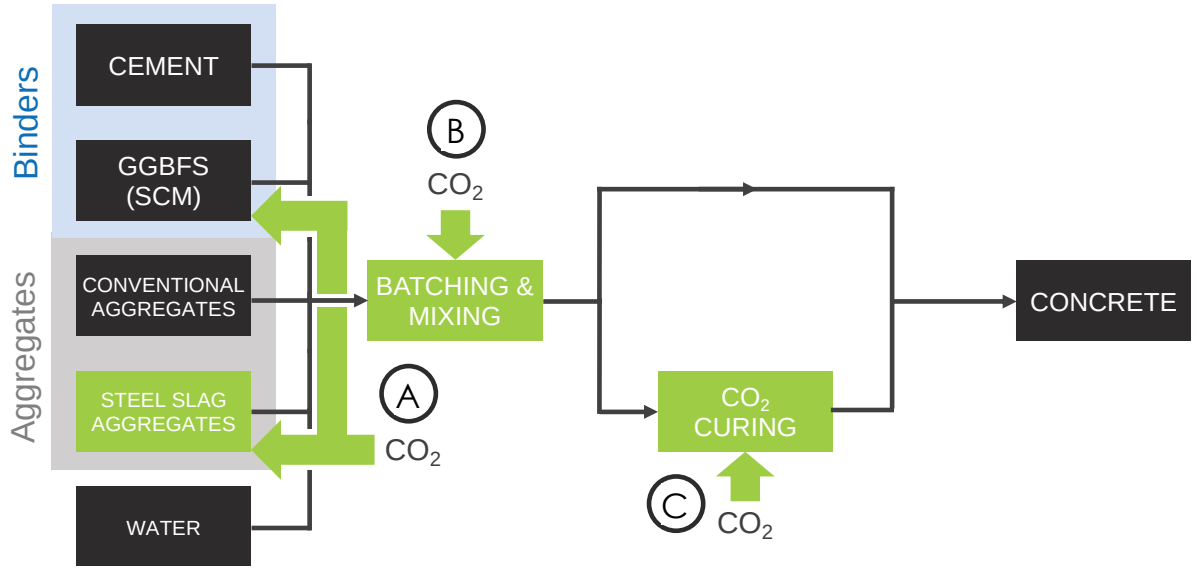
Approach

- Use publicly available literature and common life cycle scopes and boundaries to build life cycle models of and assess the various pathways for using CO2 in concrete production to reduce the carbon intensity.

Outcome

- Comparative global warming potential assessment of various methods of concrete production to inform research and decision makers.

Better Concrete, September 26, 3:30p-5:00p



Mineral Sustainability

LCA of CMM Recovery from Brine

Objective

- Characterize the environmental impacts, including the TRACI impact method categories, water consumption and energy consumption, of recovering critical minerals and materials from brines

Rationale

- To inform LCA of produced water in future years, a baseline life cycle analysis for lithium recovery using conventional evaporative methods is required

Approach

- Leverage previous literature review on critical minerals to perform an LCA of the process

Outcome

- Environmental tradeoffs of Li recovery from brine

netl.doe.gov/resource-sustainability/critical-minerals-and-materials

Source: NETL

List of NETL & Affiliate Presentations/Posters

- *Life cycle impacts of waste-to-energy pathways: A comparative analysis of accounting methods.*
  Using Waste. Tuesday, September 24, 2024. 8:30a-10:00a
- *Comparative life cycle analysis of carbon dioxide utilization in concrete products.*
  Better Concrete. Thursday, September 26, 2024. 3:30-5:00p
- *NETL LCA Tools for Carbon Conversion Technology Appraisals.*
  Using Carbon. Wednesday, September 25, 2024. 10:30a-12:00p
- *Life Cycle Impact Assessment as a Vehicle for Quality Review: A New Carbon Balance Tool.*
  Poster

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NETL LCA Update

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