U.S. DEPARTMENT OF ENERGY
Fossil Energy and Carbon Management

Life Cycle Analysis for CDR Pathways

2022 Carbon Management Research Project Review Meeting

August 16, 2022

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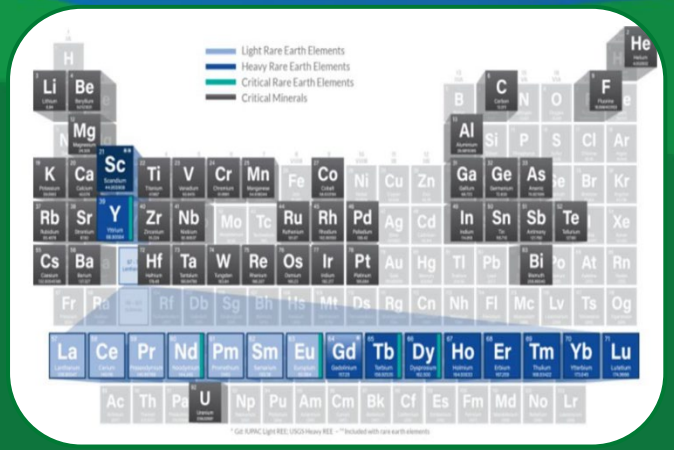

What is LCA and how do we use it in FECM?

Life Cycle Assessment (LCA) is an analytical approach that helps people make better decisions to improve and protect the environment by accounting for the potential impacts from cradle-to-grave

- Establish National Technology Baselines
- Assess Emerging and Existing Tech
- Compare Policy and Scenario Tradeoffs
- Plan for the Future and Look Ahead

Why do we need LCA when evaluating CDR?

Adapted from CDR Primer (2021)

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- Materials
- Chemicals
- Energy
- Water
- Land

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- Materials
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- Co-product
- Transport
- Storage
- Waste Mgmt

Adapted from CDR Primer (2021)

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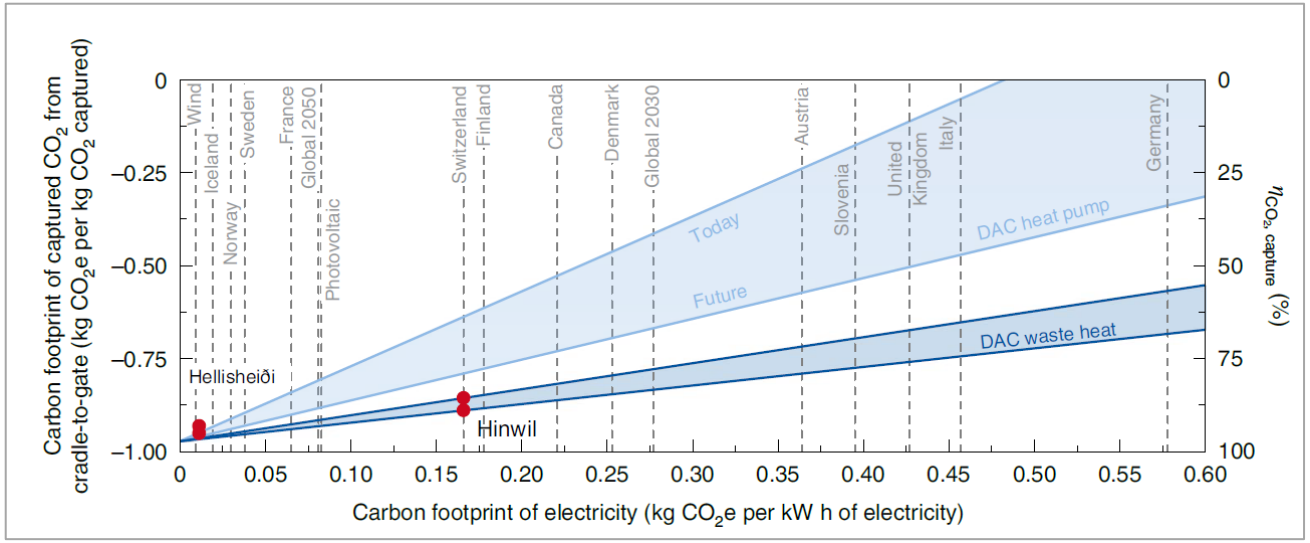
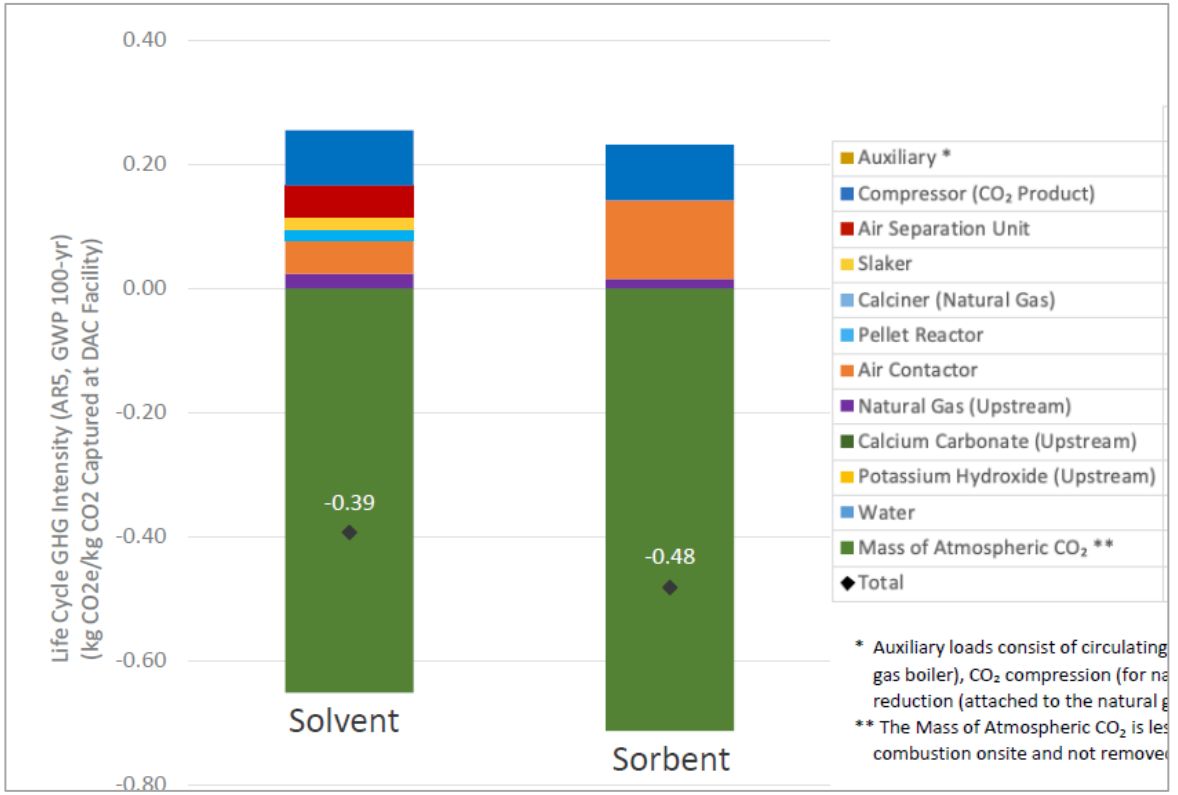


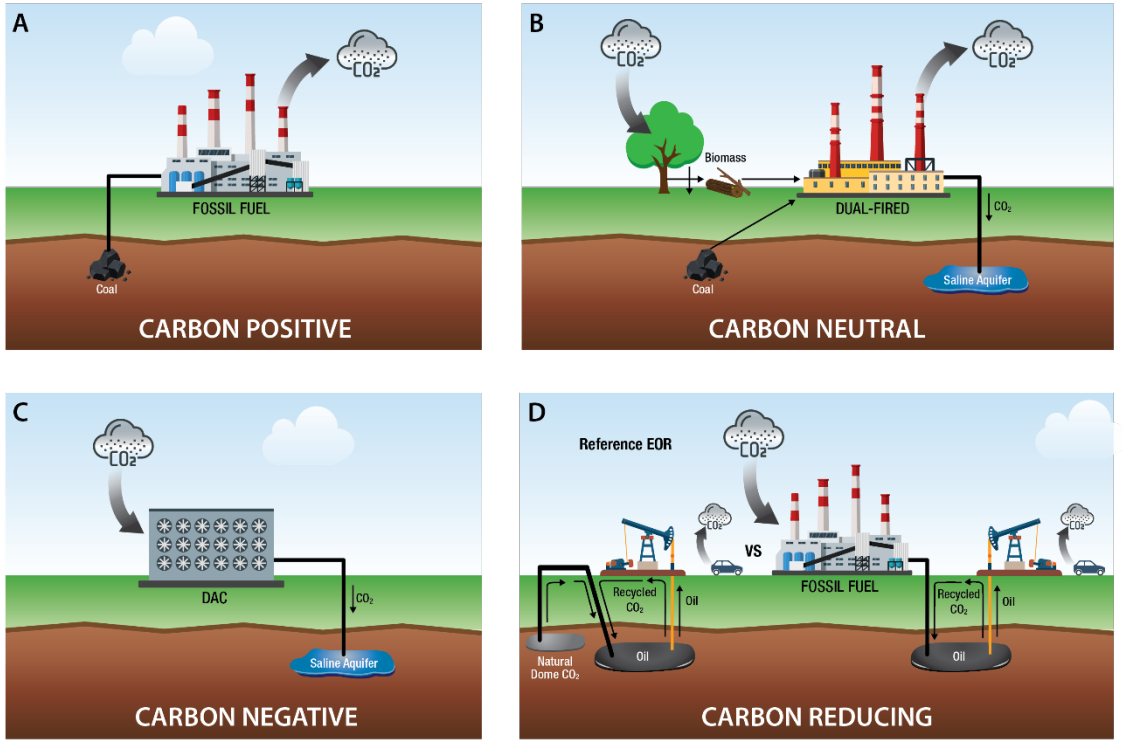
Deutz and Bardow (2021)



NETL (2021)

LCA can help us make sense of GHG mitigation approaches

- CDR comprises a **variety** of different approaches
- LCA can be used as a framework to account for the **net emissions** of proposed pathways
- It can also be used to assess **potential tradeoffs** in other environmental impacts

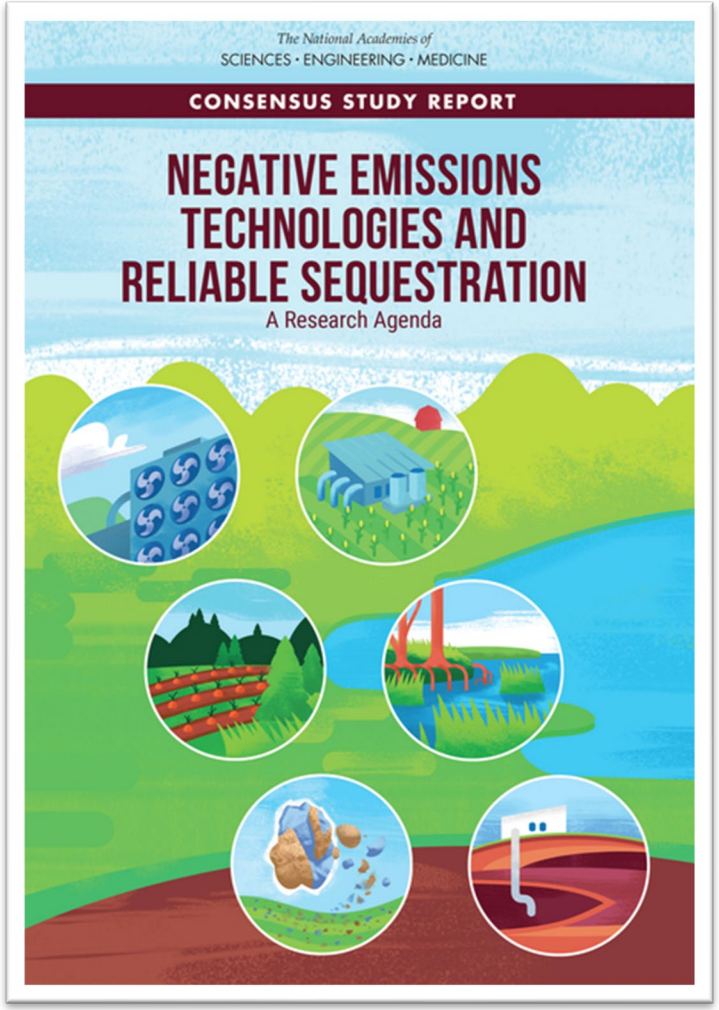


Source: NETL (2022)

Monitoring, Reporting, and Validation (MRV)

"The committee considered a range of factors that will affect the scale-up…these factors include the availability of land…, other environmental constraints, energy requirements, high cost, practical barriers, permanence, **monitoring and verification**, governance, and insufficient scientific or technological understanding."

"**Monitoring and verification** will be critical components of any large-scale deployment of NETs."



Source: NASEM (2019)

LCA can support all phases of MRV

Monitoring

- Development of project-specific cradle-to-grave models
- Ongoing refinement of assumptions and data gaps

Reporting

- Standardization of key analysis metrics
- Identification of sensitivities and uncertainties

Verification

- Third-party, independent evaluation of LCA

Key considerations for applying LCA to CDR

- Clarity and consistency in functional unit
- System boundary definition
- Negative emissions accounting
- LCI data consistency/representativeness
- Temporal dynamics for removal and emissions
- Early TRL scaling uncertainty

Specificity in function is essential

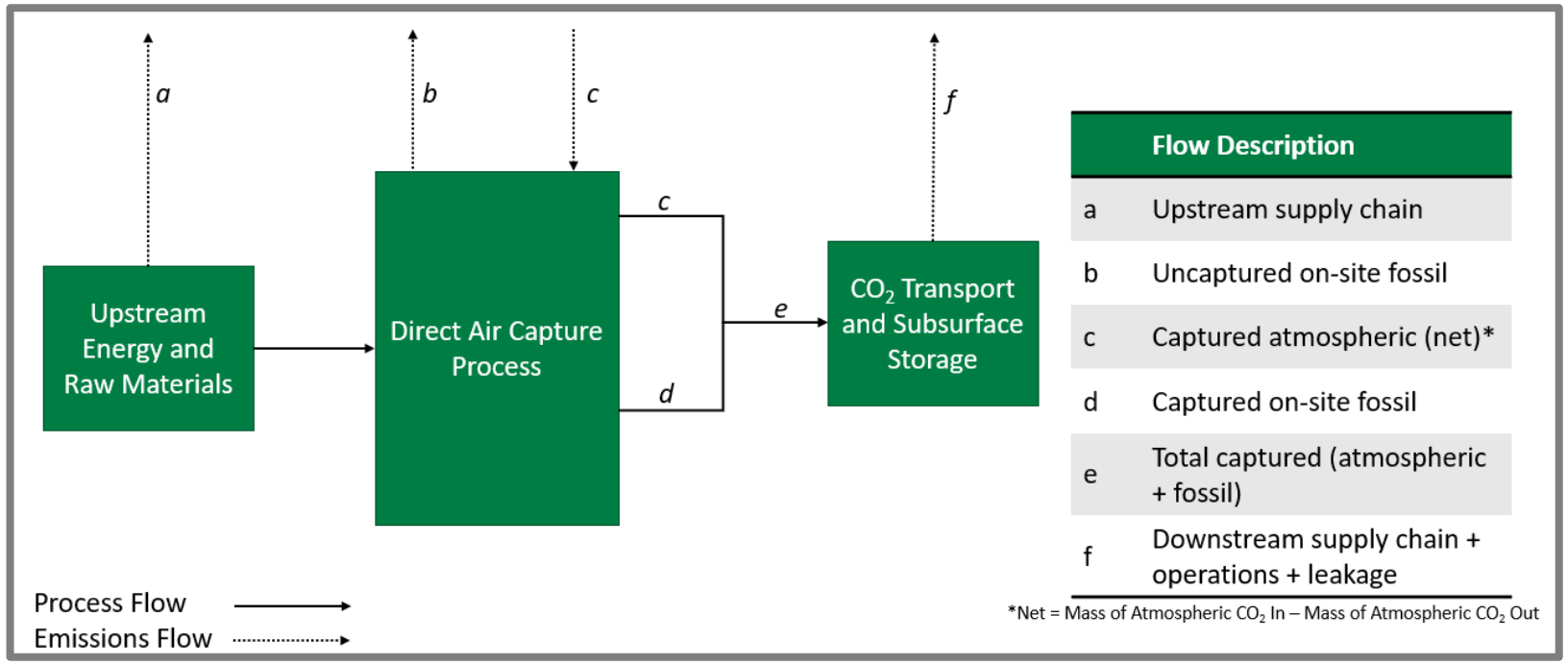
Potential Functional Units

<u>Cradle-to-gate:</u>

1. Mass of CO_2 captured
2. Mass of CO_2 captured from the atmosphere

<u>Cradle-to-grave:</u>

3. Mass of CO_2 captured from the atmosphere and permanently stored
4. Mass of net CO_2e captured from the atmosphere and permanently stored

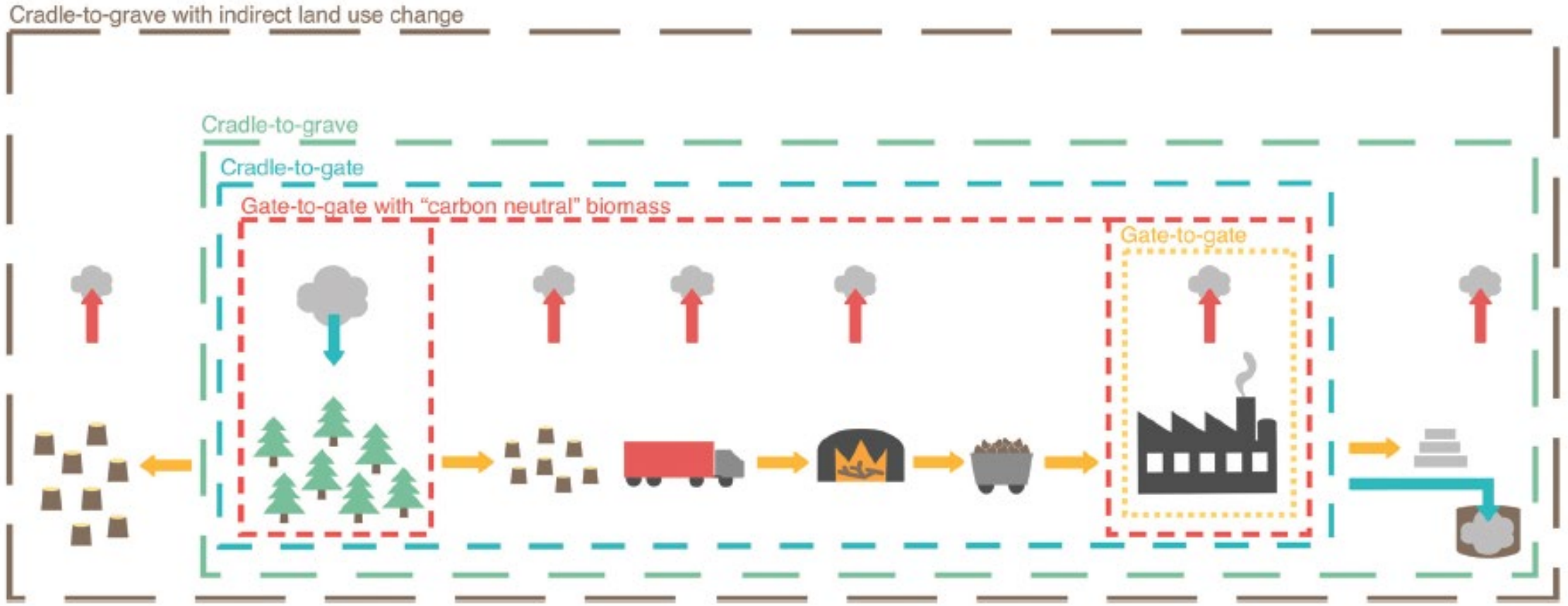


	Flow Description
a	Upstream supply chain
b	Uncaptured on-site fossil
c	Captured atmospheric (net)*
d	Captured on-site fossil
e	Total captured (atmospheric + fossil)
f	Downstream supply chain + operations + leakage

*Net = Mass of Atmospheric CO_2 In – Mass of Atmospheric CO_2 Out

Boundaries matter; cradle-to-grave is best

Notional steel mill example; functional unit is 1 t of steel

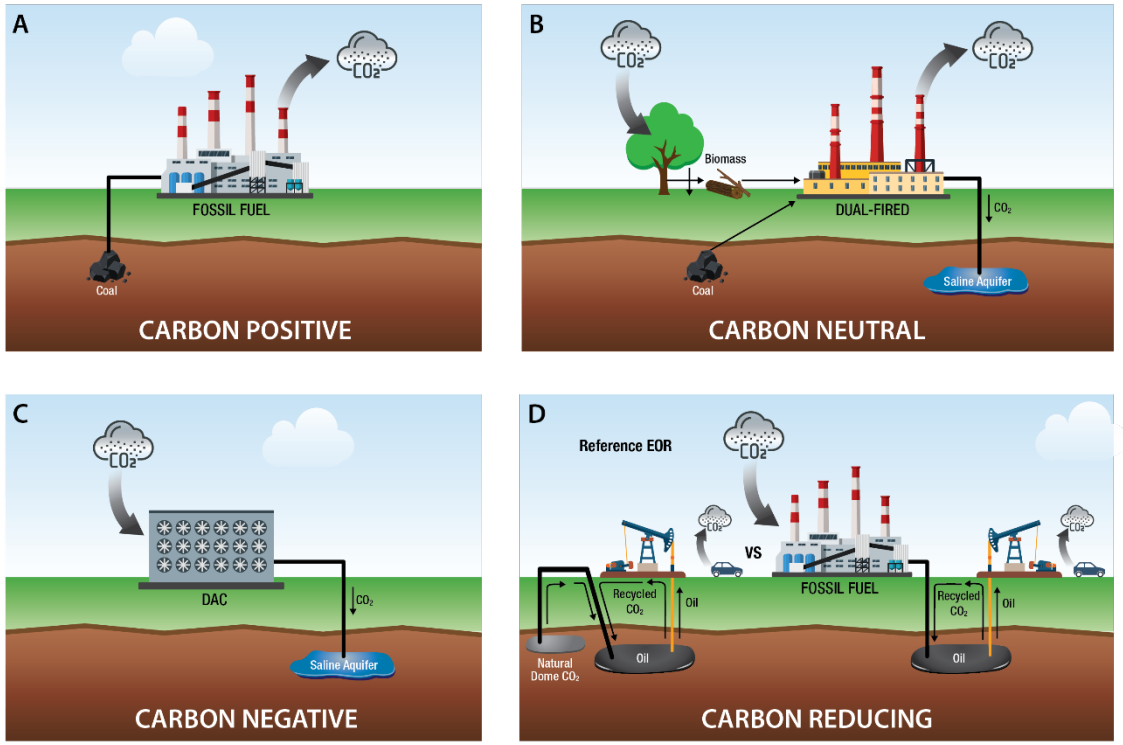


Source: Tanzer & Ramirez (2019)

Correctly interpreting negative emissions

In LCA, negative emissions can arise from one of two situations:

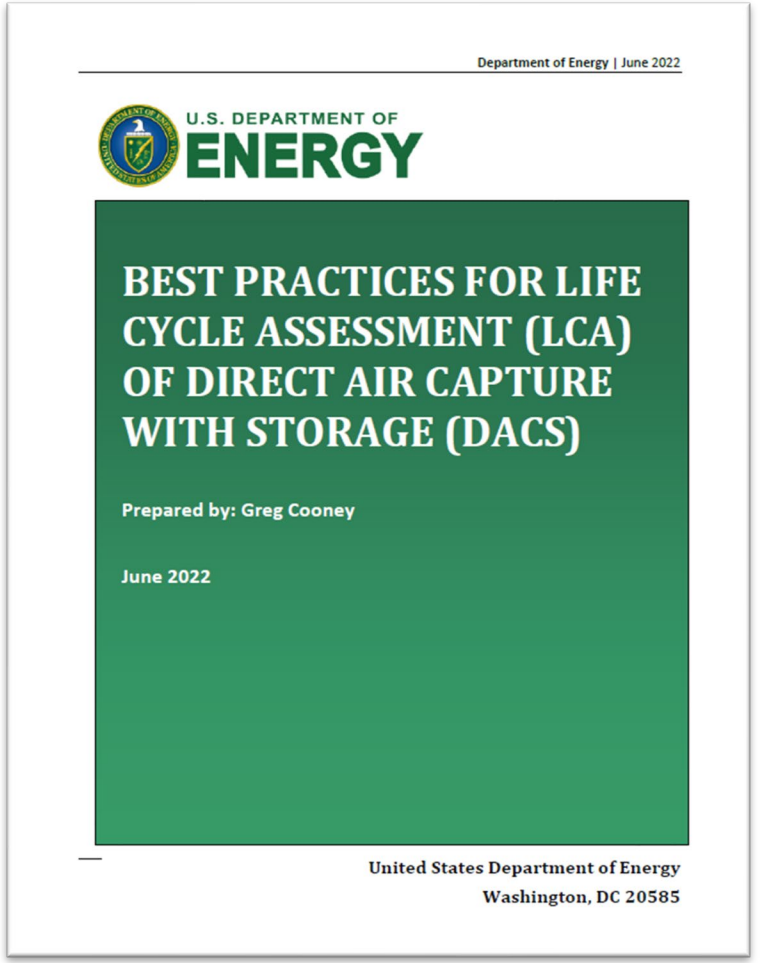
1. **Removal** of the emission species from an environmental compartment
2. **Avoided** emissions associated with the production of a product by another means



Source: NETL (2022)

DOE FECM Best Practices for LCA of DACS

1. Foster **consistency** of LCA of DACS systems to enable more complete understanding of potential impacts of CDR
2. Assess **sensitivity and uncertainty** in results to provide confidence in the study outcomes and potential risk envelopes for technology performance
3. Understand **potential tradeoffs and co-benefits** of DACS systems
4. Leverage **best practices** from the LCA research and practitioner community



https://www.energy.gov/fecm/best-practices-LCA-DACS

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Thank You

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