Carbon Capture and Storage – Recent progress and future outlook

Presented to: ISCC Technical Stakeholder Meeting Sustainable Aviation Fuels

Cologne, Germany; September 19, 2023

Steffen Mueller; PhD
Principal Economist
University of Illinois Chicago
Energy Resources Center

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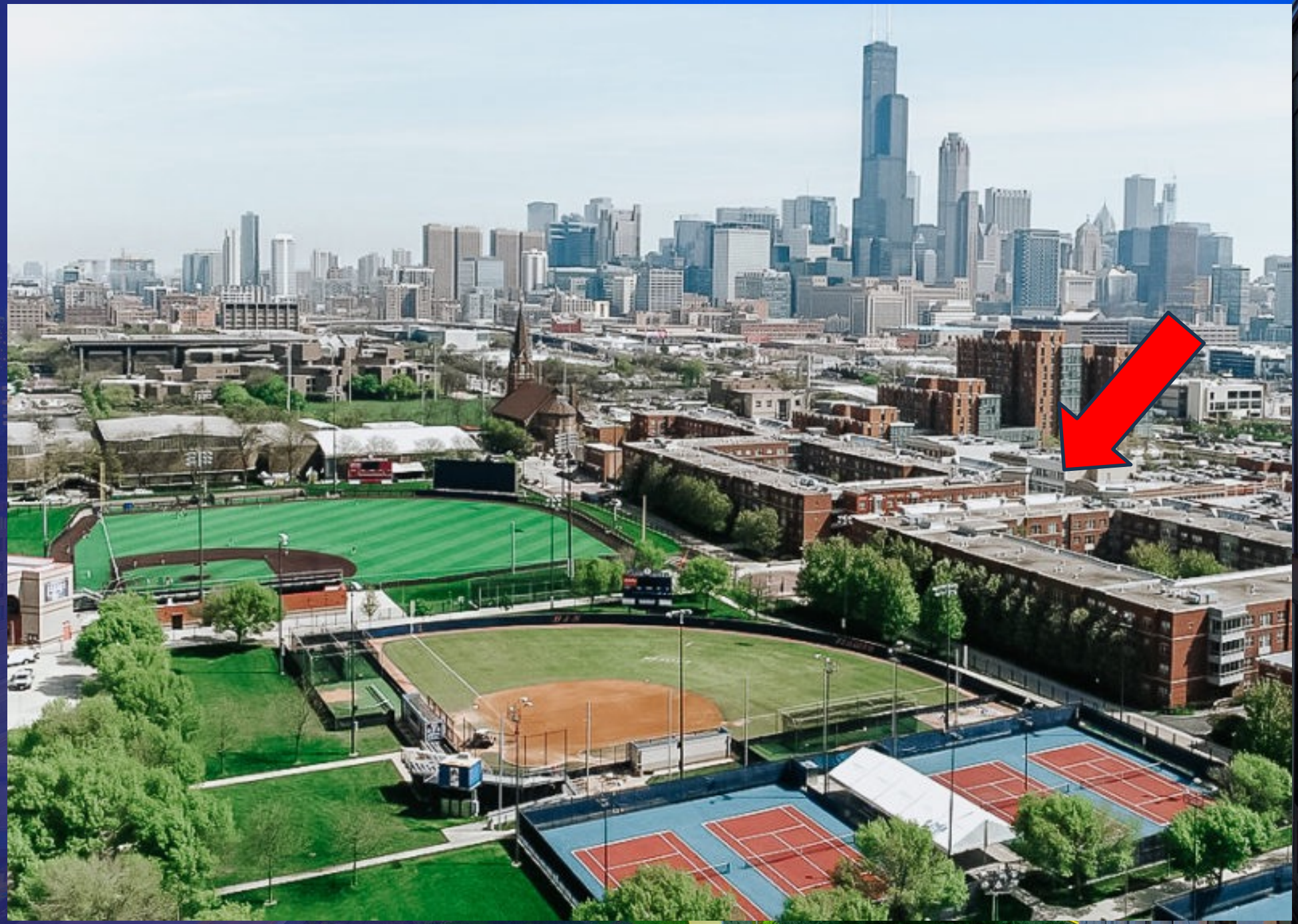

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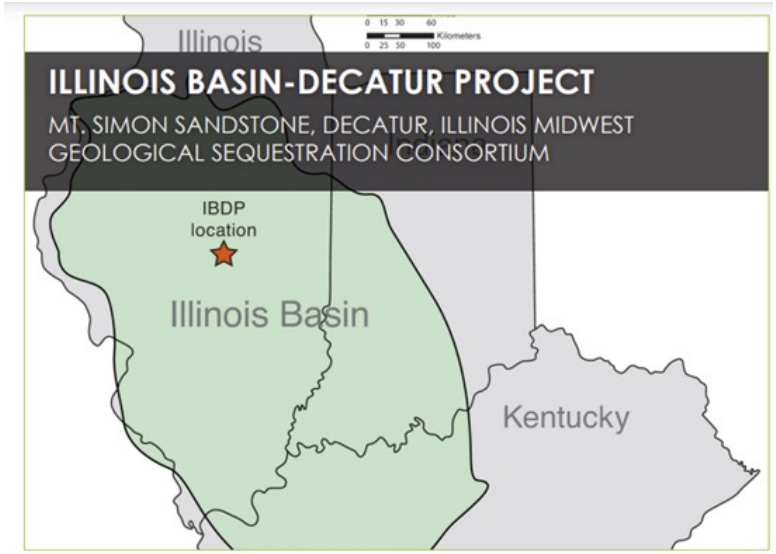
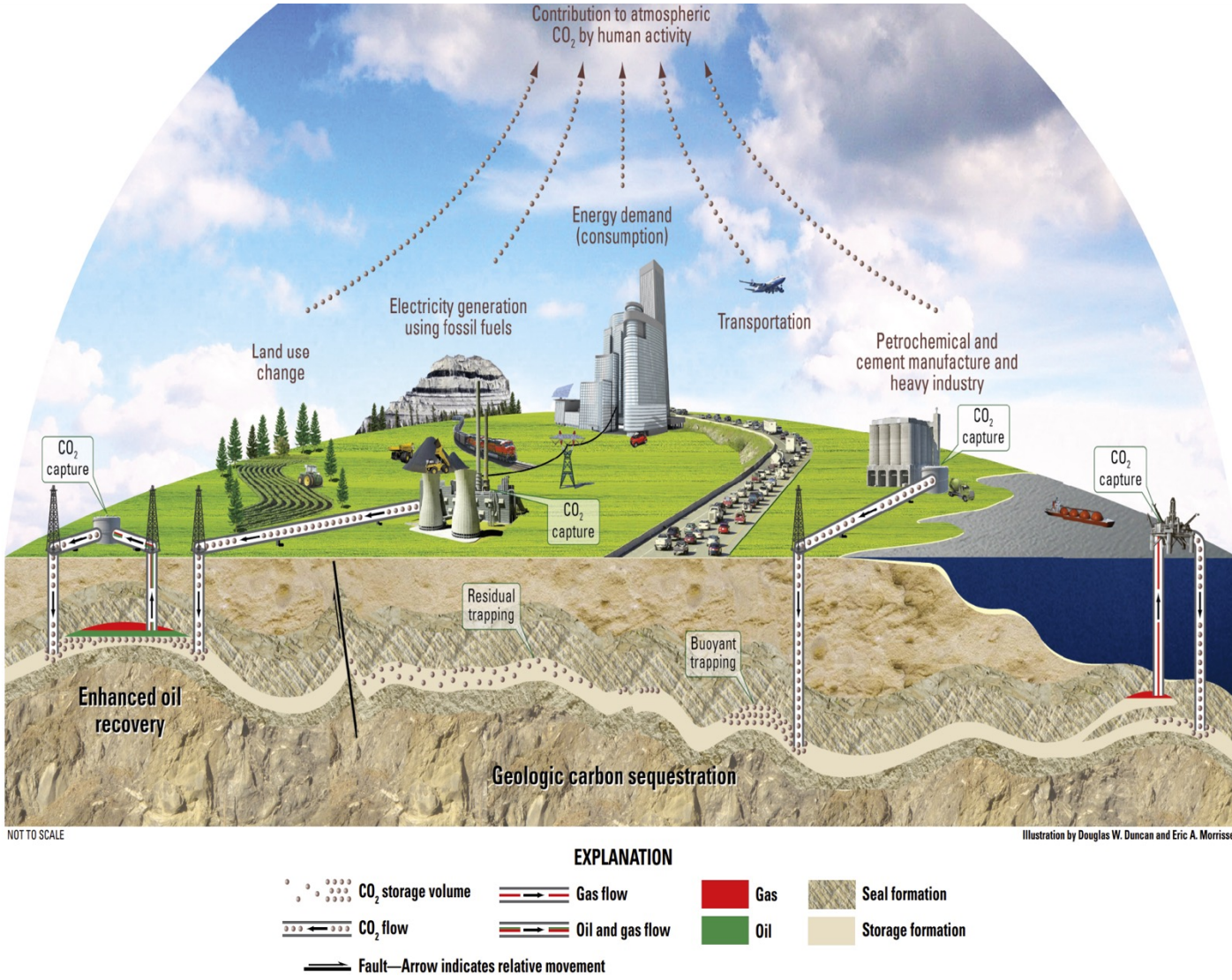
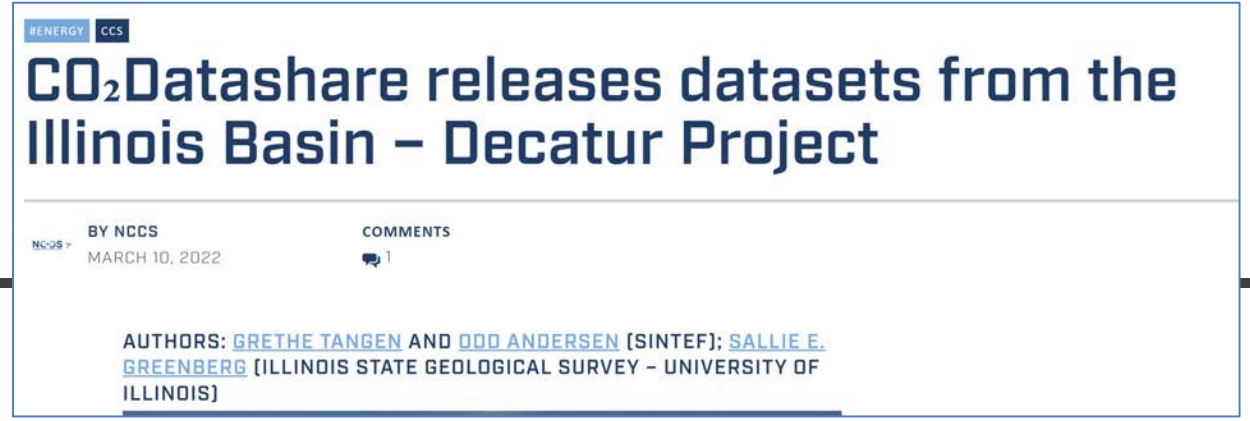
Geological Sequestration

- Geologic carbon capture sequestration (CCS) is a method of securing carbon dioxide (CO_2) in deep geologic formations to prevent its release to the atmosphere
- The Mt. Simon Sandstone in Illinois has a potential sequestration capacity of between 27 and 109 billion metric tonnes of CO_2





Source US. Geological Survey



#ENERGY CCS

CO_2Datashare releases datasets from the Illinois Basin – Decatur Project

BY NCCS
MARCH 10, 2022

COMMENTS
1

AUTHORS: GRETHE TANGEN AND ODD ANDERSEN (SINTEF); SALLIE E. GREENBERG (ILLINOIS STATE GEOLOGICAL SURVEY – UNIVERSITY OF ILLINOIS)

- "Illinois Basin – Decatur Project (IBDP) successfully demonstrated the safe geologic storage of carbon dioxide (CO2) at the near commercial-scale.
- The datasets that have been released contain information from the IBDP workflow, from pre-injection site characterization (2007-2011), to injection and monitoring (2011-2014), and post-injection (2014-2021).
- The infrastructure installed for the IBDP includes three deep wells; 17 shallow groundwater monitoring wells, microseismical monitoring with down-hole, four-component sensors in the injection well, an in-well geophysical monitoring array for repeat plume monitoring using vertical seismic profile (VSP) methods, a compression/dehydration facility, and a 1.9 km pipeline."

Monitoring: Satellite Data Use

Project Title: **MONITORING OF GREENHOUSE GAS EMISSIONS FROM SUBSURFACE SOURCES USING REMOTE SENSING**

ICCI Project Number:	08-1/US/7
Principal Investigator:	Kenneth Copenhaver, University of Illinois Energy Resources Center (ERC)
Other Investigators:	Shilpa Venkataraman, Dr. Steffen Mueller, Robert Ealy, ERC
Project Manager:	Debalina Dasgupta, ICCI

- Funded by Illinois Clean Coal Institute ICCI
- UIC conducted study to use satellite imagery for monitoring of CO_2 leakage at sites
- Leaked CO_2 from underground storage will likely produce change in crop signature which can be detected via satellite given the relatively homogenous corn/soy landscape in Illinois
- Project used University of Illinois Research Agricultural Plots (SoyFACE) to calibrate satellite images
- SoyFACE (Soybean Free Air Concentration Enrichment) is an innovative facility for growing crops under production field conditions in an atmosphere that has higher levels of carbon dioxide

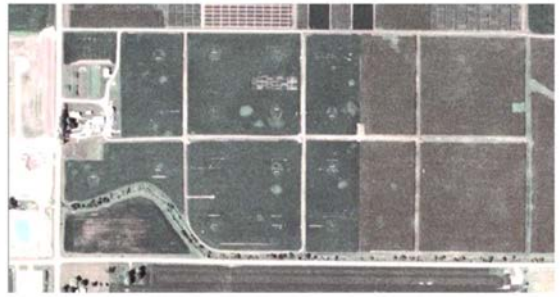
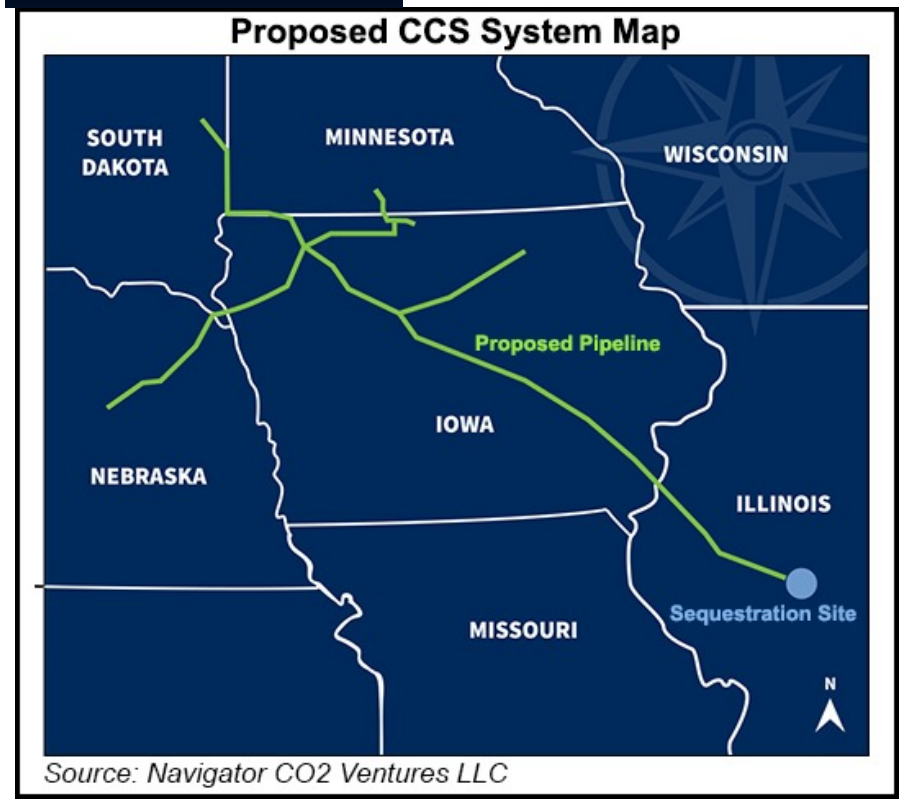


Figure 2. 2009 SoyFACE Aerial Photograph and Layout of Plot Site

Pipeline Projects: CCS Pooling by Multiple Plants

Navigator CO_2



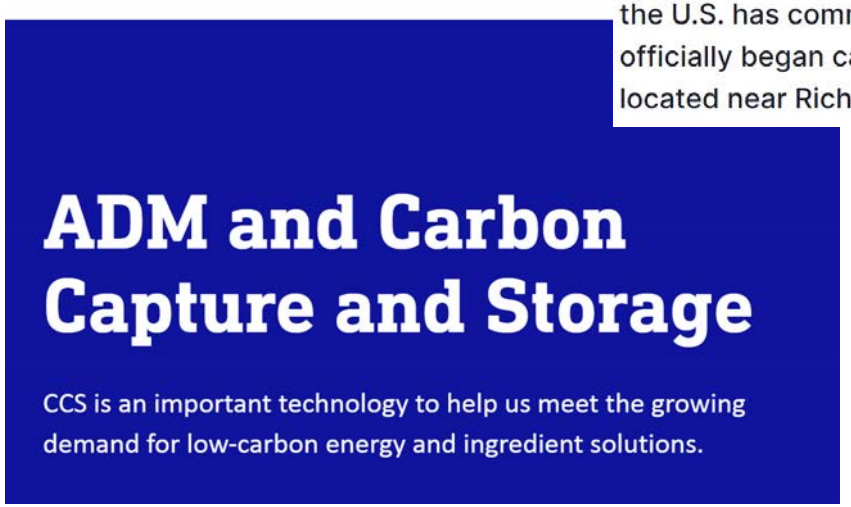
Also Includes CO_2 from a fertilizer plant

Direct Injection by Individual Plants

Red Trail Energy Begins Carbon Capture And Storage

JULY 17, 2022 BY RED TRAIL ENERGY LLC

The first carbon capture and storage project allowed under state primacy in the U.S. has commenced operations. Red Trail Energy LLC announces it officially began carbon capture and storage (CCS) at its ethanol facility located near Richardton, North Dakota, on June 16.



CCS Impact on LCA

Life Cycle Assessment of CCS

- In the United States GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation) is the key life cycle model.
- Allows both for fuel and vehicle LCA assessment. Comparison of different fuel/vehicle pathways
- Developed by Argonne National Laboratory.
  - Sustainable Aviation Fuel Modeling also included
  - Different submodels including Feedstock CI Calculator Tool for agricultural feedstocks or AFLEET for fleet management.
  - California Low Carbon Fuel Standard uses a variation of GREET called Cal GREET3/GREET4.
  - Japan performed their own life cycle analysis making use of selected GREET databases
  - Used for emissions assessments under the Inflation Reduction Act (IRA)

Carbon Capture Sequestration Treatment in GREET

- GREET electricity requirement for CCS: 130 kWh/ton CO_2
- includes compression for CO_2 transportation via pipeline
- CO_2 capture rate of 97.5%.
- electricity can be sourced from various US electricity grid aggregations (NERC regions) or renewables, or custom parameterization

Emissions for Co-Products Accounting

Corn to Ethanol
Displacement
Mass
Energy Content
Market Value
Process Purpose

Switchgrass to Ethanol
Displacement
Energy Content
Market Value

Soybeans to Biodiesel
Displacement
Mass
Energy Content
Market Value

Soybeans to Renewable Diesel
Displacement
Mass
Energy Content
Market Value
Hybrid Allocation

Biofuel pathway	Co-products	Displaced products
Corn to ethanol	DGS	Corn, soybean meal, N-Urea
Switchgrass to ethanol	Electricity	U.S. average electricity
Soybeans to biodiesel	Soybean meal Glycerin	Soybeans Petroleum glycerin

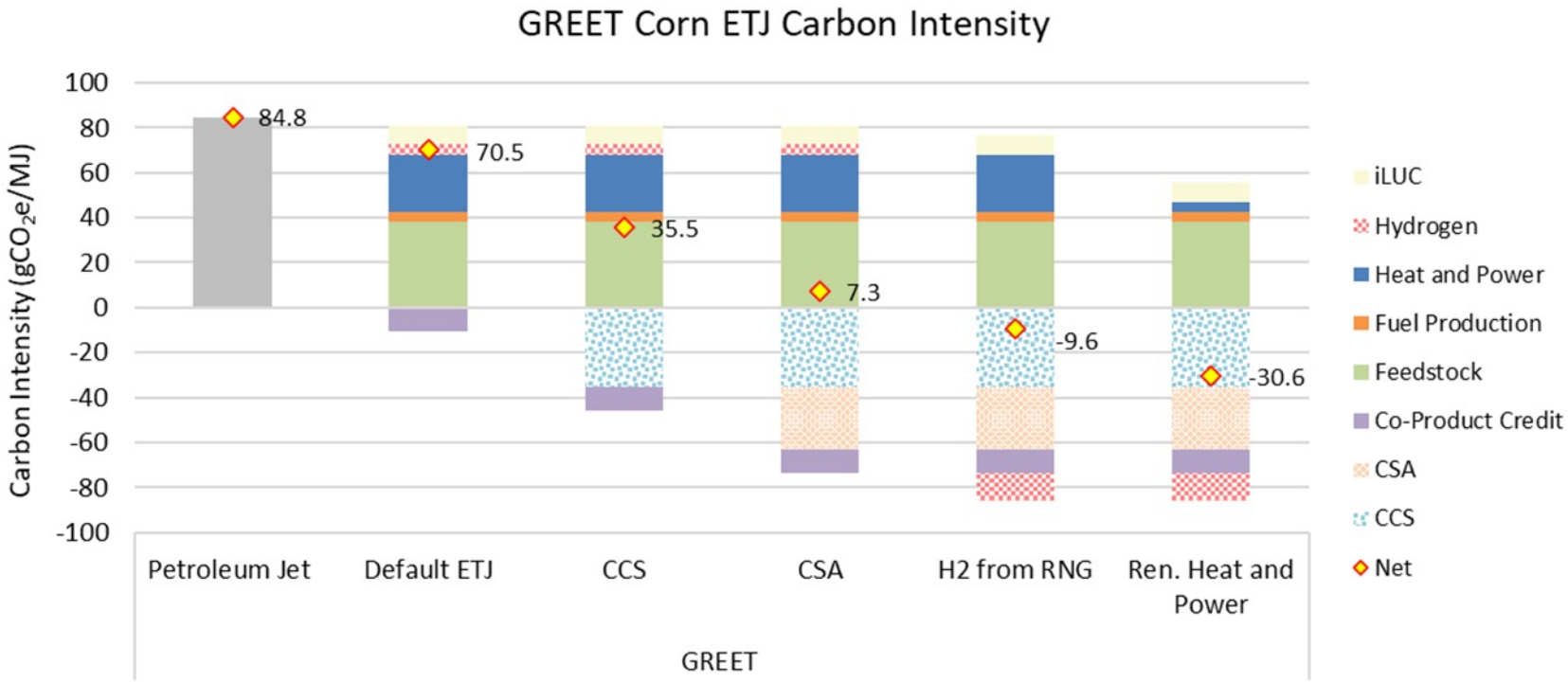
Methods of dealing with co-products of biofuels in life-cycle analysis and consequent results within the U.S. context

Michael Wang [a,*], Hong Huo [b], Salil Arora [a]

[a] Center for Transportation Research, Argonne National Laboratory, Argonne, IL 60439, USA
[b] Institute of Energy, Environment, and Economics, Tsinghua University, Beijing, 100084, China

Example GREET: Corn Ethanol to Jet

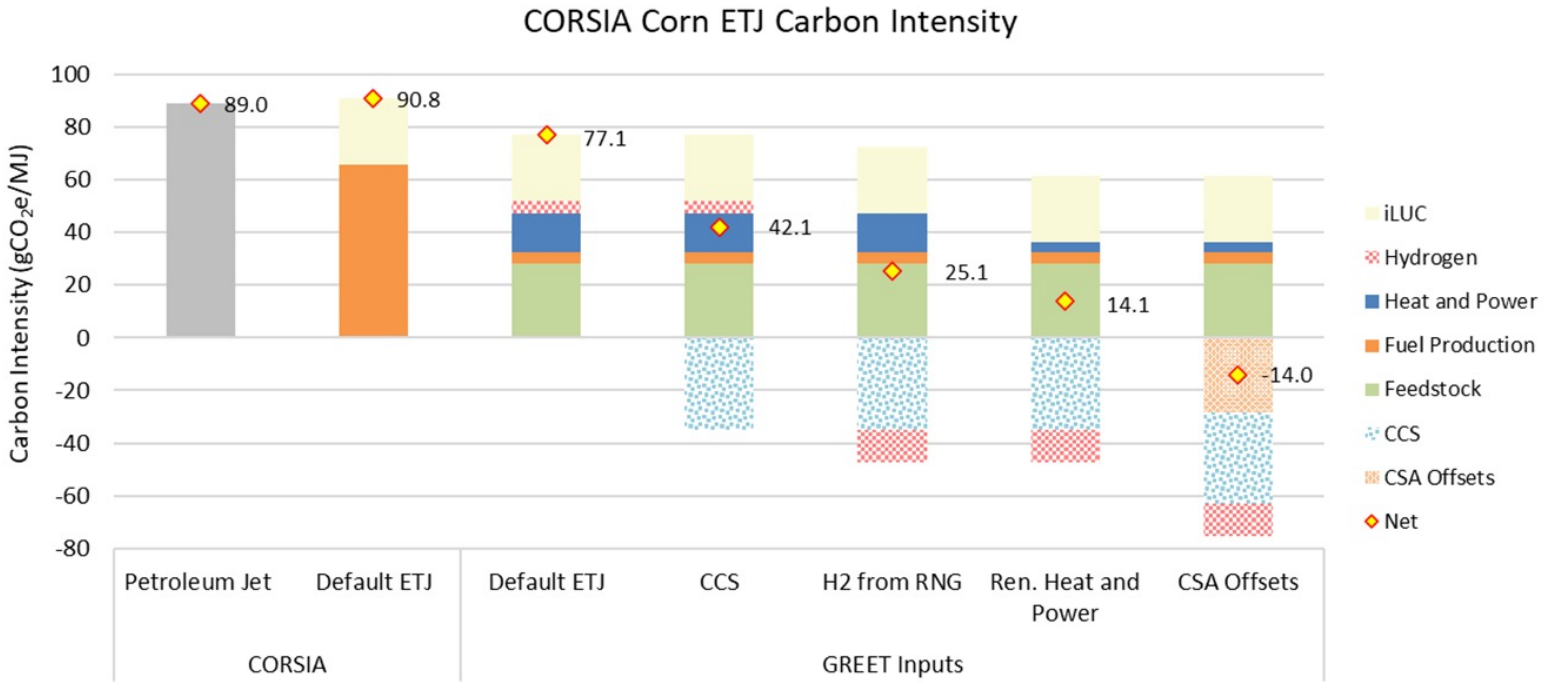
- GREET default inputs
- Displacement method for coproduct accounting
- Petroleum Aviation Fuel Baseline: 84.8 gCO2/MJ
- GREET-CCLUB iLUC (8.28 g CO_2e/MJ Jet)
- CCS from fertilizer plant provides opportunity for further reduction: saving of upstream fertilizer production emissions (up to 3-4 gCO_2/MJ)



Source:
S. Unnasch and S. Mueller; “GHG Life Cycle Analysis of Ethanol to Jet for Export Markets” Performed for the U.S. Grains Council; September 2023

Example CORSIA: Corn Ethanol to Jet

- GREET inputs with energy allocation
- Petroleum Aviation Fuel Baseline: 89 gCO2/MJ
- Default CORSIA iLUC (25.1 gCO_2e/MJ, U.S. Ethanol to Jet)
- CCS from fertilizer plant provides opportunity for further reduction: saving of upstream fertilizer production emissions (up to 3-4 gCO_2/MJ)



Main Conclusions

- CCS provides significant CI reductions for fermentation-based sustainable aviation fuels
- Commercial scale demonstrations of CCS have been successful
- For example, corn ethanol plants provide concentrated & pure source of CO_2 for sequestration.
  - They are therefore a good “first adopter” industry segment with fertilizer industry and other high GHG emitting industry to follow
- Comprehensive monitoring can be and needs to be implemented

Announcement

sustainability

an Open Access Journal by MDPI

IMPACT FACTOR 3.9

CITESCORE 5.8

Biofuel-Induced Land Use Changes: Theory, Modeling Practices, Historical Observations, and Sustainability

Guest Editors:

Prof. Dr. Farzad Taheripour
Department of Agricultural Economics, Purdue University, 403 Mitch Daniels Blvd., West Lafayette, IN 47907, USA

Dr. Steffen Mueller
Energy Resources Center, University of Illinois at Chicago, 1309 South Halsted Street, Chicago, IL 60607, USA

Message from the Guest Editors

Over the past 15 years, many papers have studied the economic and environmental impacts of biofuel production and policy. In this area of research, a large number of papers have studied the extent to which biofuel production and policy may Induce Land Use Changes (ILUC) around the world. While from a theoretical point of view, several papers have shown that various market-mediated responses and biophysical conditions are the main factors that affect land use emissions due to biofuels, the numerical assessments of these effects vary significantly across the literature.

mdpi.com/si/183985

This Special Issue aims at developing testing and verification methods of these estimates. Validating technological progress in agricultural activities and changes in crop yields, observing land use changes and associated carbon implications in countries that produce biofuels and elsewhere, studying changes in crop prices and their drivers over time, examining changes in trade pattern of crops and food products, and assessing changes in the consumption of food products around the world are important verification approaches. These approaches could also capture sustainability of biofuel production.

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Additional Slides

Annual Monitoring of CCS: ADM Example

Part 98 Mandatory Greenhouse Gas Reporting
Subpart RR – Geologic Sequestration of Carbon Dioxide

Annual Monitoring Report

Reporting Period: January 1 – December 31, 2021

Archer Daniels Midland Company (ADM)
Decatur Corn Processing Plant
4666 Faries Parkway
Decatur, Illinois 62526

March 25, 2022

ADM is operating under a Monitoring, Reporting, and Verification (MRV) Plan CCS2 for carbon capture and sequestration at its ADM Decatur location. The plan lists several monitoring efforts with associated monitoring equipment and its period of operation. It also lists tests and/or surveys that must be conducted in the previous calendar year. The monitoring and testing efforts conducted over the previous calendar year include:

- **Continuous monitoring of injection pressure, annulus pressure, and temperature monitoring at the injection well;**
- **Groundwater quality monitoring in the local drinking water strata, the lowermost underground source of drinking water (USDW), and the strata immediately above the Eau Claire confining zone;**
- **External mechanical integrity testing (MIT) and, when required, pressure fall-off testing at the injection well;**
- **Plume and pressure front monitoring in the Mt. Simon using direct and indirect methods (i.e., brine geochemical monitoring, pulse neutron / RST logs, VSP and 3D seismic surveys).**

https://www.epa.gov/system/files/documents/2022-09/2021_archer_daniels_midland_decatur_mrv_report.pdf