

Smart CO₂ Transport-Route Planning Tool



Providing Data and Insights for Accelerating Carbon Transport & Storage Deployment

2024 FECM/NETL Carbon Management Research Project Review Meeting

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The image illustrates the workflow of the Smart CO₂ Transport-Route Planning Tool. On the left, three stacked maps represent different data layers. An arrow points to a large map of the United States with a color-coded overlay. A second arrow points to a screenshot of the software interface. The interface features the following elements:

- Logos for NETL, U.S. DEPARTMENT OF ENERGY, and discover.
- Title: Smart CO₂ Transport-Routing Tool
- Map of the United States with a location pin in the central region.
- Navigation controls: +, -, and a location pin icon.
- Legend: Identify Route, Evaluate Corridor; Start, End.
- Input field: Add Start Location in World Geodetic System WGS 1984(WGS 84)
- Form fields: Latitude: [], Longitude: [], and a Save Start button.
- Form field: Select known CCS project as start location.
- Logos for BIL and EDX 4CCS Energy Data eXchange.



Disclaimer



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Meeting CTS Challenges with Smart and Spatial Solutions

Need & Overview

Challenge: CTS pipeline models *fail to integrate complex social, economic, and environmental variables* that can greatly affect the success of developing new pipelines and increase project costs.



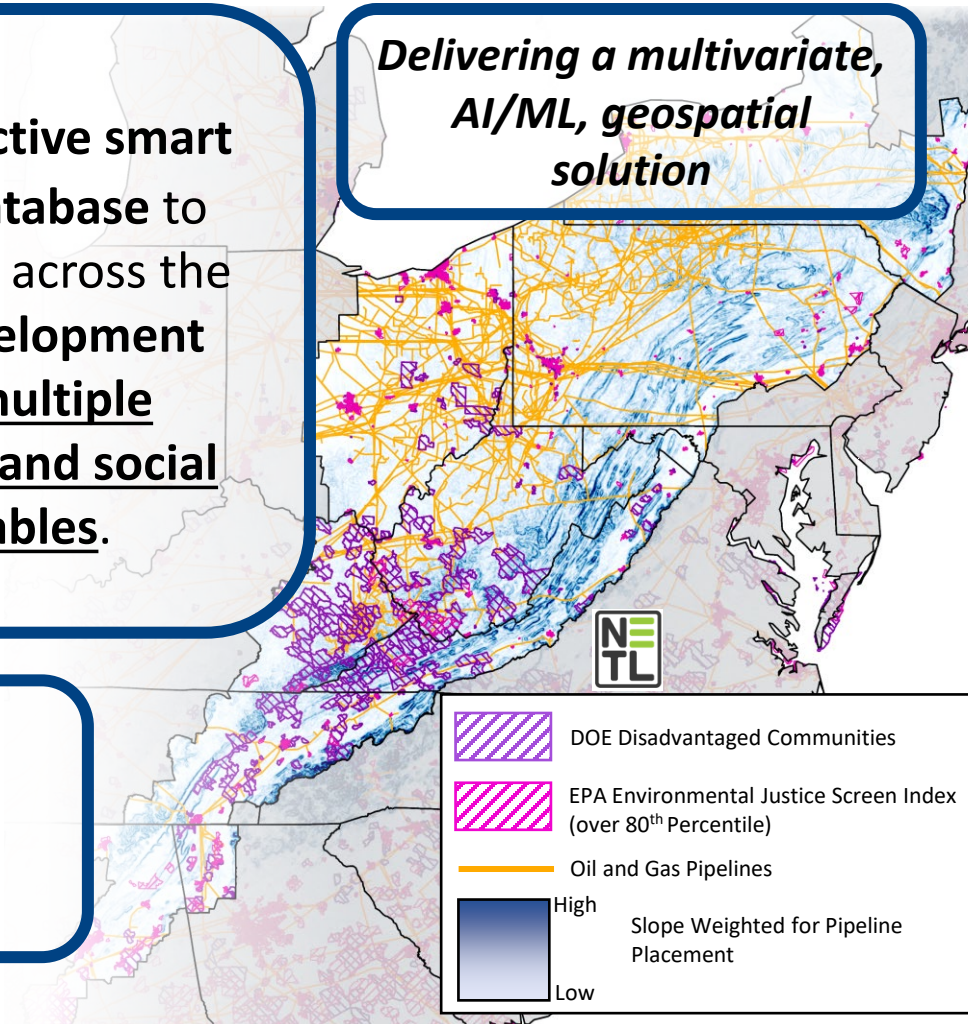
Need for evaluation of existing transport corridors for reuse

Solution: An interactive smart tool and geospatial database to assist in route planning across the U.S. to accelerate development while considering multiple environmental justice and social justice (EJSJ) variables.

Stakeholders

Industry
Regulators
Researchers

Delivering a multivariate, AI/ML, geospatial solution

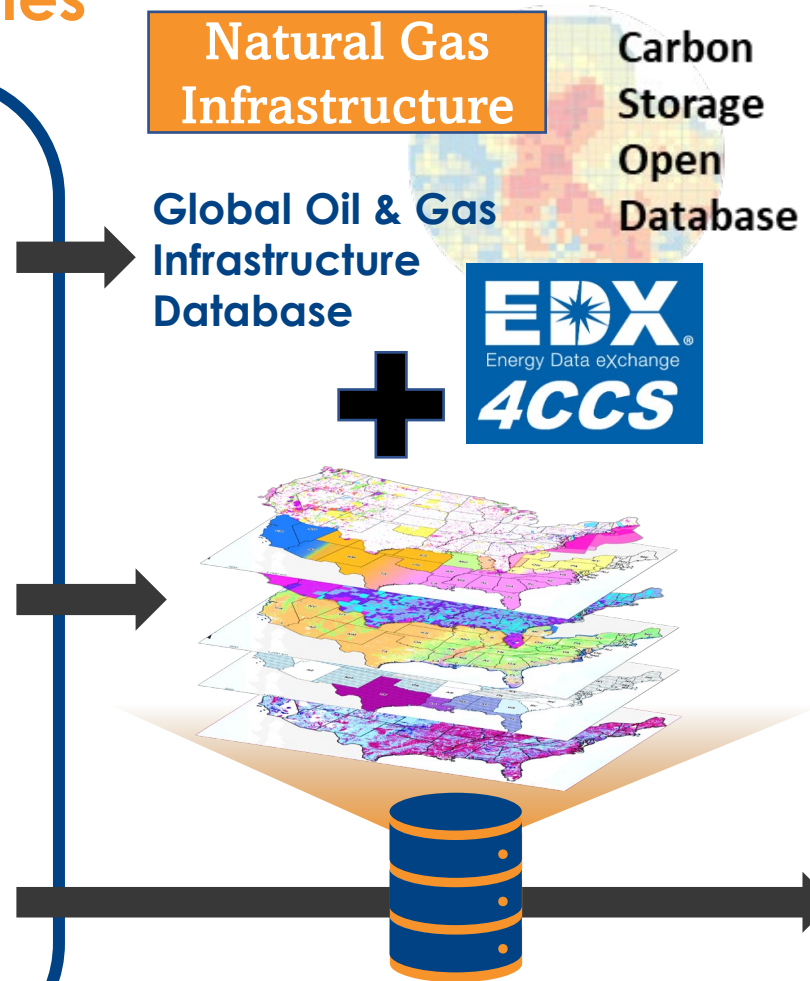


Delivering Transformative Resources

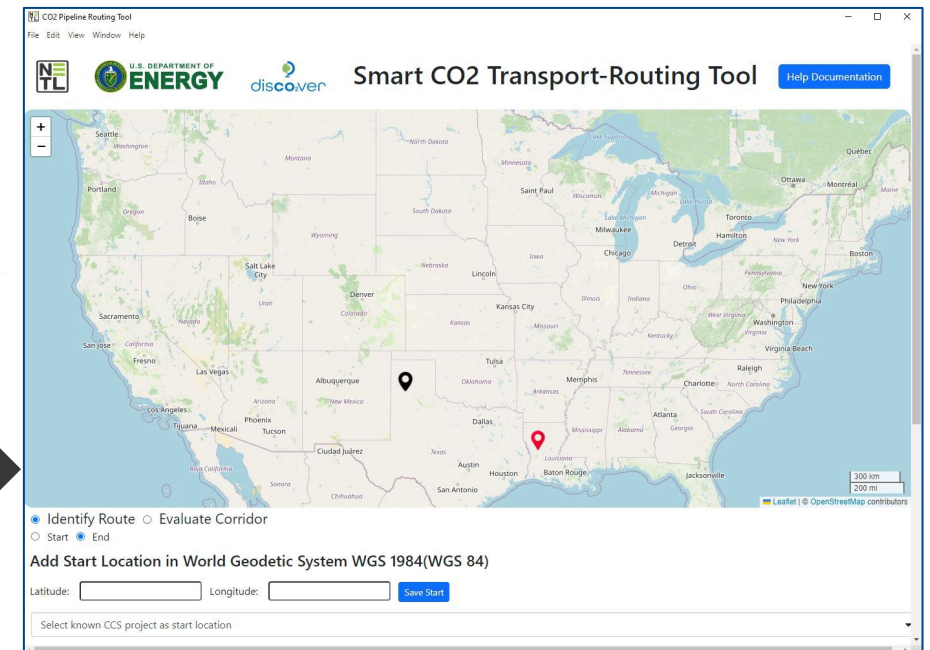
Objectives & Outcomes

Objectives:

1. Build-off existing resources to provide a national comprehensive spatial database
2. Integrate data and critical qualitative governance to support safe transport planning
3. Enable stakeholders to identify potential routes AND evaluate existing corridors

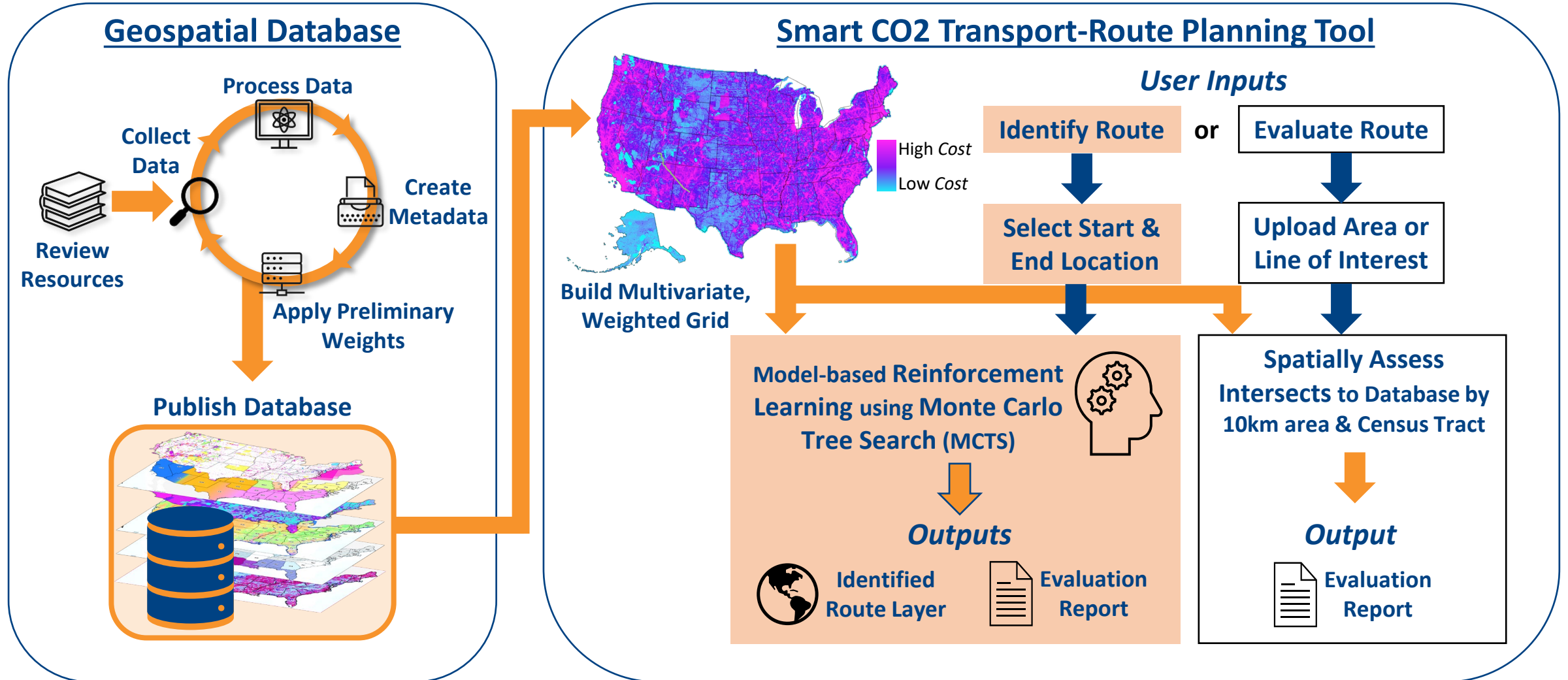


Advancing DOE Program Goals by developing of *scientific, smart, and geospatial technologies* to accelerate the **economically, socially, and environmentally prudent planning** and development of *carbon transport*



Multivariate, AI/ML, & Geospatial Method

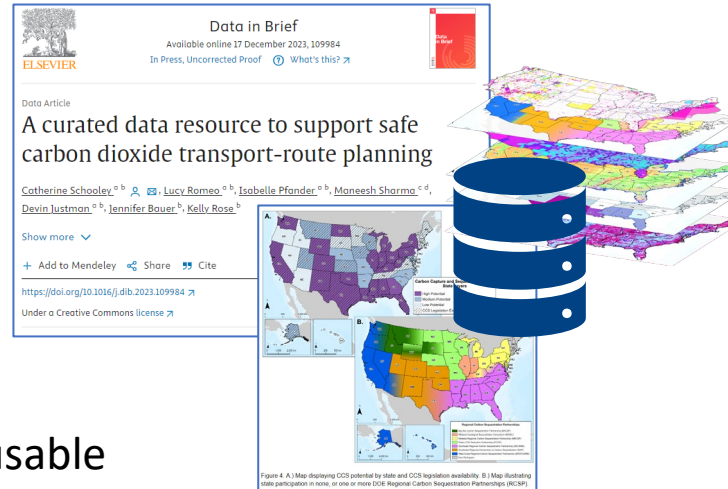
Technical Approach to Inform CTS Planning & Development



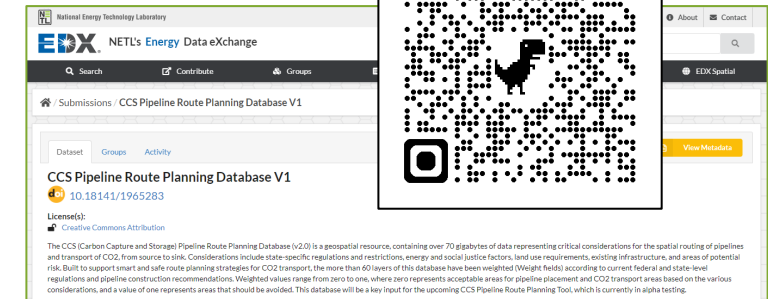
Published and Utilized Data Resource

Database Accomplishments (March 2022 to present)

- Paper published (*Schooley et al. 2024*)
- **550+** downloads
- Geospatial database (v. 2), March 2024
 - **60+** weighted layers
 - **Metadata** and **weight definitions**
 - **F**indable, **A**ccessible, **I**nteroperable, **R**eusable



Available on
EDX



*Led to an increase of
collaboration & coordination
with stakeholders and
researchers*

Category	Layer Examples
CCS by State	Restrictions & regulations
Boundaries	Protected areas, urban areas, land cover, buildings
Infrastructure	Pipelines, wells, roads
EJSJ	Social Vulnerability Index, Environmental Justice Screen
Natural Hazards	Floodplains, earthquake, wildfire, slope, landslides
Hydrology	Lakes, rivers, aquifers, groundwater



Smart CO₂ Transport-Route Planning Tool



Tool Accomplishments (March 2022 to present)

- Open-source & stand-alone
- *Identifies Routes* using Monte Carlo Tree Search
 - Model-based Reinforcement Learning (RL)
 - Heuristic algorithm finding 'near optimal' solutions
 - Relatively simple → explainable
- Updated user-interface



The screenshot shows the 'Smart CO2 Transport-Route Planning Tool' interface. At the top, it features logos for NREL, U.S. DEPARTMENT OF ENERGY, and discover. The main area is a map of the United States with a highlighted route from the West Coast to the East Coast. On the right side, there are several data panels:

- General Route Information:** Route Area: 45,772,463.8 km²
- Countries by State:** A table listing states and their corresponding countries.
- Spatially Intersecting Features by Category:** A list of features intersecting the route, such as 'Developed Lands Coverage' and 'Historic Sites by Source'.

At the bottom of the interface, there are two buttons: 'Identify Route' (selected) and 'Evaluate Corridor'. Below these buttons, there are input fields for 'Start' and 'End' locations, and a 'Save Start' button. A text box below the input fields says 'Add Start Location in World Geodetic System WGS 1984(WGS 84)'. At the bottom right, there is a 'discover' logo and the text 'Data Infrastructure to Accelerate CCS'.

- Added *Evaluate Route* option
 - Reporting functionality
- Revised help documentation

The screenshot shows the 'CO2Pipeline' help documentation page. It is divided into several sections:

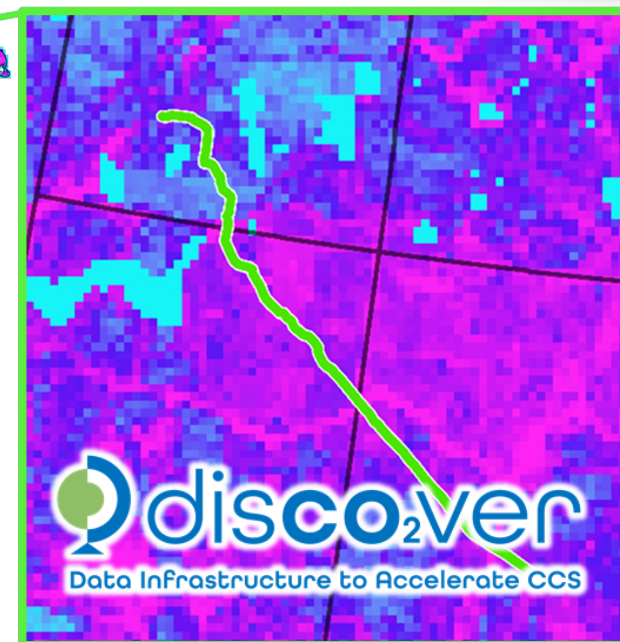
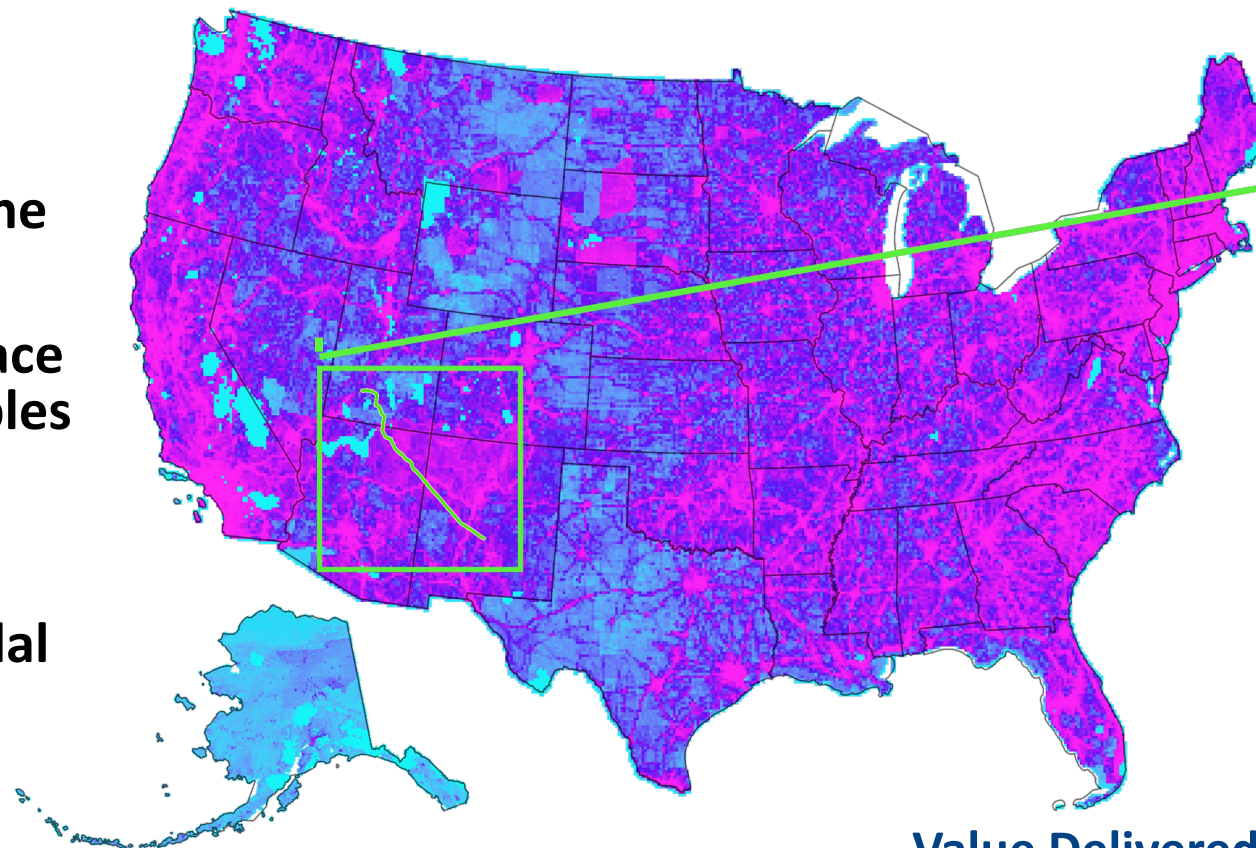
- Operation:** The CO2 Pipeline-Routing Tool has two primary modes: Identification and Evaluation. Identification mode allows the user to select two points, generate a proposed pipeline route, and download a shapefile of the route and relevant PDF report on route details. Evaluation mode allows the user to upload a shapefile of an existing route, and generate a PDF report on route details.
- Identification Mode:** To start evaluation mode, click on the 'Identify Route' radio button below the map. This enables all Identification Mode buttons and fields that are otherwise greyed-out.
- Start and End Points:** There are two ways to enter the start and end points of the desired pipeline route. Selecting 'Start' or 'End' radio button, and then click on the map to place a marker representing the chosen type of point. Selecting 'Start' and clicking on the map will create a black marker to represent the point. Selecting 'End' and clicking on the map will create a red marker to represent the end of the pipeline route.
- Tip:** You do not need to click the 'Save Start' button, as those are only for entering points manually via coordinates.
- Entering Coordinates:**

Increasing Useability & Usefulness

Communication & Collaboration is Key

Next Steps

- International Pipeline Conference
- Enable direct interface with mapped variables
- Support dynamic weighting
- Integrate multi-modal functionality
- Decrease run times
- Publication
- **Version 2**,
Spring 2025



Value Delivered

Interactive, stand-alone, geospatial tool designed to accelerate safe route planning for CO₂ transport that accounts for state and Federal regulations, best practices, EJSJ considerations, and is complementary to related capabilities

DOE CO₂ Transport Technologies



Scope – Filling a Technology Niche & Supporting Model Validation

	Stakeholders	Supports	Tool is...				Analytics apply...					Variables include...						Baseline Data Published	Outputs Include
			Open-Source	Stand-alone	Spatial	Temporal	AI/ML	Multi-scale	Multi-modal	Multi-stops	Phase-based	Environmental	Energy infrastructure	Public infrastructure	Economic	EJSJ	Risk Likelihood		
FECM/NETL CO₂ Transport Cost Model (CO2_T_COM)	Researchers (i.e., government, academic, non-profit), industry	Estimating the cost of new CO ₂ pipelines	X	X	X	X	-	X	-	-	-	-	X	X	X	-	/	-	Pipeline diameter, number of pumps, cash flows, NPV, break-even CO ₂ price
SimCCS (LANL)	Industry, researchers (i.e., government, academic, non-profit)	Transport network modeling and cost analysis	X	-	X	X	-	X	X	X	X	X	X	X	X	X	-	-	Optimal network; costs for capture, transport, and storage
Smart CO₂ Transport-Route Planning Tool & Database (NETL)	Regulators, industry, researchers (i.e., government, academic, non-profit)	Inform planning, development, and repurposing; risk assessments	X	X	X	-	X	X	/	-	-	X	X	X	X	X	X	X	Optimal network as spatial layer; report of route evaluation against variables

X Currently supports

/ In progress

- Not in planned scope

the stats

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RIC PRESENTATIONS

22

POSTERS

30

TOOL DEMOS

MONDAY

Presentations
(10:30AM - 5:25PM)

- 16 disCO₂ver presentations

TUESDAY

Presentations
(10:30AM - 5:45PM)

- 17 SMART presentations
- 2 disCO₂ver presentations
- 2 Geographic focus/tool presentations

Posters

(5:45PM - 7:45PM)

- 18 CTS Posters
- 2 PSCC Posters
- 1 CDR Poster
- 1 MLEF Poster

Tool Demos

(5:45PM - 7:45PM)

- 30 Tool Demos
 - SMART
 - NRAP
 - EDX
 - EDX4CCS

WEDNESDAY

Presentations
(2:10PM - 4:30PM)

- 3 transport, research, development, and demonstration activities presentations
- 1 transport modeling presentation
- 1 secure storage (basalts/mafic) presentation

THURSDAY

Presentations
(10:30AM - 5:20PM)

- 8 NRAP presentations
- 2 NETL RIC Presentations
- 2 Offshore presentations



<https://edx.netl.doe.gov/disco2ver>

NETL Carbon Storage Outreach Example

2024 FECM/NETL Carbon Management Research Project Review Meeting

100+ DOE-sponsored CTS presentations

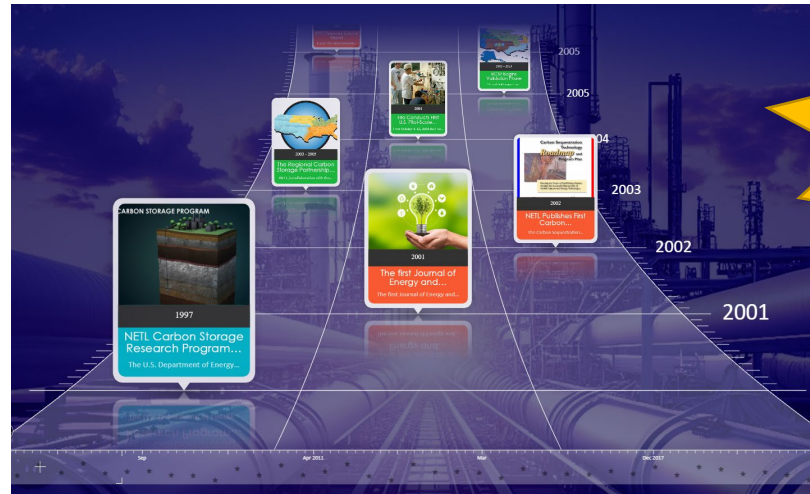
Presentations on EY23 CTS work:

- Advanced Storage FWP
- Carbon Storage Data FWP
- Carbon Storage Analysis FWP
- Multi-Modal Transportation FWP
- EDX4CCS
- NRAP
- SMART

Open to the public

Attendees from government agencies, utilities, research, universities, industry

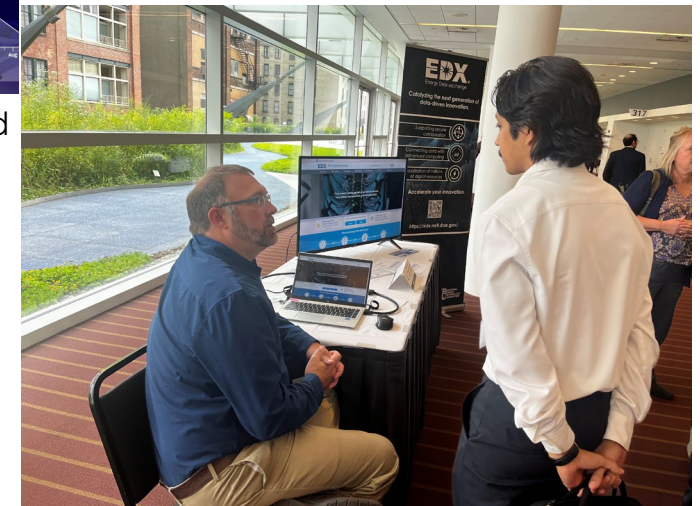
Poster and tool/app demo session – Tuesday Aug. 6th evening



Carbon Storage Timeline summarizing field, lab and computational contributions to CTS' digital future
Live, interactive demo at the booth!

Source: NETL

Stop by the CTS booth in the exhibit hall to learn more!
Take-aways, information, expertise in one stop shop



Multiple tool demos will be hosted
Source: NETL

Acknowledgments



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NETL RESOURCES

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*Thank
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