Los Alamos NATIONAL LABORATORY

SimCCS: Development and Applications

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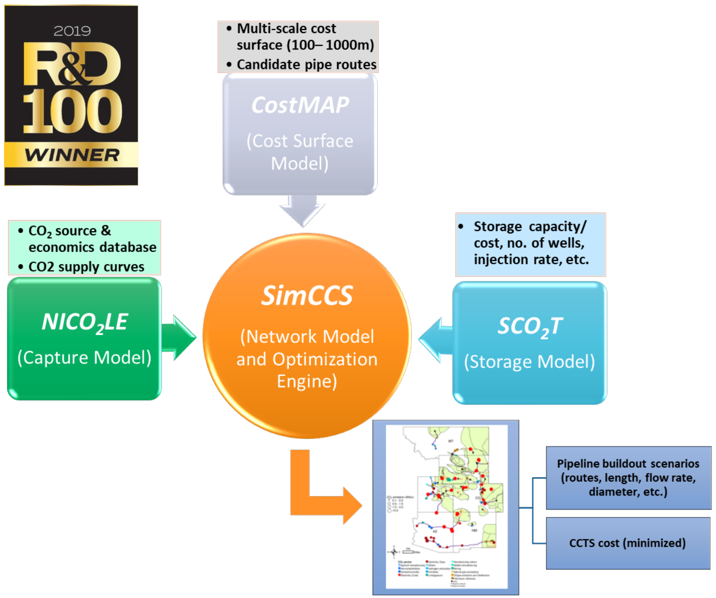
LA-UR-24-27873

SimCCS: Determines Costs and Optimized Transport Routing by Integrating Factors Across the CCS Value Chain

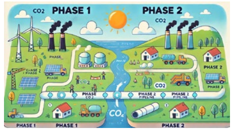


Publicly available @ https://simccs.lanl.gov/

- ***NICO$_2$LE***
  - Understand commercial-scale capture opportunities
  - Geodatabase: Source locations, CO_2 streams, & capture costs
- ***SCO$_2$T***
  - Rapidly calculate realistic injection and storage costs
- ***CostMAP***
  - Identify likely corridors
  - Develop candidate pipeline routes for *SimCCS* optimization engine
- ***SimCCS***
  - Determine optimal regional/national network of CO_2 sources, CO_2 sinks, and CO_2 transport pipeline that meet desired CCS goals

Address Emerging CCUS Infrastructure Deployment Challenges

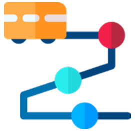
National-, regional-, and commercial-scale deployment



Phased modeling to account for dynamic nature of CO_2 sources

Potential utilization of existing CO_2 pipelines and ROWs

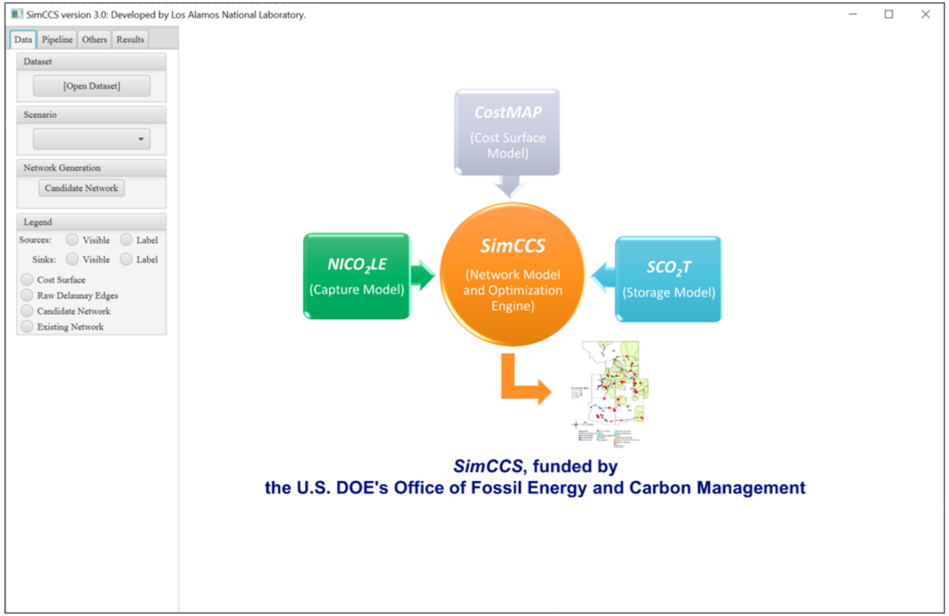
Onshore and offshore transport and storage



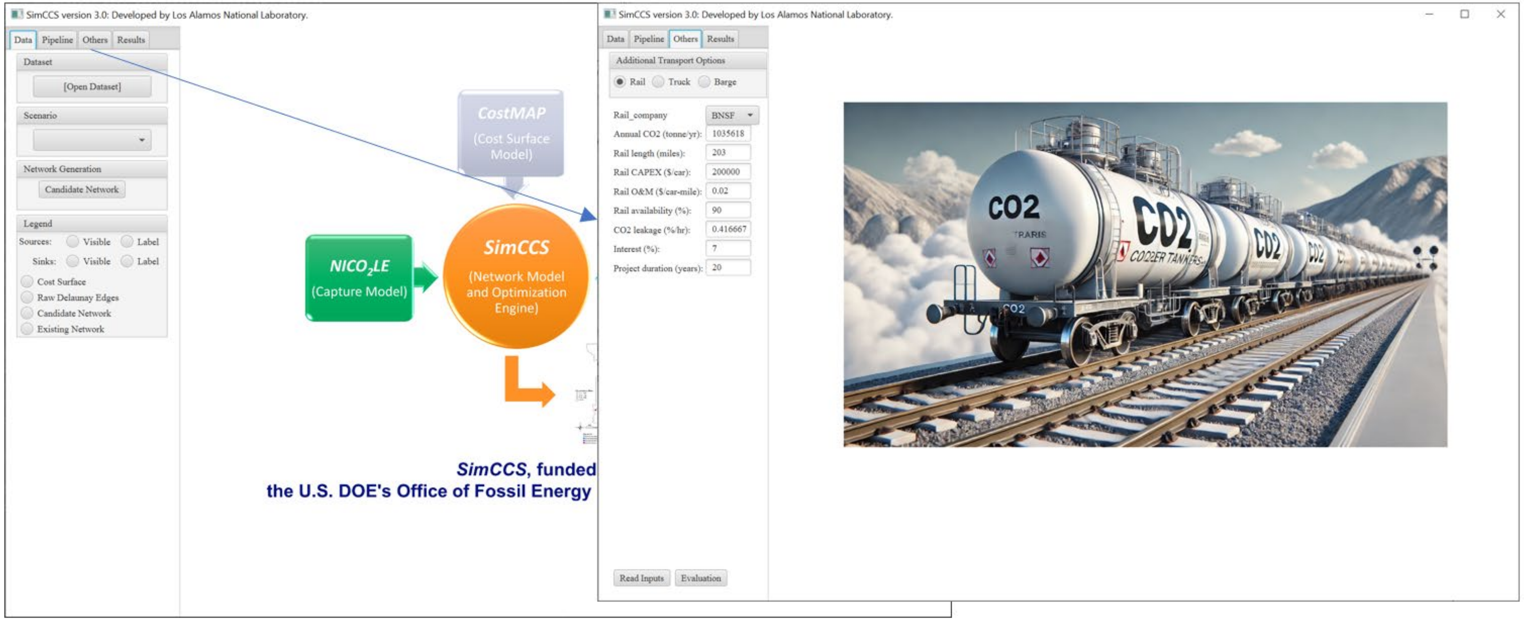
Multi-modal transport modeling: pipelines, trucks, and rails

Disadvantaged communities and environmentally sensitive areas

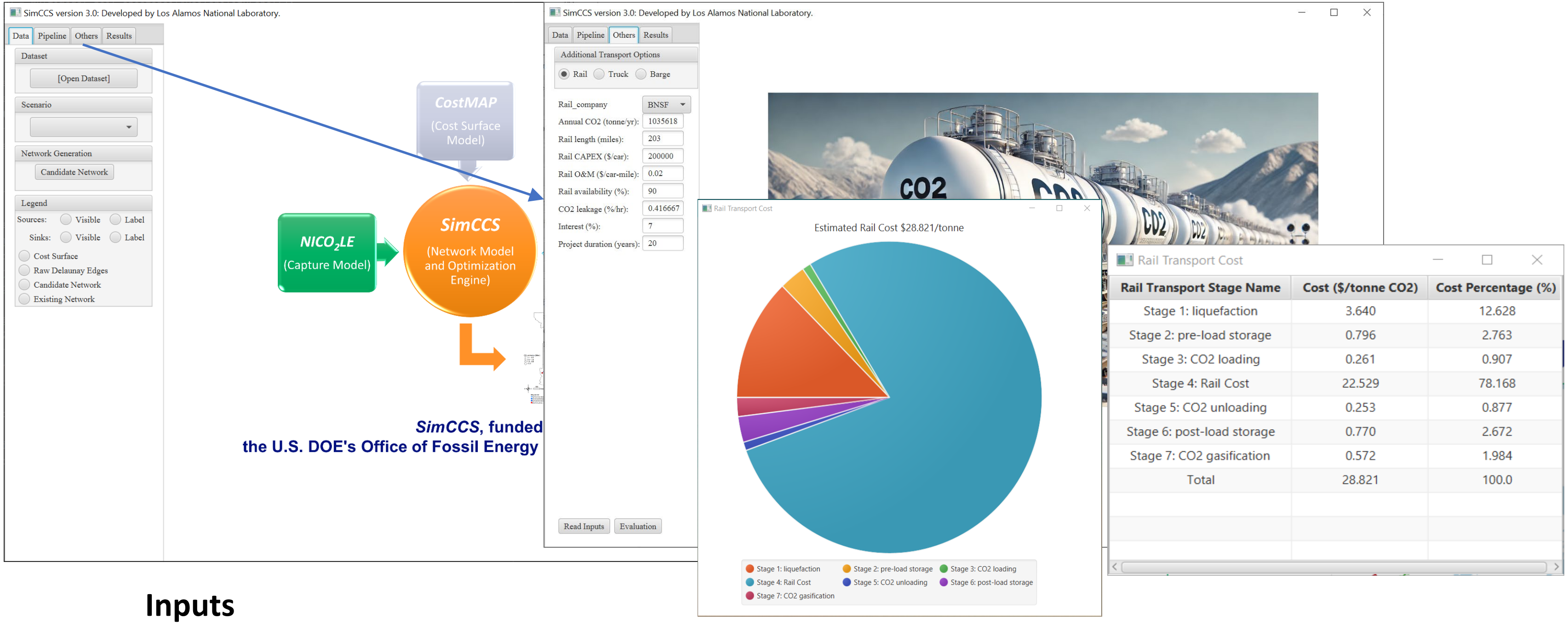
User Interface, Inputs & Outputs



User Interface, Inputs & Outputs



User Interface, Inputs & Outputs



Rail Transport Stage Name	Cost ($/tonne CO2)	Cost Percentage (%)
Stage 1: liquefaction	3.640	12.628
Stage 2: pre-load storage	0.796	2.763
Stage 3: CO2 loading	0.261	0.907
Stage 4: Rail Cost	22.529	78.168
Stage 5: CO2 unloading	0.253	0.877
Stage 6: post-load storage	0.770	2.672
Stage 7: CO2 gasification	0.572	1.984
Total	28.821	100.0

Inputs

- Locations of CO_2 sources and sinks, capture amounts & costs, storage resources & costs

Outputs

- Pipeline: Optimal transport network, pipeline lengths, diameters, flow rates, costs, etc.
- Rail/Truck: CAPEX, OPEX, FINEX at different stages

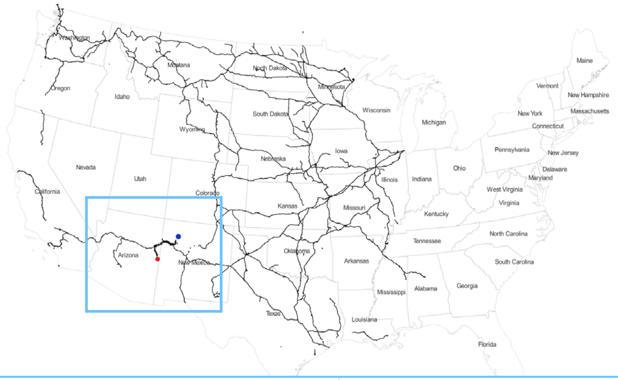
SimCCS Applications

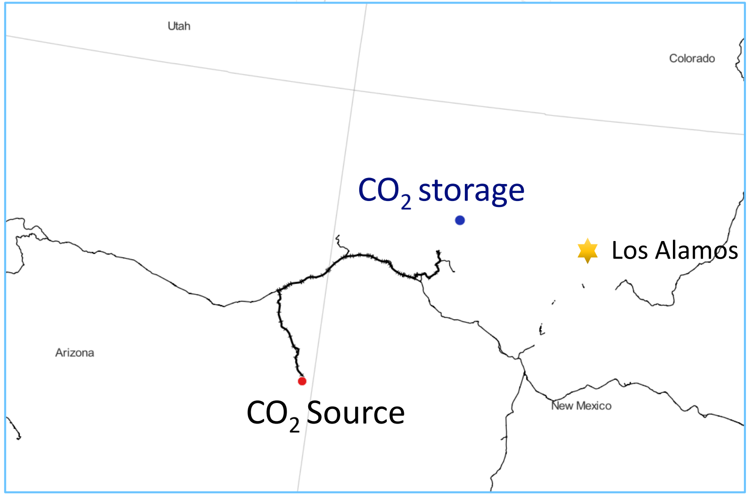
- **Support infrastructure modeling**
  - National scale CCS pipeline network modeling – DOE FECM
  - Power Plant CO_2 pipeline analysis – DOE Office of Policy & EPA
  - Regional CCUS partnership (CUSP, SECARB-USA, MRCI)
  - I-WEST Energy Transition initiative
  - CarbonSAFE initiative

- **LANL is providing technical support to industry, academia, and government stakeholders**

Example 1: Multi-modal Transport

- **CO_2 source**
  - Apache Station coal-fired power plant
  - Located in Cochise, Arizona
  - ~1.0 million tonnes per year
  - Unlikely to be retired by 2040
- **CO_2 storage**
  - San Juan Basin in New Mexico
- **Rail availability**
  - 203 miles rail owned by BNSF railway
  - The largest freight railroad in the United States
  - One of six North American Class I railroads
  - 33,400 miles of track in 28 states, and over 8,000 locomotives

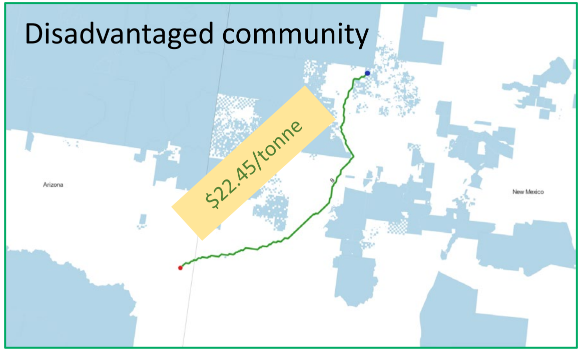




Hypothetical CO_2 Transport Designs

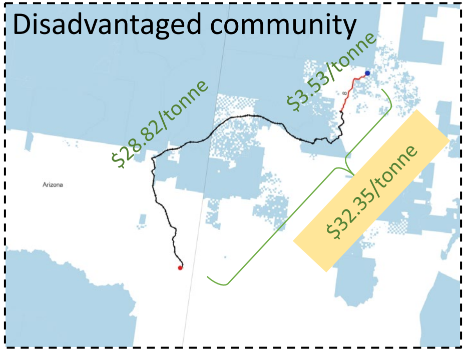
Pipeline

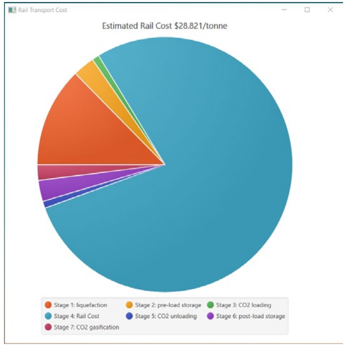
- ~176.5 miles of 8-inch pipeline needs to be constructed



Multi-modal (Rail + pipeline)

- 203 miles of BNSF rail
- ~27.8 miles of 8-inch pipeline needs to be constructed





Rail Transport Cost

Rail Transport Stage Name	Cost ($/tonne CO2)	Cost Percentage (%)
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Total	28.821	100.0

- While pipeline transport is generally more cost-effective, multi-modal transport can be advantageous in scenarios where obtaining interstate pipeline construction permits is challenging.

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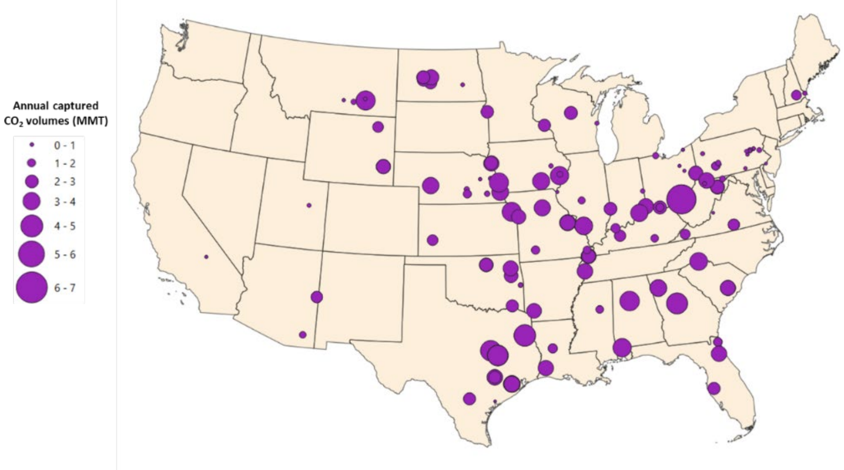
Example 2: Power Sector CO_2 Pipeline Analysis

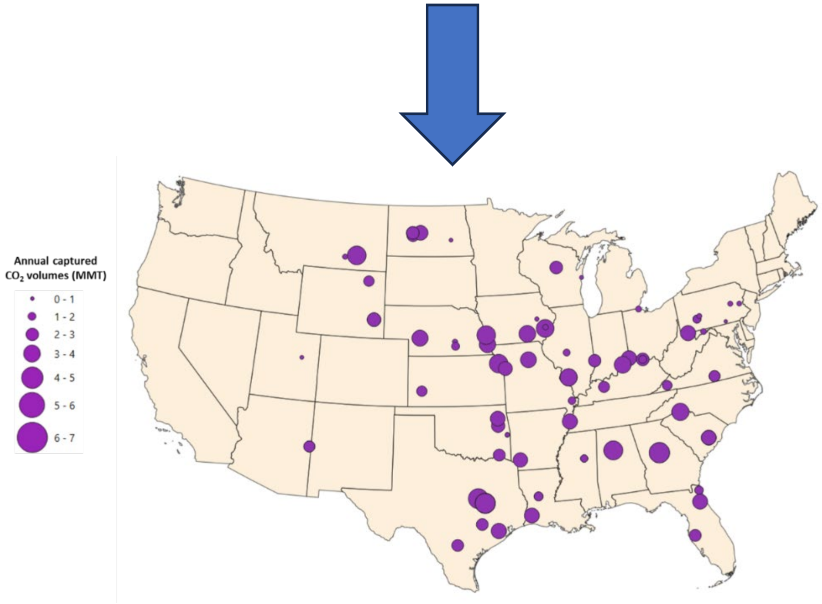
- **Background**: Policy makers need to understand the size of a CO_2 pipeline system needed to address significant portions of power sector emissions.
- **Objective**: Estimate the size and investment in the CO_2 pipeline network and storage sites necessary to meet proposed EPA power sector greenhouse gas emissions rules to inform feasibility assessment.
- **Sponsor**: DOE-Office of Policy

Coal Power Plant Fleets



Scenario 1: All Coal Units with No Retirement Dates

206 units
396 MMT/year

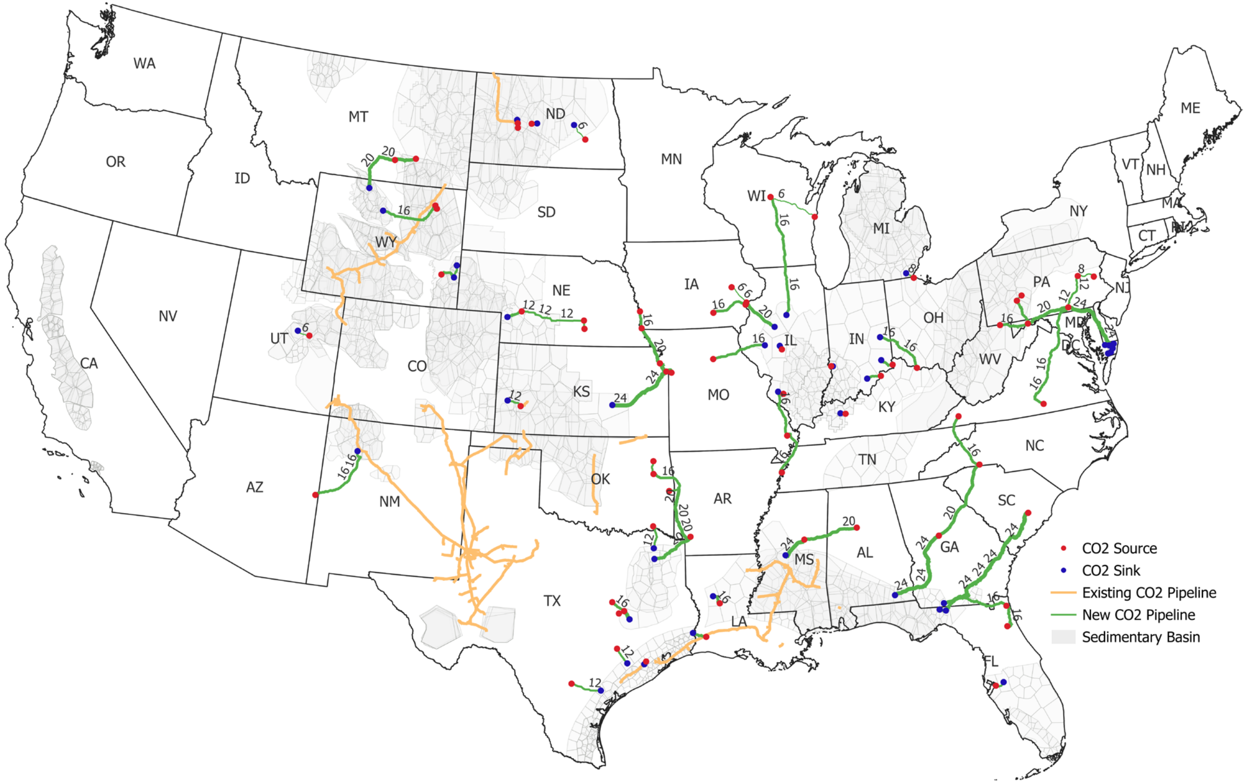


Scenario 2: Coal Units Unlikely to Retire by 2040

99 units
229 MMT/year

Chen, B., Sun, X., Ma, Z., Velasco Lozano, M., de Figueiredo, M., & Donohoo-Vallett, P. (2024). *CO_2 PIPELINE ANALYSIS FOR EXISTING COAL-FIRED POWER PLANTS* (No. LA-UR-24-23321). Los Alamos National Laboratory (LANL), Los Alamos, NM.

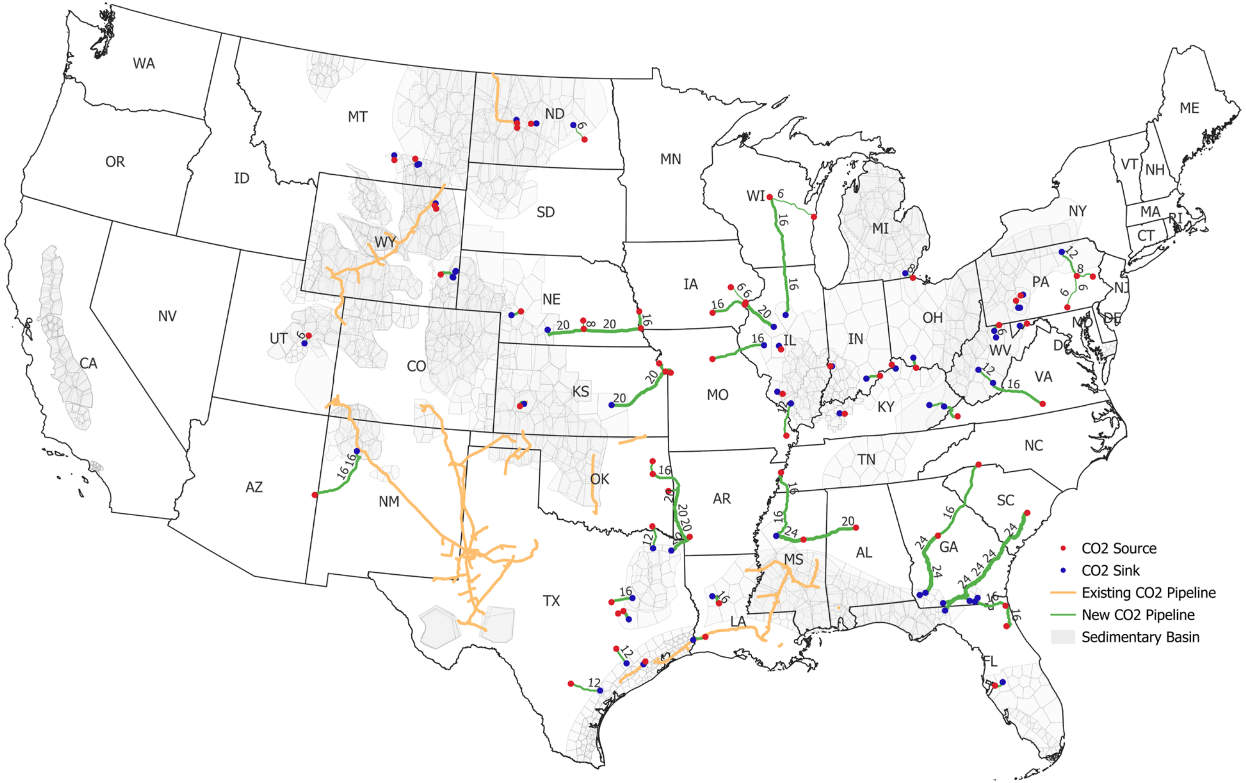
Scenario 2 – Case 1: Minimize Cost



- Existing CO_2 pipeline length in miles: 5,300

- Total new CO_2 pipeline length in miles: 5,661.3
- Total number of state crossing pipelines: 34

Scenario 2 – Case 2: Minimize Length



- Existing CO_2 pipeline length in miles: 5,300

- Total new CO_2 pipeline length in miles: 4,658.0
- Total number of state crossing pipelines: 27

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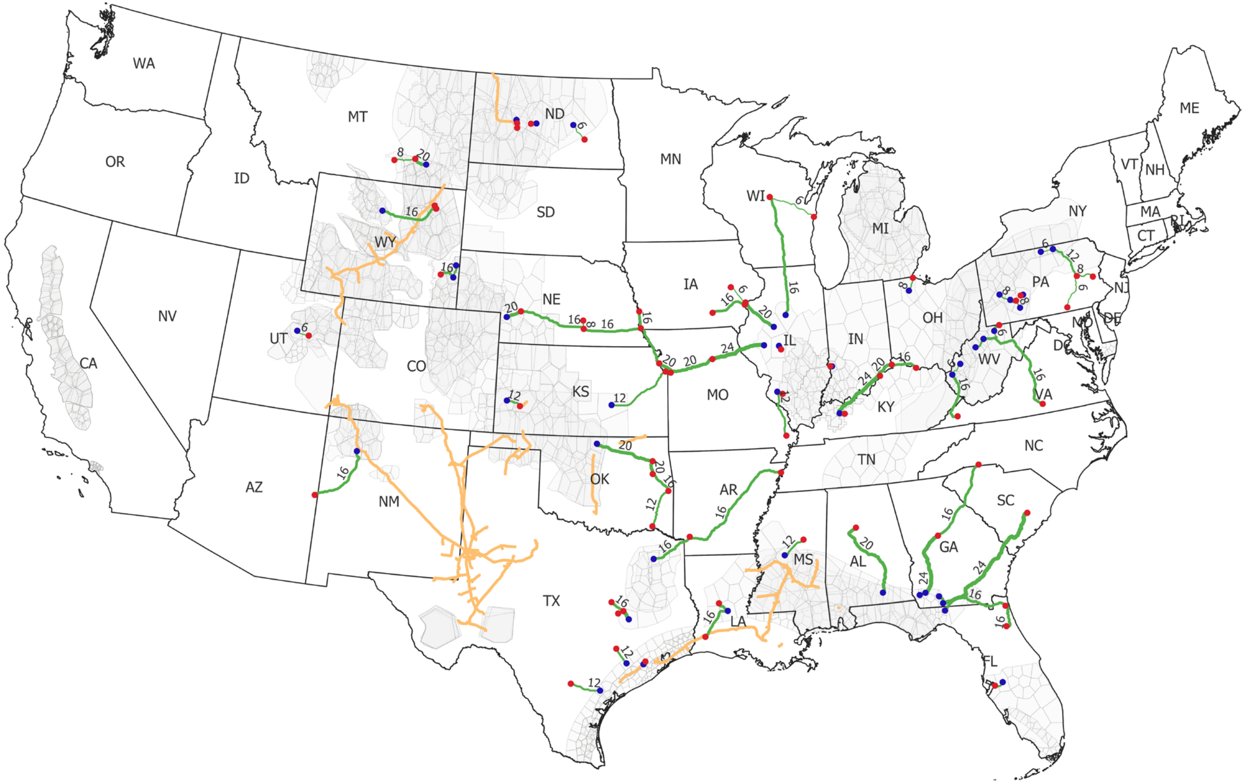
Scenario 2 – Case 3: Minimize State Crossing



- Existing CO_2 pipeline length in miles: 5,300

- Total new CO_2 pipeline length in miles: 5,990.0
- Total number of state crossing pipelines: 17

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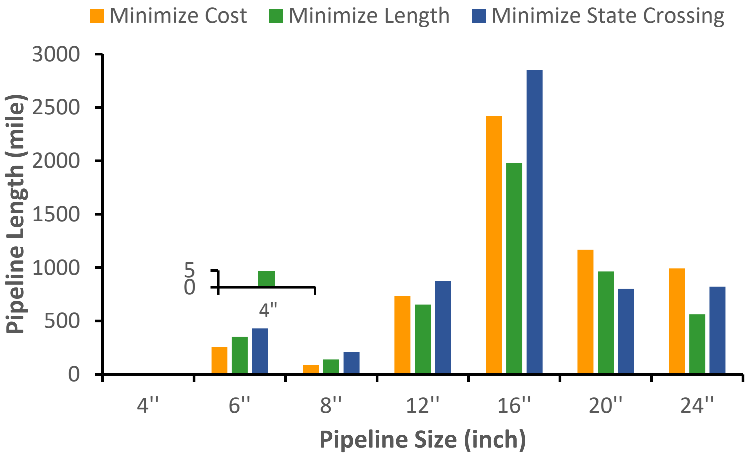
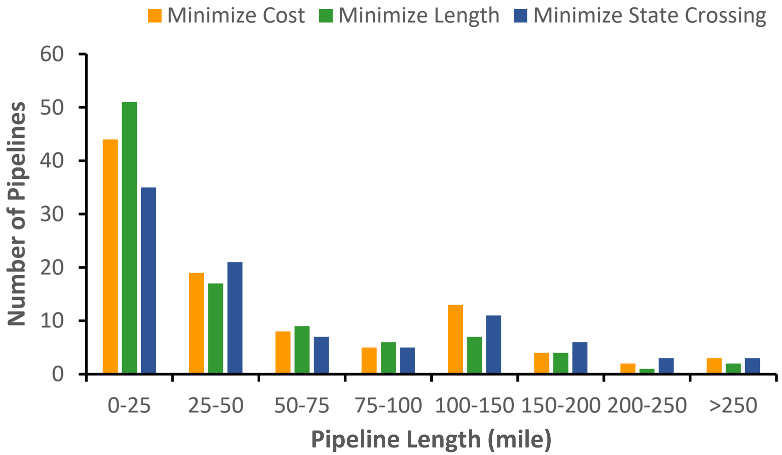
Scenario 2: Pipeline Size and Length

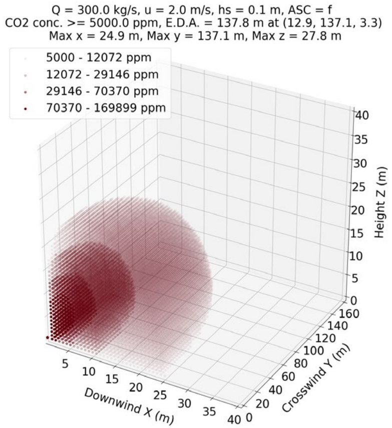


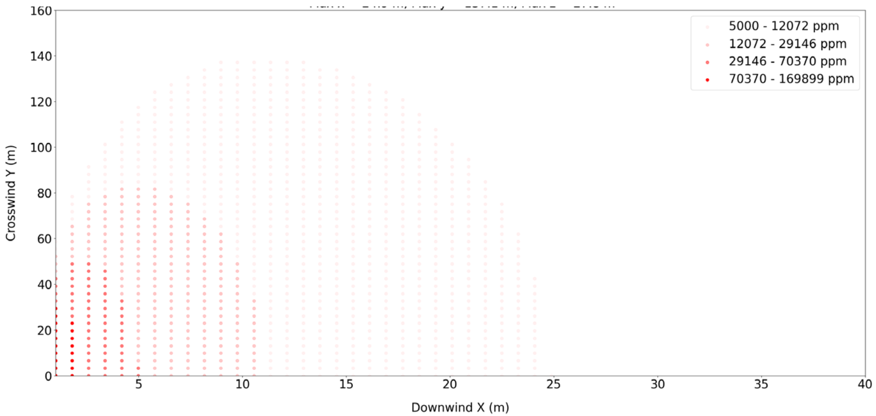


Scenario-Case	# of Coal Units	Total New Pipeline Length (miles)	% Segments < 25 miles	% Segments < 100 miles	# of State Crossings
S2C1 – Min cost	99	5,661.3	44.90%	77.55%	34
S2C2 – Min length	99	4,658.0	52.58%	85.57%	27
S2C3 – Min state crossing	99	5,990.0	38.46%	74.73%	17

Key Takeaways

- SimCCS demonstrates to be an effective toolset to support decision-making in the deployment of CCS transport infrastructure.
- Modeling of multi-modal transport, including pipeline, rail, truck, barge/ship, will be fully functional by the end of this calendar year.
- Expanding tool for transport safety and risk assessment.





Example of Potential Impact Radius estimate using SimCCS if a leak event happens

Thank you!

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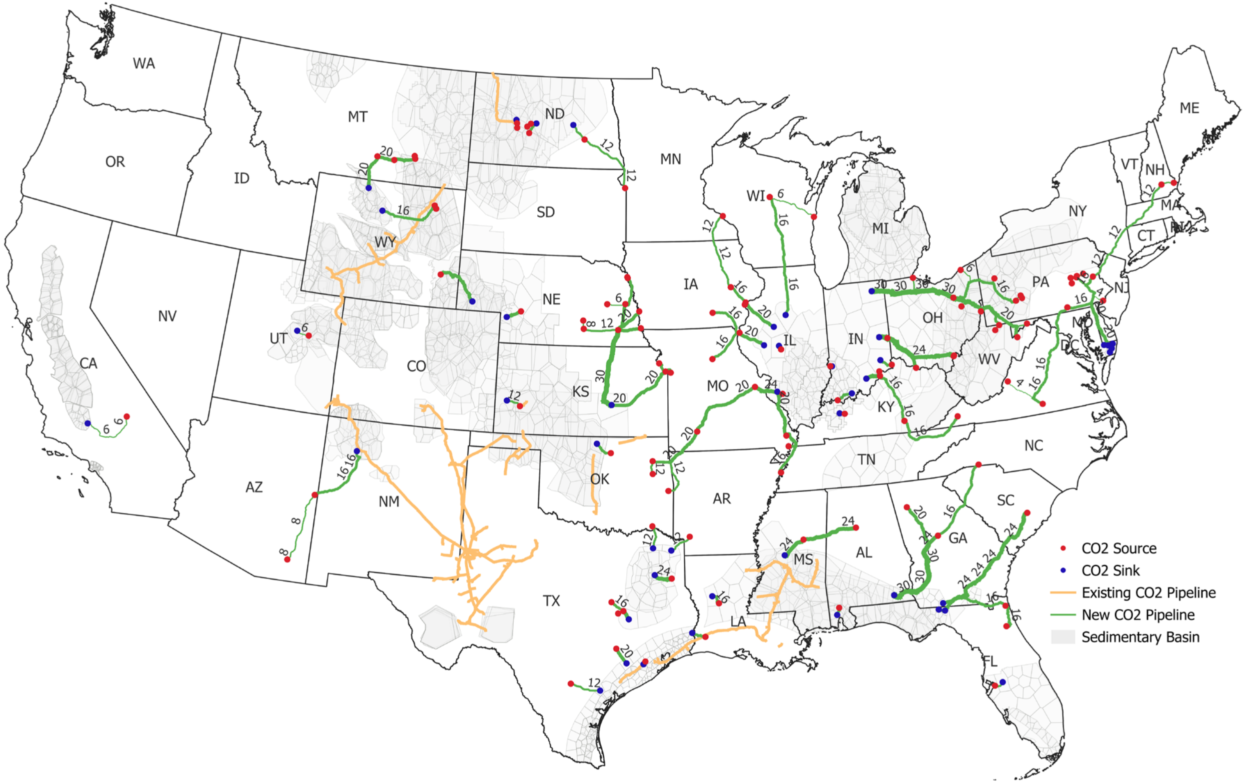
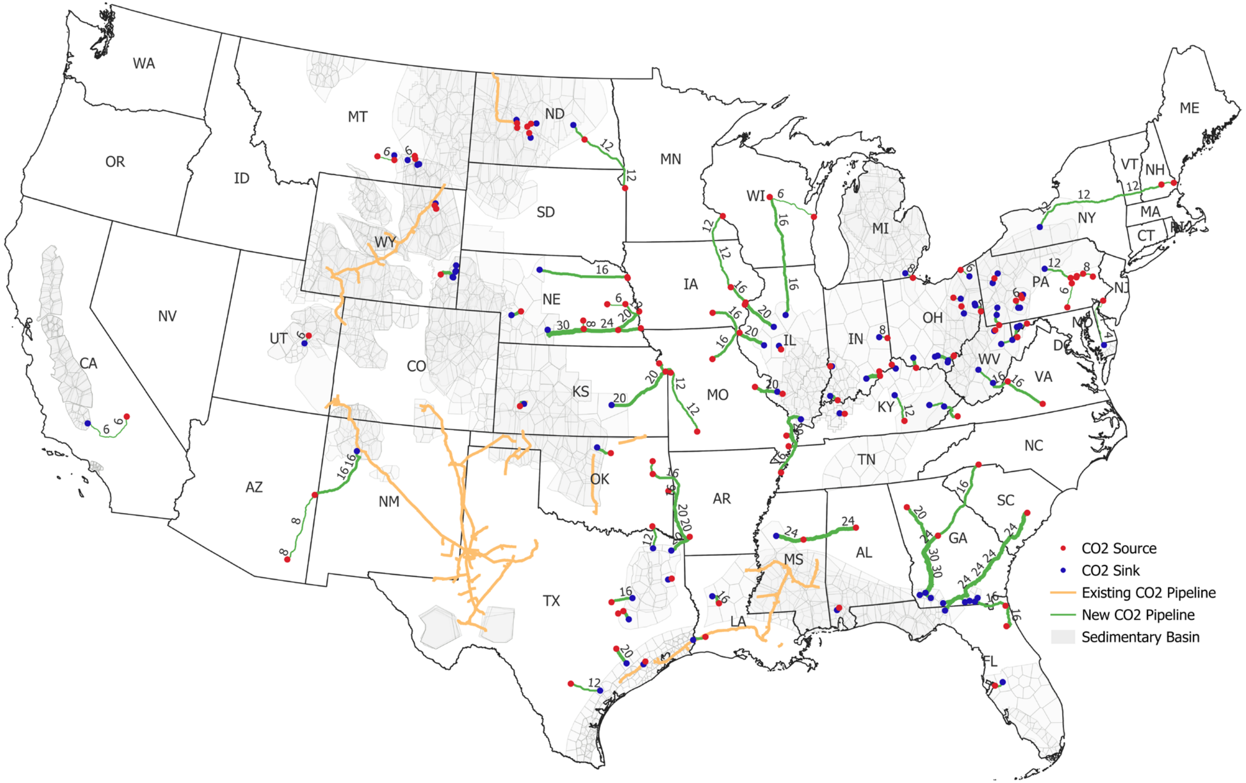
Scenario 1 – Case 1: Minimize Cost



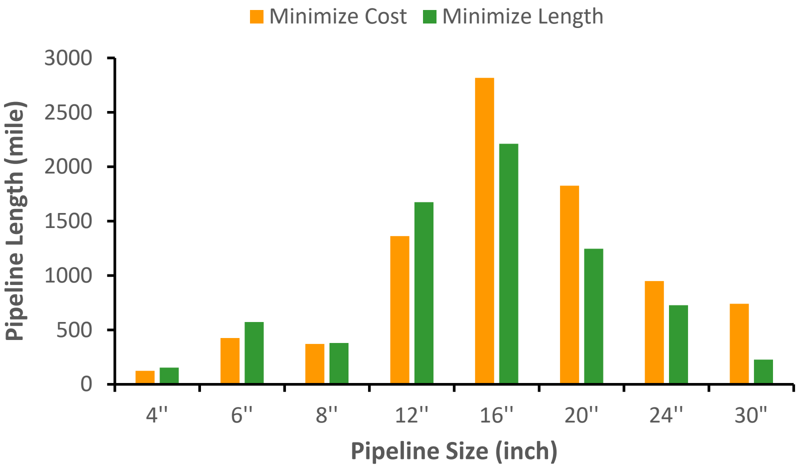
- **Total new CO_2 pipeline length in miles: 8611.5**
- **Total number of state crossing pipelines: 54**

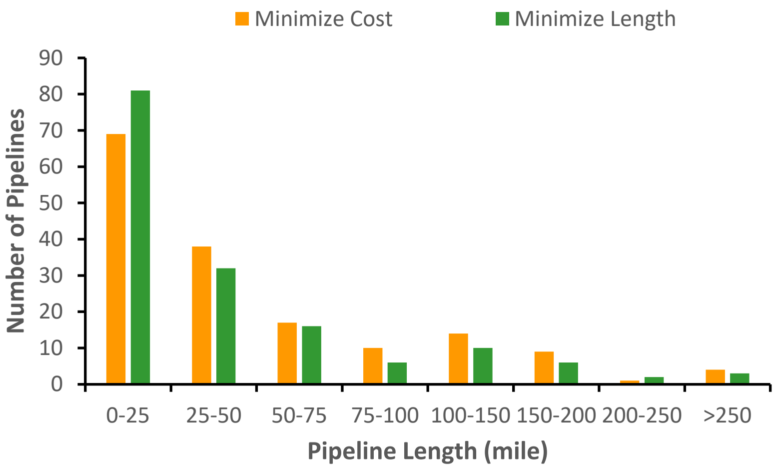
Scenario 1 – Case 2: Minimize Length



- **Total new CO_2 pipeline length in miles: 7,188.6**
- **Total number of state crossing pipelines: 42**

Scenario 1: Pipeline Size and Length





Scenario-Case	# of Coal Units	Total New Pipeline Length (miles)	% Segments < 25 miles	% Segments < 100 miles	# of State Crossings
S1C1 – Min cost	206	8,611.5	42.59%	82.72%	54
S1C2 – Min length	206	7,188.6	51.92%	86.54%	42