SimCCS: An Open-source Toolset for Regional CCS Infrastructure Decision Support

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FECM/NETL

Carbon Management Research Project Review Meeting

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Project Participants

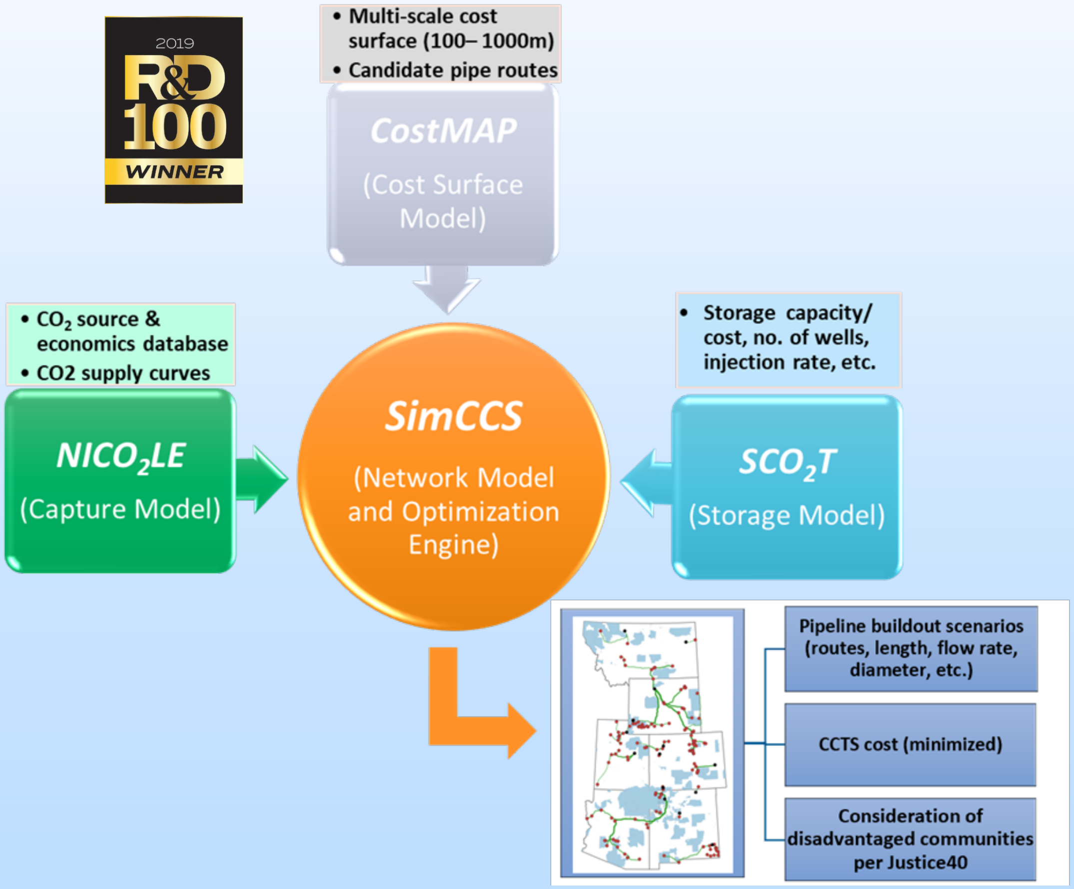
– LANL: Martin Ma, Bulbul Ahmmed, Mohamed Mehana, Richard Pratt, Meng Meng, Rajesh Pawar
– Resources for the Future (RFF): Alan Krupnick, Shih-Shyang Shih, Alexandra Thompson

Project Scope

– Produce a toolset that can be utilized by a range of users to help address emerging CCUS infrastructure deployment challenges including,
  - National-scale, regional-scale deployment
  - Phased deployment
  - Account for disadvantaged communities per Justice40 initiative
  - Account for environmentally sensitive areas
  - Dynamic nature of future CO_2 capture (decommissioning of sources, new sources, variable capture amounts)
  - Potential utilization of existing CO_2 pipelines and ROWs
  - Onshore and offshore transport and storage

Technology Background

– *SimCCS*: determines costs and optimized pipeline routing by integrating factors across the CCUS value chain

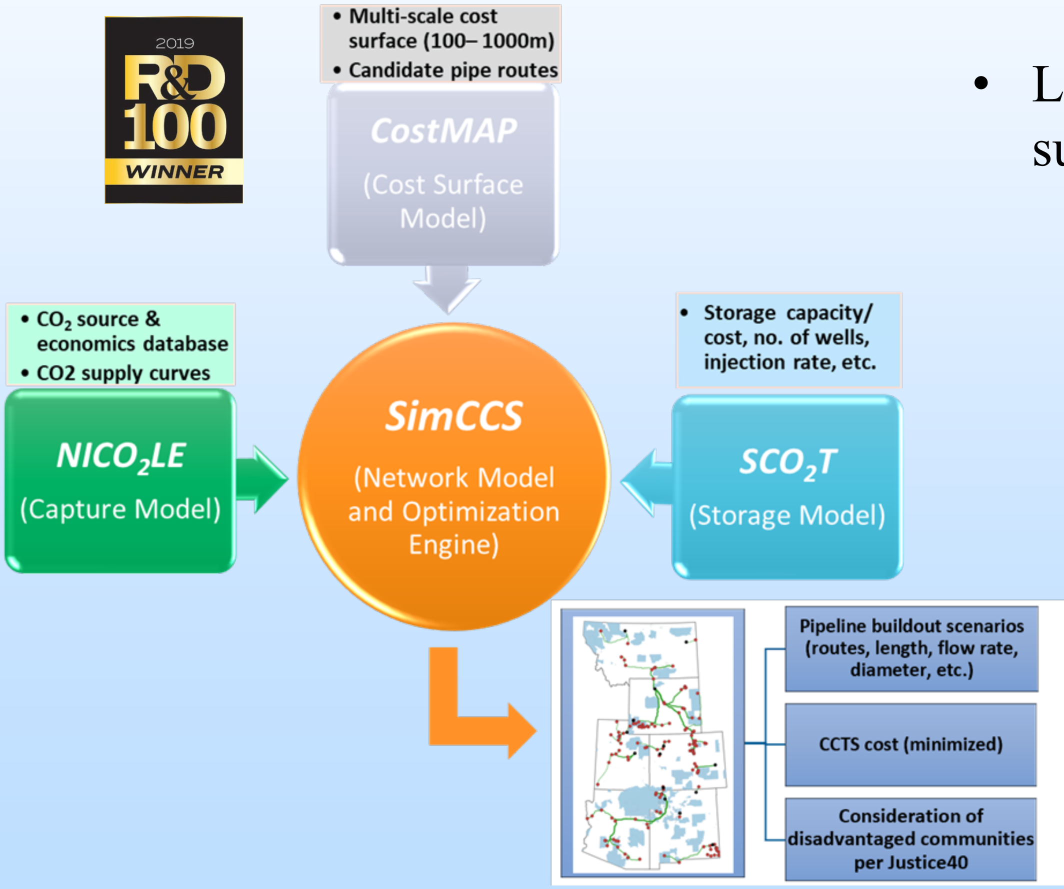


- ***NICO₂LE***
  - ➢ Understand commercial-scale capture opportunities.
  - ➢ Geodatabase: Source locations, CO_2 streams, & capture costs.
- ***SCO₂T***
  - ➢ Rapidly calculate injectivity & storage resource & costs.
- ***CostMAP***
  - ➢ Identify likely corridors.
  - ➢ Develop candidate pipeline routes for *SimCCS* optimization engine.

SimCCS is publicly available @ https://simccs.lanl.gov/

Technology Background

– *SimCCS*: determines costs and optimized pipeline routing by integrating factors across the CCUS value chain



- LANL is utilizing *SimCCS* to support infrastructure modeling:
  - ➢ National scale CCS pipeline network modeling
  - ➢ Three regional CCUS initiatives (CUSP, SECARB-USA, MRCI)
  - ➢ One energy transition initiative (I-WEST)
  - ➢ CarbonSAFE initiative

SimCCS is publicly available @ https://simccs.lanl.gov/

FY23 Work Scope

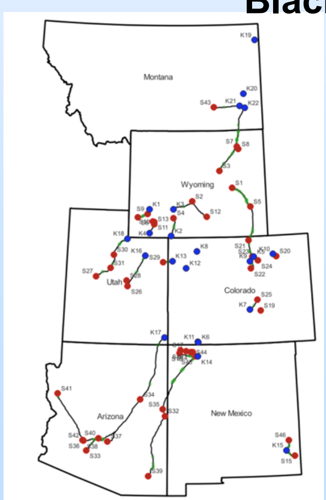
- T1: Extend the capability to take into account existing pipeline ROWs.
- T2: Extend the capability to model offshore CO_2 transport infrastructure development
- T3: Develop capability to take into account storage site risks
- T4: Extend *SCO_2T* storage model to depleted hydrocarbon (HC) bearing reservoirs
- T5: Extend the capability to account for environmentally sensitive areas to national scale

Technical Progress

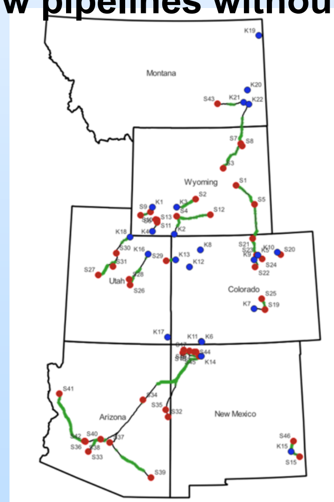
T1: Implementation of Capability to Take into Account Existing Pipeline ROWs

- There are over 3 million miles of existing pipelines to transport various types of liquid or gas
- The proper usage of existing pipeline ROWs would significantly reduce the overall CO_2 transport cost

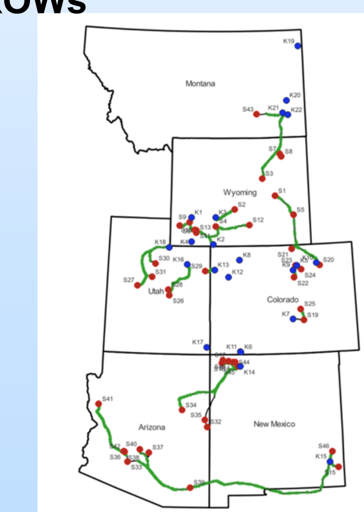
Green lines: new pipelines using existing ROWs
Black lines: new pipelines without using ROWs



(a) Cost weight: 1.0 (do nothing)
Total pipeline length: 3632 km
9% pipelines using existing ROWs



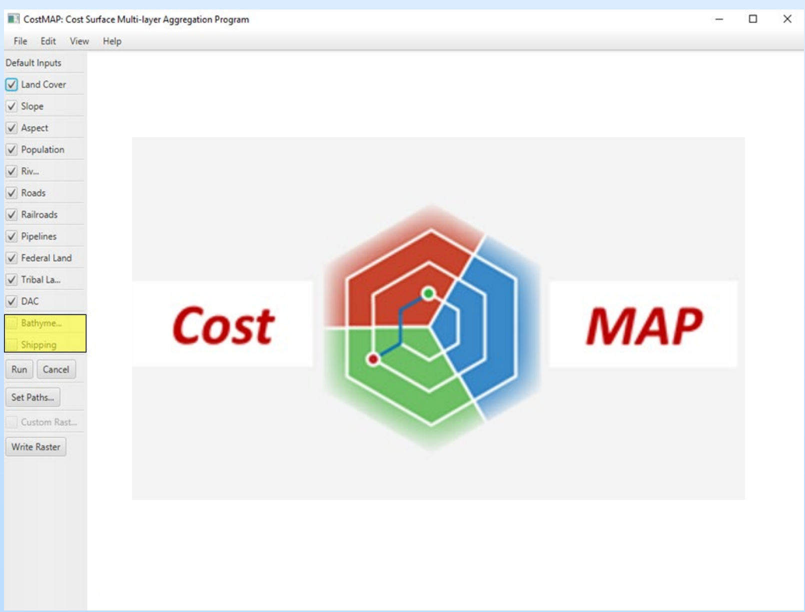
(b) Cost weight: 0.75
Total pipeline length: 3674 km
49% pipelines using existing ROWs

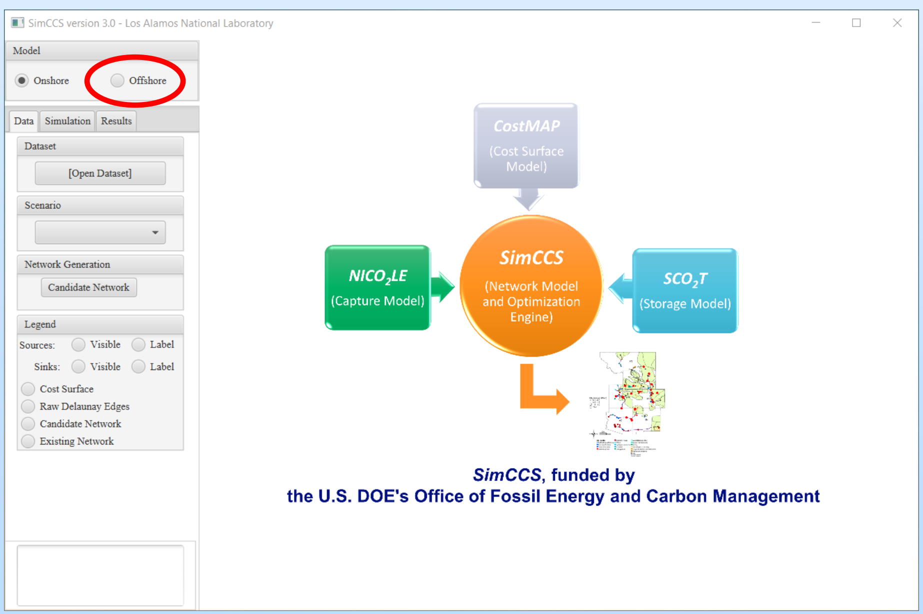


(c) Cost weight: 0.3
Total pipeline length: 3960 km
84% pipelines using existing ROWs

T2: Implementation of Capability for Offshore Transport Modeling

- Generated new cost surface which includes the bathymetry and shipping route data
- Developed and implemented cost models for CO_2 offshore transport: pipeline & shipping
- Updated GUIs for *SimCCS* and *CostMAP*





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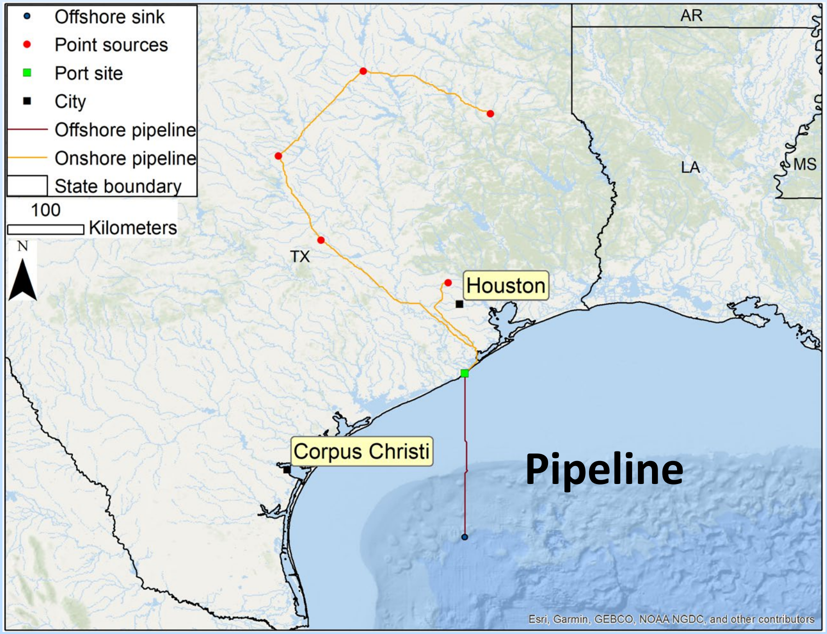
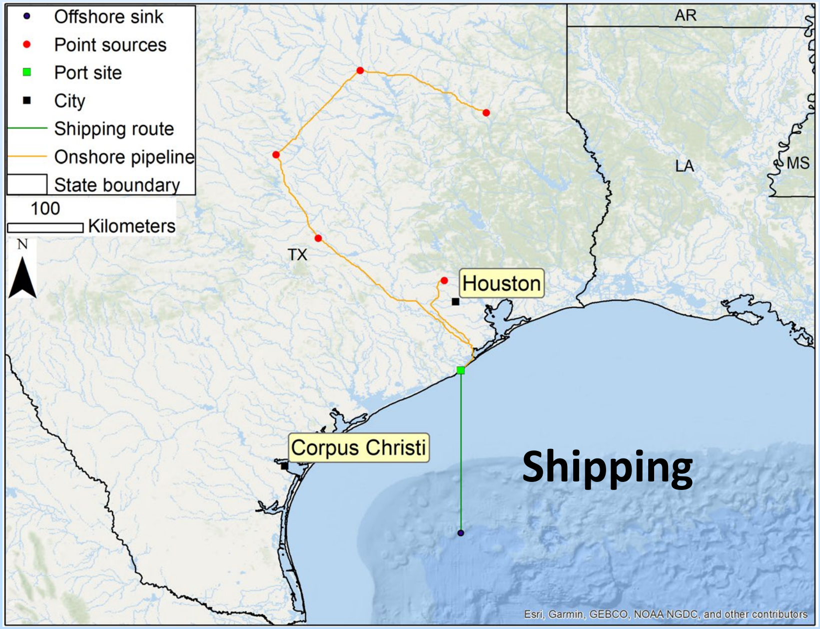
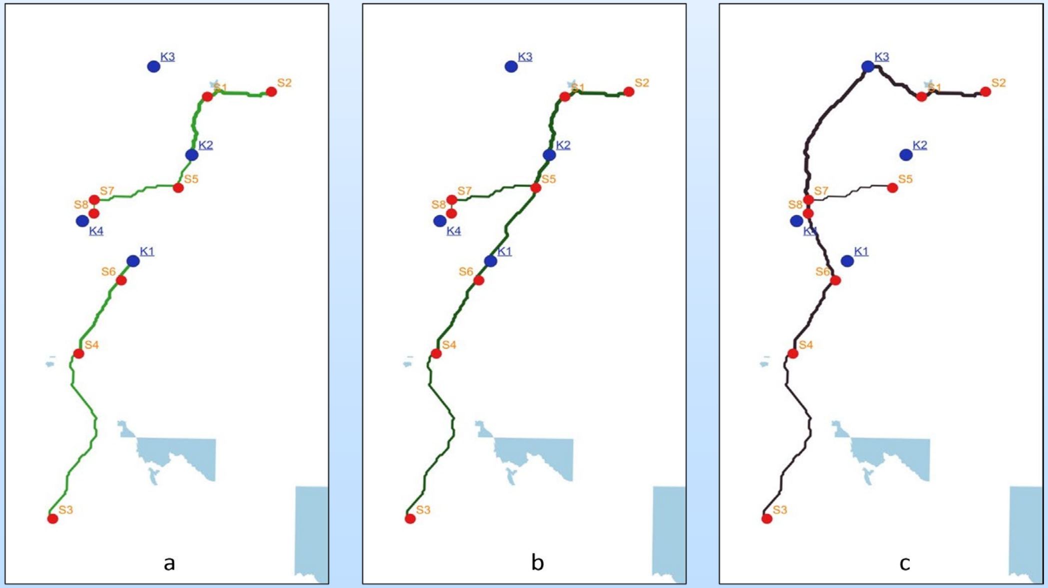




T3: Implementation of Capability to Account for the Storage Site Risk

– Developed and implemented approach to account for the storage site risk due to leakage from legacy wells and induced seismicity

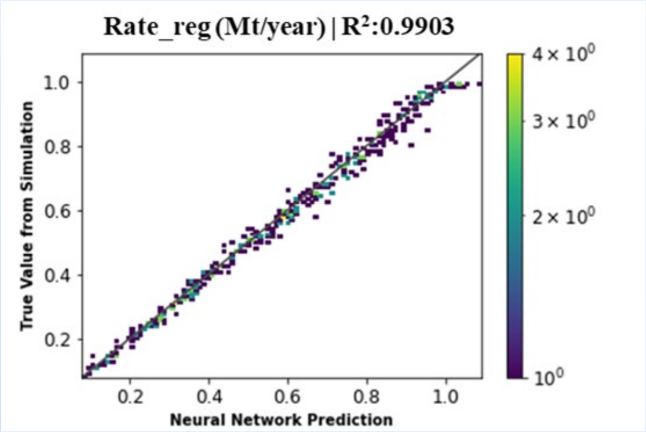
(a) Low legacy well density (0.25 well/mile^2) **(b) Medium legacy well density (1 well/mile^2)** **(c) High legacy well density (>10 wells/mile^2)**



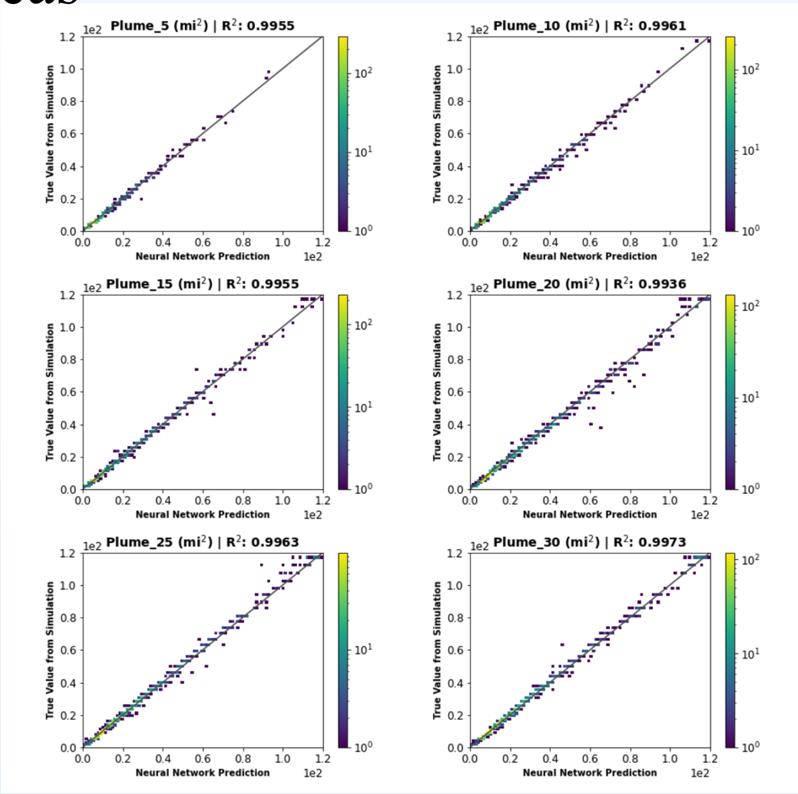
Optimized pipeline route by increasing the legacy well density at sites K1 and K2

T4: Extend *SCO_2T* Storage Model to Depleted HC Bearing Reservoirs

– Developed reduced-order models (ROMs) for the predictions of injectivity and CO_2 plume areas



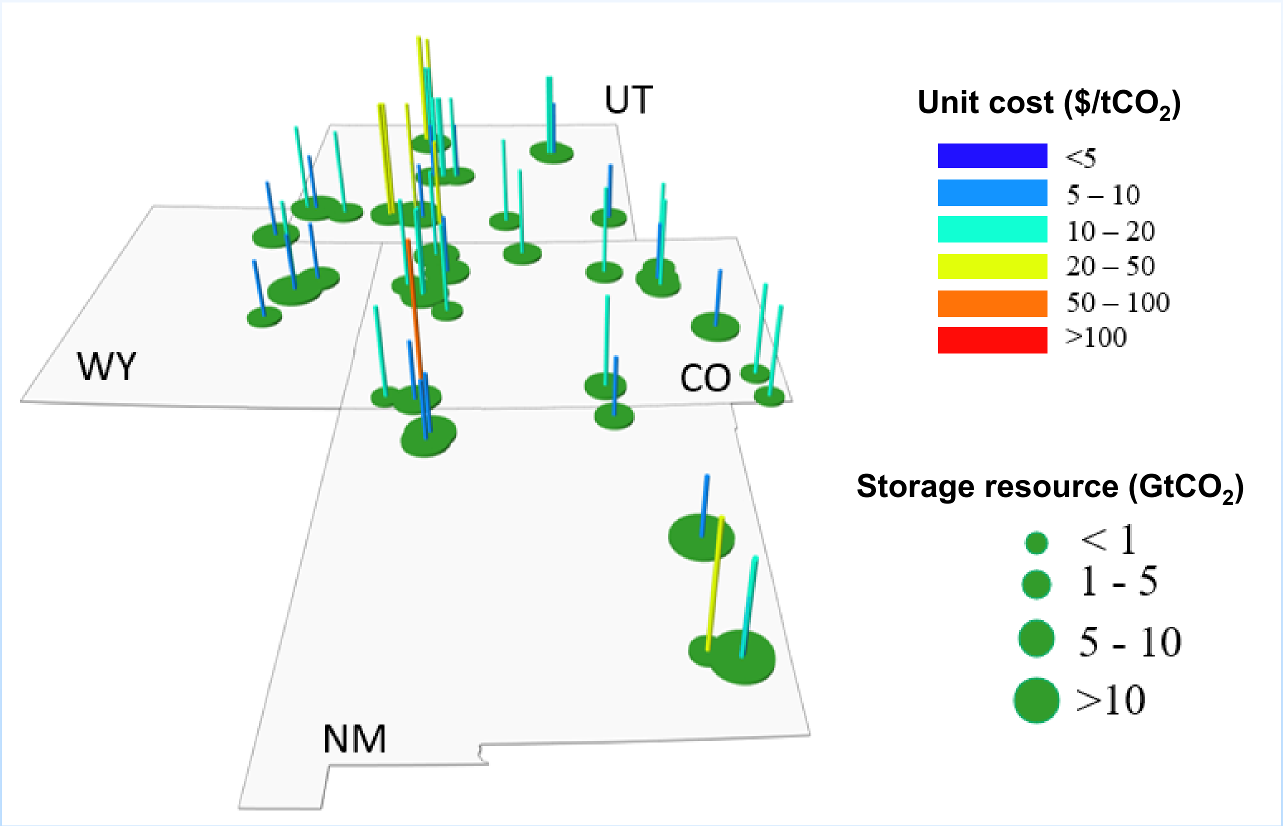
ROMs performance of the injection rate in MMt/year



ROMs performance of plume area prediction in mile²

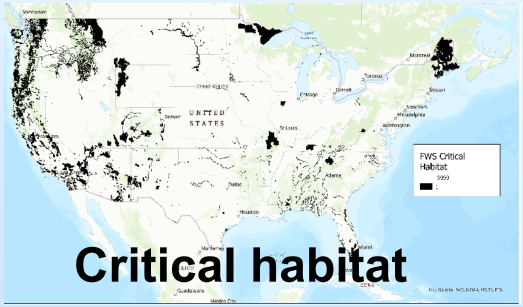
T4: Extend *SCO_2T* Storage Model to Depleted HC Bearing Reservoirs

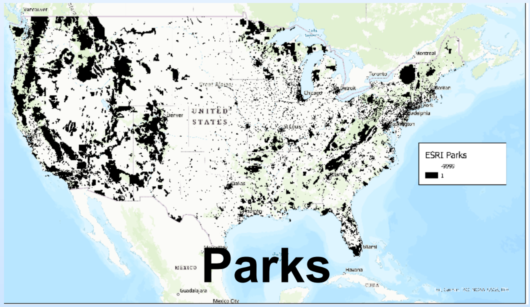
– Estimates of CO_2 storage resource and cost (hypothetical case)

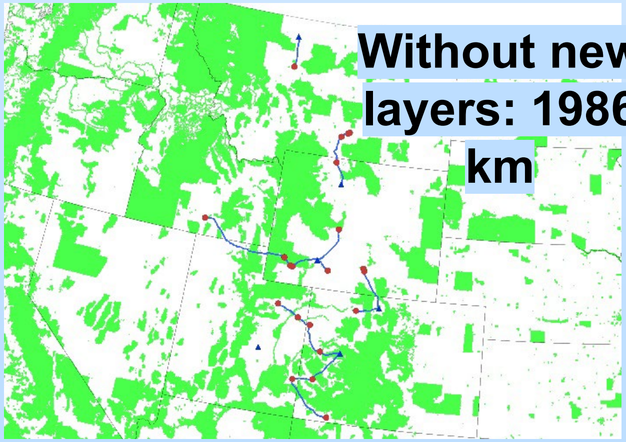


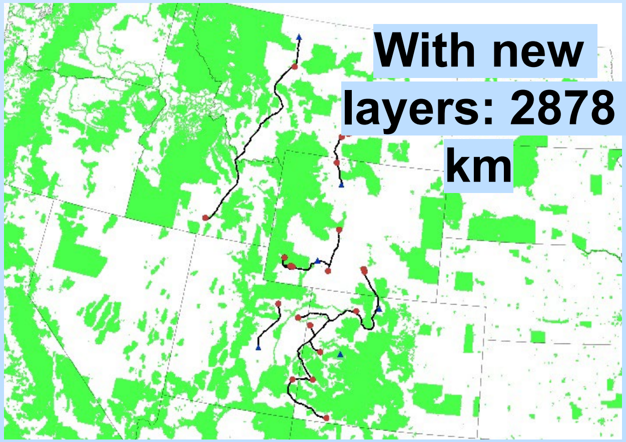
T5: Extend the Capability to Account for Environmentally Sensitive Areas to National Scale

- Created a set of geospatial layers (e.g., critical habitat, parks, historic/cultural areas, permanently protected areas) in cost surface
- Conducting case studies to investigate the impact of environmentally sensitive areas on pipeline routing









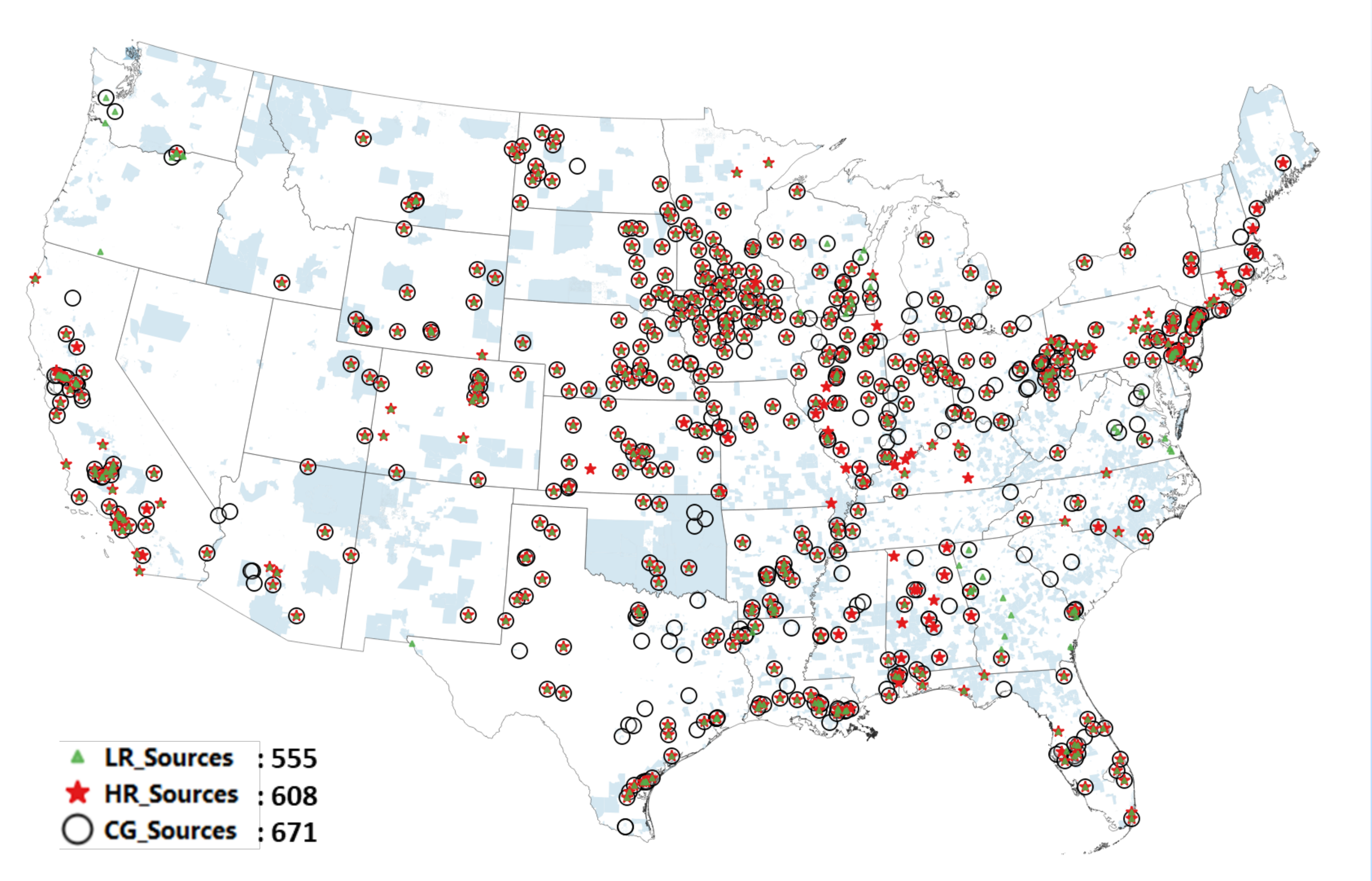
Application: National Scale CCS Pipeline Network Modeling (FY23)

- **Objective**: Use *SimCCS* platform to understand potential national scale CCS infrastructure deployment scenarios
- In coordination with DOE-FECM
- In collaboration with OnLocation Inc.

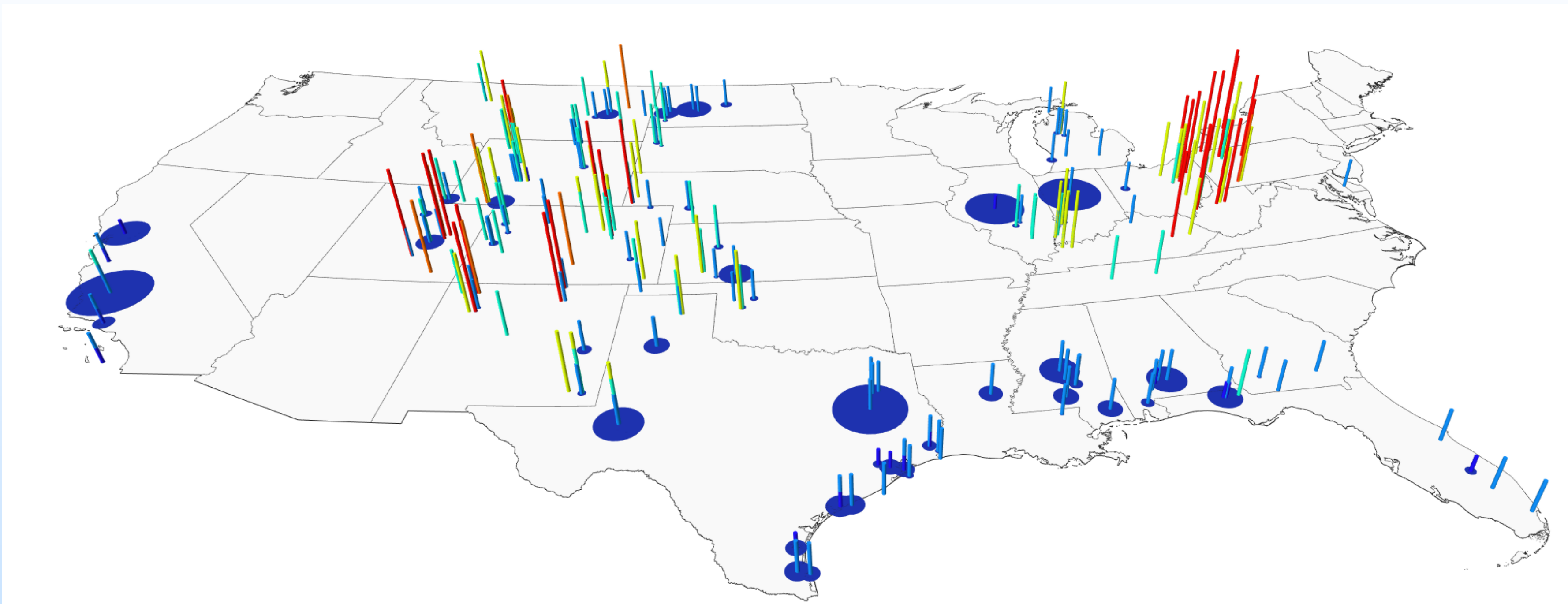
CO_2 Source Locations – Comparison Across Scenarios

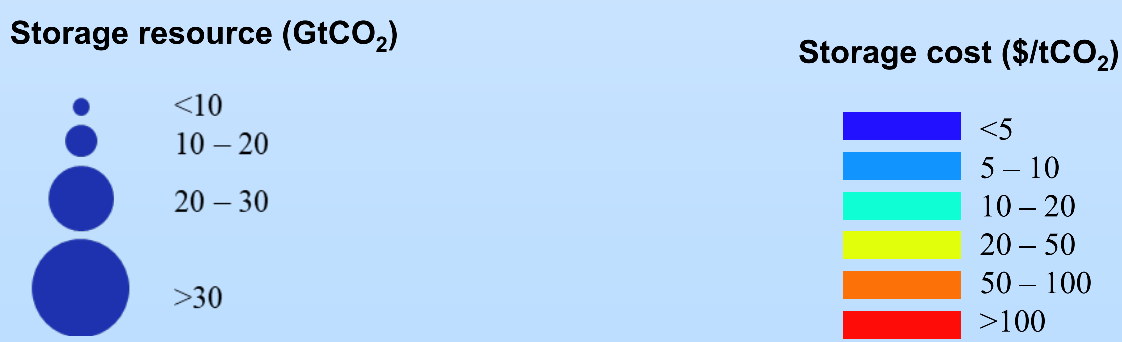
Low CO_2 Removal: advanced technology in all sectors hence a low need for CO_2 removals

High CO_2 Removal: standard technologies in all sectors except electricity, requiring highest level of CO_2 removals

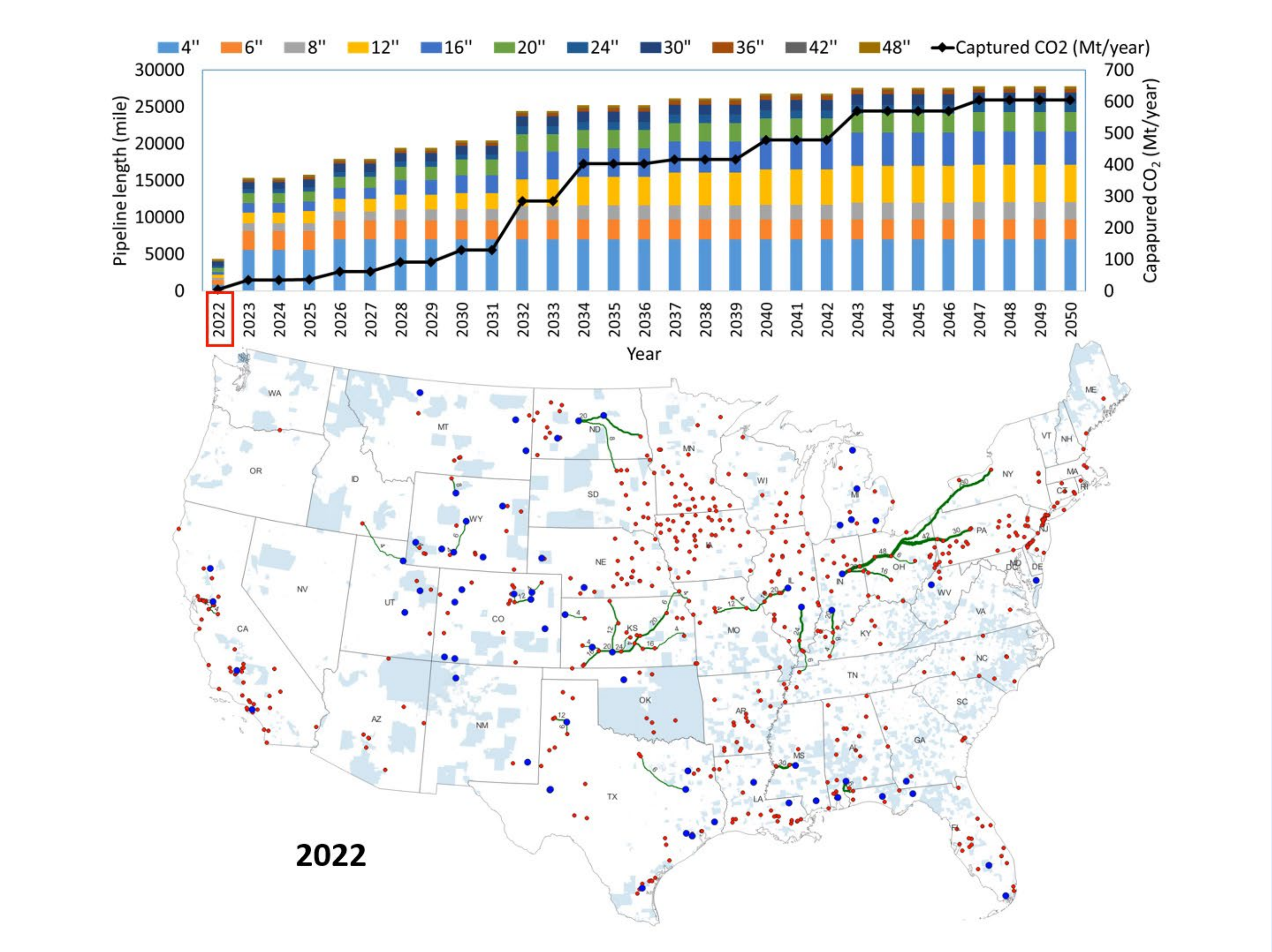


CO_2 Storage Resource & Costs (Saline Aquifer Only)





High Removal (HR) Scenario – Evolution of Pipeline Infrastructure



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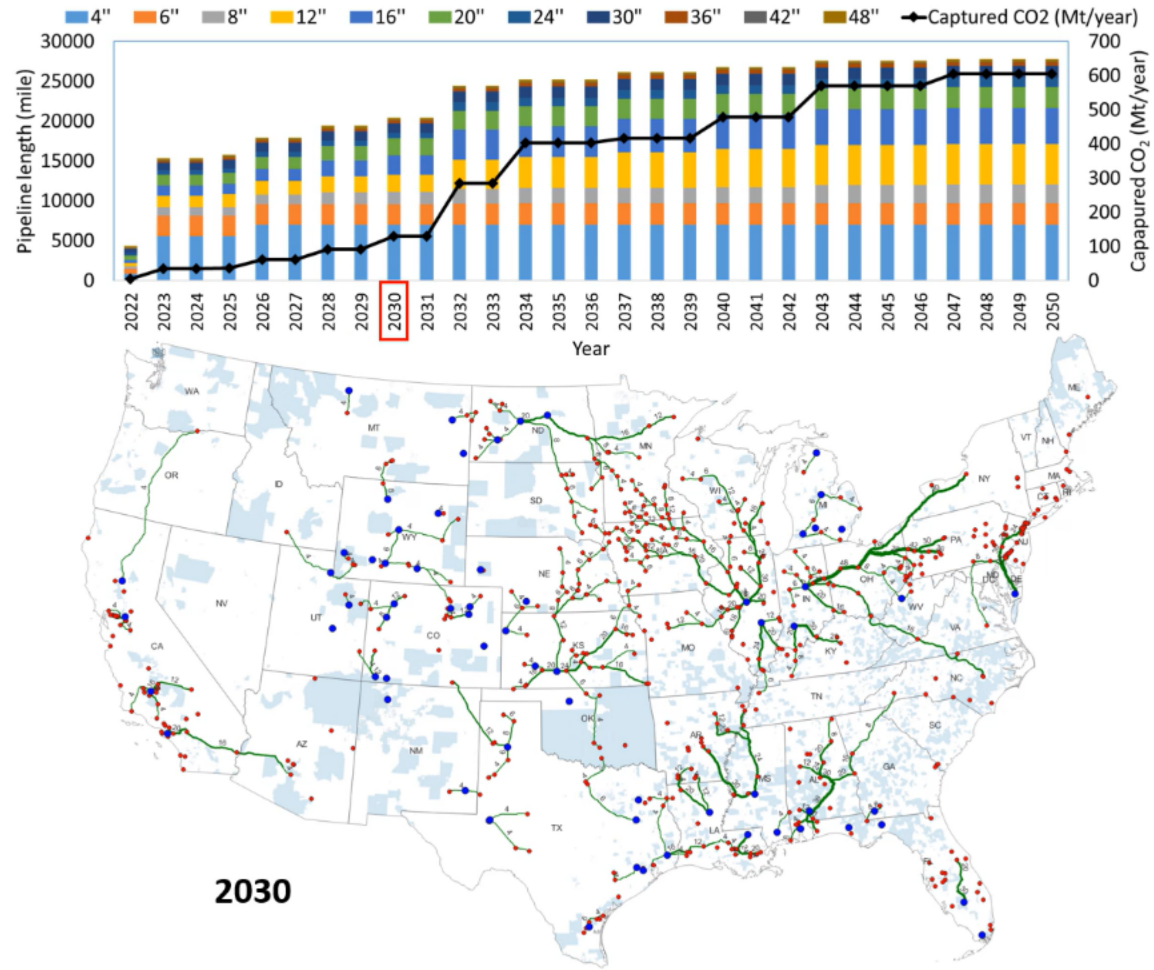

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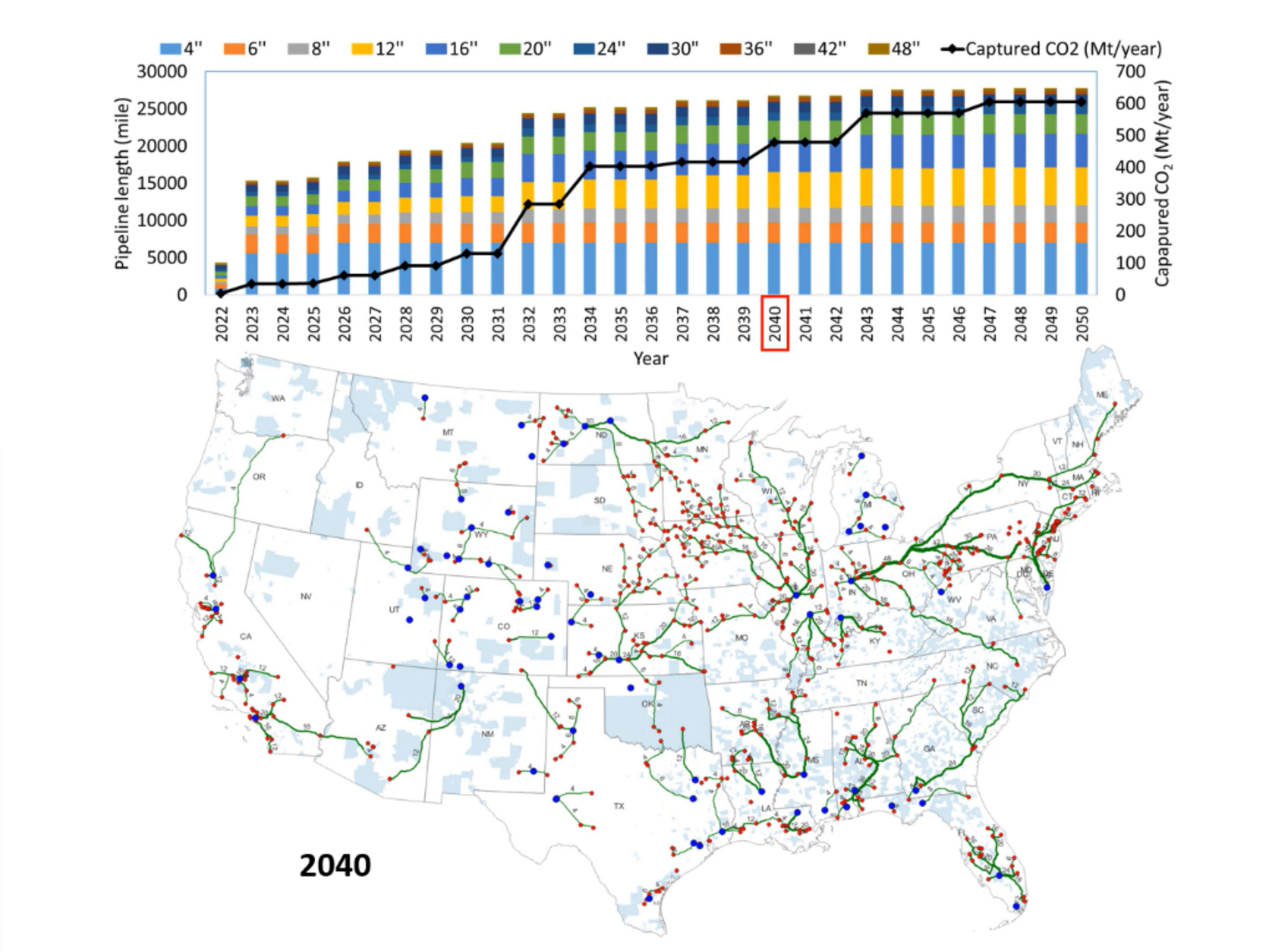
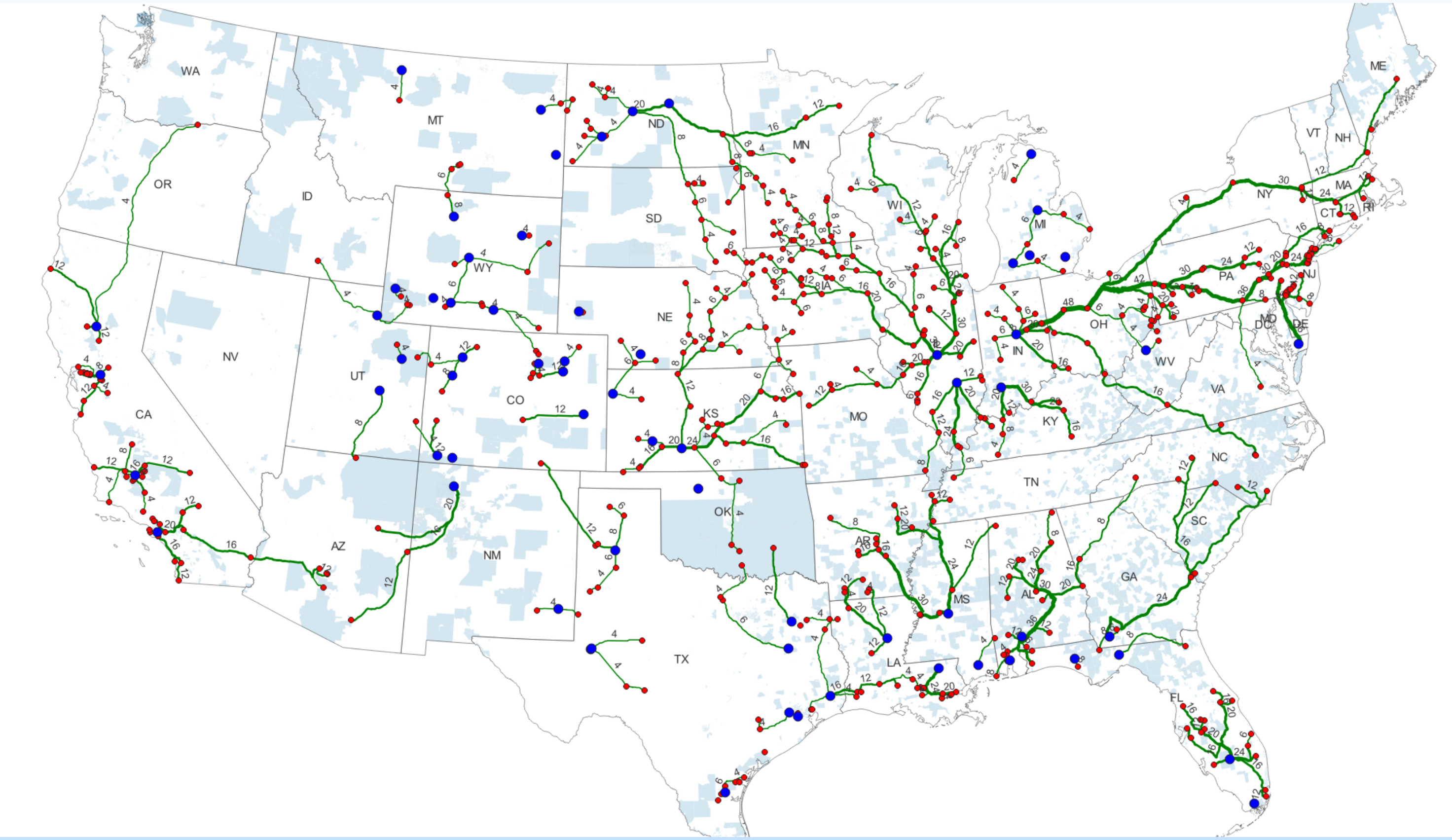
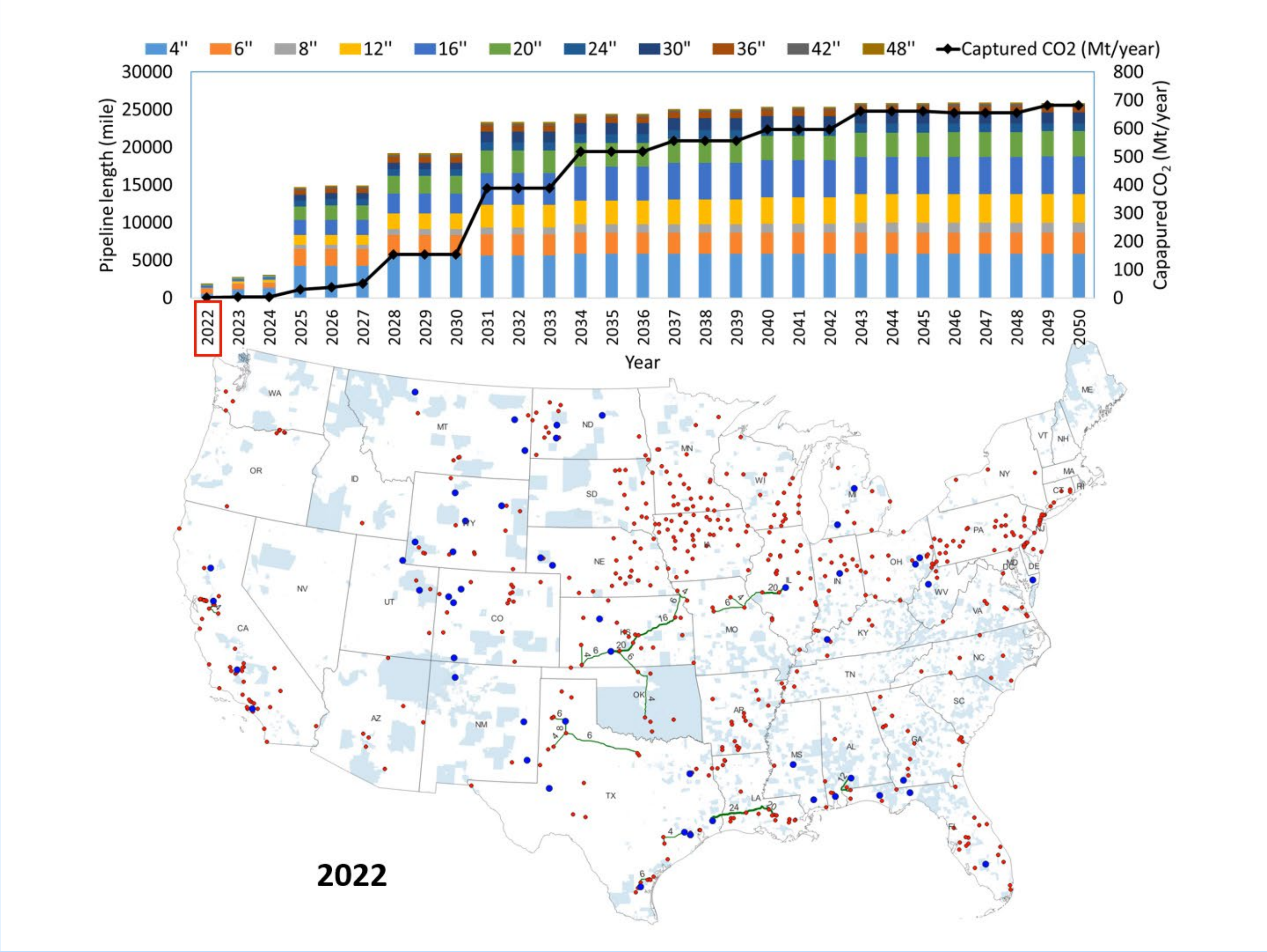


High Removal (HR) Scenario – Pipeline Infrastructure in 2050

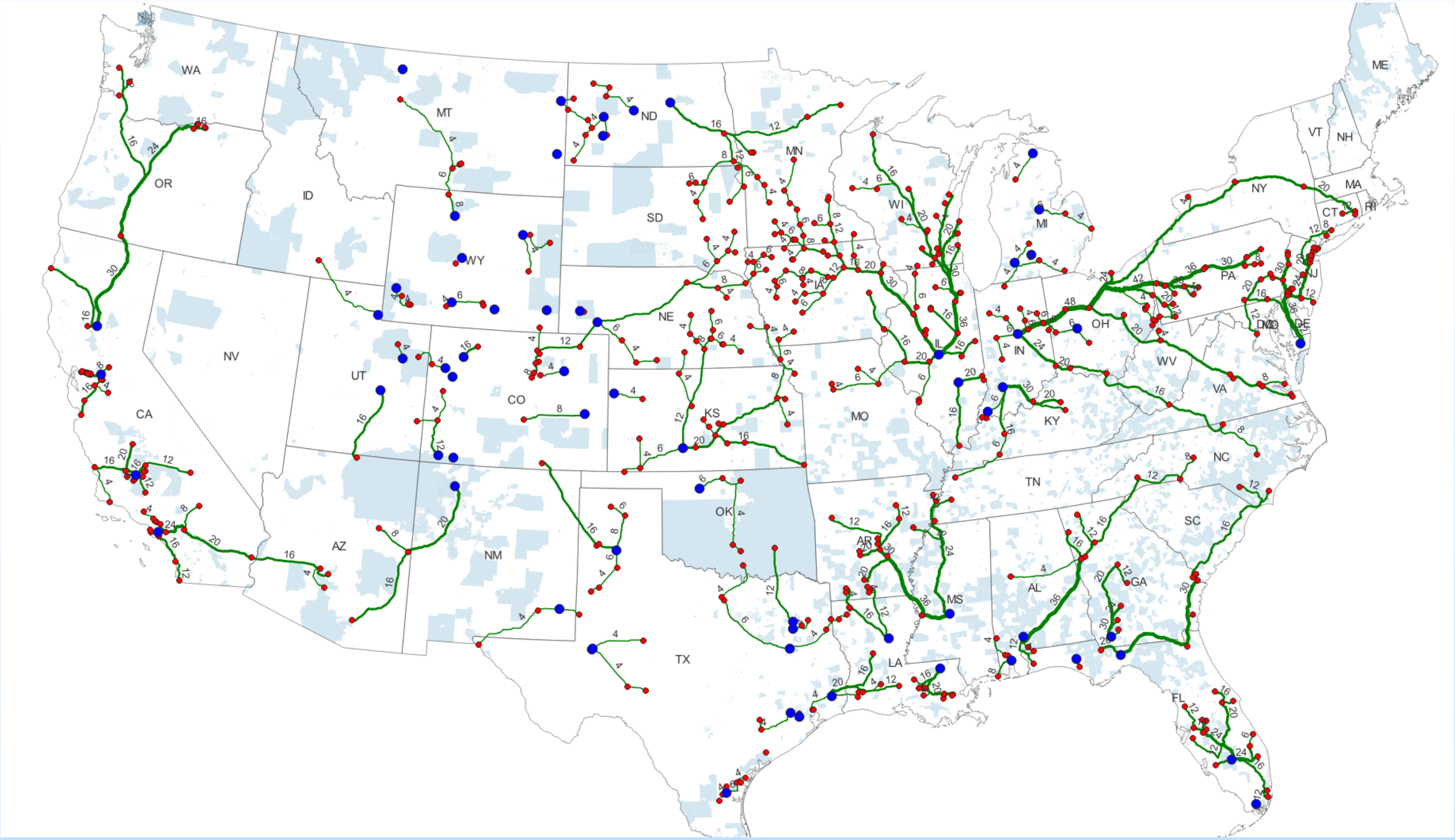


- Total pipeline length: 28,130 miles
  - ➢ By 2035: 25,317 miles (90%)

Low Removal (LR) Scenario – Evolution of Pipeline Infrastructure

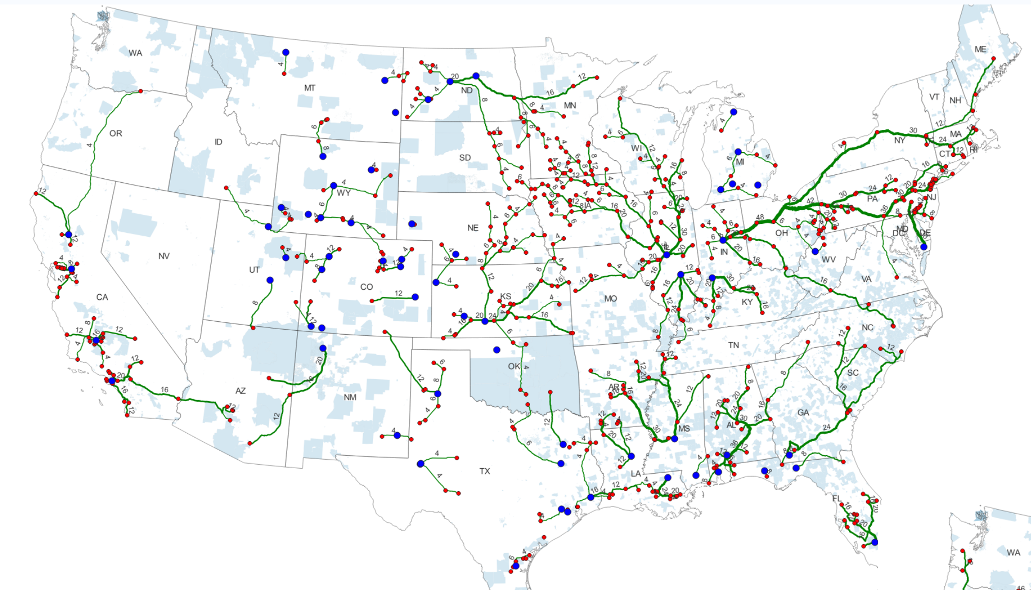


Low Removal (LR) Scenario – Pipeline Infrastructure in 2050



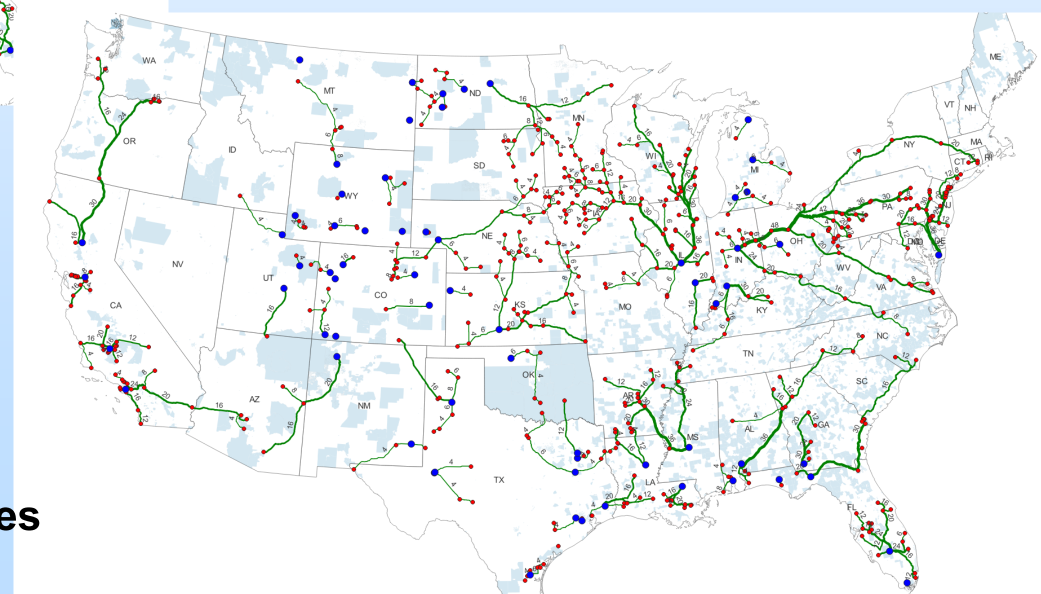
- Total pipeline length: 26,078 miles
  - By 2035: 24,431 miles (93.7%)

High Removal (HR) vs. Low Removal (LR)



- HR: total pipeline length 28,130 miles

LR_Sources : 555
HR_Sources : 608



- LR: total pipeline length 26,078 miles

Summary

– *SimCCS* has been demonstrated to be an effective toolset to support the CCS pipeline infrastructure decision making
– New features such as utilization of existing pipeline ROWs, offshore transport, storage site risk factor, and HC-bearing storage model, have been implemented in *SimCCS* for transport modeling in FY23
  - More to come in FY24, e.g., unified platform, multi-modal modeling, and critical safety and risk assessment
– National CCS pipeline modeling results indicate
  - ~26,000-28,000 miles of new pipelines will need to be constructed to capture and storage the emissions (as identified in OnLocation scenarios)
  - The eastern, mid-western, western regions of US will need to have higher number of trunk lines to facilitate transport of captured CO_2

Thank you

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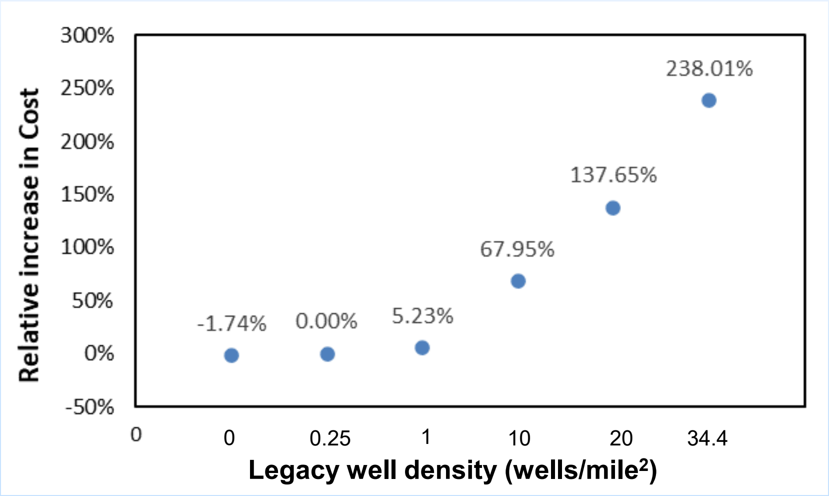
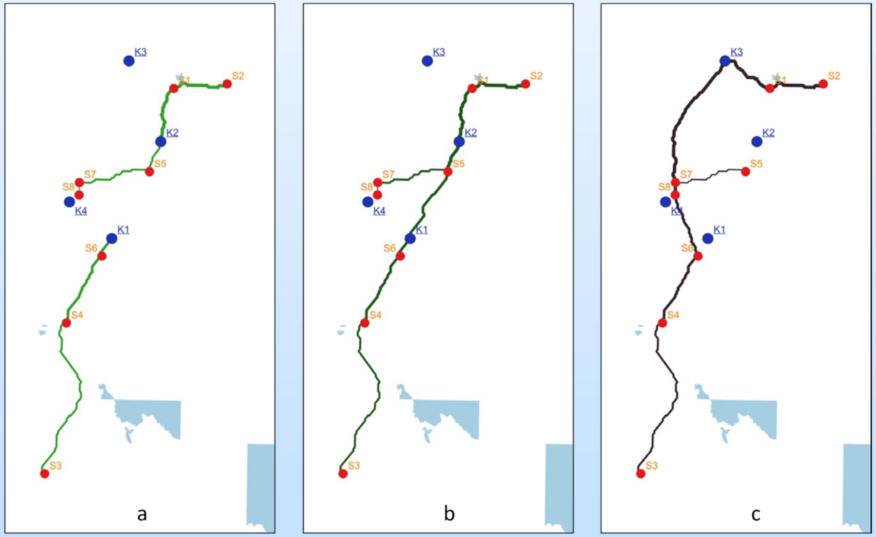
Backup

– Developed and implemented approach to account for the storage site risk due to leakage from legacy wells and induced seismicity

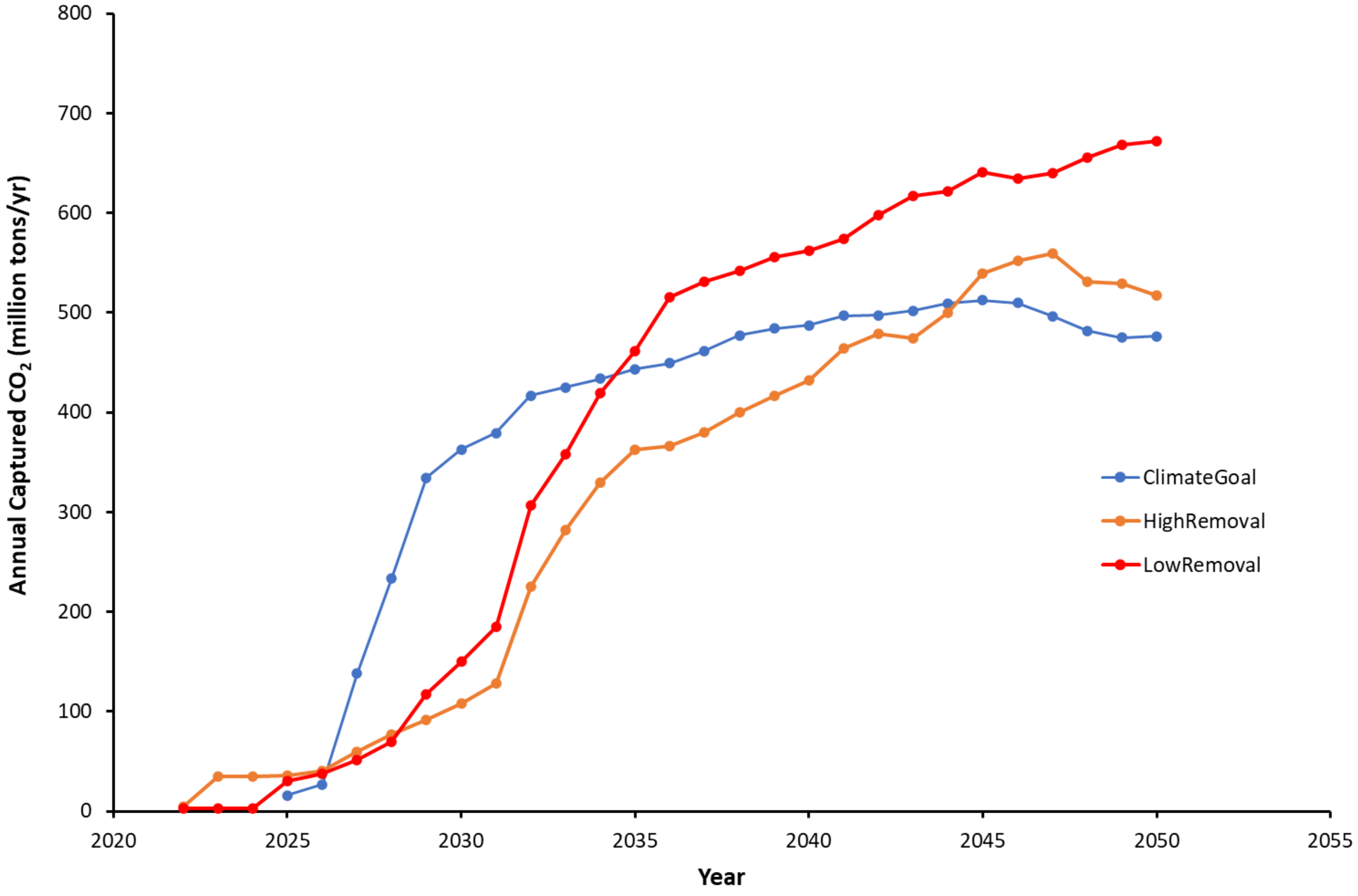


Relative increase in storage cost with-respective-to the base scenario

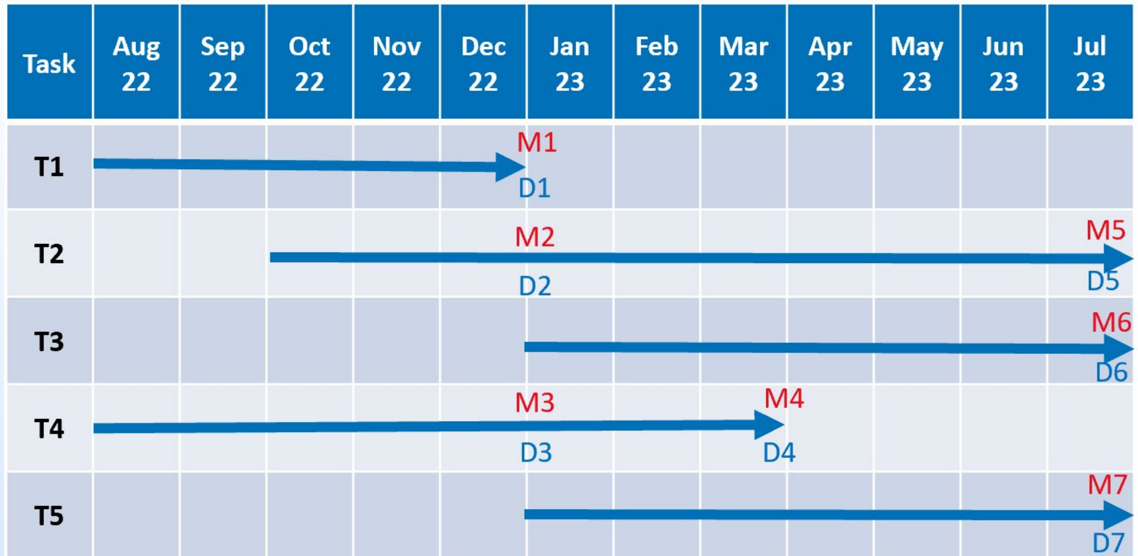


Optimized pipeline route by increasing the legacy well density at sites K1 and K2

CO_2 Capture Targets – Comparison Across Scenarios



Milestone Status



- M1 – Complete the implementation of the capability to take into account existing pipeline ROWs.
  - **Status – Successfully completed on 12/31/2022**
- M2 – Complete data collection for offshore storage sites.
  - **Status – Successfully completed on 12/31/2022**
- M3 – Complete the physics-based training simulations and the development of the ROMs to predict CO_2 storage resource in depleted oil reservoirs.
  - **Status – Successfully completed on 12/31/2022**
- M4 – Complete the implementation of economic models in *SCO_2T*-OG to assess the CO_2 injectivity, storage resource & costs of storing CO_2 in depleted oil/gas reservoirs.
  - **Status – Successfully completed on 03/31/2023**
- M5 – Complete the development of transport cost models for pipeline and ship/port-based CO_2 transport under the context of offshore storage.
  - **Status – Successfully completed on 07/31/2023**
- M6 – Complete the implementation of risk factors for storage reservoirs in pipeline network modeling.
  - **Status – Successfully completed on 07/31/2023**
- M7 – Complete the implementation of the functionality for pipeline modeling with the constraint of environmentally sensitive areas in national scale.
  - **Status – No Cost Extension; to be completed on 9/30/2023**