Carbon Storage Technical Viability Approach and National Data Assessment

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NETL CSIL evaluation with Great Plains Institute Carbon and Hydrogen Hubs overlain
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Data are key resource for successful carbon storage

- All projects begin with data collection to inform storage resource and project feasibility.
- Understanding key data gaps and overlooked data categories (e.g. regulatory, EJ/SJ, hazard) can reduce siting, development and operational issues.

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Carbon Storage Technical Viability Approach (CS TVA)

**Problem:** Lack of workflow that integrates classic CO₂ storage resource assessments with environmental and socio-economic factors, and infrastructure to assess the data available to inform technically viable carbon storage assessments.

**Solution:**
- Define evaluation criteria that considers these additional factors.
  - Addresses potential limitations/benefits not identified in Class VI process.
- Develop workflow for technically viable carbon storage data availability analysis.

Where are the data?? Are they useful?

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First Pass: Cumulative Spatial Impact Layers (CSIL) tool applied to collection of subsurface, census, environmental data

Cumulative Spatial Impact Layers (CSIL)
- GIS-based tool that summarizes spatio-temporal datasets based on overlapping features and attributes (Romeo et al., 2019)

Spatially visualizes basic data availability, however, does not indicate data utility based on category nor is comprehensive for Carbon Storage Technical Viability data requirements

NETL CSIL evaluation with Great Plains Institute Carbon and Hydrogen Hubs (Abramson, 2022) overlain

Defining Carbon Storage Technical Viability and data availability

- **Definition: Carbon Storage Technical Viability**
  - A comprehensive evaluation of potential carbon storage sites that includes classic subsurface resource assessment components such as reservoir suitability in addition to hazard, environmental, social, regulatory, and jurisdiction components that may enhance or hinder successful carbon storage.

- **Data** for assessments of **technically viable carbon storage span many categories, types; are disparate and numerous**
  - Variables and types of data required to support CS assessments were previously not clearly defined and documented.

- **Contextualizing available data** indicates their utility, potential uncertainty, and gaps.

- This forms the approach.

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Carbon Storage Technical Viability Approach

**Approach:** Assemble database, evaluation criteria, and workflow to gather, visualize, and assess data availability and utility to inform and accelerate technically viable GCS assessments in the USA.
Components of Technical Viability

- Numerous components need to be considered to comprehensively define and assess carbon storage technical viability
- Reflects multidisciplinary requirements of carbon storage projects

Retention and Geomechanical Risk
- Seals and Pressure
- Trap
- Faulting

Hazards
- Subsurface Hazards
- Surface Hazards

Reservoir Suitability
- Reservoir Quality
- Reservoir Geometry
- Reservoir Conditions

Environmental Justice, Social Justice, and Community Impacts
- Community Sentiment
- Impact on Community

Siting, Regulatory, and Jurisdiction Considerations
- Land Rights/Use
- Population and Habitats
- Jurisdiction
- Regulatory

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Technical viability sub-components and determinations

- Each component can be broken down into sub-components
- Necessary aspects of those components is detailed in CS TVA matrix to evaluate data utility

Reservoir Suitability

- Reservoir Quality
- Reservoir Geometry
- Reservoir Conditions

Porosity
- Impact of permeability on injectivity
- Quality of internal reservoir characteristics

Permeability
- Impact of alteration on pore space, connectivity, and resulting injectability
- Spatial variability of reservoir, thickness distribution, connectedness, and impact on development
- Formation depth relative to 800 m and realistic drilling depths

Depositional Environment, Lithology, Grain size, and Sorting

Diagenesis, Grain Scale Deformation, Secondary Alteration

Reservoir Thickness, Spatial Extent, Variability, Geobody Architecture, and Net-to-Gross

Depth to Top of Formation

Reservoir Temperature and Pressure

In-situ Fluids and Salinity

Reservoir Temperature and Pressure
- Temperature and pressure relative to drilling requirements and technology

Reservoir Fluid types and TDS values relative to 10,000 ppm

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Carbon Storage Technical Viability Matrix

- Developed by reviewing previous studies to make a comprehensive, quantitative where possible matrix
- Components of technical viability are described for designations ranging from “Non-Viable to Excellent Viability”
- Viability designations help evaluate data utility

Viability Designations assigned at the sub-component level to create the CS TVA Matrix

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Unpacking CS TVA components and data required

- Components of the CS TVA include necessary aspects of **complete carbon storage viability assessments**
- Example: breaking down reservoir suitability
- Reservoir suitability can be divided into **subcategories of data** indicating reservoir geometry, quality, and conditions
- Multiple data types may satisfy multiple components and subcategories

Subsurface data for the Illinois Basin area

![Reservoir Quality](https://edx.netl.doe.gov/disco2ver)
- **Depositional environment**
- **Lithology**

![Reservoir Conditions](https://edx.netl.doe.gov/disco2ver)
- **Porosity**
- **Permeability**
- **Temperature**
- **Pressure**

Reservoir Suitability part of CS TVA Matrix
Relating required data and Technical Viability

- Data types required to inform each component of technical viability are mapped across components
- Informs database development

Data Required
- Porosity - Reservoir
- Permeability, Relative Permeability, Anisotropy Ratio (Reservoir)
- Well Logs, Down-Hole Geophysical Logs, Log Interpretations
- Core, Core Logs, Core Samples, Core Analysis
- Petrographic Analysis, Thin Sections
- Paleontology, Micro-Paleontology
- Well Image Logs, Image Log Interpretations
- Secondary Alteration, Diagenetic History, Basin History Model
- Seismic Data, Derived Data Volumes, Horizons and Surfaces, and Interpretations (2D/3D)
- Geomodels, Well Correlations, Cross-Sections, Stratigraphic Columns, Sedimentary Facies, Lithology, geo-body interpretations, Volume of Shale/Clay (vshale)
- Reservoir Depth
- Reservoir Thickness
- Reservoir Extent, Outer Radius of Reservoir, Hydrodynamic Boundary
- Water Chemistry Measurements, Salinity, Hydraulic Flow
- Temperature Measurements
- Pressure Measurements, Pore Pressure Model, Capillary Pressure Curve
- Permeability (Seal)

Technical Viability Categories
- Reservoir Suitability
- Reservoir Quality
- Reservoir Geometry
- Reservoir Conditions

Retention and Geomechanical Risk
- Seals and Pressure
- Trap
- Faulting

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Database Development

- Initial release includes first pass of available data; subsurface/physiographic and socioeconomic spatial feature datasets
  - >1,200 shapefiles, >40 GB of data combined
  - v1.0 database to-be-released will contain updated resources, updated metadata, and additional file types based on CS TVA development
- Being utilized for data availability analysis

Initial v0.1 database catalog

Initial v0.1 database available on EDX

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Database development

Database v1.0 leverages other EDX4CCS project databases for data availability assessment to update CS TVA

Find these data and CS TVA Database 1.0, to be released on DisCO$_2$ver by April 2024

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Leveraging the URC Tool, Data Analytics component:
Analyze data availability against required data, originally developed for critical mineral applications (Creason et al., 2023)

- Tag and catalog data available
- Define links between required data and technical viability components

**Database**

**Required Data**
- Porosity - Reservoir
- Permeability, Rel. Permeability, Anisotropy Ratio
- Well Logs, Down-Hole Logs, Log Interp
- Core, Core Logs, Core Samples, Core Analysis
- Petrographic Analysis, Thin Sections
- Paleontology, Micro-Paleontology
- Well Image Logs, Image Log Interpretations
- Secondary Alteration, Diagenetic History, Basin History Model
- Seismic Data, Derived Data Volumes, Horizons & Surfaces, Interpretations (2D/3D)
- Geomodels, Well Correlations, Cross-Sections, Stratigraphic Columns, Sedimentary Facies, Lithology, Geobody Interpretations, V-Shale/Clay
- Reservoir Depth
- Reservoir Thickness
- Reservoir Extent, Outer Radius of Reservoir, Hydrodynamic Boundary
- Water Chem., Salinity, Hydraulic Flow
- Temperature Measurements
- Pressure Measurements, Pore Pressure Model, Capillary Pressure Curve
- Porosity (Seal)
- Permeability (Seal)
- Seal Thickness
- Structural Interpretations, Faults, Natural Fractures
- Historical Subsurface Use, Oil and Gas Production, Mines, Geothermal Recovery

**Technical Viability Components**
- Reservoir Suitability
  - Reservoir Quality
  - Reservoir Geometry
  - Reservoir Conditions
- Retention and Geomechanical Risk
  - Seals and Pressure
  - Trap
  - Faulting
- Hazards
  - Subsurface Hazards
  - Surface Hazards
- Environmental Justice, Social Justice, and Community Impacts
  - Community Sentiment
  - Impact on Community
- Siting, Regulatory, and Political Considerations
  - Land Rights/Use
  - Population and Habitats
  - Jurisdiction
  - Regulatory

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Data linkage to CS TVA components

- Solving the “one-to-many” problem where data relate to multiple components
- Twofold process of manual QAQC and looking for opportunities to automate tagging, metadata review

Data Required: Tagged & Labeled Data

Components
- Reservoir Quality
- Reservoir Geometry
- Reservoir Conditions
- Seals & Pressure
- Trap
- Faulting
- Subsurface Hazards
- Surface Hazards
- Infrastructure
- Ecological Hazards
- Land Rights
- Population
- Regulatory
- Community
- Sentiment
- Community Impact

Categories
- Hazards
- Retention & Geomechanical Risk
- Siting, Regulation, & Jurisdictional Feasibility
- Reservoir Suitability
- Environmental, Justice, Social Justice, & Community Impacts

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After available data is inventoried and components are assigned, the availability of data within CS TVA database is spatially assessed.
Example results: Infrastructure Data Availability in California

- Summation of data required to meet CS TVA component reveals the data availability for that component
- Manual/keyword labeling component is critical
- Metadata tagging is one major advancement
Continued iteration to progress suite of products

- Database development and aggregation of relevant resources
- Trials of workflow and utilizing data science, spatial inventory tools
- Continued workflow development and refinement to support data availability assessments

- Ultimately, suite of products will form the Carbon Storage Technical Viability Approach (CS TVA) to support identification of ideal carbon storage locations
Next steps for the Carbon Storage Technical Viability Approach

- **Technical report** detailing criteria matrix
- **Nationwide data availability assessment release**
- **Technically Viable Carbon Storage Database v1.0** release to DisCO$_2$ver

- **Automating** data availability workflow to **accelerate manual components**
  - Natural Language Processing and GenAI for **data labeling**
  - Discovery of **useable data** using AI-informed image embedding tool

[Image link: https://edx.netl.doe.gov/disco2ver]
References


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