SMART Task 6: Evaluation of the Costs of Geologic CO_2 Storage for the Illinois Basin Decatur Project Site Using the NRAP/SMART Technoeconomic and Liability Evaluation for Storage (TALES) Model

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Science-informed Machine Learning to Accelerate Real Time (SMART) Decisions in Subsurface Applications

Overview

The cost of designing, permitting, constructing, operating and closing a CO_2 saline storage project is of vital importance to project developers. The National Energy Technology Laboratory has developed the NRAP/SMART Technoeconomic and Liability Evaluation for Storage (TALES) model to provide quantitative cost-based insights to support developers planning CO_2 injection and storage projects. TALES calculates the revenues, costs, and financial performance of candidate CO_2 saline storage project based on site-specific activity costs and financial parameters. TALES is being integrated as a module pertaining to storage cost as part of the broader SMART Visualization and Decision Support Platform (SVDSP). In this study, the TALES model was applied using real activity cost data associated with the development and operations at the Illinois Basin Decatur Project (IBDP) CO_2 storage project site. Scenario analysis was implemented in which crucial operational and cost attributes were varied and the associated cost implications observed. Key results data and project cost summary metrics like first-year breakeven price of CO_2 ($/tonne) and net present value (NPV) are presented in similar fashion to how they will appear in the SVDSP.

Technoeconomic and Liability Evaluation for Storage (TALES) Model Overview

- TALES is a Python-based CO_2 storage project engineering economic and liability evaluation model and is part of the broader SMART Visualization and Decision Support Platform (SVDSP).
- TALES utilizes CO_2 storage project activities to generate costs. Activity costs ($ac_{ie}(t)$) occur at specific points in time over the project duration. TALES accounts for not just the cost of activities, but also the timing for when costs occur as part of the model's cash flow calculations. These activities can be:
  - Discrete cost items that occur at specific times (cash flows)
  - Capital costs, fixed operational and maintenance (O&M) costs, or variable O&M costs
  - If an activity is a capital cost, the costs must be in one depreciation category

$$ac_{ie}(t) = acstat_i * acf_{ie} * \upsilon_{ie}(t) * s_{ie}(t)$$

Cost for specific activity	State of activity *i*	Activity cost factor for activity *i*	Measure of operational or physical variable that may vary in time and activity cost depends upon	Schedule when costs associated with activity *i* are incurred.
Subscript *e* refers to the type of cost (capital cost, fixed O&M cost, or variable O&M cost)	1 if the activity is being implemented or 0 if the activity is not being implemented	Time-independent constant value in constant or real dollars One-time cost or a cost that recurs over time	e.g., CO_2 plume area at time *t*, rate of injection	Value is either 0 or 1 depending on when in time *t* the activity cost occurs

Illinois Basin Decatur Project (IBDP) Technical Overview

- IBDP injected and stored one million metric tonnes of CO_2 over three years from the Archer Daniels Midland's ethanol fermentation plant in Decatur, Ill.
- The project used an extensive suite of wells and monitoring approaches.
- Studies by the University of Illinois at Urbana-Champaign, Illinois State Geological Survey, and Trimeric Corporation [1, 2] summarized activities conducted at IBDP, when they occurred, and their associated costs.
- These studies also provided a costs estimate of a theoretical commercial-scale capture and storage operation at IBDP – i.e., 20 yrs injection at 1 MMt/yr.

Map of the IBDP storage project showing locations of wells and near-surface monitoring equipment

Setting up TALES to Evaluate CO_2 Storage Cost for IBDP

- The TALES model was run under four separate scenarios that reflect different operational cases using IBDP site activities and associated costs provided from the Greenberg (2021) and Greenberg et al. (2022) references noted below.
- TALES input for each scenario was modified to reflect conditions in the table below. All other project variables were assumed fixed across scenarios.

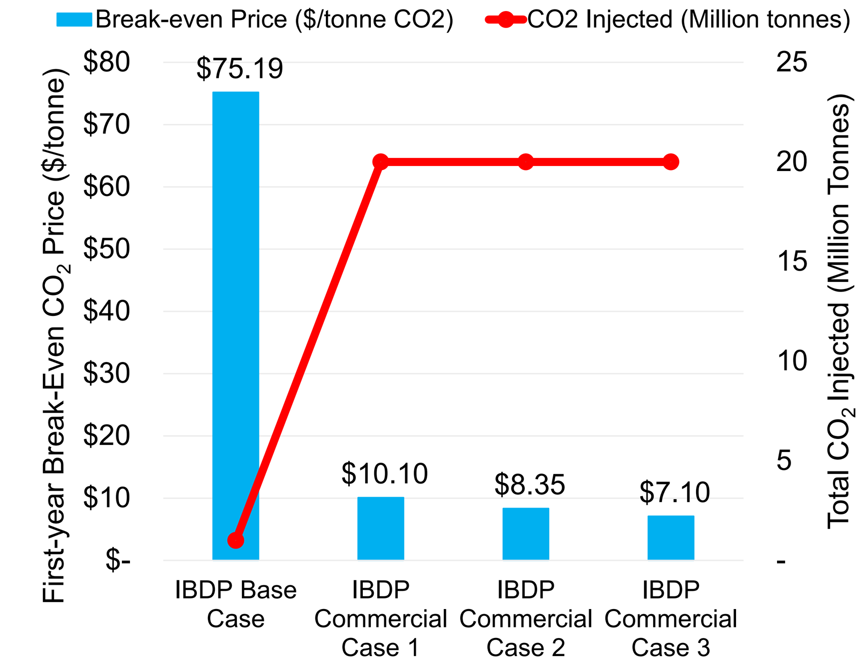
Cost and operational parameters varied across modeling scenarios

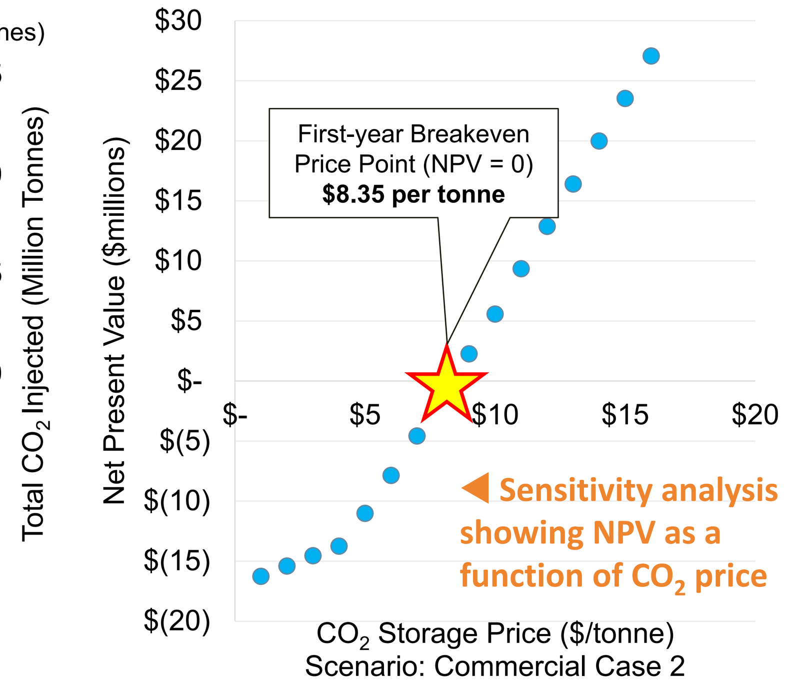
Attribute Assumption	IBDP Base Case	Commercial Case 1	Commercial Case 2	Commercial Case 3
CO_2 Price	$20 / tonne			
Injection Duration	3 years	20 years		
Post-injection Site Care (PISC) Duration	6 years	50 years	20 years	
Injection Rate	0.333 MMT/yr	1 MMT/yr		
Injection Well Count	1 injection well			
Monitoring Well Count	1 deep; 1 geophone	1 deep monitoring well		
2D seismic	2 lines during site characterization	2 lines during site characterization – length based on anticipated diameter of calculated seismic area		
3D seismic	1 pre-injection; 1 post injection (cost = $930K per event; $250K per mi^2 for 3D seismic)	Every 5 years during operations and PISC (cost = $250K per mi^2)		Every 5 years during operations and PISC (cost = $80 mi/^{2})
Project Equity	100%	45%		
Financial Responsibility	Self-insurance	Trust Fund		
Pore Space Rights and Surface Leases	No	Yes		
Long-term Stewardship and Emergency and Remedial Response Fees (per tonne)	No	Yes		
Site closure	No	Yes		

- Key financial variable settings used across all modeling scenarios included:
  - Minimum desired internal rate of return on equity (%/yr) at 10%
  - Cost of debt (%/yr) at 6%
  - Effective tax rate (federal and state) (%/yr) at 25.74%
  - Escalation rate from project start year and beyond (%/yr) at 0%

Results Overview

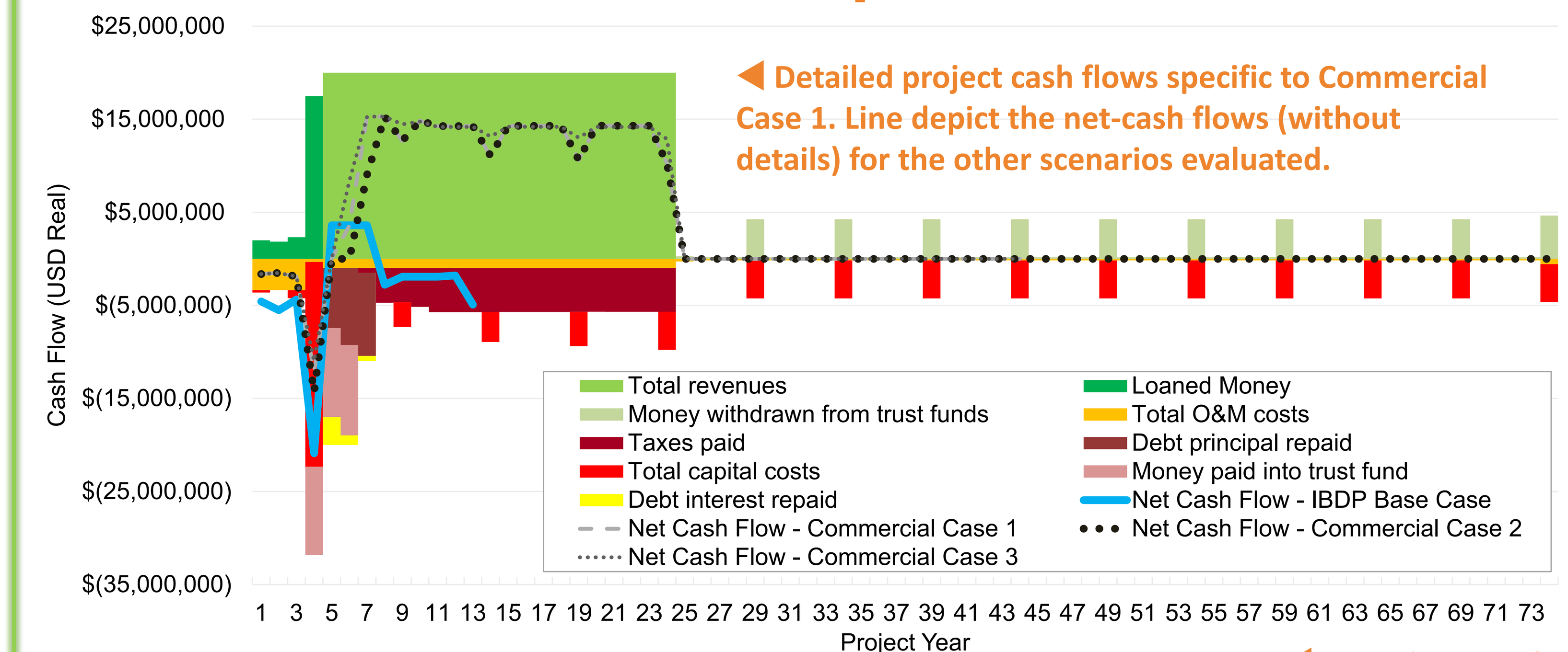
- Cost data are presented below in a fashion that enable comparison across scenarios.
- All costs data are in 2007$; aligning to the actual start date of the IBDP field project initial characterization efforts.



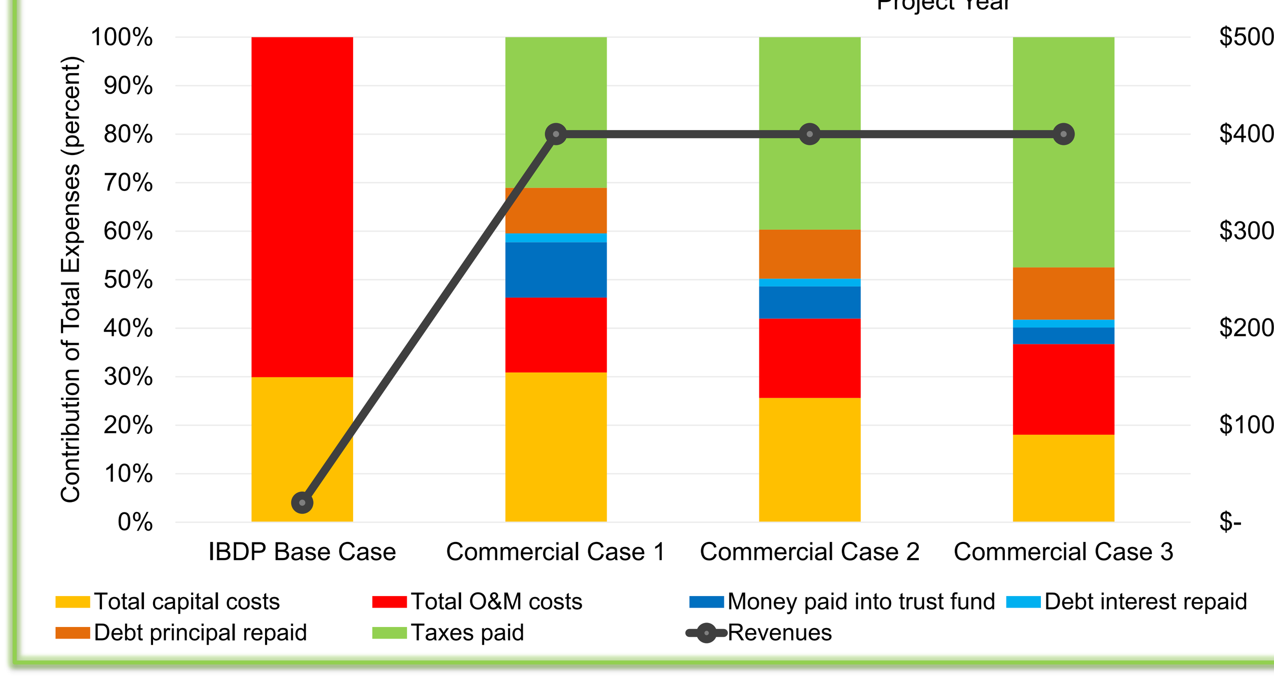


◀ Sensitivity analysis showing NPV as a function of CO_2 price

▲First-year breakeven price assessment between scenarios. Higher annual CO_2 injection volumes over longer injection periods provides $/tonne cost advantages to the commercial cases. Shorter PISC duration in Commercial Cases 2 and 3 and lower 3D seismic unit costs in Case 3 reduces the cost of the storage operation resulting in reduced first-year break-even CO_2 price.



◀ Detailed project cash flows specific to Commercial Case 1. Line depict the net-cash flows (without details) for the other scenarios evaluated.



◀ Contribution of total project expenses by scenario. IBDP Base Case is not profitable at $20/tonne CO_2 price, so no taxes paid. Lower contribution of capital and operating costs as PISC timeframe reduced and seismic costs drop.

Disclaimer

References

[1]Greenberg, S. 2021. "Illinois Basin Decatur Project Final Report – An Assessment of Geologic Carbon Sequestration Options in the Illinois Basin: Phase III. Illinois State Geologic Survey. Champaign, Illinois

[2]Greenberg, S., Whittaker, S., Vance, A., and McKaskle, R. 2022. "Projecting CCUS project costs using the Illinois Basin – Decatur Project as a cost basis." 16th International Conference on Greenhouse Gas Control Technologies, GHGT-16. Lyon, France

Conclusions

- This study shows how CO_2 storage cost evaluation capability provided by TALES offers key decision support insights that can be used to inform future project planning.
- Project cost assessment capabilities enabled by TALES can be coupled with the rapid predictive modeling provided by the broader SMART toolsets, collectively offering improved and more robust decision support than considering only technical feasibility aspects of project development and operation in isolation.