SMART-Phase 2: Science-informed Machine Learning to Accelerate Real Time (SMART) Decisions in Subsurface Applications

Overview of the NRAP/SMART Technoeconomic and Liability Evaluation for Storage (TALES) Model

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Project Overview

- Objectives
  - Develop an engineering economic model for a CO_2 saline storage project
  - Should be site-specific
  - Needs to work with SMART tools
  - Needs to integrate into the SMART Platform
- Justification
  - SMART tools provide insight into the technical aspects of a storge project
  - Project developers and other stakeholders care (a lot) about the cost and financial performance of a storage project
  - Integration of an engineering economic model with SMART tools provides developers and stakeholders with a more complete appraisal of a storage project
- Project history
  - Development of an engineering economic model or module started with Phase 2 of SMART as part of Task 6 (currently sub-task 6.6)
  - Performance dates are April 1, 2022 to March 31, 2027
  - Funding is approved on an annual basis

Engineering Economic Module

- Implemented as the Technoeconomic and Liability Evaluation for Storage (TALES) Model
  - Python-based model that uses the FECM/NETL CO_2 Saline Storage Cost Model (CO2_S_COM) as its foundation
  - Cash flow model that includes revenues and costs for all aspects of a storage project
  - Includes all costs needed to comply with Class VI regulations including costs of financial instruments to comply with financial responsibility requirements of Class VI regulations
  - Includes a financial model
- Assumes storage project occurs in five stages with typical durations in parentheses:
  - Site screening, selection and characterization (1-3 years)
  - Permitting and construction (1-4 years)
  - Operations (varies, e.g., 30 years)
  - Post-injection site care (PISC) and site closure (varies, e.g., 10 years, 50 years)
  - Long-term stewardship (indefinite future, may be responsibility of the state)

Cost and Revenue Calculations in TALES

- Foundation of costs are activities
  - Activities are discrete cost items that occur at specific times, such as drilling and completing injection wells, implementing a 3D seismic survey every 5 years during operations
  - ac(t) = acf * sc(t) * u(t)

    ac(t) = activity cost in year t

    acf = activity cost factor (constant in time)

    sc(t) = scheduling variable (0 if activity does not occur, 1 if activity occurs at time t)

    u(t) = variable depending on an operational or physical process (OpPh) variable such as mass of CO_2 injected each year
  - Activity costs are classified as capital costs, fixed O&M costs or variable O&M costs
  - Activity costs classified as capital costs must be applicable to a single depreciation category
- Revenues
  - rv(t) = rriv * u(t)

    rv(t) = revenue in year t

    rriv= revenue-related input variable (constant in time), such as the price for storing CO_2

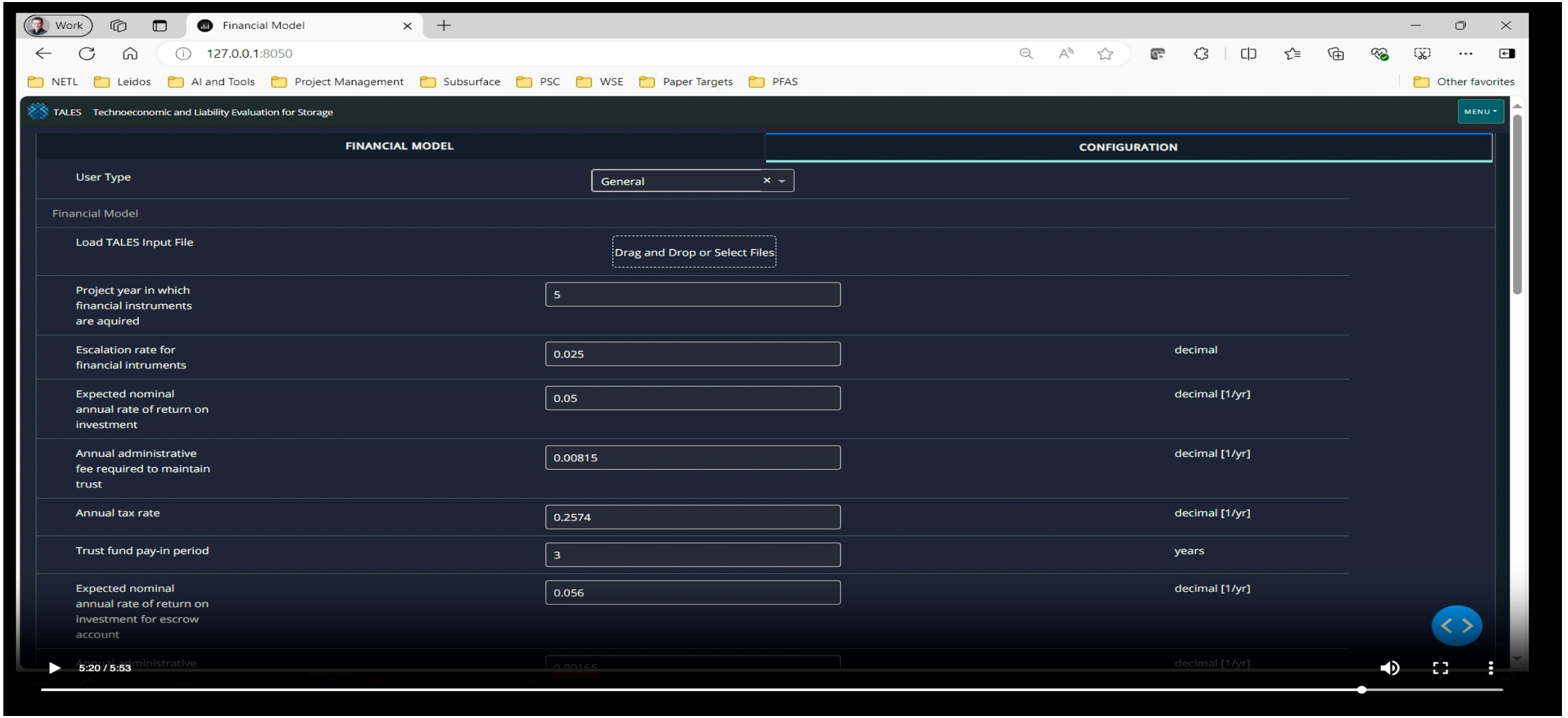
Financial Calculations in TALES

- Revenues, capital costs and O&M costs are expressed as cash flows in constant and nominal dollars
- Cost of financial instruments to address financial responsibility (e.g., trust fund) are calculated
- Capital costs are depreciated, and taxes calculated
- Earnings to project are calculated in nominal dollars
  - earn(t) = cash_in(t) – cash_out(t)
    - cash_in(t) = sources of cash. These are cash flows into the project.
      - Revenue, cash from financial instrument, debt proceeds, equity investment
    - cash_out(t) = uses of cash. These are cash flows out of project.
      - Capital costs, O&M costs, payments into financial instrument, debt interest payments, debt principal payments, taxes paid
- Earnings to owners are earnings to the project minus equity investment (aka earnings to owners)
- Earnings to owners are discounted to give cash flow of earnings in present value dollars
- Earnings to owners in present value dollars are summed to give the net present value (NPV) for the project
  - If NPV exceeds zero, price for storing CO_2 is high enough for project to be viable
  - TALES also calculates the break-even CO_2 price where NPV equals zero (project is viable at this CO_2 price, but just barely viable)

Inputs

- Most inputs are provided through an Excel file
- Some inputs are provided through a graphical user interface (GUI) using the STRIVE API and the Plotly/Dash front end
  - More inputs will be provided through the GUI in the future
  - Developing capability to use GUI to define scenarios where user can alter input variables, and the model is run for each scenario to examine the influence of these altered inputs
- Currently working with developers of other SMART tools to obtain inputs from these tools
  - USM: CO_2 injection rates over time, CO_2 plume areas over time, pressure front areas over time
  - Risk: AoR
- Starting interactions with RTFO model to obtain inputs and provide costs as a component of the optimization process
- Working with developers of the SMART Platform to integrate TALES into the Platform

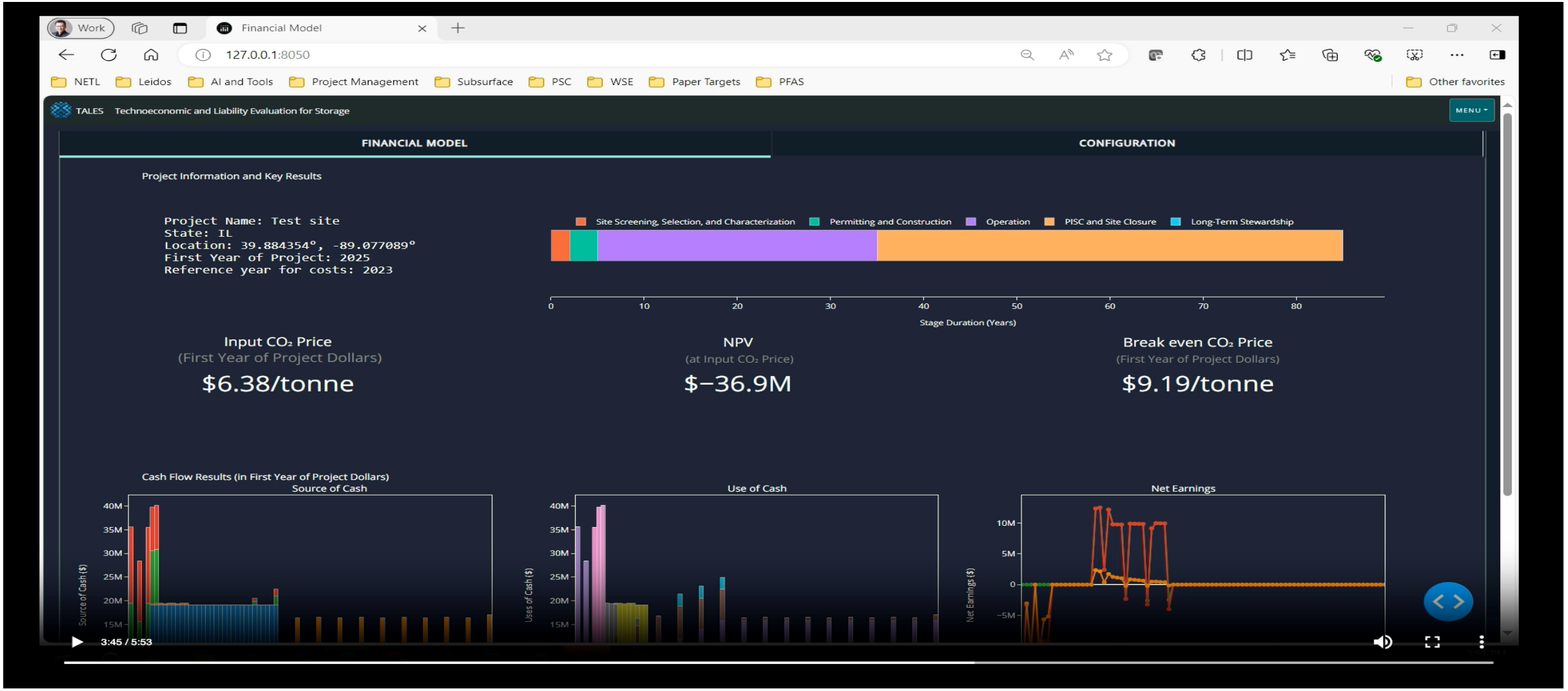
Inputs


Work
Financial Model
127.0.0.1:8050
NETL
Leidos
AI and Tools
Project Management
Subsurface
PSC
WSE
Paper Targets
PFAS
Other favorites
TALES Technoeconomic and Liability Evaluation for Storage
MENU
FINANCIAL MODEL
CONFIGURATION
User Type
General
Financial Model
Load TALES Input File
Drag and Drop or Select Files
Project year in which financial instruments are aquired
5
Escalation rate for financial intruments
0.025
decimal
Expected nominal annual rate of return on investment
0.05
decimal [1/yr]
Annual administrative fee required to maintain trust
0.00815
decimal [1/yr]
Annual tax rate
0.2574
decimal [1/yr]
Trust fund pay-in period
3
years
Expected nominal annual rate of return on investment for escrow account
0.056
decimal [1/yr]
5:20 / 5:53

Outputs

- Detailed results provided in csv file that can be opened directly in Excel
- GUI currently provides graphical display of key results
  - NPV at CO_2 price input by the user and break-even CO_2 price
  - Sources of cash—these are cash flows into the project (in constant dollars in first year of project)
    - Revenue, trust fund withdrawals, debt proceeds, equity investment
  - Uses of cash—these are cash flows out of project (used to pay costs or financial obligations of project) (in constant dollars in first year of project)
    - Capital costs, total O&M costs, payments into trust fund, debt interest payments, debt principal payments, taxes paid
  - Earnings
    - Earnings to project in constant dollars in first year of project: Sources of cash minus uses of cash
    - Earnings to owners in constant dollars in first year of project: Earnings to project minus money invested by owners (equity)
    - Earnings to owners in present value dollars: Earnings to owners in nominal dollars that are then discounted
      - Note: The net present value (NPV) of the project is the sum of the earnings to owners in present value dollars
  - More results will be added as GUI is developed further

Outputs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PFAS
Other favorites
TALES Technoeconomic and Liability Evaluation for Storage
MENU
FINANCIAL MODEL
CONFIGURATION
Project Information and Key Results
Project Name: Test site
State: IL
Location: 39.884354°, -89.077089°
First Year of Project: 2025
Reference year for costs: 2023
Site Screening, Selection, and Characterization
Permitting and Construction
Operation
PISC and Site Closure
Long-Term Stewardship
0
10
20
30
40
50
60
70
80
Stage Duration (Years)
Input CO₂ Price
(First Year of Project Dollars)
$6.38/tonne
NPV
(at Input CO₂ Price)
$−36.9M
Break even CO₂ Price
(First Year of Project Dollars)
$9.19/tonne
Cash Flow Results (in First Year of Project Dollars)
Source of Cash
Use of Cash
Net Earnings
40M
35M
30M
25M
20M
15M
10M
5M
0
−5M
Source of Cash ($)
Uses of Cash ($)
Net Earnings ($)
3:45 / 5:53

Conclusions

- Alpha version 0.5 of the NRAP/SMART TALES Model will be released soon
  - Currently the Python console version can be run
    - Contact: David Morgan (david.morgan@netl.doe.gov) or Chung Yan Shih (chungyan.shih@netl.doe.gov)
  - GUI version uses STRIVE API and Plotly/Dash as the front end platform, so it requires STRIVE to be installed first
- Next steps:
  - October 2024:
    - Integration of output from USM and Risk Module into TALES
    - Initial integration with RTFO
    - Improved GUI and initial integration into SMART Platform
    - Demonstration using data from IBDP project
  - January
    - Merit review of SMART project
  - March 2025:
    - Better integration with RTFO
    - Advanced integration with SMART Platform
    - Updated user's manual, example input and output data sets, report on results using data from IBDP site

Poster and Demonstration

- Poster: 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
- Demonstration of NRAP/SMART TALES Model

Contributors

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Questions?

- Thank you

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