# FE/NETL CTS Cost Models and Benefits Assessment of Carbon Storage R&D Program


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Developing the Technologies and Building the Infrastructure for $CO_2$ Storage

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# Presentation Outline

- Overview of benefits assessment
- Overview of FE/NETL models used to assess benefits of $CO_2$ capture and storage
- Benefits evaluation of Storage Program's R&D projects using a model to estimate costs of $CO_2$ storage in a saline aquifer
- Description of model used to estimate costs of $CO_2$ enhanced oil recovery (EOR)

# Typical Approach to Benefits Assessment

- Benefits
  - As in cost-benefit
  - Benefit of NETL R&D to the US economy & taxpayer
- Estimate cost of technology (e.g., $CO_2$ storage in saline aquifer) in absence of R&D (Baseline Scenario)
- Review R&D program to determine how R&D can influence costs
- Estimate cost of technology assuming R&D program is successfully implemented (R&D Scenarios)
- Difference in costs between Baseline Scenario and R&D Scenarios is measure of benefit

# Factors Complicating Benefits Assessment of $CO_2$ Storage

- Baseline Scenario costs are highly uncertain
  - $CO_2$ storage is new technology
  - Applicable regulatory framework is evolving
  - Very few field projects to estimate/validate costs
- Not all R&D projects will result in quantifiable cost reductions (i.e., they have other benefits)
  - Benefits of infrastructure projects
    - Demonstrate feasibility of $CO_2$ storage
    - Establish/validate baseline scenario costs
- Model of $CO_2$ storage in a saline aquifer will be used to establish Baseline Scenario and R&D Scenario costs

# An Alphabet Soup of Models

**FE/NETL $CO_2$ Transport & Storage (CTS)-Saline Cost Model**
- Point-to-point pipeline transport cost (pending)
- Cost and revenue from $CO_2$ storage in saline aquifer

**FE/NETL $CO_2$ Transport & Storage (CTS)-EOR Cost Model**
- Point-to-point pipeline transport cost (pending)
- Cost and revenue from $CO_2$ enhanced oil recovery (EOR)

**FE/NETL CTUS Model**
- Sources of $CO_2$
- $CO_2$ pipeline network
- Cost and revenue from $CO_2$ storage in saline aquifer and from $CO_2$ EOR

**FE/NETL NEMS-CCUS Model**
- Macroeconomic model of US economy
- Detailed model of US energy sector

# Features of FE/NETL CTS-Saline Cost Model

- Estimates profit (or loss) for a project storing $CO_2$ in saline aquifer
- Includes cost of complying with Class VI injection well regulations and Subpart RR regulations
- Determines break-even price of $CO_2$
- Develops cost-supply curves for potential injection formations in US
- Identifies cost drivers for saline storage

# FE/NETL CTS-Saline Cost Model: Injection Characteristics

- Specify mass of $CO_2$ to be stored annually: 3.2 million tonnes/yr
- Specify duration of injection: 30 years
- Select a formation from database of 151 geologic formations
- Model calculates:
  - $CO_2$ plume area
  - Number of injection wells needed

# FE/NETL CTS-Saline Cost Model: Timeline of Operational Activities

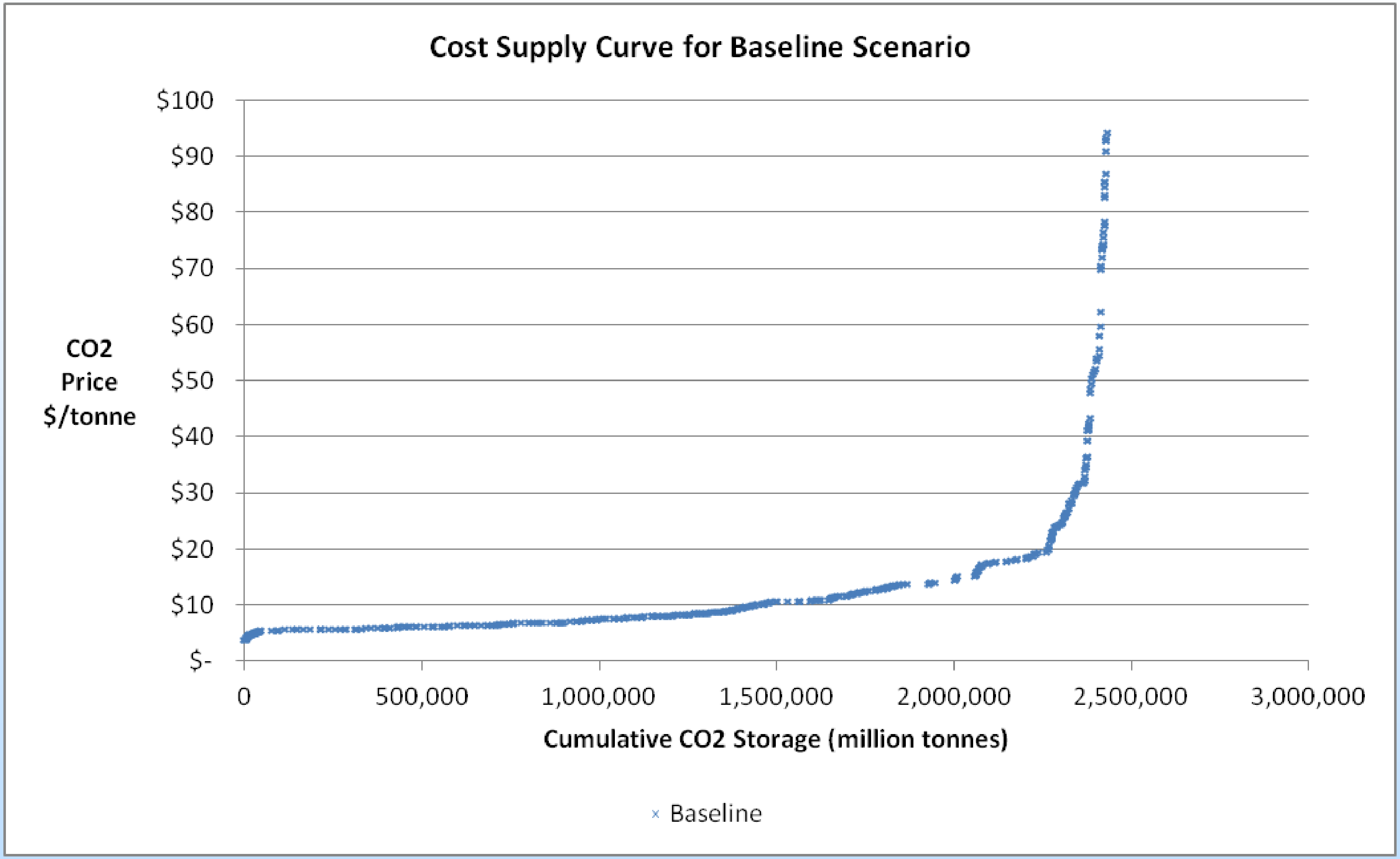
Timeline (years): 0, 1, 4, 6, 36, 86

- Site selection - 1 yr
- Site characterization - 3 yrs; strat-wells, 3-D seismic
- Permitting - 2 yrs; design, submit plans, install injection wells
- Operations - 30 yrs
  - Operate and maintain injection wells
  - Monitoring: 3D seismic; monitoring wells: in reservoir, above reservoir, groundwater, vadose zone
  - Emergency & Remedial Response (ERR): insurance policy at $0.75/tonne
  - Plug injection wells at end of operations
- Post-injection site care (PISC) & closure – 50 yrs
  - Monitor using same techniques & schedule as operations
  - Plug monitoring wells and remove surface equipment at closure
- Long-term stewardship – indefinite future

# Procedure for Calculating Cost-Supply Curve

- Calculate break-even first-year price of $CO_2$ for each formation (first year is 2012)
- Calculate total mass of $CO_2$ that can be stored in each formation
- Sort data by break-even price of $CO_2$
- Calculate cumulative mass of $CO_2$ that can be stored
- Plot break-even price of $CO_2$ against cumulative mass of $CO_2$ that can be stored

# Baseline Cost-Supply Curve for Saline Storage



# Cost Drivers for $CO_2$ Saline Storage

- Cost drivers (based on present value costs):
  - Strat-wells: about 10% of total costs
  - Injection wells: about 20% of total costs
  - Deep monitoring wells: about 20% of total costs
  - 3-D seismic: about 30% of total costs

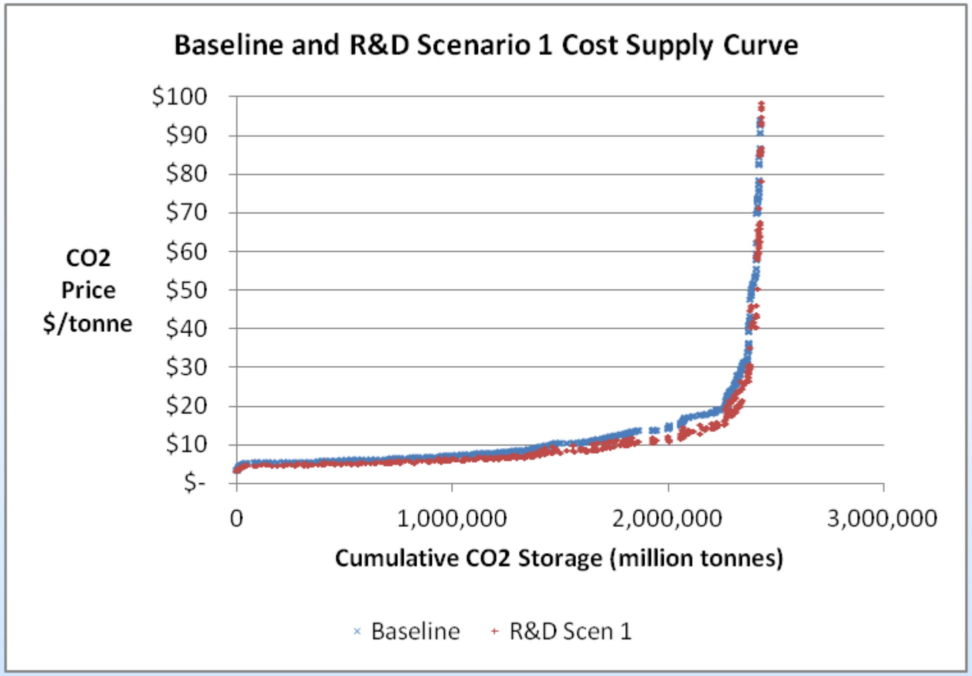
# R&D Scenario 1

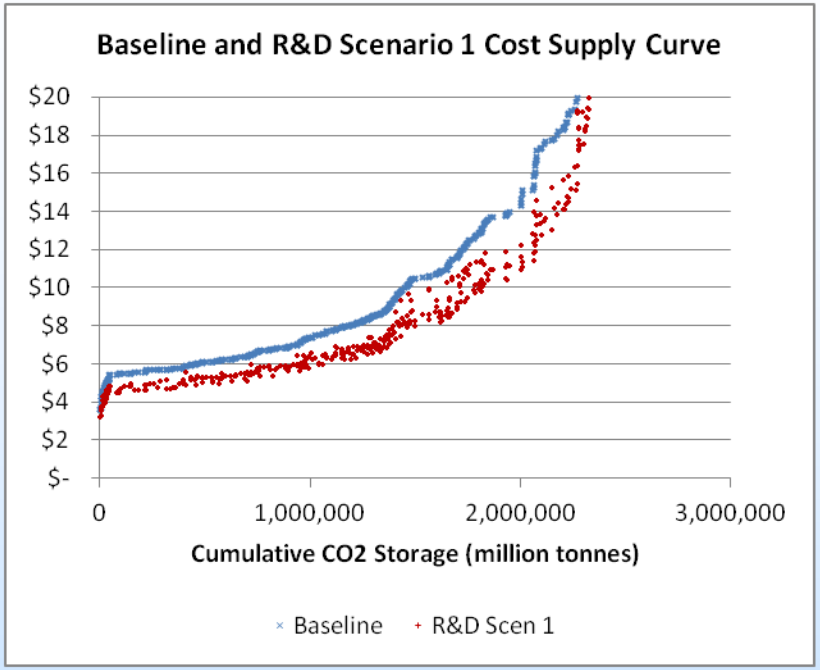
- Reduce 3-D seismic cost
  - R&D: Improve seismic imaging through rock core tests, model calibration and improved data processing
  - Model changes: $5 million for lab tests & model calibration; reduce 3-D seismic from $160K/mi^2$ to $90K/mi^2$
- Reduce monitoring well density
  - R&D: Integrate models, monitoring data & improved data processing methods to better forecast $CO_2$ plume
  - Model changes: Reduce number of deep monitoring wells by about a third; add $100K per year for increased data processing
- Reduce ERR cost
  - R&D: Characterize risks of storage, better locate storage sites to reduce risks, mitigate small leaks if they are detected
  - Model changes: Reduce ERR insurance policy premium from $0.75/tonne to $0.50/tonne of $CO_2$ injected

# R&D Scenario 2

- Reduce 3-D seismic cost
  - R&D: Improve seismic imaging through rock core tests, model calibration and improved data processing
  - Model changes: $5 million for lab tests & model calibration; perform 3-D seismic during site characterization; replace 3-D seismic with 2-D seismic (10 lines)
- Maintain monitoring well density
  - R&D: Integrate models, monitoring data & improved data processing methods to better forecast $CO_2$ plume
  - Model changes: Maintain monitoring well density to partially compensate for 2-D rather than 3-D seismic; add $100K per year for incr. data process.
- Reduce ERR cost
  - R&D: Characterize risks of storage, better locate storage sites to reduce risks, mitigate small leaks if they are detected
  - Model changes: Reduce ERR insurance policy premium from $0.75/tonne to $0.50/tonne of $CO_2$ injected

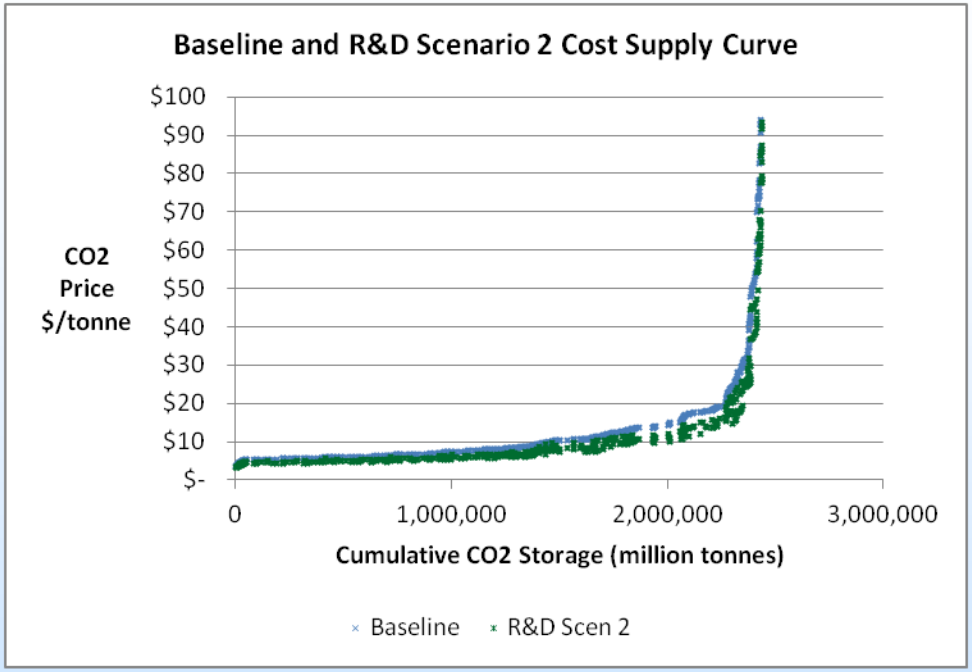
# Influence of R&D Scenario 1 on Costs

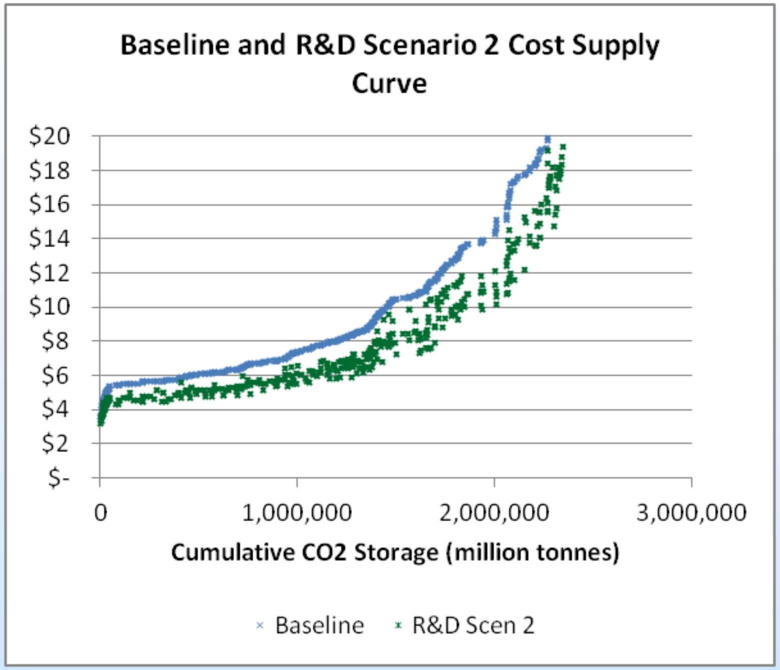



- Costs reduced 10 to 16%

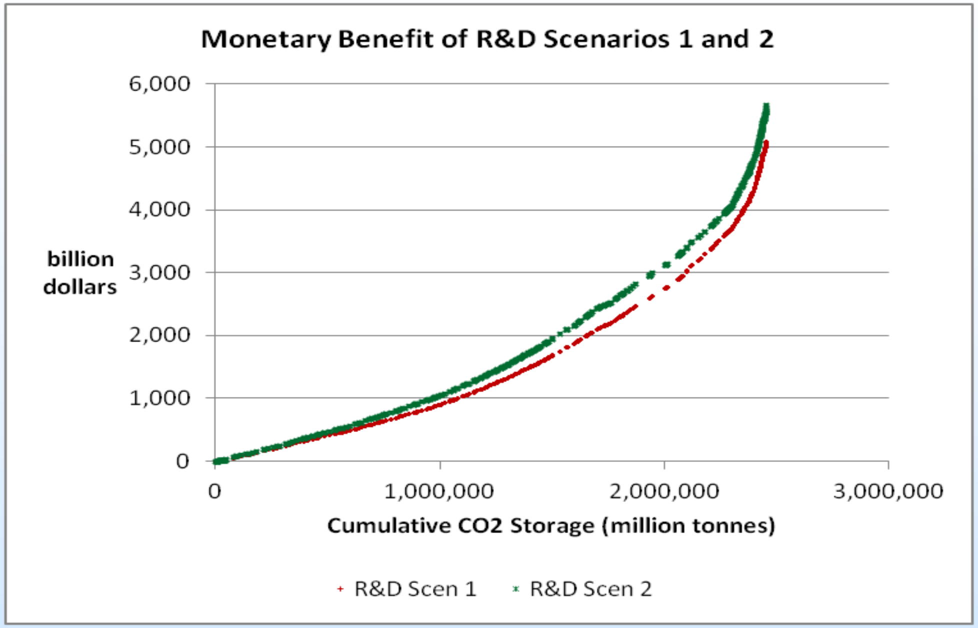
# Influence of R&D Scenario 2 on Costs

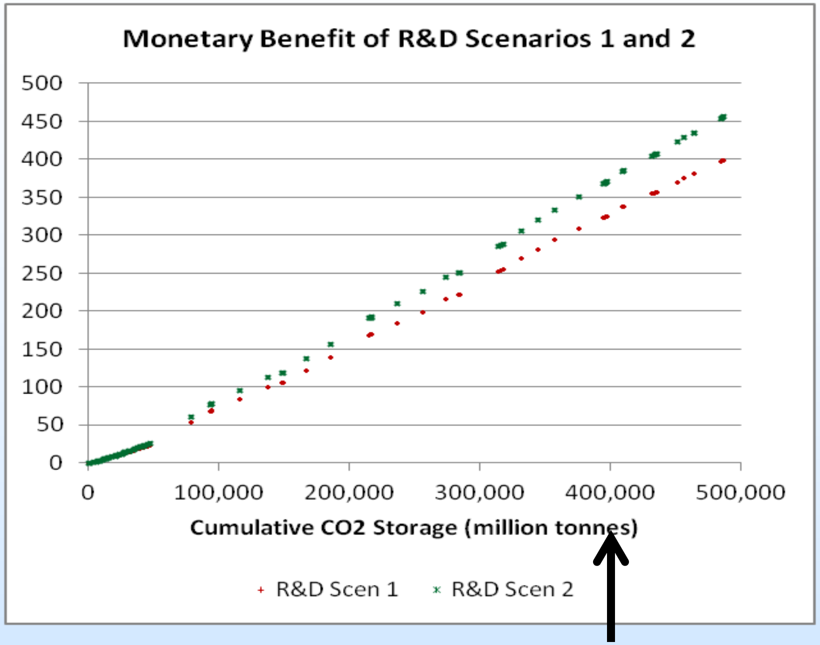



- Costs reduced 11 to 17%

# Potential Monetary Benefit of R&D




- 90% of estimated $CO_2$ emissions from electric power generation and industrial sources for next 100 years: 400,000 Mtonnes
- Benefit could potentially be many billions of dollars over next 100 years
- Benefit depends on how much $CO_2$ is stored and when it is stored (i.e., benefit needs to be discounted appropriately)

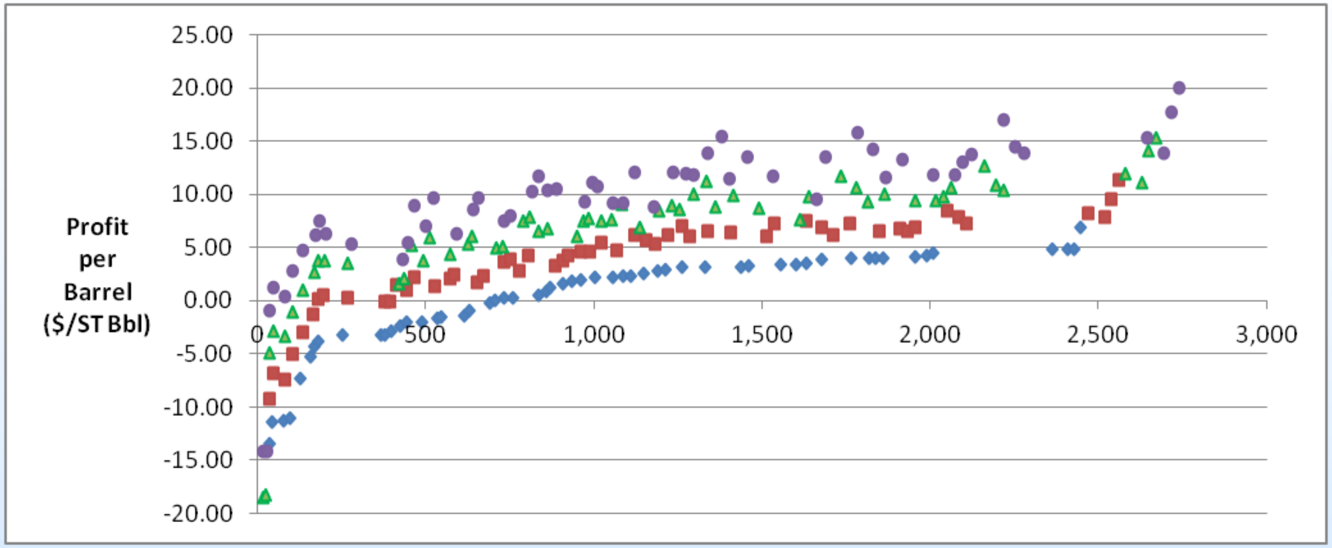
# Next Steps in Benefits Evaluation (FY 2013)

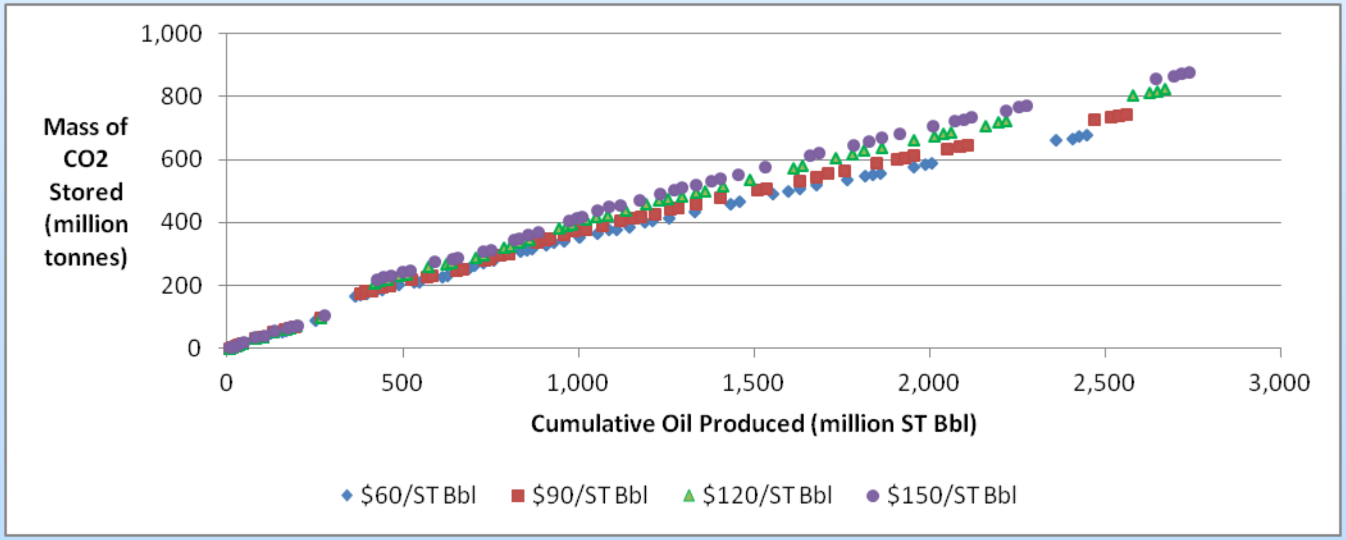
- Continue to map R&D projects to activities in cost model
- Add activities to cost model, as necessary
- Work with NETL project managers and Principal Investigators to
  - Estimate possible impact of R&D projects on costs
  - Improve cost estimates for activities
  - Develop additional R&D scenarios

# Features of FE/NETL CTS-EOR Cost Model

- Uses FE/NETL's $CO_2$-Prophet model to estimate oil production and $CO_2$ storage over time using a 5-spot pattern
- Implements patterns over time in oil reservoir
- Includes EIA's database of 1,831 oil reservoirs that EIA views as potential targets for $CO_2$ EOR
- Estimates profit (or loss) for a $CO_2$-EOR project and $CO_2$ stored in reservoir
- Example: Profit (or loss)/ST Bbl and $CO_2$ stored for reservoirs with OOIP over 50 million ST Bbl
  - $CO_2$ cost: $30/tonne
  - Wellhead oil price: $60, $90, $120, $150/ST Bbl

# Very Preliminary Results: Profit per Barrel of Oil Produced and Total Mass of $CO_2$ Stored




- As wellhead oil price rises, profitability increases
- However, cumulative oil production does not increase dramatically
- Also, mass of CO2 stored does not increase dramatically

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  - NETL: Tim Grant, David Morgan, Charles Zelek
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# Thank you

- Questions?