## **Direct Air Capture:** NETL Technoeconomic Analysis **Capabilities and Related Efforts**

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### **Energy Process Analysis - Overview**



Process Modeling & Performance Assessment

#### Capital and O&M Cost Estimation

Quality Guidelines for Energy System Studies

#### **Core Functions**

- Conceive, plan, and execute process- and plant-• level performance and cost model development and analysis, including those incorporating novel energy conversion, energy storage, and/or environmental control technologies.
- Develop, maintain, and apply standards, tools, and databases to support the efficient, consistent execution of high-quality analyses, including those carried out by external entities (e.g., extramural NETL projects).

#### **Analysis Process** 1. Process Simulation and Conceptual Design Cost Data Process Synthesis and System Integration Vendor Quotes Simulation of Major Chemical Processes •EPC Database Modeling of Major Equipment Published Data Commercial Software •DOE RD&D Projects Internal Estimates **Performance Calculations** Tools • R&D Targets Detailed Mass and • Aspen Plus ® **Energy Balances** Thermoflow Efficiency and Emissions Chemcad Water Consumption NETL Models Equipment Sizing, Specs CAPEX

 NETL Models 2. Cost Estimation

(equipment, labor, EPC fees, contingencies) O&M Costs

Tools NETL's Power Systems **Financial Model (PSFM)** Other financial tools

- 3. Discounted Cash Flow Analysis
- Project finance structure
- Capital expenditure and operational schedule
- Taxes and Depreciation
- Inflation and escalation rates



### **Energy Process Analysis - Cost Estimation**



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Cost Estimating Approach Reflective of Intended Use and Available Data

#### • Economic Inputs

- Capital Cost
  - Equipment
  - Construction
  - Design
  - Contingency
  - Owners Costs
  - Time Value of Money
  - Operating and Maintenance (O&M) Cost
    - Labor
    - Maintenance
    - Consumables
    - Fuel
    - Byproduct Sale
    - Waste Disposal
- Operating Metrics (i.e., annual operating hours)

- Analysis Outputs
  Figure of Merit required to meet financial hurdle (i.e., internal rate of return)
  - \$/MWh ٠
  - \$/bbl liquids





### DAC Case 0B Block Flow Diagram







### **DAC System Assumptions**



Parameter	Assumed Value
Adsorber Vessel Type	Monolith
DAC Net Capture Rate, tonne CO <sub>2</sub> /yr	100,000
Plant Capacity Factor, %	85
CO <sub>2</sub> Product Purity	Meets pipeline specification without purification
DAC System Pressure Drop, psi (in. H <sub>2</sub> O) <sup>A</sup>	0.3 (7.78)
DAC System Capture Fraction	0.6
DAC Sorbent Desorption Temperature, °C (°F)	100 (212)
DAC Sorbent Regeneration Energy, GJ/tonne CO <sub>2</sub> (Btu/lb CO <sub>2</sub> )	4.3 (1,847)
DAC Sorbent Adsorption Temperature	Ambient
DAC Sorbent Adsorption Capacity, mol $CO_2/kg$ (lb $CO_2/lb$ sorbent)	1.2 (0.053)
DAC Sorbent Lifetime, years	0.5
Sorbent Cost, \$/ft <sup>3</sup> (\$/lb)	4.0 (0.09)

<sup>A</sup>Includes pressure drop across ducting and DAC vessels



## **Special Considerations On Reported Costs**



#### • Capital Cost Estimates

- DAC -50/+50, Class 5 AACE Classification
- Concept Screening

### • Not FOAK or NOAK Costs

- Consistent methodology applied as for commercial systems
- Detailed depiction of assumptions and design
- Capital costs and scaling parameters for the DAC system components were developed by Black & Veatch using in-house cost estimating references

### • Other Factors

• Site/project specific (Scale, Capacity Factor, Financing, Labor Rates, Regulations, etc.)

#### • Future Cost Trends

• Effect of R&D



# Breakeven CO<sub>2</sub> Selling Price







### **Sensitivity Analysis Summary**





### **Sensitivity - Capture Fraction**







### Sensitivity - Sorbent Cost







### **Types of Data for TEA Analysis**



- Development focus
- Proposed commercial process block flow diagram
- Proposed commercial sorbent reactor-regenerator process description
- Proposed sorbent reactor and regenerator contacting mode descriptions
- Test-sorbent properties (physical, equilibrium)
- Test-sorbent absorber/regenerator vessel characteristics
- Test-sorbent absorber/regenerator operating conditions
- Test-sorbent absorber/regenerator test results
  - Concentrations vs time
  - Energy used vs time



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# Questions/ Comments

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