

Techno-Economic Analysis



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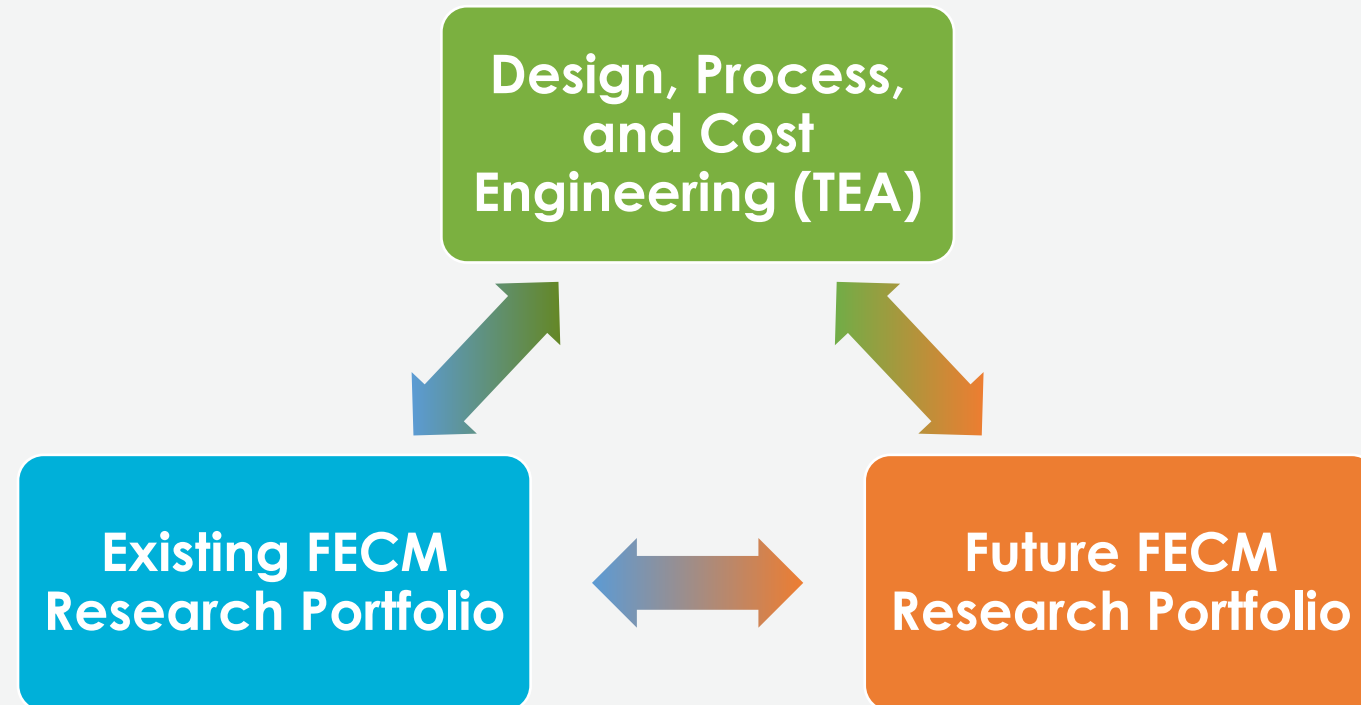


Southeast Regional Carbon Conversion Procurement Grant Program Workshop
August 30, 2022

NETL Role with FECM Programs

Design, Process, and Cost Engineering at NETL

DOE-FECM Program Goals and Objectives



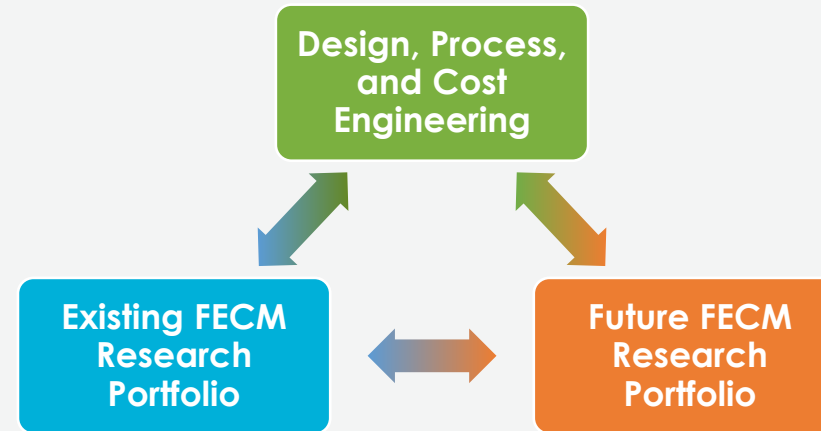
NETL Role with FECM Programs

Design, Process, and Cost Engineering at NETL

DOE-FECM Program Goals and Objectives

Existing FECM/NETL Research Portfolio

- Intramural and extramural R&D, spanning the technology readiness spectrum, from new concepts to commercial technologies.
- Provide bases for the evaluation of external techno-economic analyses, technology maturation plans, technology readiness assessments, etc.
- Support quantitative R&D goal setting, strategic planning, portfolio analysis, and program evaluation efforts.
- Provide public performance and cost data for use in energy system models.



Direct DOE-FECM Support

- Provide rapid response analyses on an *ad hoc* basis for NETL and the Office of Fossil Energy and Carbon Management.
- Periodic stakeholder progress and product briefings.

Future FECM/NETL Research Portfolio

- Support the future research portfolio through the identification of new energy conversion concepts and development of insight on the potential of new technology ideas.
- Assist in the establishment of new FECM programmatic thrusts (i.e. R&D opportunity, performance/cost metric establishment)
- Direct input into programmatic Funding Opportunity Announcements (FOA) and other extramural funding opportunities.
- Multi-laboratory initiative and consortium participation.

- **Introduction**
 - What is Techno-Economic Analysis?
 - Why Techno-Economic Analysis?
- **Basic Methodology for Conducting Techno-Economic Analysis**
 - NETL Quality Guidelines for Conducting Techno-Economic Analysis
- **Additional Available and Near-Term Documentation**
 - NETL Example Analyses / Technology Expertise
 - Performing a Techno-Economic Analysis for Carbon Conversion Technologies
 - Capital Cost Scaling Methodology for Carbon Conversion Technologies
- **Wrap Up**

What is Techno-Economic Analysis

- **Techno-Economic Analysis (TEA) provides a methodology for systematically assessing technology states against a fixed reference case**
 - It is a method of analyzing the economic performance of an industrial process, product, or service including carbon-derived products.
 - Objectives:
 - Guiding investment pathways for technology development
 - Quantification of R&D performance targets and priority
 - Provide a summary of results in a concise and visually coherent form
- **NETL has established robust knowledge and a set of tools relating to process modeling and cost estimation**
 - Results fed into or developed in parallel with Life Cycle Analysis (LCA), which derives the impacts of the technology from cradle-to-grave

Introduction

Why Techno-Economic Analysis

- TEA informs the discovery, design, and operation of processes that benefit from systematic decision-making techniques **for the often-competing** goals of maximizing profits, minimizing costs, addressing market and policy drivers, and meeting environmental and technical constraints.
- Provides a **transparent** and **verifiable** cost/performance comparison to business-as-usual production methodologies when following established methodologies for critical review
- Provides uncertainty quantification
- Provides an ideal performance/cost operating configuration to serve as a target for lower TRL technologies

NETL Techno-Economic Analysis Methodology



Quality Guidelines for Energy System Studies

- The methodology applied to TEA development involves the following four-step process:

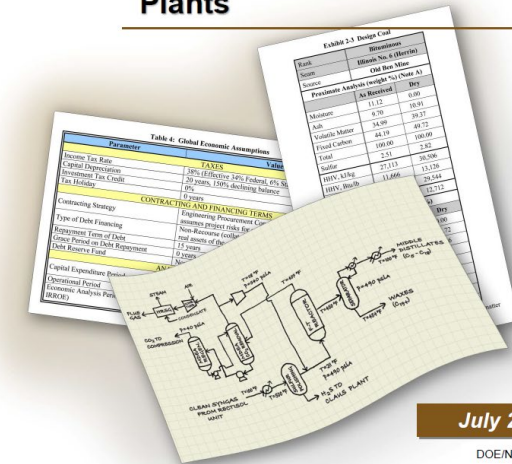
1. Development of a Technology Analysis Plan
2. Creation of a Performance Model
3. Cost Estimation
4. Reporting



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QUALITY GUIDELINES FOR ENERGY SYSTEM STUDIES

Performing a Techno-economic Analysis for Power Generation Plants



July 2015

DOE/NETL-2015/1726

NATIONAL ENERGY TECHNOLOGY LABORATORY



[NETL Performing a TEA Guideline Document Link](#)

Step One: Technology Analysis Plan

1. Technology Analysis Plan

- A technology analysis plan (TAP) is a roadmap for executing a TEA
 - Discusses the approach and methodology required to conduct the TEA
 - Develops a basic process flow diagram (PFD)
 - Should be discussed with end-users prior to initiating the analysis
 - Updated as the TEA is performed
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- **The Technology Analysis Plan should address the following:**
 - Analysis Objective
 - Reference Case/Scenario
 - Novel Cases/Scenarios to be Evaluated
 - Novel Design Basis (performance, cost, sensitivity analysis, etc.)
 - Execution Timeline

Step Two: Performance Model

2. Create a Performance Model

- Utilize available tools/software (ASPEN, ChemCAD, Thermoflow, etc.)
 - Hold product amount constant (i.e. chemical product rate, etc.)
 - Understand how balance-of-plant equipment will be affected
 - Develop a detailed process flow diagram
 - Include feed purity specifications, conversion rates, heat duties, rate constants, emissions potential, etc.
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- **Generating Useful Information:**
 - Develop material and energy balances consistent with baseline procedure
 - Generate similar performance/output results from model
 - Supply additional detail for modeling novel equipment
 - Design equations, scaling methodology, design basis

NETL Techno-Economic Analysis Methodology



Step Three: Cost Estimation

3. Cost Estimation

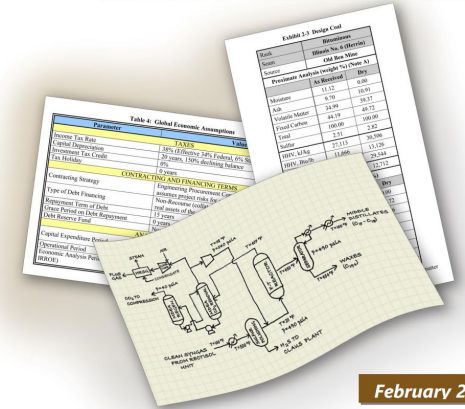
- Understand accuracy of cost estimation. NETL relies of AACE Estimate Class
 - Concept Screening (-20%/+100% Accuracy)
 - 0-2% Project Definition, based on technical analogs/engineering judgment
 - Feasibility Study (-15%/+50% Accuracy)
 - 1-15% Project Definition, based on preliminary mass and energy balances
 - Budget Estimate (-10%/+30% Accuracy)
 - 10-40% Project Definition, based on detailed process and economic modeling
- **Capital cost estimation, capital charge factors, contingencies, global economic assumptions, etc., should be considered**
- **Detailed cost estimation guidelines are provided by NETL**



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QUALITY GUIDELINES FOR ENERGY SYSTEM STUDIES

Cost Estimation Methodology for NETL Assessments of Power Plant Performance



NATIONAL ENERGY TECHNOLOGY LABORATORY



[NETL Cost Estimation
Methodology Report
Link](#)

Step Four: Reporting

4. Reporting Methodology

- Summary of Technology Analysis Plan and discussion with end users
- Performance Model
 - Block Flow Diagram
 - Detailed Simulation Model
 - Material and Energy Balance
- Cost Estimation
 - Detailed cost based on comparison metric (allowable cost of CO₂, cost of product generated, etc.)
 - Detailed total overnight capital cost estimates
 - Sensitivity studies
- **Report Deliverable**
 - Summarize the above and include enough detail to reproduce stated results
 - Should follow NETL guidelines/template
 - Detail any assumptions made during the analysis!

Additional Available Documentation

Cost and Performance Baseline and Other TEA Examples

- **NETL has conducted a wide variety of TEA of energy systems in addition to carbon conversion technologies to draw comparison from, including the following:**
- **Technology Expertise:**
 - Combustion Systems (natural gas, biomass, and coal)
 - Gasification Systems (dry and slurry feed, coal and biomass)
 - Oxy-combustion Systems (atmospheric and elevated pressure)
 - Chemical Looping
 - Solid Oxide Fuel Cells/Solid Oxide Electrolysis Cells
 - Fuels and Chemicals(e.g., H₂, NH₃, methanol, etc.) Production from Fossil Fuels
 - Supercritical CO₂ Power Cycles (direct and indirect)
 - Process Water Treatment/ Zero Liquid Discharge Systems
 - Bulk Energy Storage
 - CO₂ Capture Systems (solvent, sorbent, membrane, cryogenic)
 - Direct Air Capture
 - CO₂ Purification and Compression
 - Air Separation Units (cryogenic, ion transport membrane)
 - Hydrogen Production / Recovery
 - Combustion Turbines
 - Steam Turbines (subcritical through adv. Ultra-supercritical steam conditions)
 - CO₂ Conversion Technologies (EOR, Cements, Algal, EC, Microwave)
 - Direct Power Extraction/ Magnetohydrodynamics

[NETL Energy Analysis Library Link](#)

COST AND PERFORMANCE BASELINE
FOR FOSSIL ENERGY PLANTS
VOLUME 1: BITUMINOUS COAL AND
NATURAL GAS TO ELECTRICITY



September 24, 2019

NETL-PUB-22638

[NETL Fossil Energy Baseline
Report Link](#)

Near-Term Guidance Documents and Toolsets

Performing a Techno-Economic Analysis for Carbon Conversion Technologies

• Details

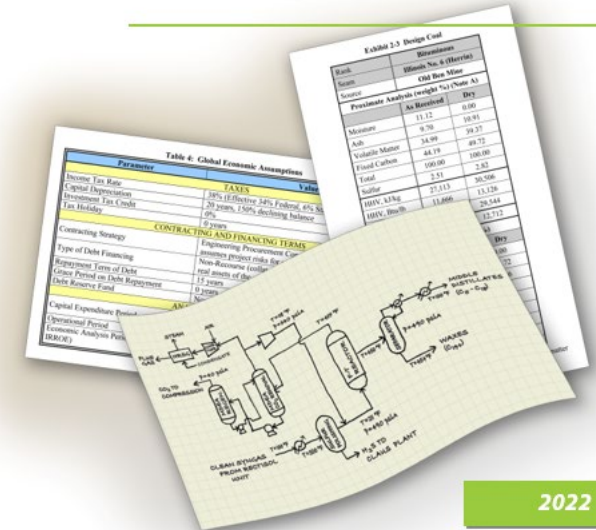
- Developing a complete process description
- Determining design basis and process/economic assumptions
- Conducting a performance analysis
- Developing cost estimates
- Reporting metrics for comparison between CO₂ conversion technologies
- Quality control guidance
- Issues to address qualitatively

• Reporting Metrics and Template

- Reporting metrics are standards of measurement that allow for consistent comparison between competing technologies
- Metrics describe essential aspects of the technology including performance, costs, emissions, and market considerations
- Sample calculations are included for each metric and are based on a specific case study
- Reporting template to be included

QUALITY GUIDELINES FOR ENERGY SYSTEM STUDIES

Performing a Techno-Economic Analysis for Carbon Conversion Technologies



2022

DOE/NETL-2022/XXXX

Scaling Methodology Specific to CO₂ Conversion Technology

Justification

- Cost estimation for bench-scale CO₂ conversion technologies requires analogous reference costs and well-established cost scaling methodologies

Approach

- NETL has been developing a novel, excel-based library that documents the costs and scaling methodologies, along with associated performance parameters and process descriptions, for various CO₂ conversion technologies previously assessed both internally and externally to NETL
- The library will be supplemented by a QGESS document providing instructions on using the library as a cost scaling tool for CO₂ conversion TEAs

Outcome

- The final document and a public-facing version of the library is expected to be released soon
- The library is intended to be updated regularly as new TEA are completed

QUALITY GUIDELINES FOR ENERGY SYSTEM STUDIES

Capital Cost Scaling Methodology: Revision 4 Report



October 2019

NETL-PUB-22697

Wrap Up

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Questions/ Comments

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