Overview of Techno-Economic Analysis Process

NATIONAL ENERGY TECHNOLOGY LABORATORY

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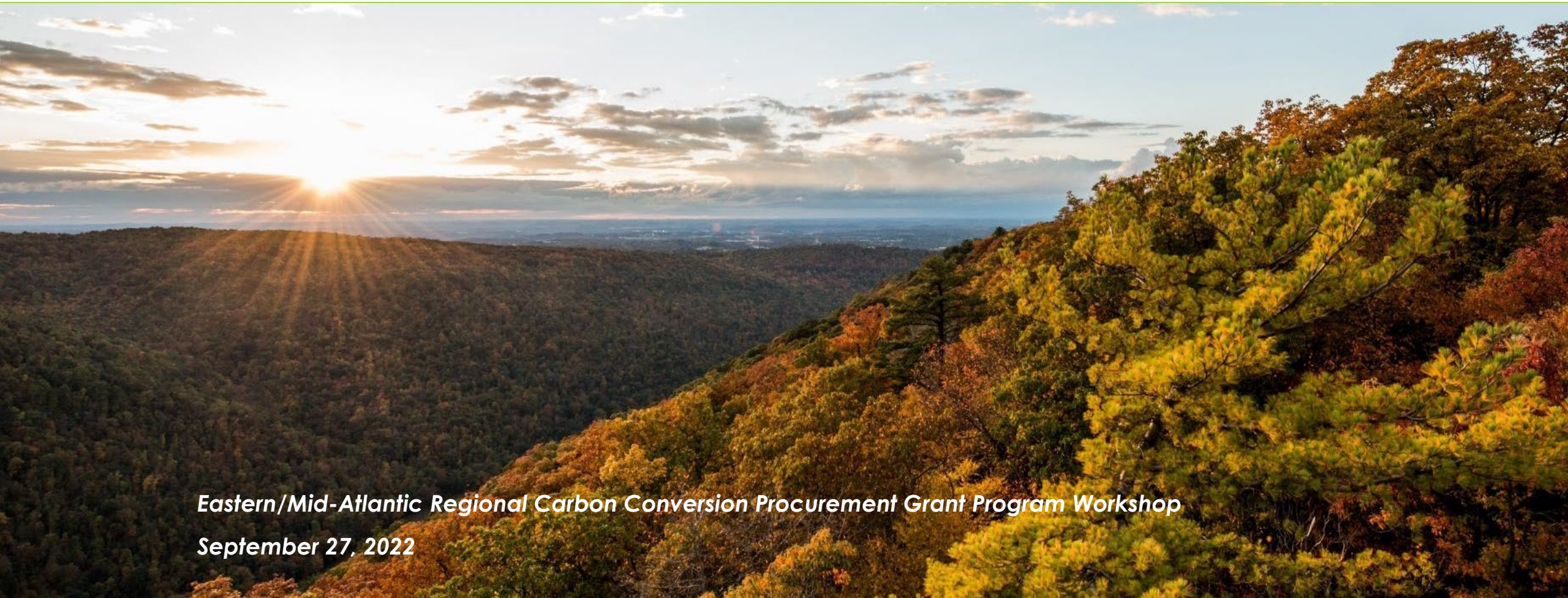


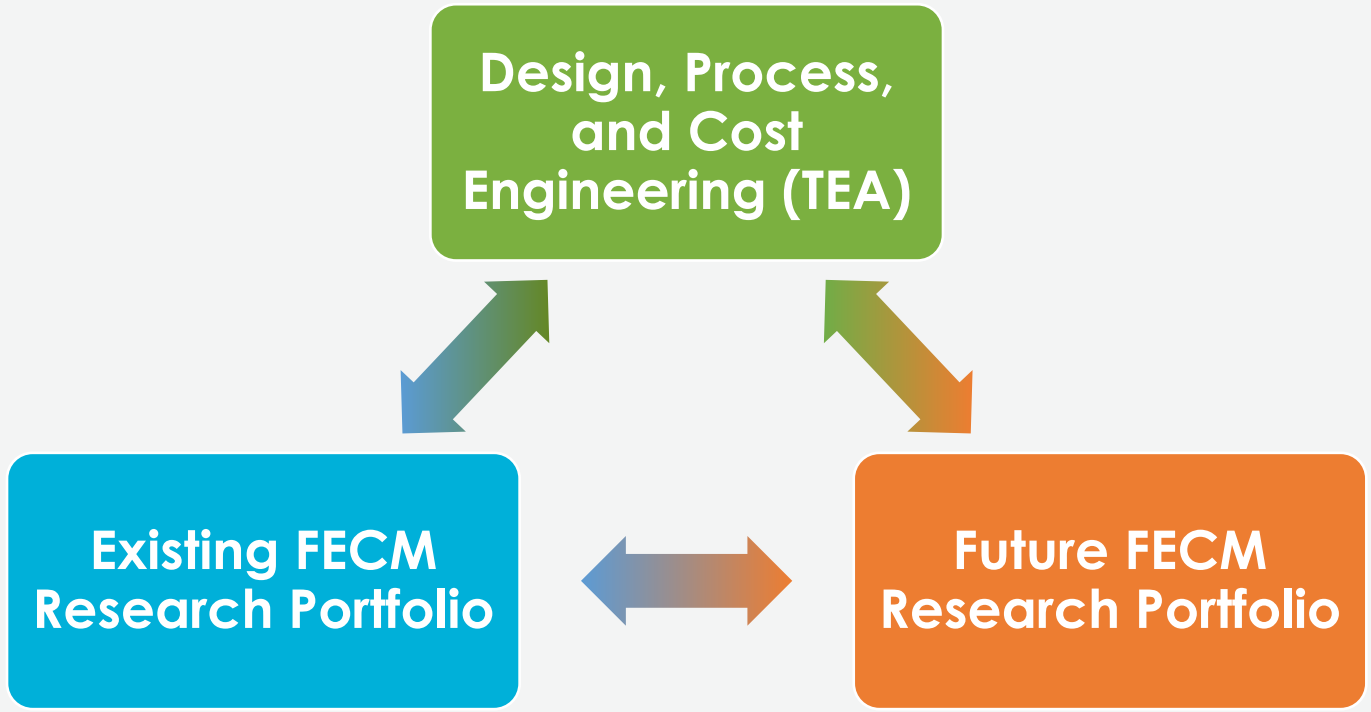
Eastern/Mid-Atlantic Regional Carbon Conversion Procurement Grant Program Workshop

September 27, 2022

NETL Role with FECM Programs

Design, Process, and Cost Engineering at NETL

DOE-FECM Program Goals and Objectives



NETL is the only Government Owned, Government Operated DOE National Laboratory

NETL Role with FECM Programs

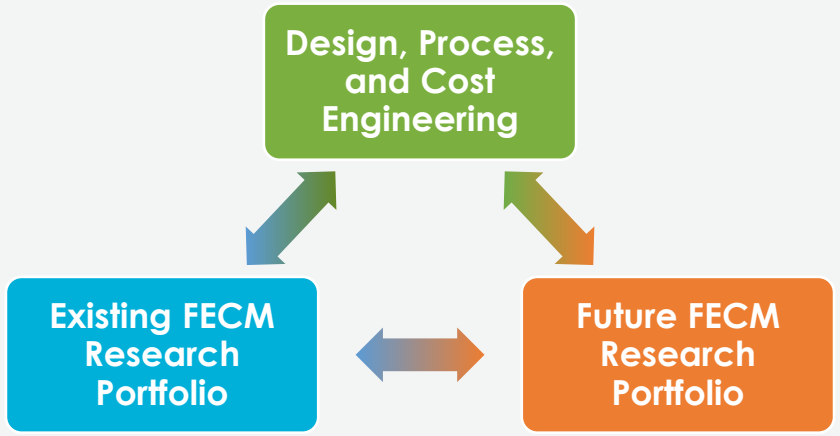
Design, Process, and Cost Engineering at NETL

NATIONAL ENERGY TECHNOLOGY LABORATORY

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.

Outline

- **Introduction**
  - What is Techno-Economic Analysis?
  - Why Techno-Economic Analysis?
  - Connecting with Life Cycle Analysis
- **Basic Methodology for Conducting Techno-Economic Analysis**
  - NETL Quality Guidelines for Conducting Techno-Economic Analysis
- **Additional Resources**
- **Wrap Up**

Introduction

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
    - Identification of critical data gaps
    - Present summary results in an organized, concise, and visually coherent form

Introduction

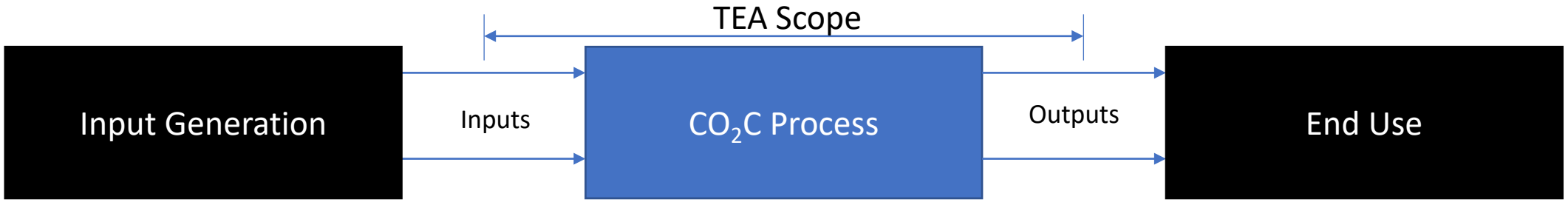
Why Techno-Economic Analysis?

- **What Techno-Economic Analysis Does:**
  - 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

Introduction

Connection with Life Cycle Analysis (LCA)

- **Techno-Economic Analysis focuses on the in-development technology, required balance-of-plant, and cost/energy state of incoming and outgoing resources and waste streams**
  - Results are fed into or developed in parallel with Life Cycle Analysis (LCA), which derives the impacts of the technology from cradle-to-grave
- **Example:**
  - TEA may consider the cost, pressure, temperature, and composition of an incoming H_2 or CO_2 stream, but LCA would be needed to assess the environmental impact of how it was generated.
  - TEA doesn't consider process components manufacturing or end-of-life disposition.
  - TEA doesn't typically consider the end use of the product.

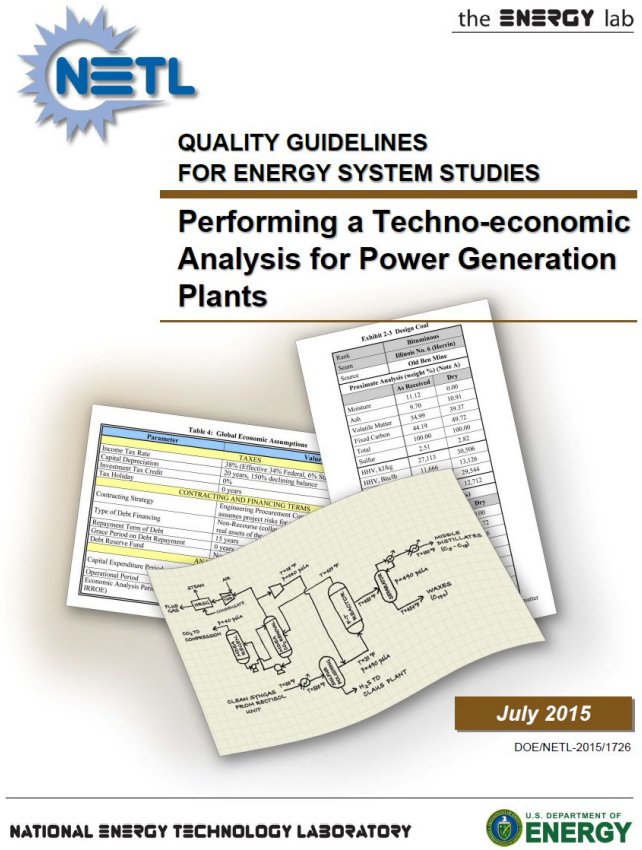


NETL Techno-Economic Analysis Methodology

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



NETL Performing a TEA Guideline Document Link

NETL Techno-Economic Analysis Methodology

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

- **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

NETL Techno-Economic Analysis Methodology

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.

- **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

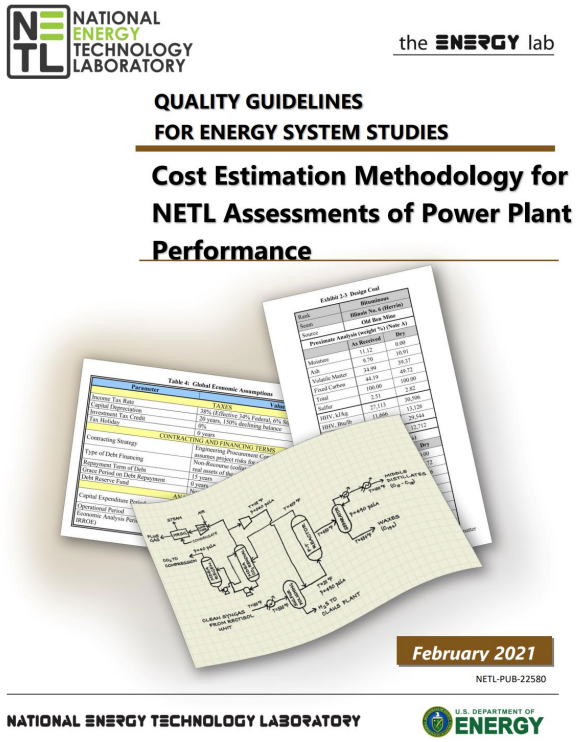
Step Three: Cost Estimation

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**



NETL Cost Estimation Methodology Report Link

NETL Techno-Economic Analysis Methodology

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 CO_2, cost of product generated, etc.)
  - Detailed total overnight capital cost estimates
  - Sensitivity studies

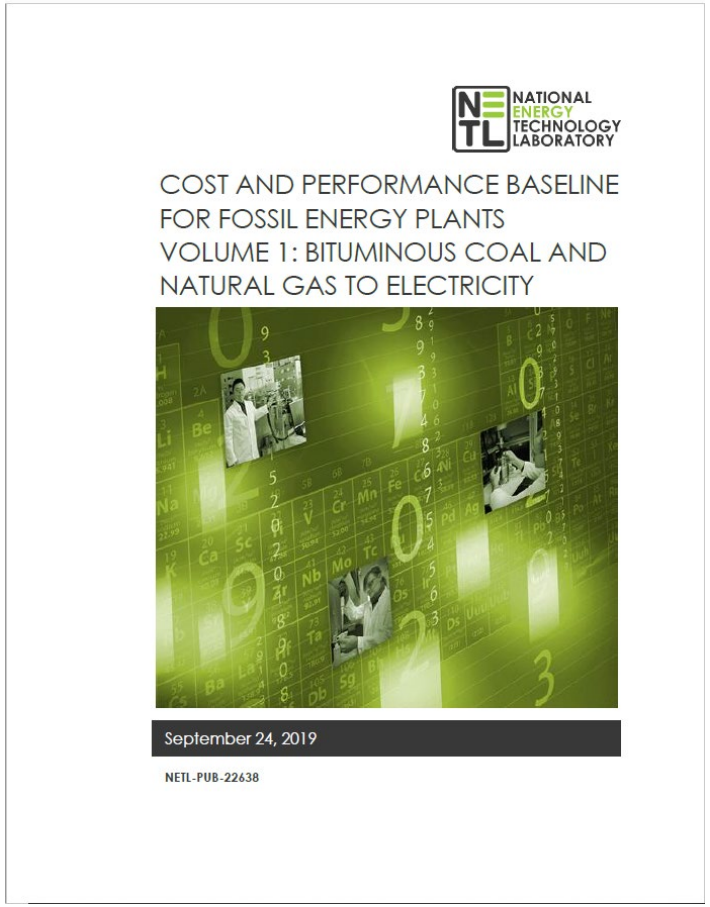
- **Report Deliverable**
  - Summarize the above and include enough detail to reproduce stated results
  - Should follow prescribed guidelines/template (may be provided by DOE)
  - Detail any assumptions made during the analysis!

Additional Resources

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**
- **Available Analyses to serve as examples:**

- 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., H_2, NH_3, methanol, etc.) Production from Fossil Fuels
- Supercritical CO_2 Power Cycles (direct and indirect)
- Process Water Treatment/ Zero Liquid Discharge Systems
- Bulk Energy Storage
- CO_2 Capture Systems (solvent, sorbent, membrane, cryogenic)
- Direct Air Capture
- CO_2 Purification and Compression
- Air Separation Units (cryogenic, ion transport membrane)
- Hydrogen Production / Recovery
- Combustion Turbines
- Steam Turbines (subcritical through adv. Ultra-supercritical steam conditions)
- CO_2 Conversion Technologies (EOR, Cements, Algal, EC, Microwave)
- Direct Power Extraction/ Magnetohydrodynamics



NETL Energy Analysis Library Link

NETL Fossil Energy Baseline Report Link

Wrap Up

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.

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Questions/ Comments

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