Forecasting the Role of CCUS in the Energy Economy with FE/NETL NEMS-CCUS

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Developing the Technologies and Building the
Infrastructure for CO_2 Storage

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NETL

Presentation Outline

- Introduction

- Background

- Model Overview

- Example Results

- Future Work

Introduction

- ## Who we are;
  - Office of Program Planning and Analysis (OPPA) Benefits Division
  - Located in NETL's Strategic Center for Coal (SCC)

- ## Our mission;
  - Conduct analysis which estimates expected benefits (the public return on investment) of successful Fossil Energy (FE)/NETL R&D programs

- ## Our products;
  - Provide DOE FE/NETL management information to assist in the defense of R&D programs to key stakeholders (Congress, Office of Management and Budget (OMB), etc.)

Introduction
A Typical Benefits Analysis

- ## Inventory what is available
  - Assess existing engineering/economic models for ability to represent technology in question
  - Assess data for adequacy/accuracy/availability

- ## Develop what is needed
  - Additional Modeling Capability
  - Data development/improvement

- ## Perform the benefits analysis
  - Compare cases with R&D goals and associated cost impacts to cases without R&D (current technology)
  - Assess differences in outputs from cases to estimate R&D program benefits (GDP, employment, etc.)

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Introduction
Deriving FE/NETL Program Benefits

- Typically, the National Energy Modeling System (NEMS) is used
  - Developed and used by the Energy Information Administration (EIA) to produce the Annual Energy Outlook (AEO)
  - Engineering Economic Model
  - Performs simulations out to 2035

- Historical treatment in NEMS of the "S" in CCUS as released by EIA was inadequate for our needs
  - $10/tonne for transportation, storage, and monitoring costs assumed for all projects

- The Benefits Division set out to refine the modeling approach of CCUS in NEMS to enable benefits analysis of FE/NETL programs
  - FE/NETL Capture Transport Utilization and Storage (CTUS) Model
  - FE/NETL NEMS-Carbon Capture Utilization and Storage (CCUS) Model

Background
Purpose of FE/NETL CTUS and NEMS-CCUS

- To demonstrate the development of a system with regard to CO_2 capture, transport, utilization and storage
  - Where? When? How much?

- To assess the impact of FE/NETL Program Goals on each of the above

- To provide a fully integrated energy system context in which to perform simulations and analysis

Background
Defining the Models

- The FE/NETL CTUS Model
  - Written in GAMS (General Algebraic Modeling System)
  - Multiple sources, sinks, and EOR sites available
  - Estimates an optimal CCUS pipeline network (dedicated and trans-shipment) through Mixed Integer Programming (MIP) based on scenario evaluated

- The FE/NETL NEMS-CCUS Model
  - Integrates the FE/NETL CTUS Model with NEMS to produce NEMS-CCUS which enables full energy economy interactions in CCUS infrastructure simulations

Background
Previous Efforts

- Model development began in 2009
- First version completed in 2010

  - FE/NETL CTUS model considered saline on-shore storage and existing coal plants (CCUS retrofits)
  - FE/NETL NEMS-CCUS model considered all existing coal plants (CCUS retrofits) and new CCUS assets (FE/NETL NEMS-CCUS Version 1)
  - Integration of CO_2-EOR interactions from CCUS assets not incorporated
  - Accepted by the Energy Information Administration (EIA) and implemented in AEO 2012
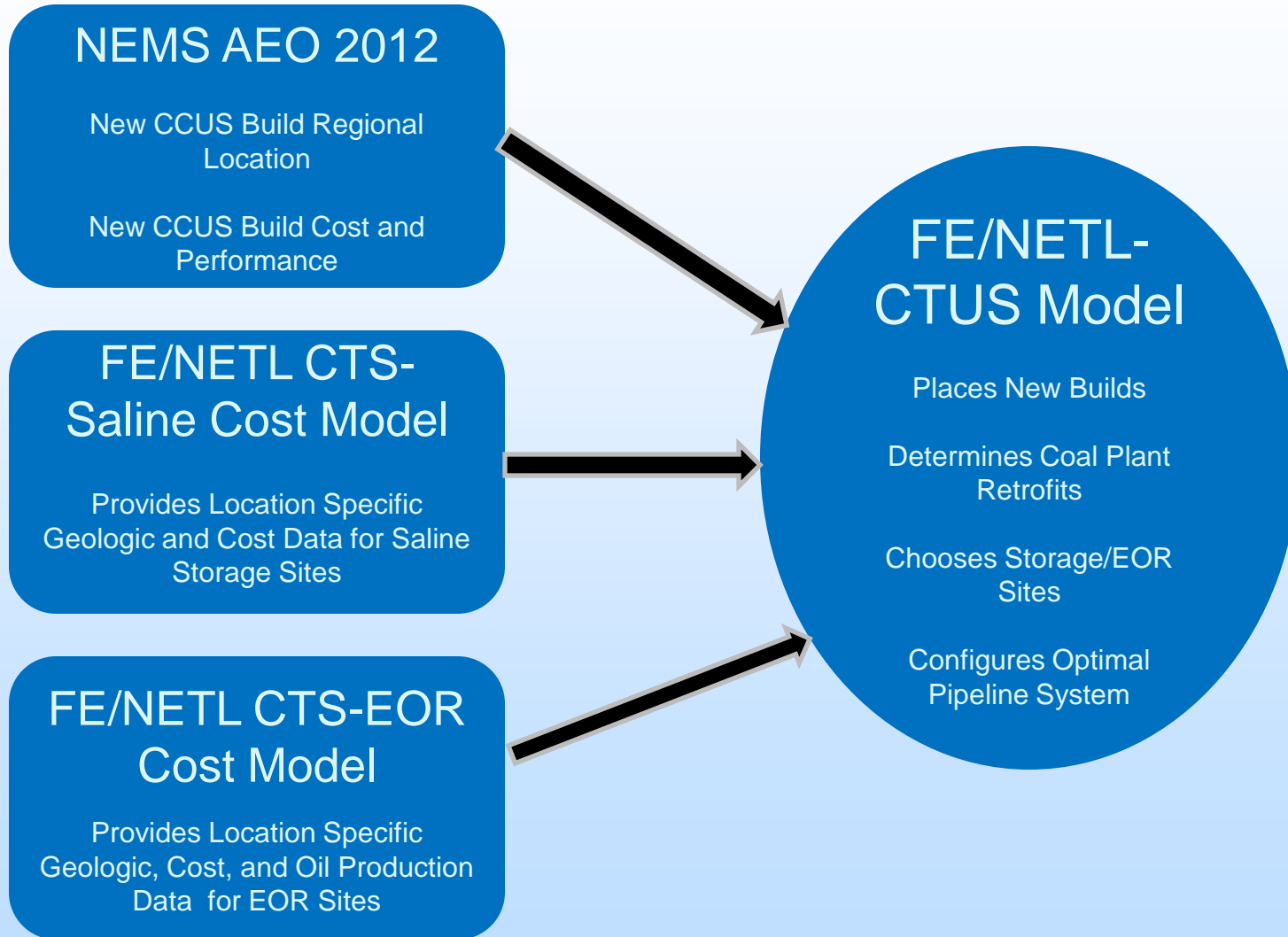
Background
Current Efforts

- CTUS Model expanded to incorporate EOR
  - EOR site representation
    - Site specific geologic representation
    - Site specific oil production profiles

- FE/NETL CTS-Saline and FE/NETL CTS-EOR cost models integrated into CTUS Model

- Full integration with NEMS Oil and Gas Supply Module (enables power sector competition with industrial and natural CO_2 sources for EOR)

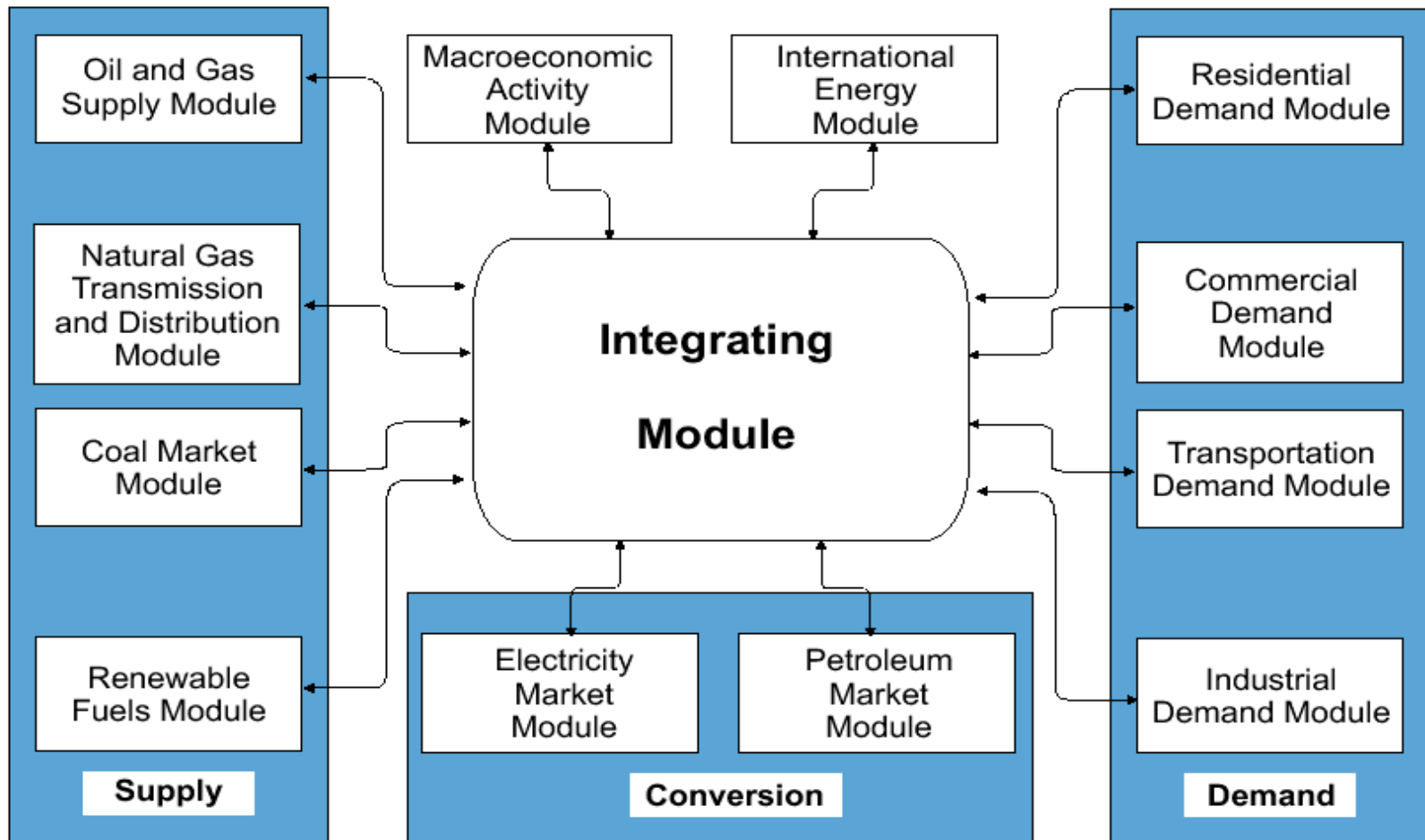- Integrated with NEMS AEO 2012 code (FE/NETL NEMS-CCUS Version 2)
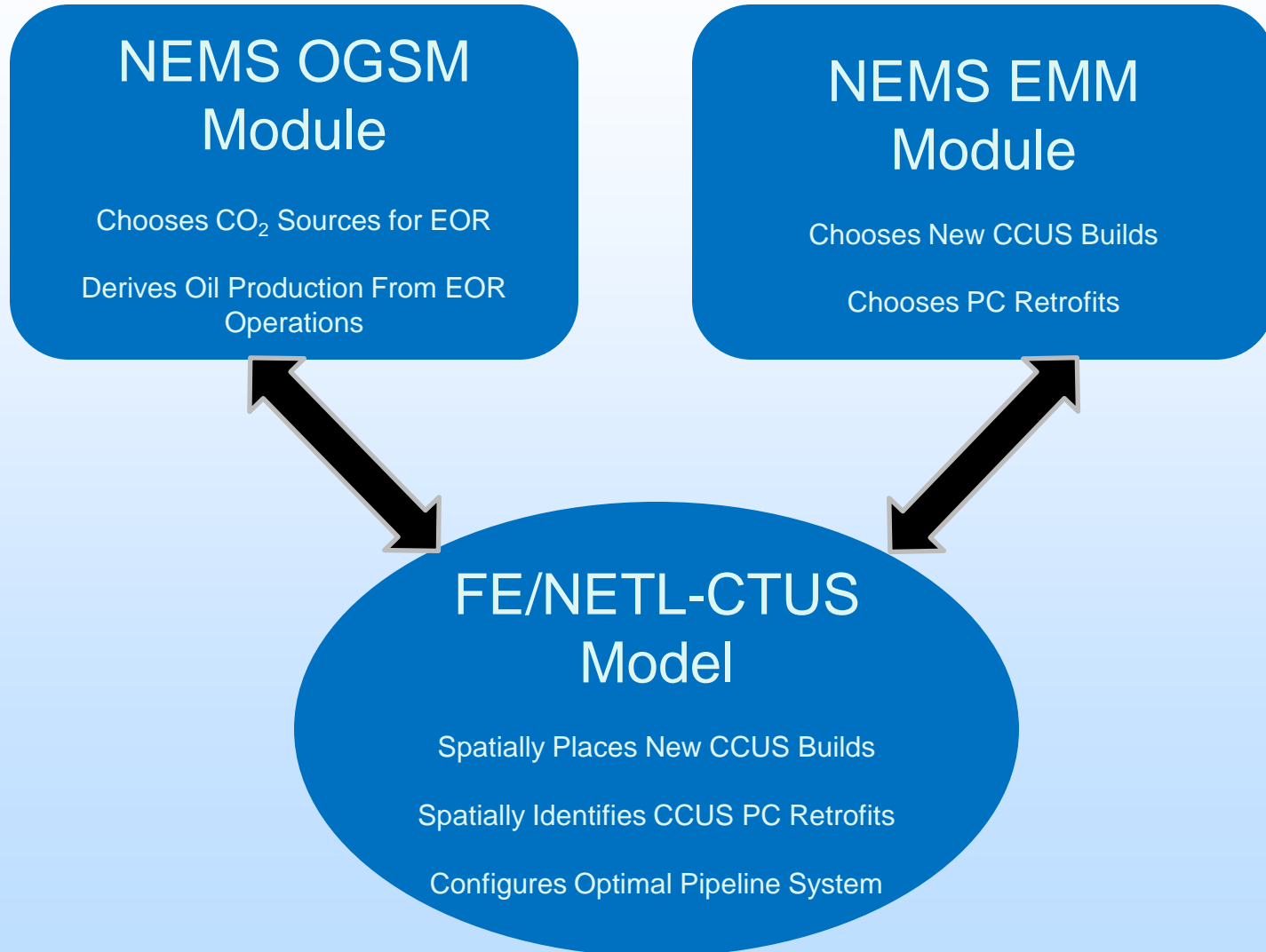
Model Overview
The FE/NETL CTUS Model

NEMS AEO 2012

New CCUS Build Regional Location

New CCUS Build Cost and Performance

FE/NETL CTS-Saline Cost Model

Provides Location Specific Geologic and Cost Data for Saline Storage Sites

FE/NETL CTS-EOR Cost Model

Provides Location Specific Geologic, Cost, and Oil Production Data for EOR Sites

FE/NETL-CTUS Model

Places New Builds

Determines Coal Plant Retrofits

Chooses Storage/EOR Sites

Configures Optimal Pipeline System

Model Overview
NEMS General Structure

Model Overview
The FE/NETL NEMS-CCUS Model

NEMS OGSM Module

Chooses CO_2 Sources for EOR

Derives Oil Production From EOR Operations

NEMS EMM Module

Chooses New CCUS Builds

Chooses PC Retrofits

FE/NETL-CTUS Model

Spatially Places New CCUS Builds

Spatially Identifies CCUS PC Retrofits

Configures Optimal Pipeline System

Example Results
FE/NETL NEMS-CCUS Version 1

- The FE/NETL Existing Plant Emissions Control (EPEC) R&D Program was evaluated using Version 1 of the FE/NETL NEMS-CCUS Model

- Cases with CCUS R&D cost reductions were compared to cases without R&D cost reductions (learning curve effects only) to assess program benefits

- Two scenarios evaluated
  - CO_2 tax case
  - Clean Energy Standard (CES) Case

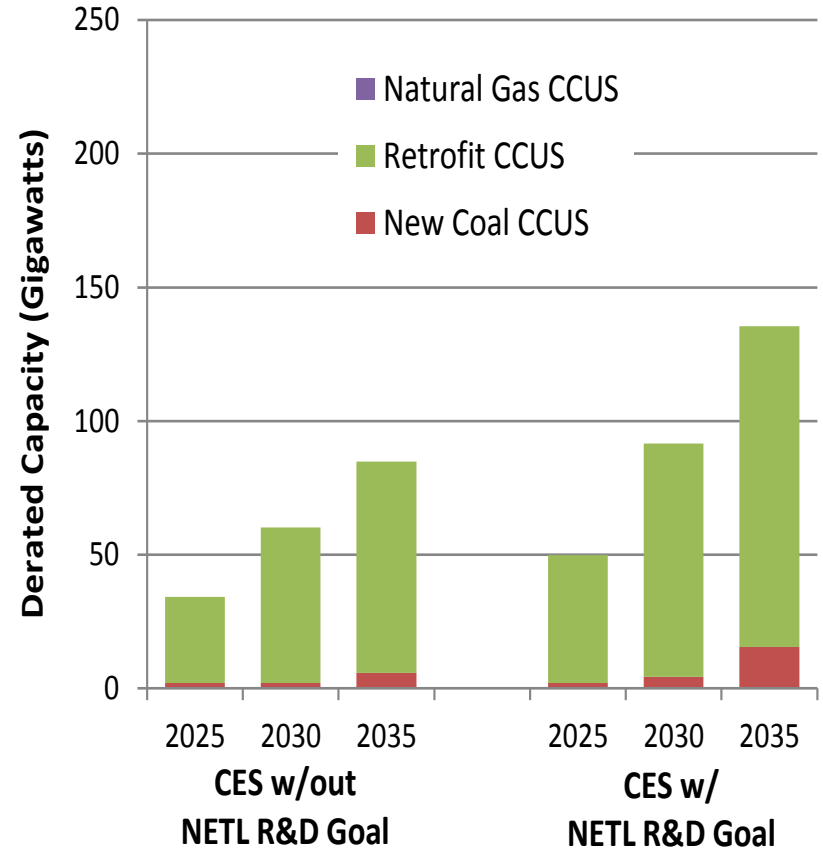- For details, the full report is posted on the NETL website
  http://www.netl.doe.gov/energy-analyses/pubs/EPECBenefitsAnalysisReport.pdf

Example Results
CCUS Deployments

Carbon Tax Case
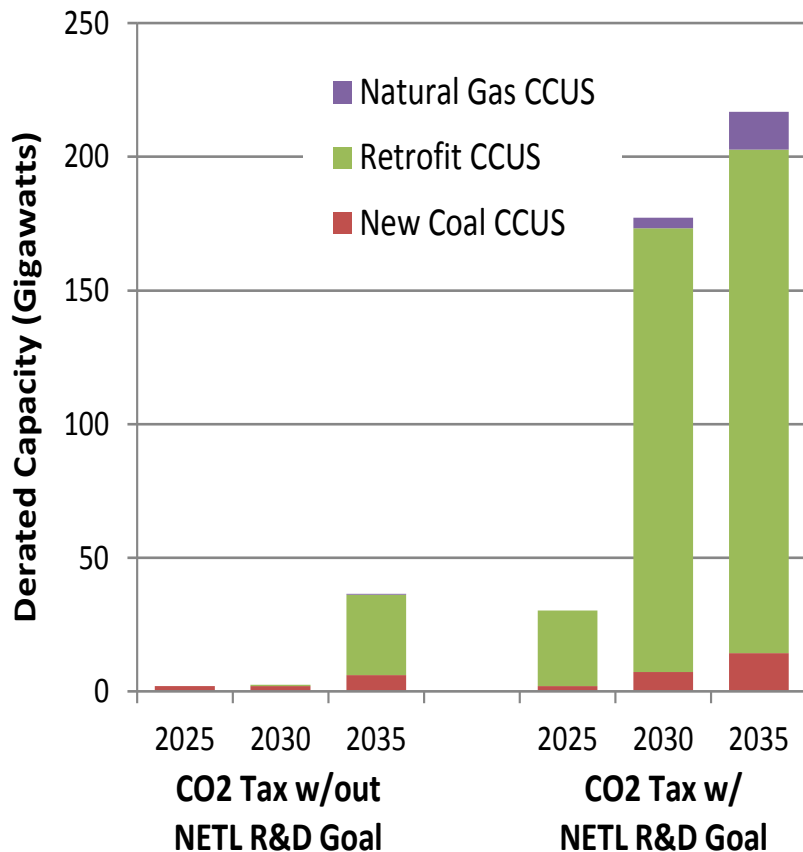
Clean Energy Standard Case

Example Results
R&D Impacts on CO_2 Emissions

Annual Emissions
CO_2 Tax Cases

Annual Emissions
CES Cases

Power Sector Emissions (mmtCO2 per year)

Reference
No NETL R&D Goal
NETL R&D Goal
KGL CO2 Target
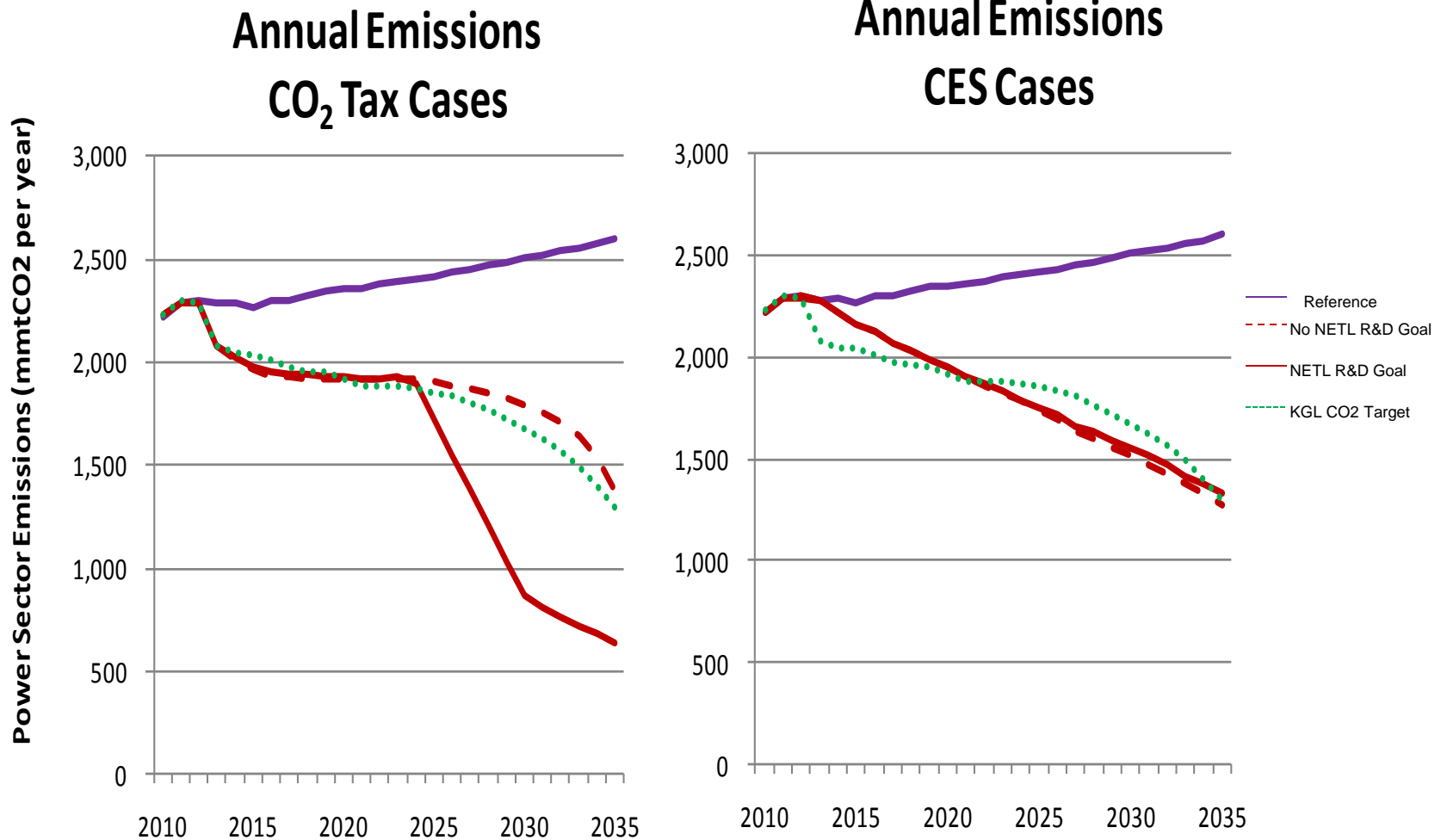
Example Results
CO$_2$ Tax vs. CES Credit Price Trajectories

CO$_2$ Tax vs. CES Credit Price

Legend:
- CO2 Tax
- CES No NETL R&D Goal
- CES NETL R&D Goal

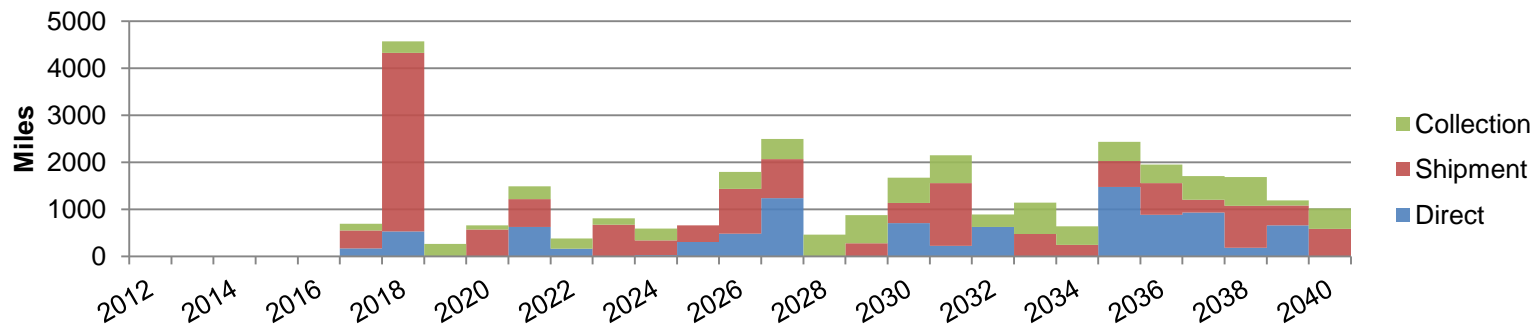Y-axis: 2008$ per metric tonne CO2
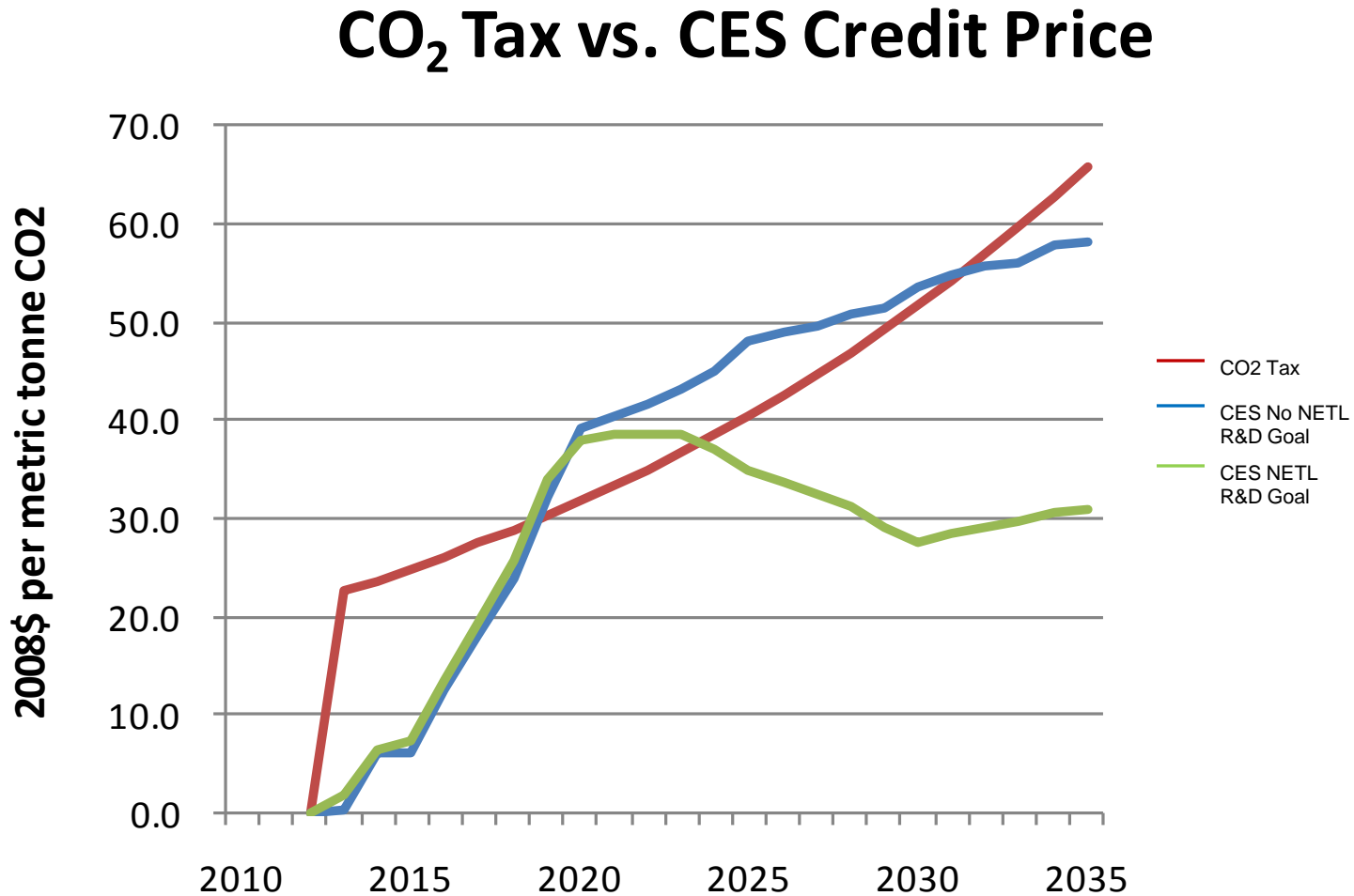
Example Results
Preliminary Results from EOR Enabled NEMS-CCUS Version 2

New Generation Capacity with CCUS in 2035
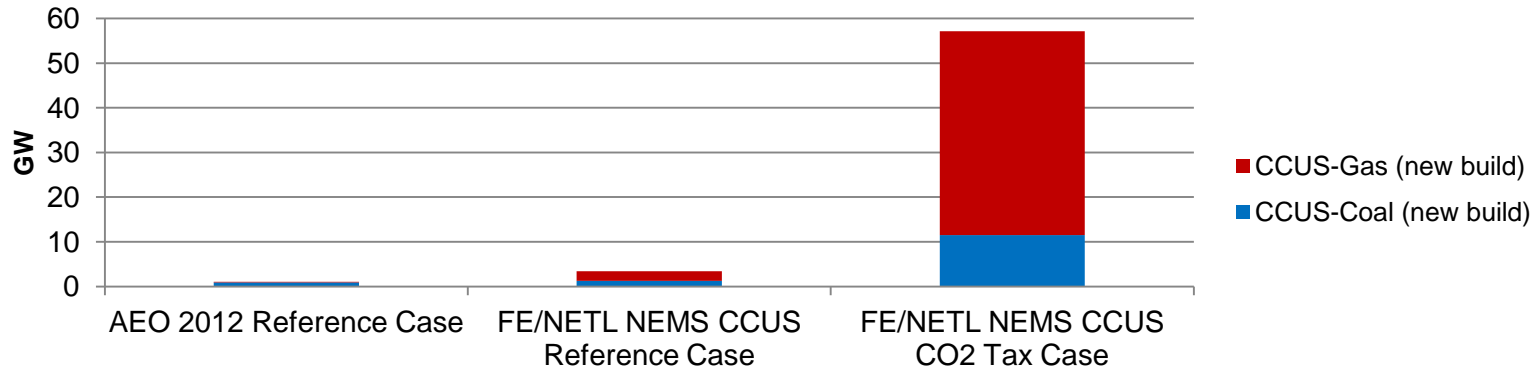
Pipeline Miles Built by Segment Type: CO2 Tax Case

Additional Verification and Validation is Required to Confirm These Results

Future Work

- FY 12: Benefits of FE/NETL Capture and Storage Programs in Process, Report Forthcoming
  - Continuing to validate results
  - Perform with and without R&D runs for Capture and Storage Programs

- FY 13: Additional Development Planned
  - Incorporation of improved representation of industrial sources
  - Incorporation of NGCC retrofits
  - Incorporation of offshore storage and EOR
  - Continued coordination with FE/NETL CTS-Saline and CTS-EOR cost models

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Questions?