Benefits Analysis of Fossil Energy R&D

NASEO Clean Coal and Carbon Capture and Sequestration Study Tour and Workshop

June 14th, 2018

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Outline

- Overview of the Systems Engineering and Analysis Directorate at the National Energy Technology Laboratory (NETL)
- Energy Market Modeling Overview
- The NETL Capture Transport Utilization and Storage - National Energy Modeling System (CTUS-NEMS)
- Benefits Evaluation of CCUS RD&D Using CTUS-NEMS
- Other Analysis Focus Areas/Capabilities at NETL
- Conclusions

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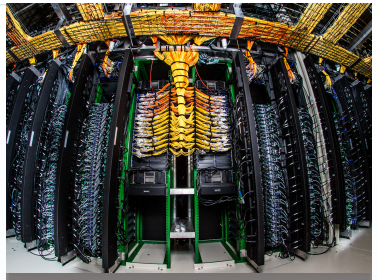
NETL Enduring Core Competencies



Computational Engineering

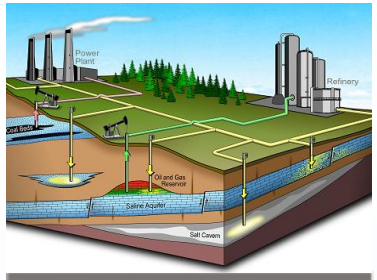
High Performance Computing

Data Analytics

Materials Engineering & Manufacturing

Structural & Functional

Design, Synthesis & Performance



Geological & Environmental Systems

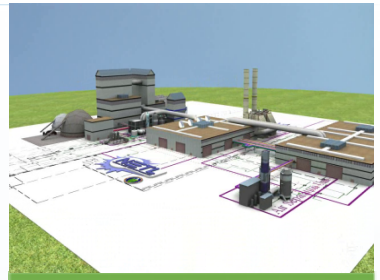
Air, Water & Geology

Understanding & Mitigation

Energy Conversion Engineering

Component & Device

Design & Validation



Systems Engineering & Analysis

Process & System

Optimization, Validation & Economics

Effective Resource Development

~

Efficient Energy Conversion

~

Environmental Sustainability

Systems Engineering & Analysis

Vision

The Systems Engineering & Analysis Directorate's vision is:

- To become the world's premier resource for the development and analysis of innovative advanced energy systems

- To provide unprecedented breadth of integrated modeling and optimization capability to support decision making and analysis across multiple scales

- This competency will support identification, evaluation and prioritization of R&D concepts at earlier stages

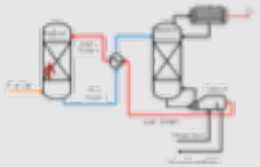
Systems Engineering & Analysis (SEA)

Teams and Scope

Energy Process Analysis

Energy Process Design, Analysis, and Cost Estimation

- Plant-level modeling, performance assessment
- Cost estimation for plant-level systems
- General plant-level technology evaluation and support



Advanced Technology Design & Cost Estimation

Energy Systems Analysis

Resource Availability and Cost Modeling

- CO_2 storage (saline and EOR)
- Fossil fuel extraction
- Rare earth elements
- General subsurface technology evaluation and support

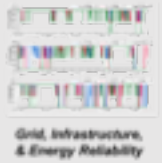
Grid modeling and analysis

Environmental Life Cycle Analysis

Energy Markets Analysis

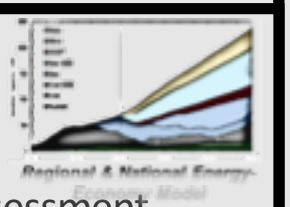
Energy Economy Modeling and Impact Assessment

- Enhanced fossil energy representation
- Multi-model scenario/policy analysis
- Infrastructure, energy-water



Grid, Infrastructure, & Energy Reliability

- Economic impact assessment
- General regulatory, market and financial expertise



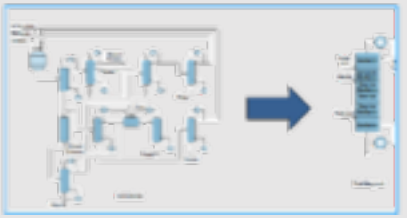
Regional & National Energy Economy Model

Process Systems Engineering Research

- Process synthesis, design, optimization, intensification
- Steady state and dynamic process model development
- Uncertainty quantification
- Advanced process control

Design, optimization, and modeling framework to be expanded to all SEA "systems"

Advanced Energy Systems through Process Systems Engineering



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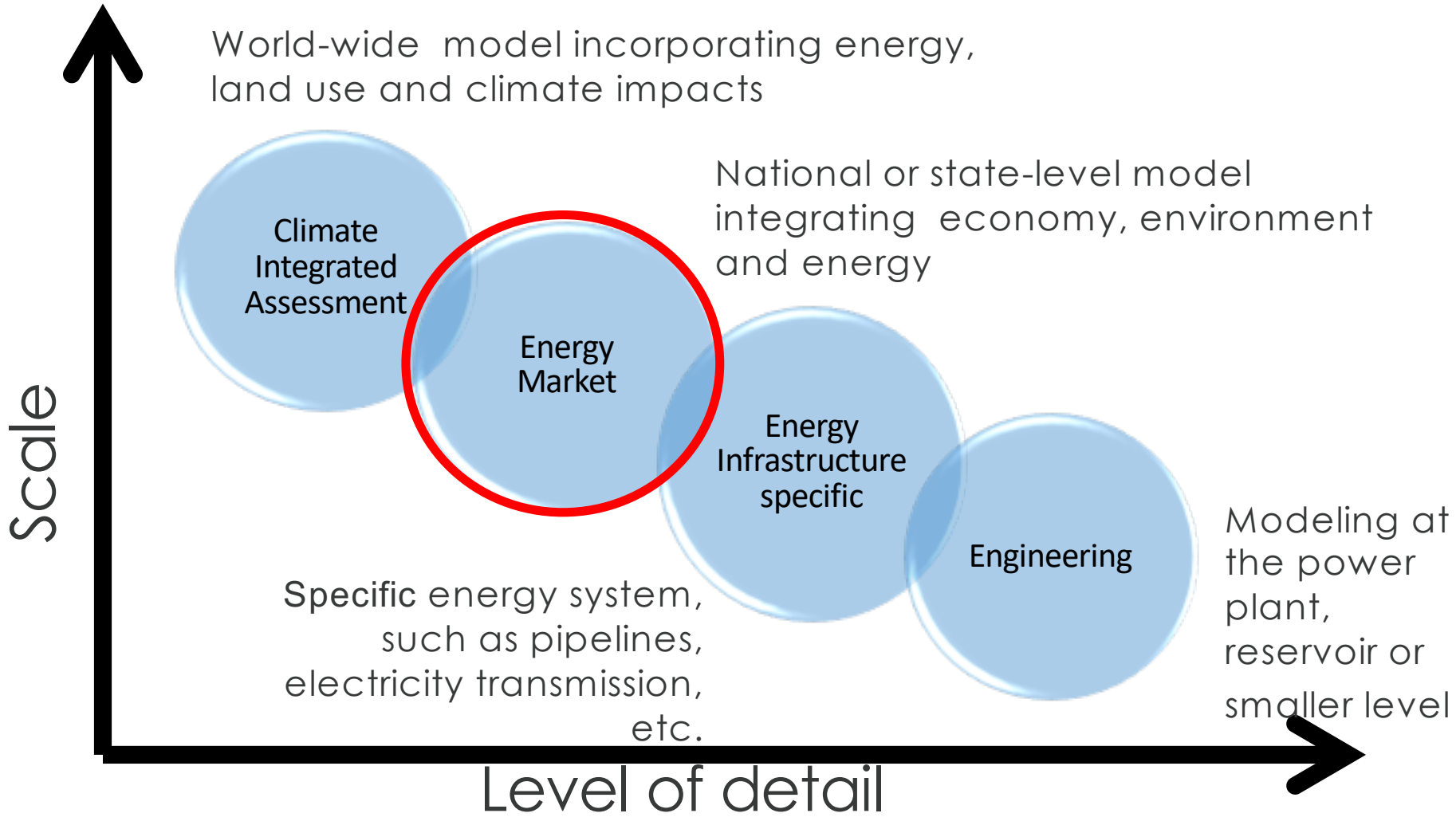
Models are Representations of the Physical World

With Scales that Vary from Holistic to Specific



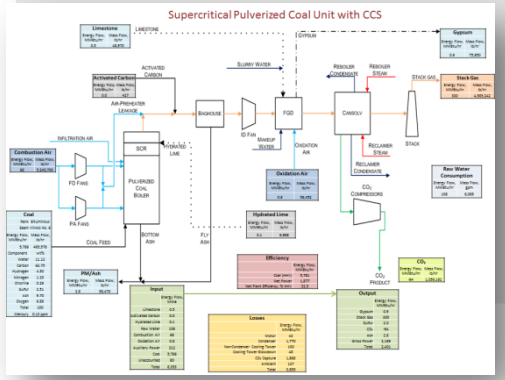
Assessing Program Portfolio Impacts:

Coal Program Example

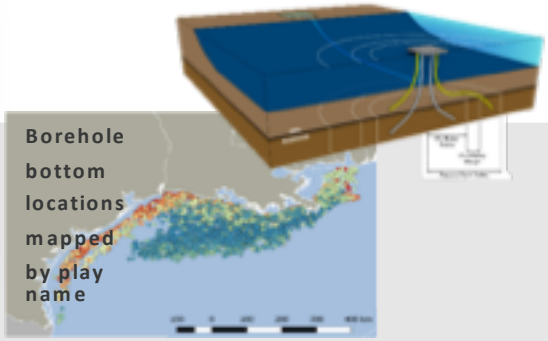
Baseline Data & Model Development → **Set R&D Goals** → **Develop Scenarios** → **Project Technology Deployments** → **Estimate Potential Benefits of RD&D**

NETL Cost and Performance Baseline for Fossil Energy Plants

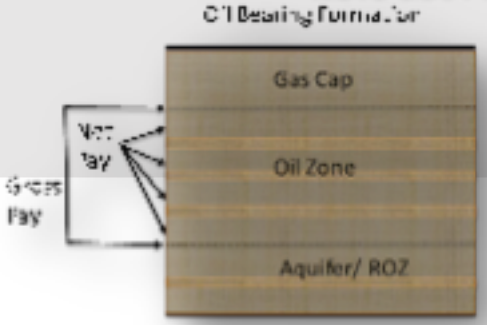
- *Detailed, transparent account of plant information*
- *Key resource for government, academia and industry*

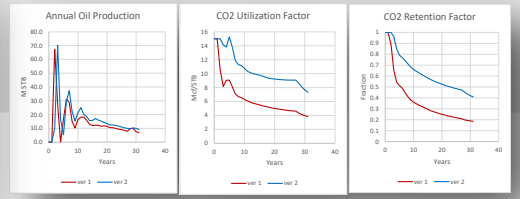


NETL CO_2 Saline Storage Cost Model (onshore and offshore)



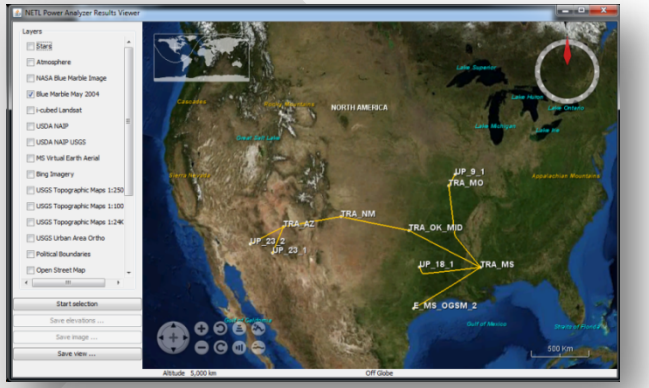
NETL CO_2 Prophet Model





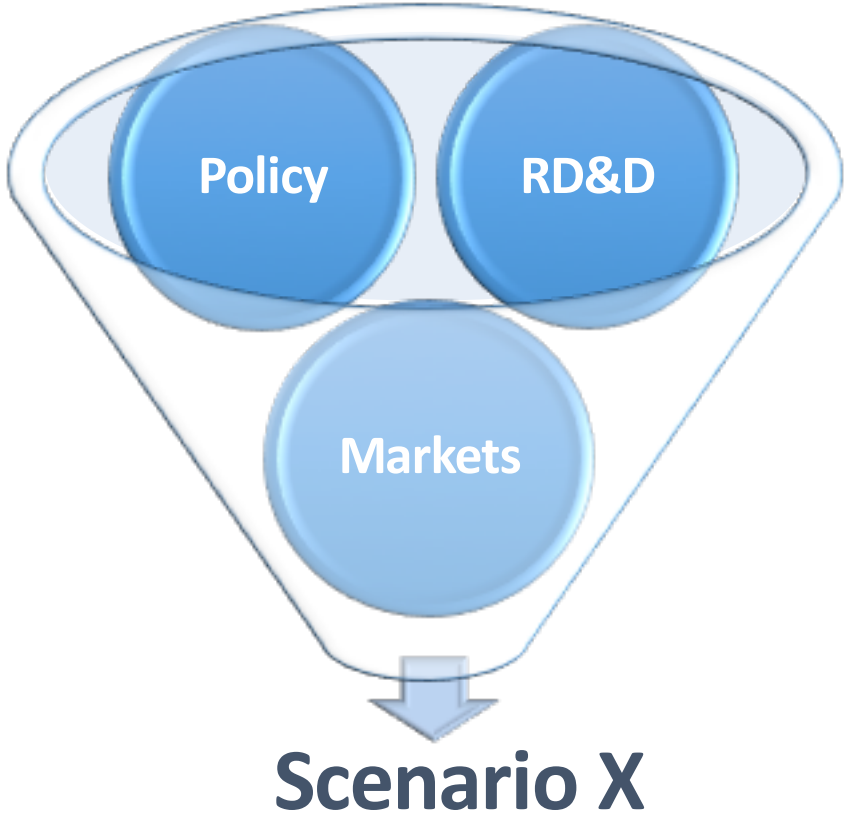
NETL CO_2 Capture, Transport, Storage and Utilization - National Energy Modeling System (CTUS-NEMS)

- *Adopted by EIA; used in AEO's Since 2014*
- *Facilitates and encourages agency interactions*



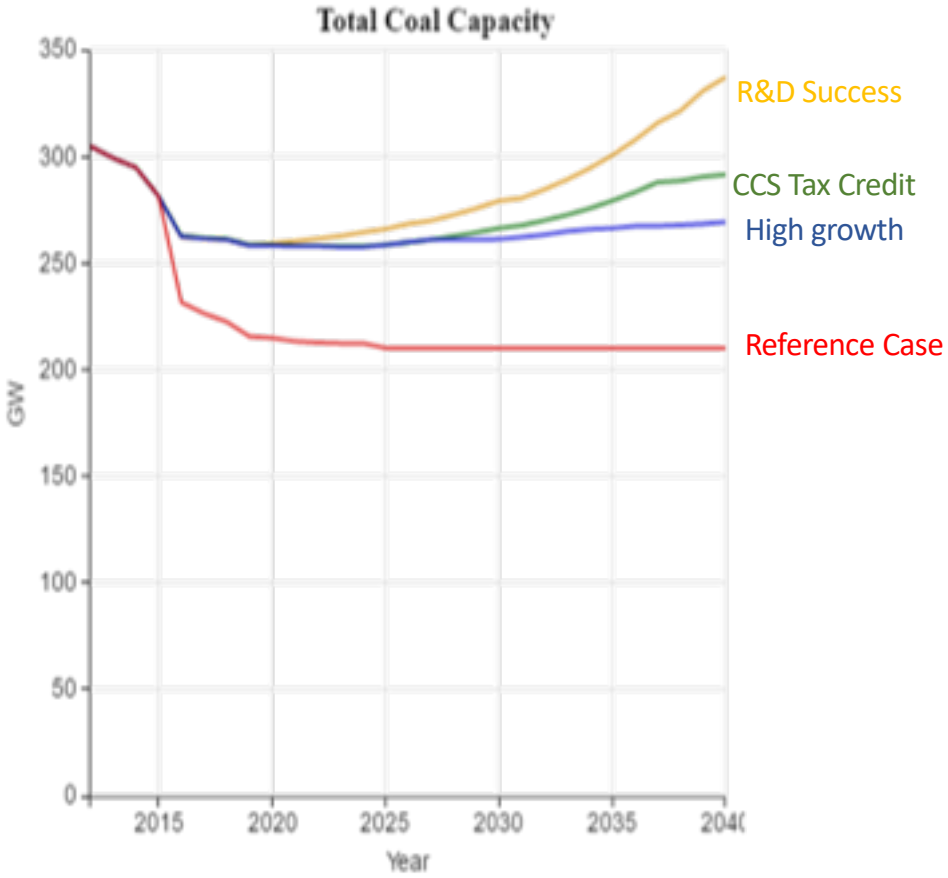
Assessing Program Portfolio Impacts:

- Scenario design is a crucial step in the assessment of impacts
- Assumptions about economic growth, policy, electricity demand, etc. will typically drive results
- These assumptions are often the most sensitive and vulnerable to debate



Assessing Program Portfolio Impacts:

Baseline Data & Model Development → Set R&D Goals → Develop Scenarios → Project Technology Deployments → Estimate Potential Benefits of RD&D



U.S. Benefits of the Program, Cumulative through 2040

Benefit Area	Metric
Economic Growth	Total Electricity Expenditure Savings
	Employment
	Income
	Gross Domestic Product (GDP)
Environmental Sustainability	CO_2 Captured at Coal and Gas CCS Facilities
Energy Security	Additional Domestic Oil Production via EOR

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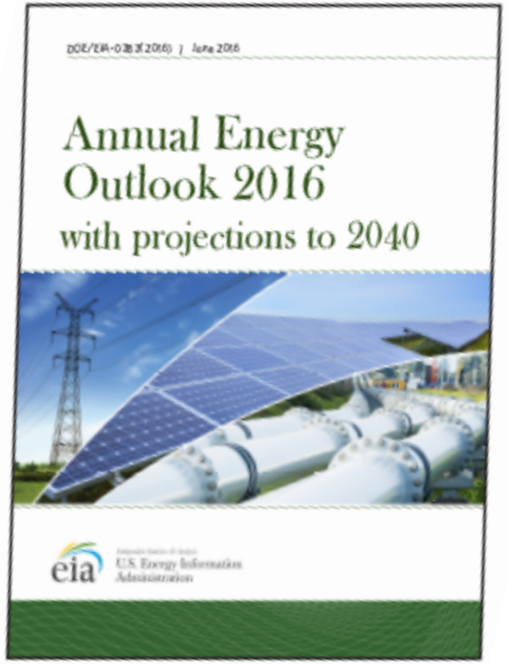
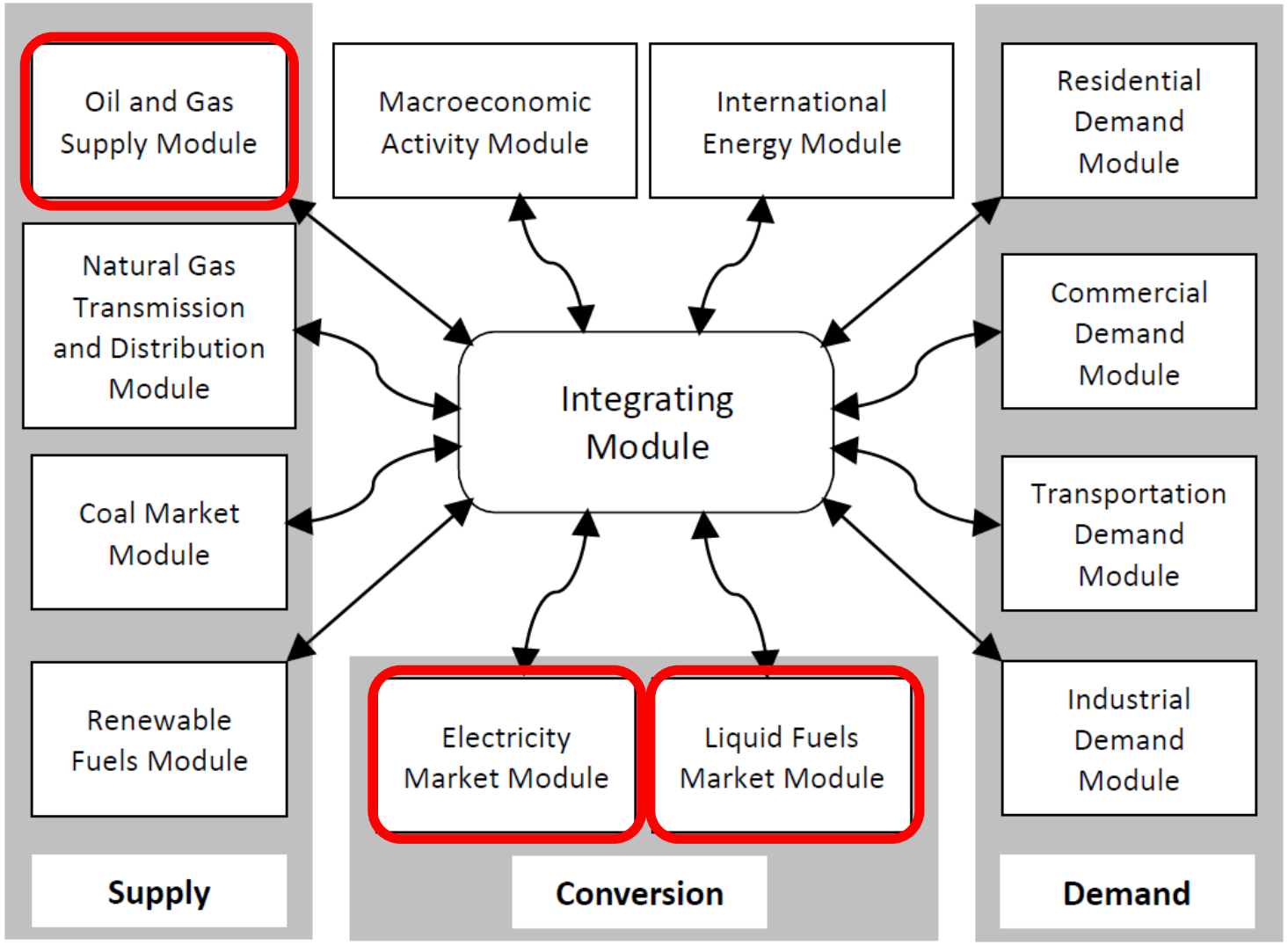
EIA-NEMS and FE/NETL CTUS-NEMS

U.S. Energy Information Administration – National Energy Modelling System

- NEMS projects the production, consumption, conversion, import, and pricing of energy
- The primary use for NEMS is to produce the *Annual Energy Outlook*
- NEMS is also used for evaluating the energy generation and landscape under a variety of scenarios including policy and regulatory constraints
- Scenario analysis performed, primarily at the request of the U.S. Congress
- A modified version of NEMS, the NETL CTUS-NEMS Model, is developed and maintained by NETL
- The CTUS-NEMS Model is used to assess the impacts of DOE Fossil Energy RD&D by NETL

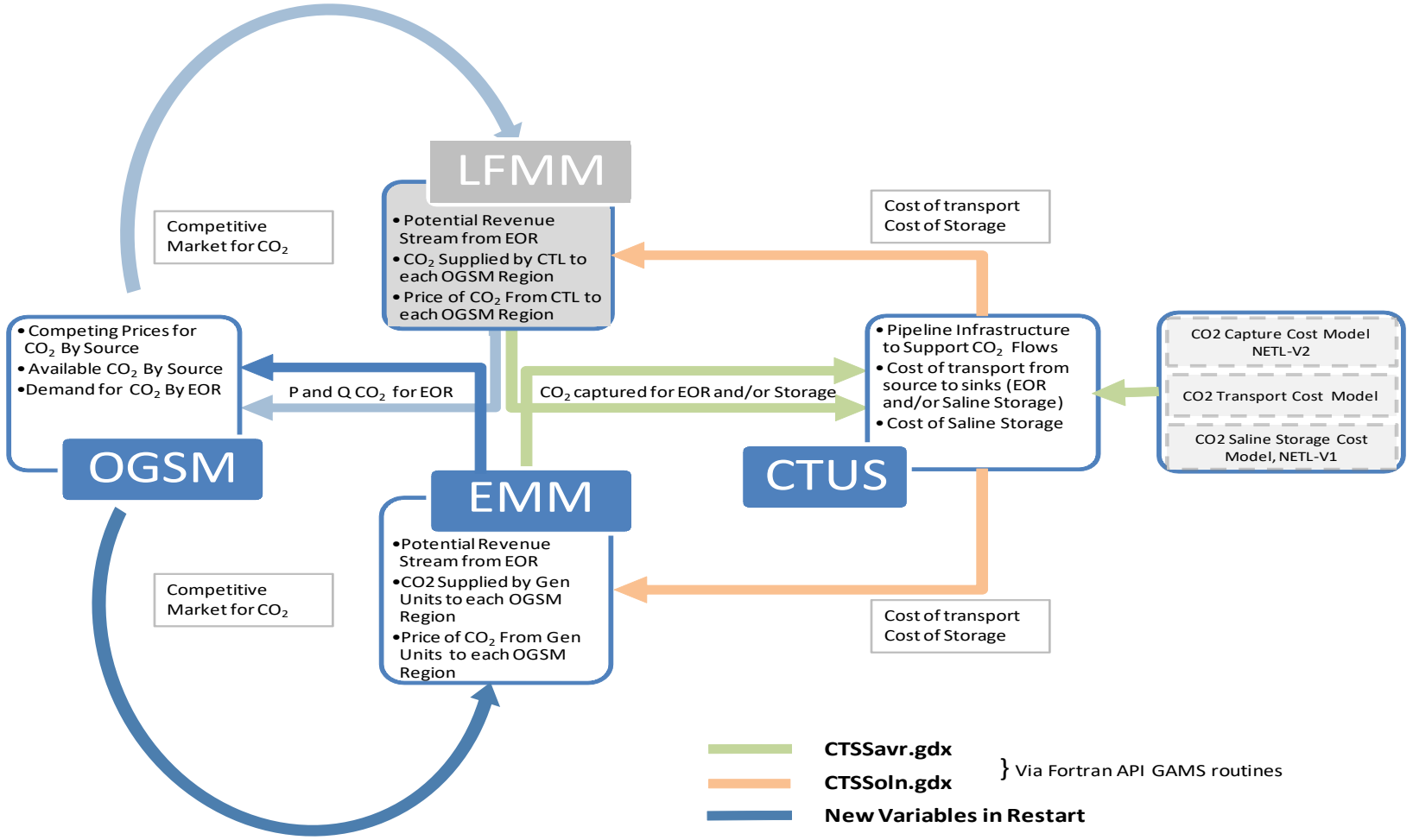


General NEMS Structure



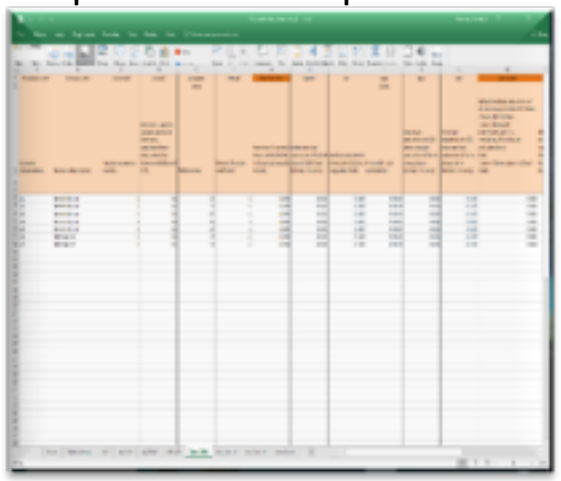
CTUS-NEMS Comprehensive Model Structure

Integrates Multiple Project Databases and Models



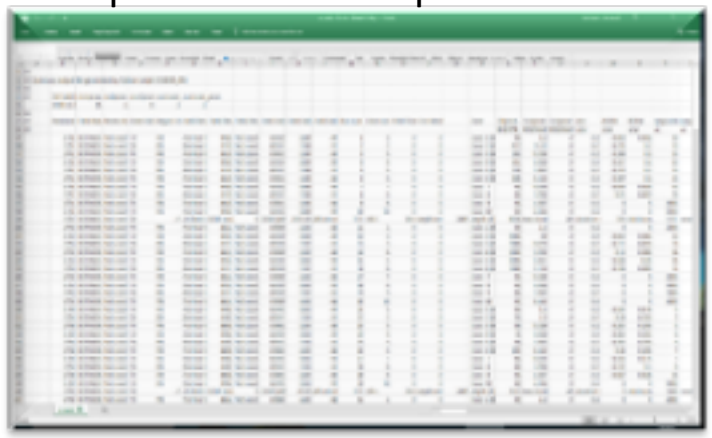
FE/NETL CO_2 EOR Modeling System Drives CTUS-NEMS

Spreadsheet Input Files

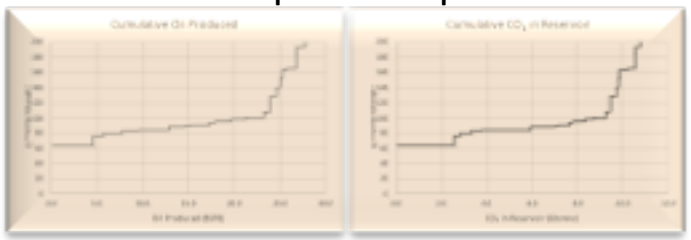


Python Scripting Tool

Spreadsheet Output Files



Graphic Output



Reservoir Data

User Control Data

FE/NETL CO_2 Prophet Model

User Control Data

Cost Data

CO_2 Prophet Results

FE/NETL Onshore CO_2 EOR Cost Model

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Publicly Available CCUS Benefits Study on CCUS RD&D

- ***Analyzing and Estimating the Economic and Job Benefits of U.S. Coal,*** **Sept 2017, Management Information Services Inc. (MISI inc.), http://www.misi-net.com/publications/DOECoal-0917.pdf**
    - Used to generate a two part series in *Public Utilities Fortnightly*, Oct. 2017 and Mid Oct. 2017
        - Part 1: http://misi-net.com/publications/PUF-1017.pdf
        - Part 2: http://misi-net.com/publications/PUF2.0-Mid1017.pdf
- **Evaluates the economic and job impacts of implementation of a successful FE/NETL R&D program and enactment of the enhanced version of 45Q**
    - ***Assumes that 45Q has no sunset provision per vintage of proposed language***
- **Results indicate that implementation of both successful FE/NETL R&D program in conjunction with an enhanced 45Q will result in (scenario dependent):**
    - Achieving DOE R&D goals will create 500K - 3.3M additional jobs
    - CCUS tax credits will create 4.3M - 6.1M additional jobs
    - Achieving DOE R&D program goals in conjunction with CCUS tax credits will create ~ 5M - 10M additional jobs

Public CCUS RD&D Benefits Study Cont'd

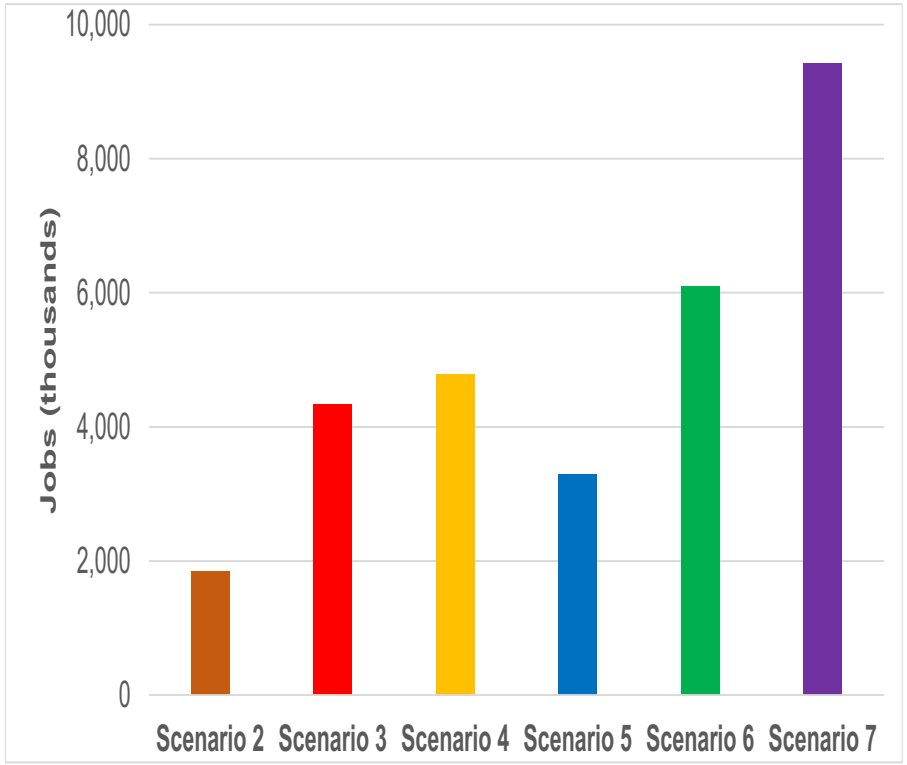
- **7 scenarios were evaluated in the CTUS-NEMS Model**

Scenarios	O&G Prices	Economic Growth	Electricity Demand	CCS Tax Credits	CCS Technology	EOR O&M
1. No CPP Reference Case	Reference	Reference	Reference	No	Reference	Reference
2. High Economic Growth Case	Reference	High	High	No	Low Learning	Low Costs
3. High Growth, CCS TC Case	Reference	High	High	Yes	Low Learning	Low Costs
4. High Growth, CCS TC, PG Case	Reference	High	High	Yes	R&D Program Goals	Low Costs
5. High O&G Prices Case	High	High	High	No	Low Learning	Low Costs
6. High O&G Prices/CCS TC Case	High	High	High	Yes	Low Learning	Low Costs
7. High O&G Prices/CCS TC/PG Case	High	High	High	Yes	R&D Program Goals	Low Costs

Source: http://www.misi-net.com/publications/DOECoal-0917.pdf

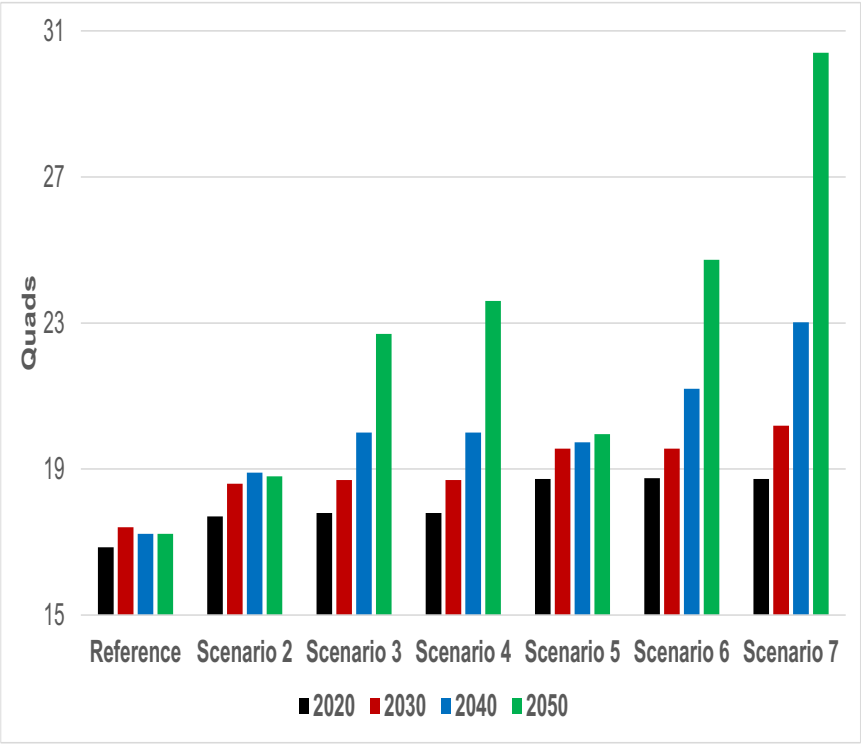
Public CCUS RD&D Benefits Study Cont'd

INCREASED JOB-YEARS GENERATED 2020-2050 COMPARED TO REFERENCE CASE



Source: http://www.misi-net.com/publications/DOECoal-0917.pdf

U.S. COAL PRODUCTION UNDER EACH SCENARIO



Source: http://www.misi-net.com/publications/DOECoal-0917.pdf

Final version of 45Q Differs from Modeled Version

- **Credit 2008-2018:**
  - $20 per metric ton in secure geologic storage
  - $10 per metric ton used for EOR or EGR in a qualified manner
  - Available credits: 75 million Tons

- **Updated Credit (included in the February 2018 "Bipartisan Budget Act of 2018"):**
  - ***Credit available to qualified facilities for 12 year period and awarded on an annual basis***
  - Applicable Amounts for projects placed in service on after the date of enactment
  - $50 per metric ton for secure geologic storage, with the credit increasing annually until the full value is reached in 2026
  - $35 per metric ton for EOR, EGR, or utilization with the credit increasing annually until the full value is reached in 2026
  - Defines qualified Carbon Oxides (CO or CO_2)
    - Captured from an industrial source or the ambient air
    - Measured at point of capture and verified at the point of disposal/injection/use
    - Excludes gases recaptured during EOR process
  - Qualified facilities
    - ***Construction must begin by Jan 1, 2024***
    - Original planning and design includes carbon capture equipment
    - 500,000 t/CO_2 captured/yr for electric generating facilities (for facilities that emit less than 500,000 t/CO_2/yr, credits available for up to 25,000 t/CO_2 captured and used)

- **Utilization, including Photo- or chemo-synthesis, chemical conversion, other purposes for which commercial markets exist**

- **Credit can be claimed by owner of capture equipment or transferred to disposal/use entity**

CCUS RD&D Benefits Results Being Re-evaluated

Sunset Provision for 45Q Requires Re-Examination of Results

The scenarios re-evaluated thus far are as follows (plan to do complete benefits assessment that mirrors original):

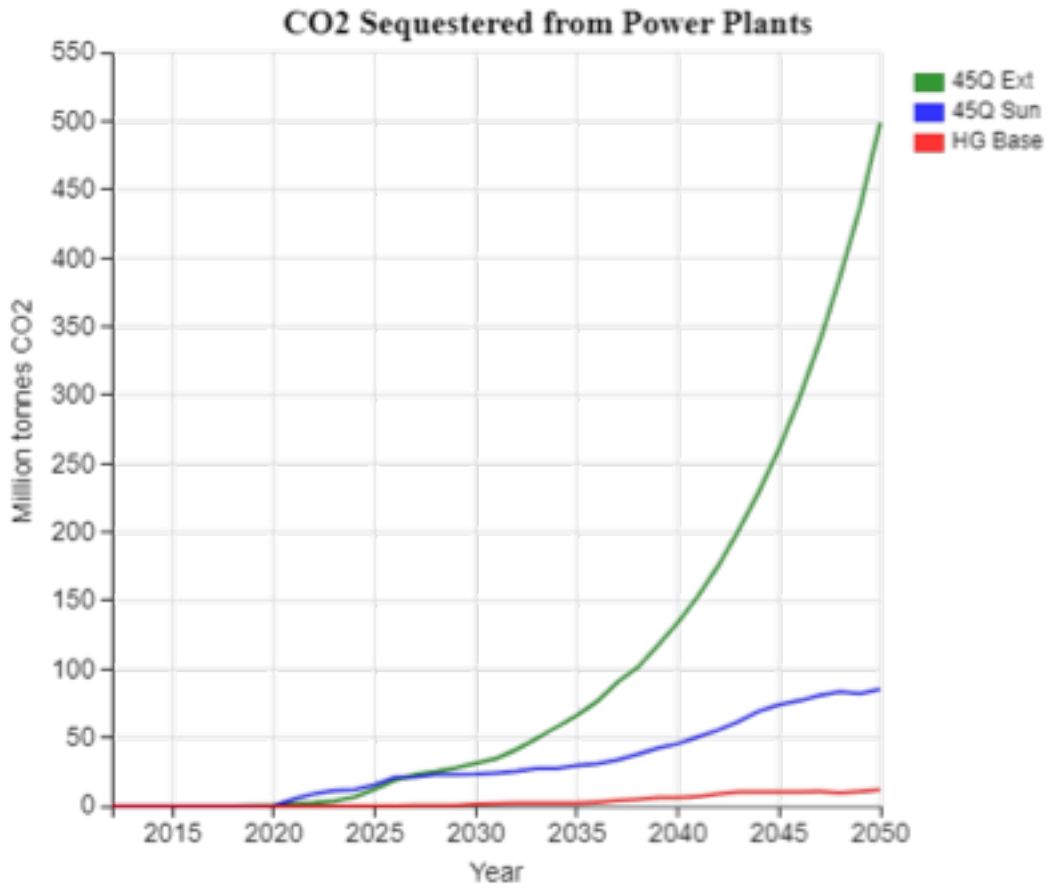
- ***High Growth Base Case ("HG Base"):*** High economic growth with 2.6% per year increase in GDP and high electricity demand of 2% per year, lower EOR O&M costs, and CCS technologies reflecting no federal R&D

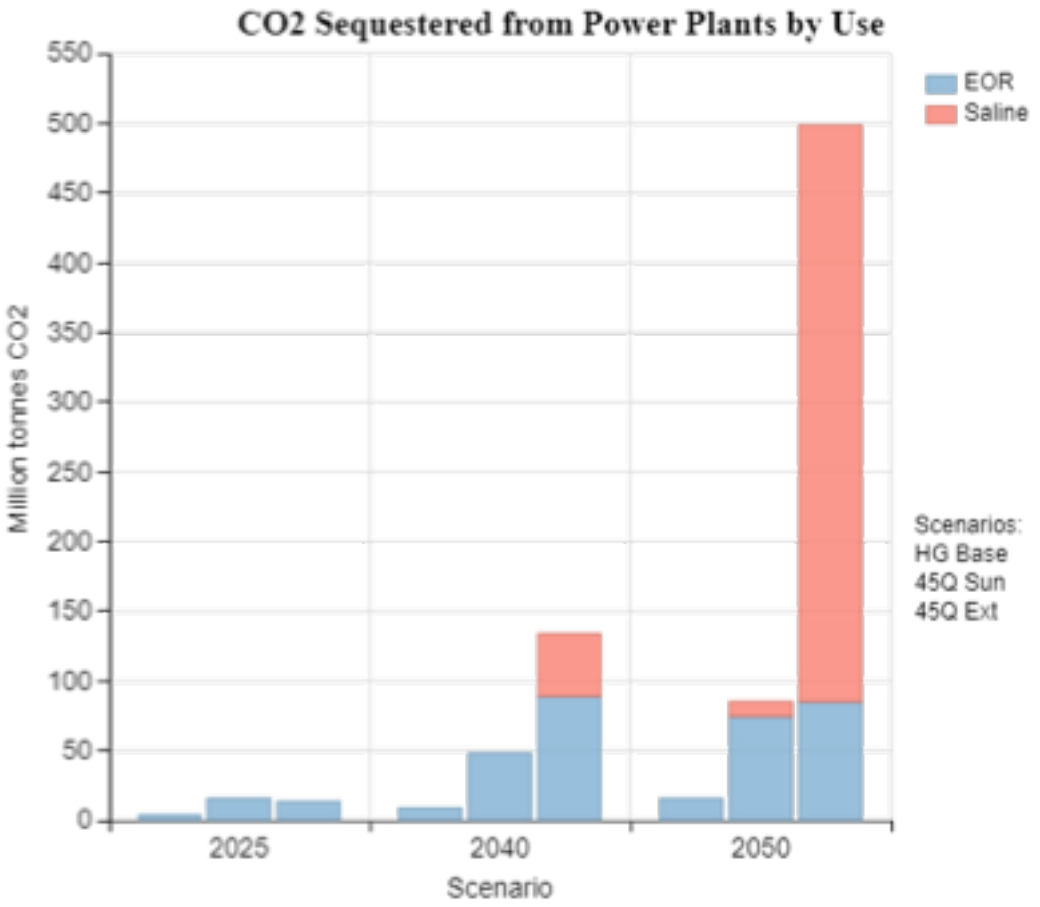
- ***45Q Tax Credit with Sunset Case ("45Q Sun"):*** High Growth with CCS Program Goals Case combined with a 45Q sequestration tax credit that provides $35/ton for captured CO_2 used for EOR and $50/ton for captured CO_2 sent to geologic storage. Credits are available for power and industrial CCS projects that start construction by January 1, 2024

- ***45Q Tax Credit Extended Case ("45Q Ext"):*** High Growth with CCS Program Goals Case combined with a 45Q sequestration tax credit that provides $35/ton for captured CO_2 used for EOR and $50/ton for captured CO_2 sent to geologic storage. Credits are available for power and industrial CCS projects indefinitely

CO_2 Sequestered from Power Plants – 45Q Sunset vs. Extended

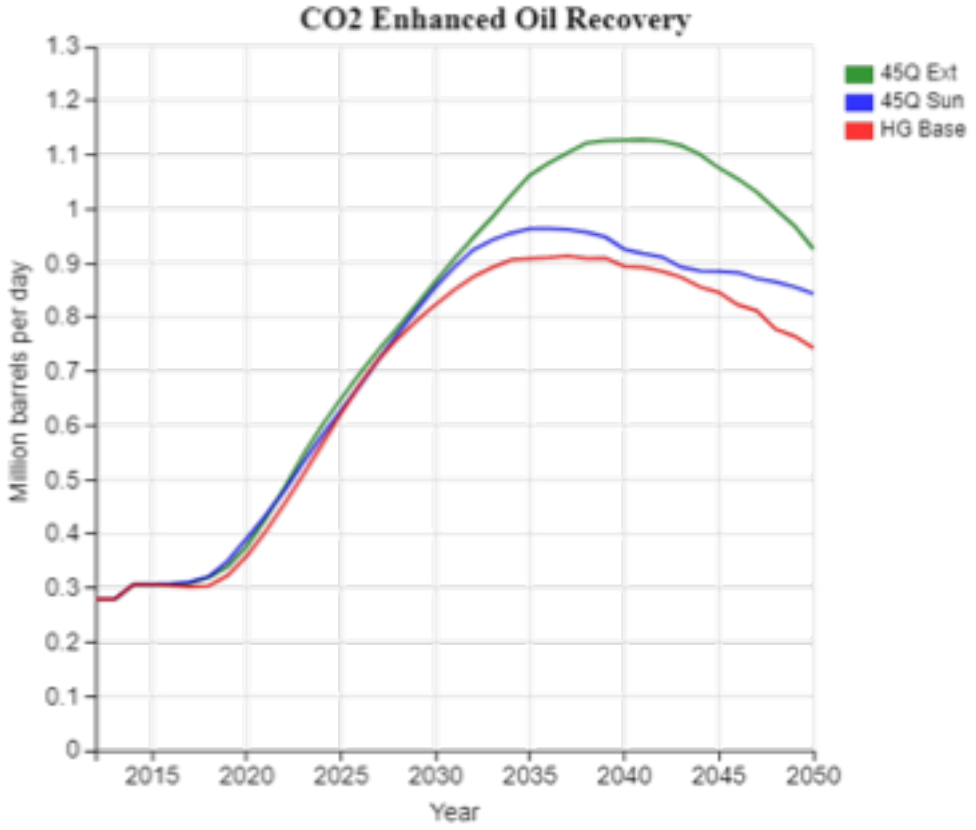
- **The 45Q Tax Credit Scenarios Significantly Impact Volume of CO_2 Sequestered**

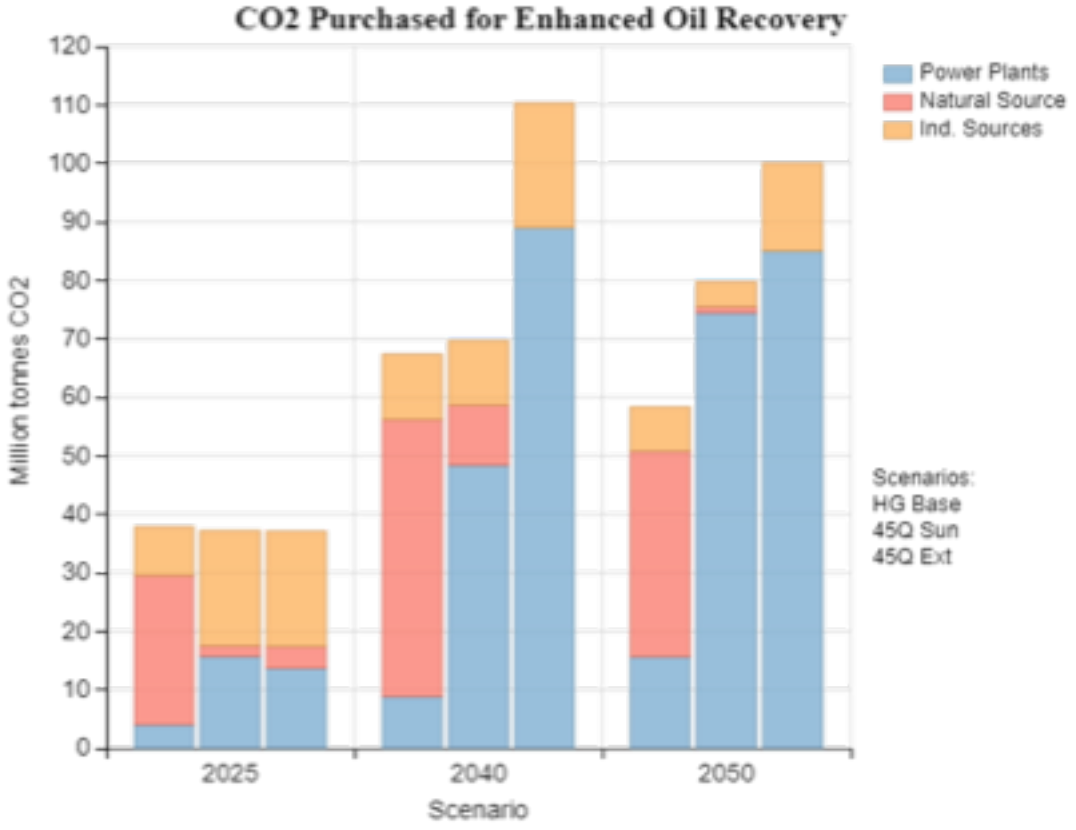




CO_2 Enhanced Oil Recovery – 45Q Sunset vs. Extended

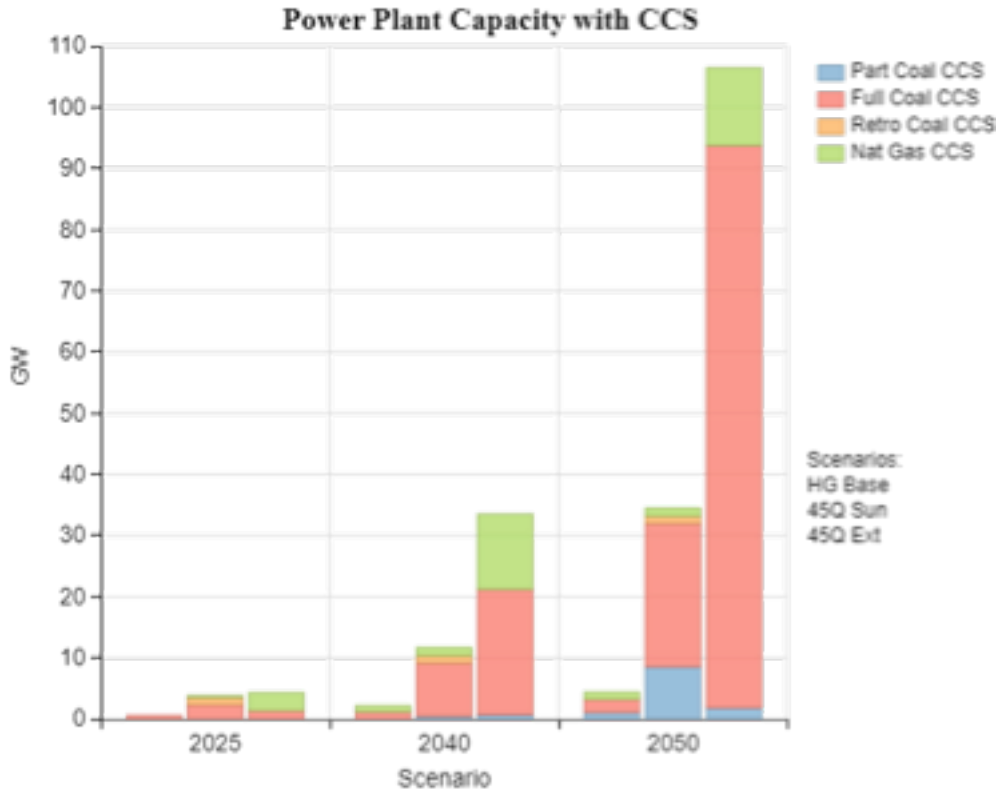
- **The 45Q Tax Credit Scenarios Result in Significant Displacement of Naturally Sourced CO_2 for EOR**

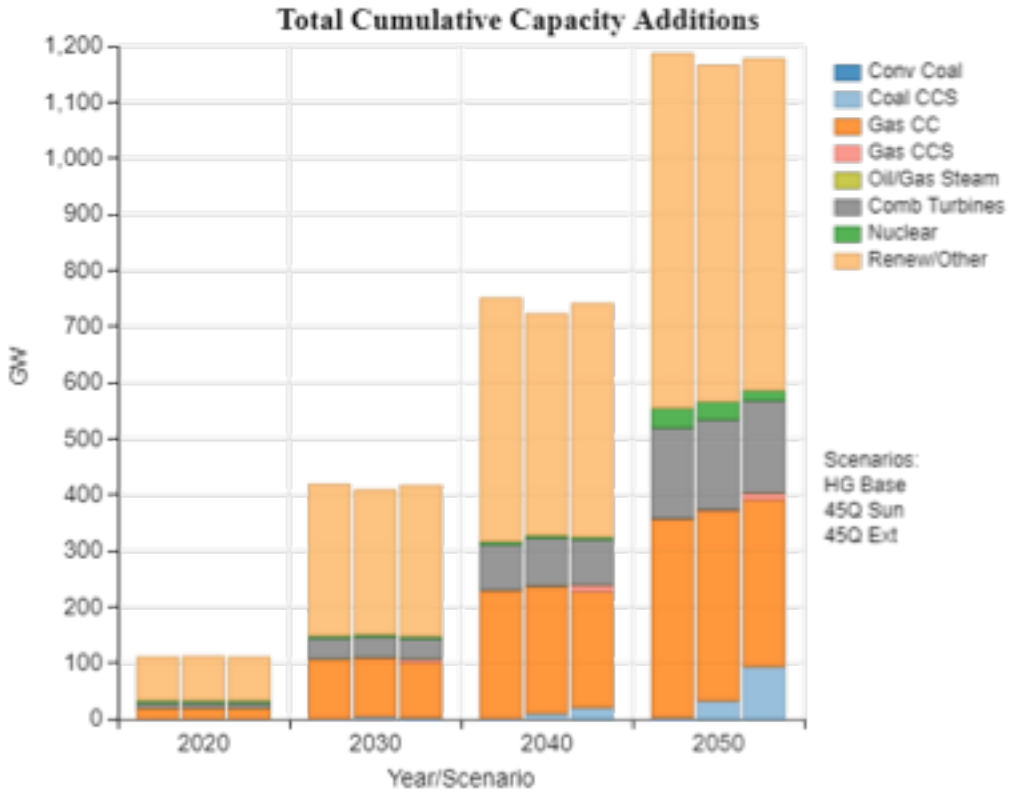




CCUS Capacity – 45Q Sunset vs. Extended

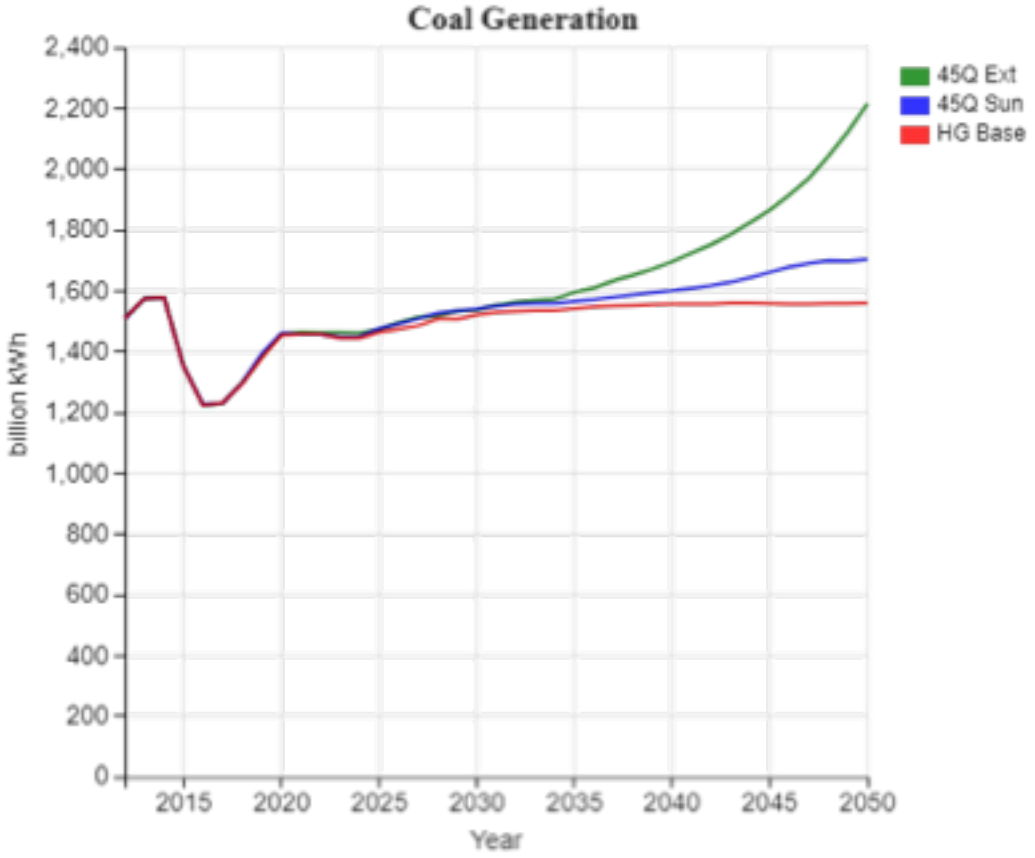
- **New Coal with 90% Capture is Dominant CCUS Technology under 45Q Tax Credit Scenarios**

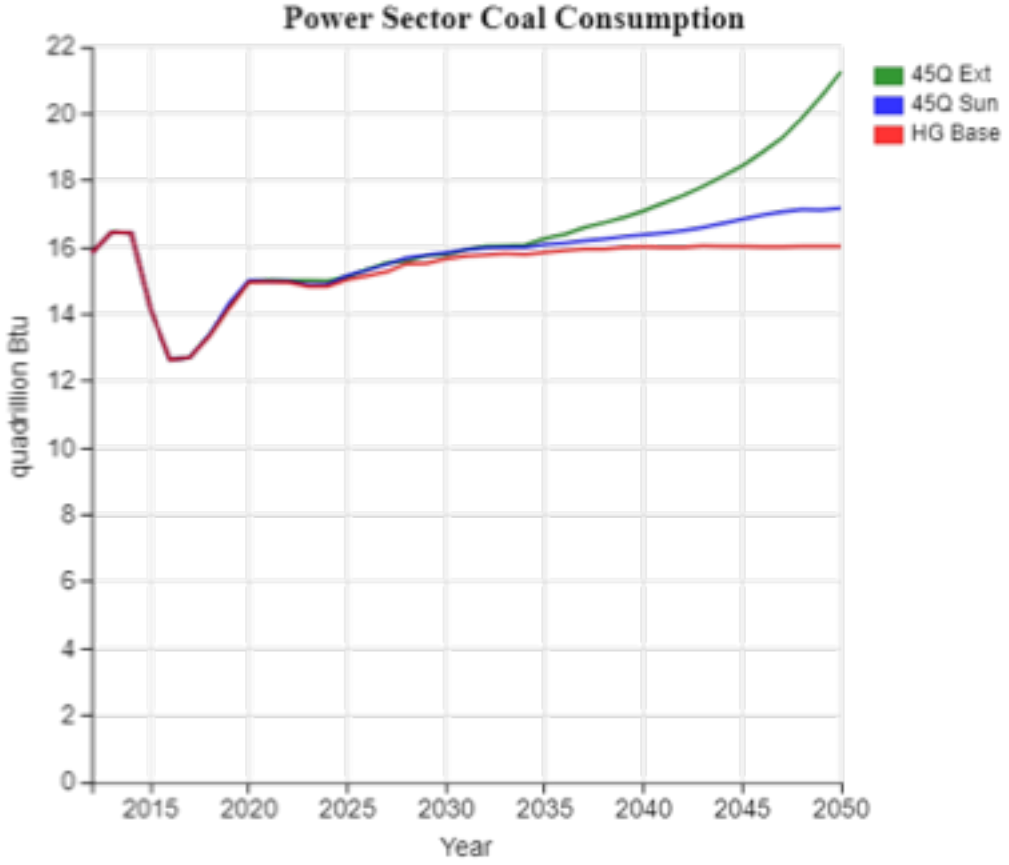




Coal Generation and Consumption – 45Q Sunset vs. Extended

- **Coal Generation and Consumption could see a Resurgence under 45Q Tax Credit Scenarios**





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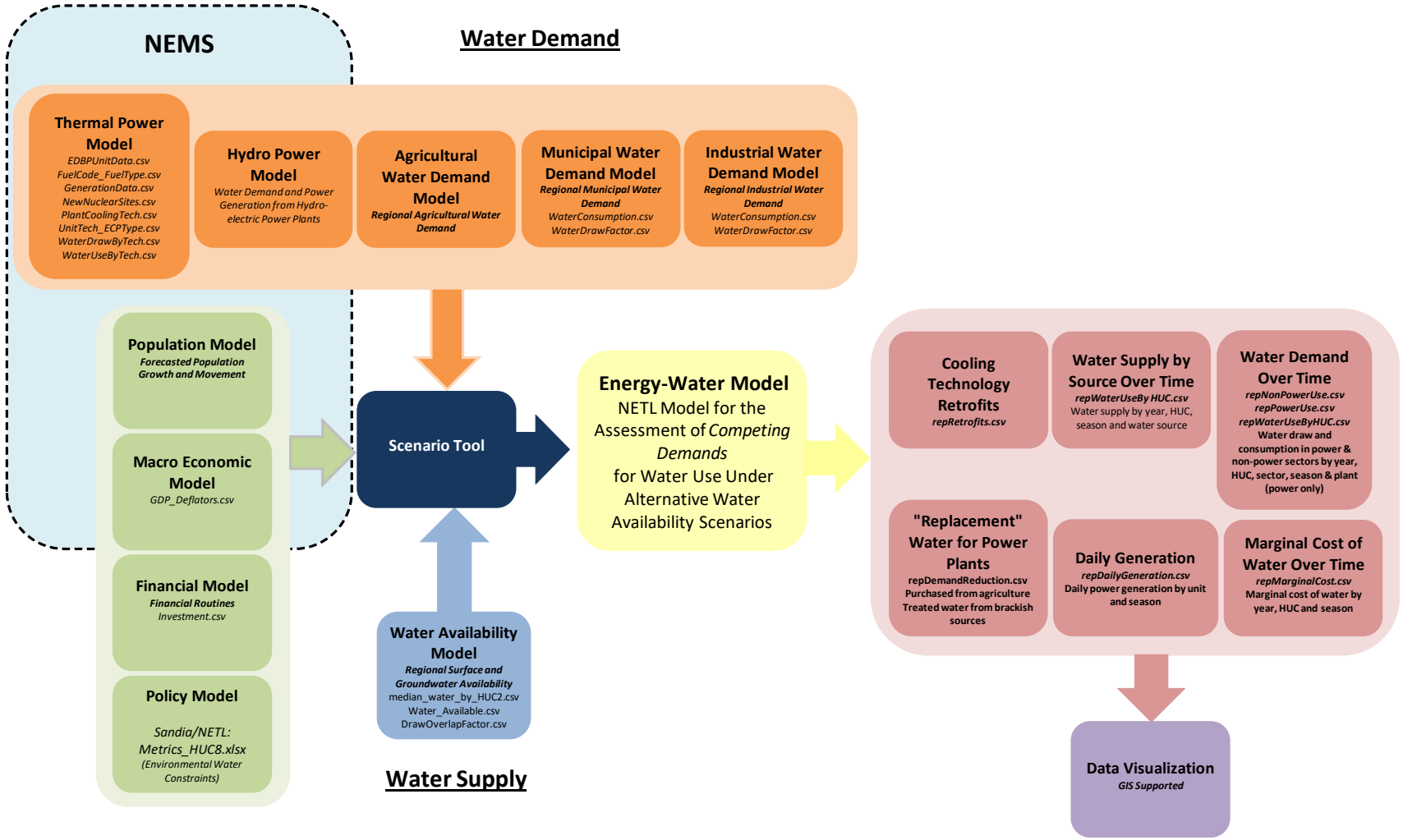
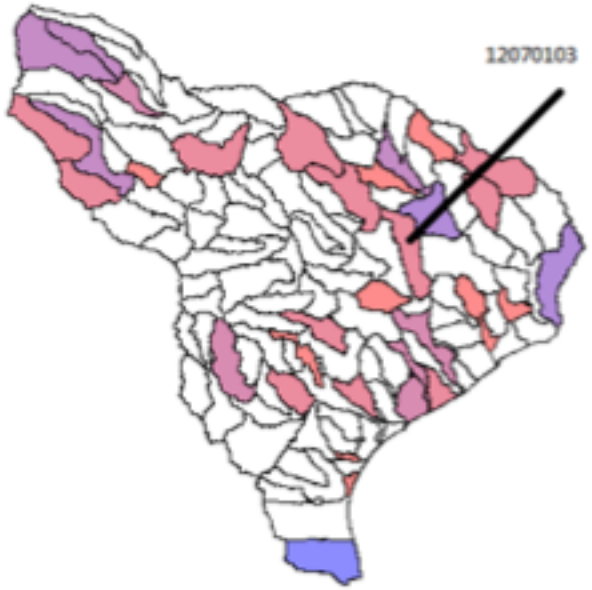
NEMS Water Energy Model (NWEM)

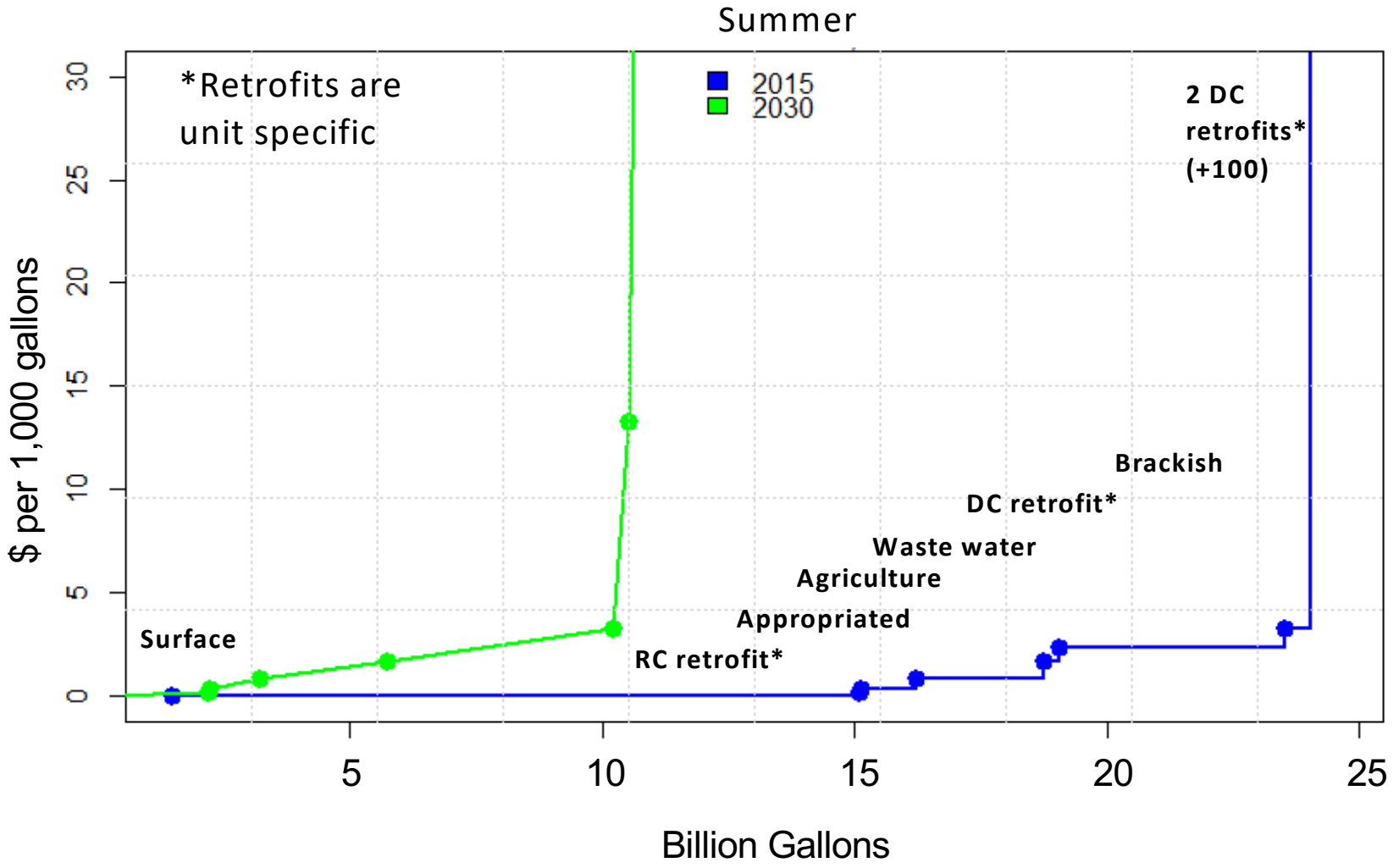
- Integrate water availability into energy-economy projections
- Forecast energy-water shortages under various drought scenarios
- Evaluate impacts of water conservation under these scenarios



Marginal Cost Supply Curve for Water in HUC
12070103 – Navasota, Texas

Forecast cost of water from alternative sources in this HUC8 region.





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Conclusions

- The Department of Energy Office of Fossil Energy/National Energy Technology Laboratory have developed unique capabilities to assess the impacts of fossil energy related RD&D through various detailed and higher level energy-economic models
- Efforts are also underway to assess technologies applicable to the existing fleet of coal fired power plants in order to estimate benefits of increased efficiency/tolerance to cycling, etc.
- These assessments are important to enable the most efficient allocation of public resources toward technologies with the highest impact and probability of success