From: Francisco De La Chesnaye
Sent: Fri, 21 Apr 2023 20:13:26 +0000
To: Iyer, Gokul; Edmonds, James A (Jae); Binsted, Matthew; Wolfram, Paul; Whitman, Peter C; Daniel Hatchell; Riera, Jefferson; Jose Bosch; Skone, Timothy; Michael Blackhurst
Cc: Curry, Thomas; Yarlagadda, Brinda; Sweeney, Amy; Harker-Steele, Amanda J (NETL); Robert Wallace; Agboola, Ajoke; Jamieson, Matthew B.
Subject: [EXTERNAL] FECM LNG Export Project Coordination
Attachments: LNG_Meeting_20230421.pdf

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All,

Many thanks for very productive and collaborative meetings today.

Please find attached the slides we went over today.

For GCAM and NEMS coordination, next week OnLocation has the following available times:

Monday: 10 am to 2 pm
Tuesday: 11:30 am to 1 pm, and 2:30 to 5 pm.

GCAM and LCA Teams, please let us know when is good for you and then we'll confirm with meeting invitation

Best, Paco

Francisco De La Chesnaye | **Vice President**
m: (b) (6) | onlocationinc.com

****

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A KEYLOGIC COMPANY

Updated Natural Gas Regulatory Analyses

GCAM and NEMS Scenario Comparison

In support of Department of Energy
Office of Fossil Energy and Carbon Management
Office of Resource Sustainability

April 21, 2023

DRAFT*DELIBERATIVE*PRE-DECISIONAL

Outline

1. NEMS Model Selection: AEO2023 and FECM-22 (both have IRA provisions, AEO2022 low macro)
2. Review of Scenarios
3. GCAM/NEMS Model Alignment

Scenarios / Model Runs	LNG Export Limit or Outcome (Bcf/d)	Global GCAM *(Benchmark to AEO 22 or 23?)*	AEO 23 NEMS	FECM-NEMS AEO 22 Low Econ
1. Existing Capacity including existing Policies and Measures	24.19 Bcf/d constraint	Same	*27.34 Bcf/d, endogenous*	*24.19 Bcf/d constraint*
2. Remove U.S. LNG Export Capacity Constraint:	Determined by GCAM market response	Yes	Input from GCAM	Input from GCAM
3. Sensitivity: High Global Demand (Econ and Pop growth)	same	Yes	Input from GCAM	Input from GCAM
4. Sensitivity: Energy Security related – EU, Russia, Qatar	Same	Yes	Input from GCAM	Input from GCAM
5. Sensitivity: Technology related (Renewables, low-emitting energy)	same	Yes	Input from GCAM	Input from GCAM
6. Energy Transition: U.S. to Net-Zero, Developed Country Pledges, etc.	Alignment among models	Define target globally (1.5 or 2) and US Net Zero	NA	Yes w/ updated FECM not EMF37

Key issues / items to consider

- **Align on natural gas and oil prices between NEMS and GCAM**
- **Between scenarios 3 to 5, try to find high and low demands (maybe don't need low bc #1?)**
- **Need to align in IRA assumption across GCAM, AEO 23, and FECM-NEMS (FECM acknowledge/onfirm IRA implementation)**
- **Align on tech assumption on #5 with GCAM and FECM-NEMS**
- **Careful coordination and consideration on #6 between GCAM and FECM-NEMS (H_2, DAC, non-NEMS GHGs, others?)**

Schedule

Complete for Internal DOE Review by Mid July

Final Inter-agency Review by End Aug

Final Report by End Sep

		PPNL and OL Teams	
weeks	w/o	Modeling efforts	Report Writing
1	4/17/2023	Decide on scenarios and align on key variables	
2	4/24/2023	GCAM and NEMS (AEO23 & FECM) coordination	D: Introduction and Scenario Design
3	5/1/2023	GCAM Run on Sce 1 to 6	
4	5/8/2023	GCAM Run on Sce 1 to 6 and Review	D: Study Methodology & Key Assumptions
5	5/15/2023	PNNL pass results to OL and start NEMS runs	**D: International GHG Outcomes**
6	5/22/2023	NEMS Runs on Sce 1 - 6	
7	5/29/2023	NEMS Runs on Sce 1 - 6	
8	6/5/2023	NEMS Runs on Sce 1 - 6	**D: U.S. Natural Gas Market Results**
9	6/12/2023	Review and comparison of NEMS and GCAM results	**D: U.S. GHG Outcomes & Econ??**
10	6/19/2023	Review and comparison of NEMS and GCAM results	
11	6/26/2023	Possible model adjustments and new runs	
12	7/3/2023	Possible model adjustments and new runs	
13	7/10/2023	GCAM and NEMS Final Results	Final Drafts
14	7/17/2023		
			Appendices and Data Annexes

NEMS Modeling Decision

FECM-22-NEMS and AEO23-NEMS

FECM-NEMS Version*
Currently in Review

FECM's Interpretation of the IRA

Represents several CO_2 mitigation technologies; capable of modeling net-zero scenarios

Based on AEO 2022 Low Economic Growth Case

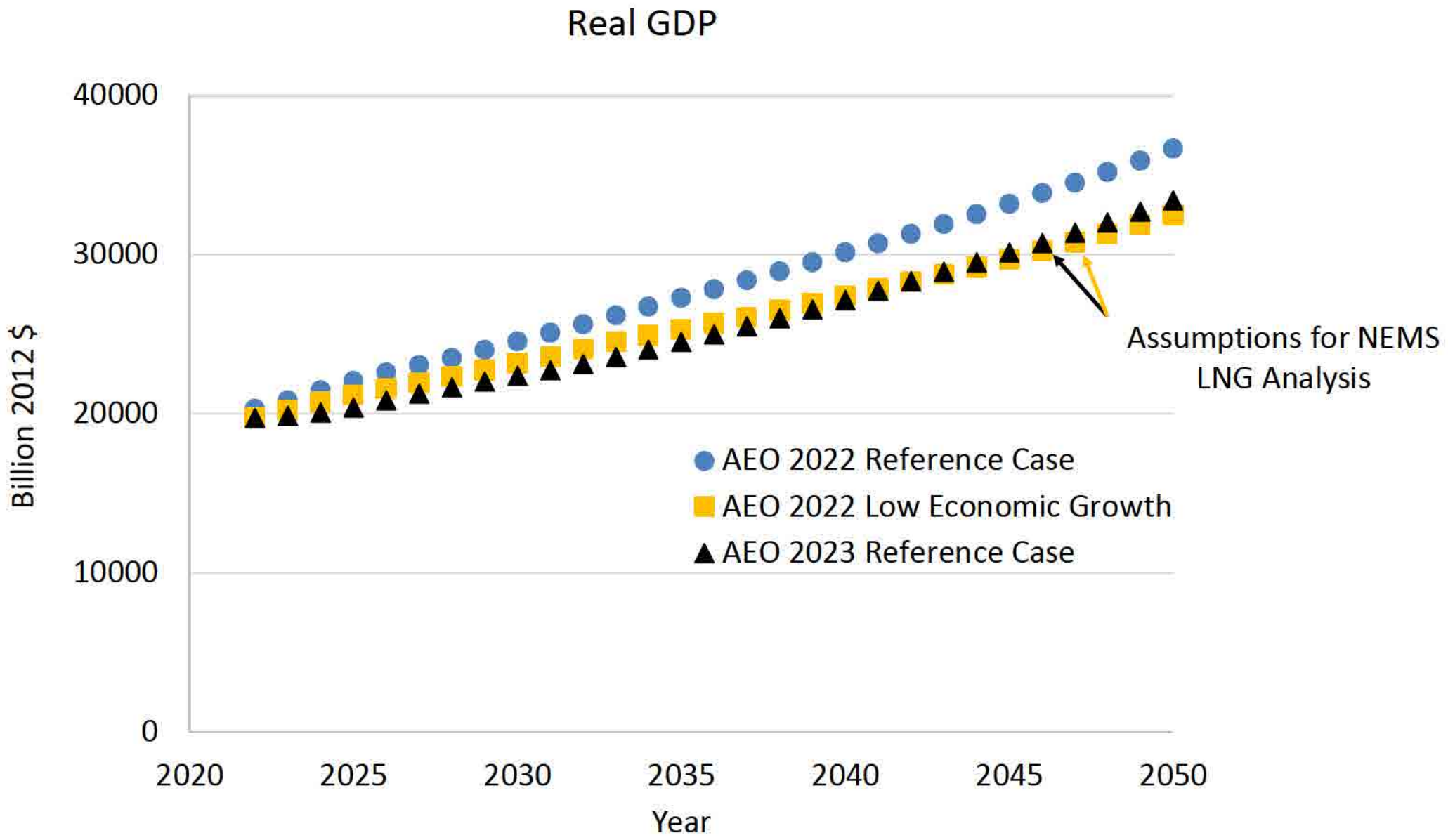
EIA AEO 2023 NEMS Version*
Ready by May 2023

EIA Independent Baseline with EIA's Analysis of IRA

Higher CO_2 emissions than FECM Version, cannot model net-zero scenarios

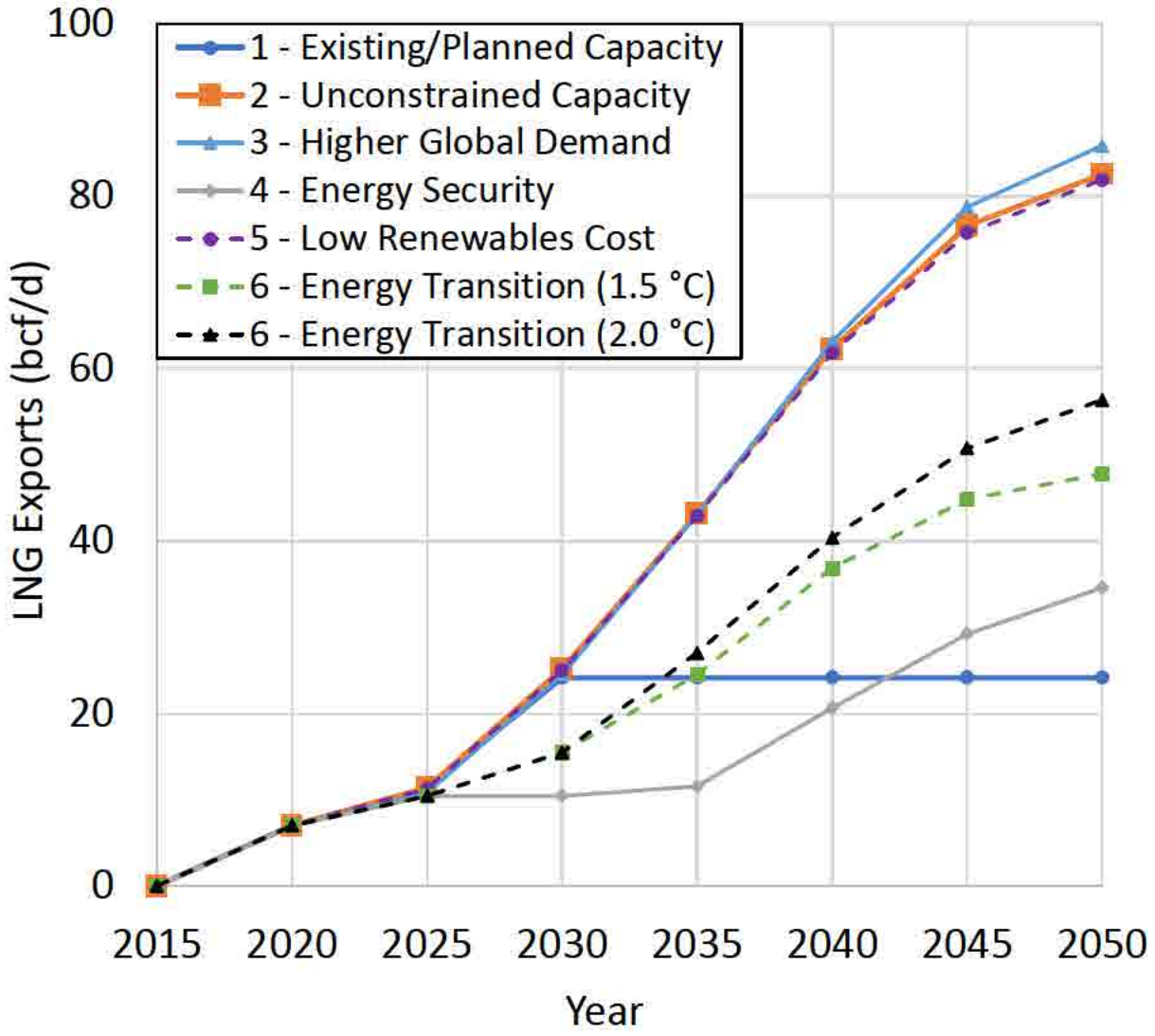
AEO 2023 Reference (similar to AEO 2022 Low Economic Growth Case)

*In Both: NEMS LNG Export Demand to match GCAM LNG Export Demand from 2025 to 2050


Real GDP
40000
30000
20000
10000
0
Billion 2012 $
2020
2025
2030
2035
2040
2045
2050
Year
AEO 2022 Reference Case
AEO 2022 Low Economic Growth
AEO 2023 Reference Case
Assumptions for NEMS LNG Analysis

Review of Scenarios

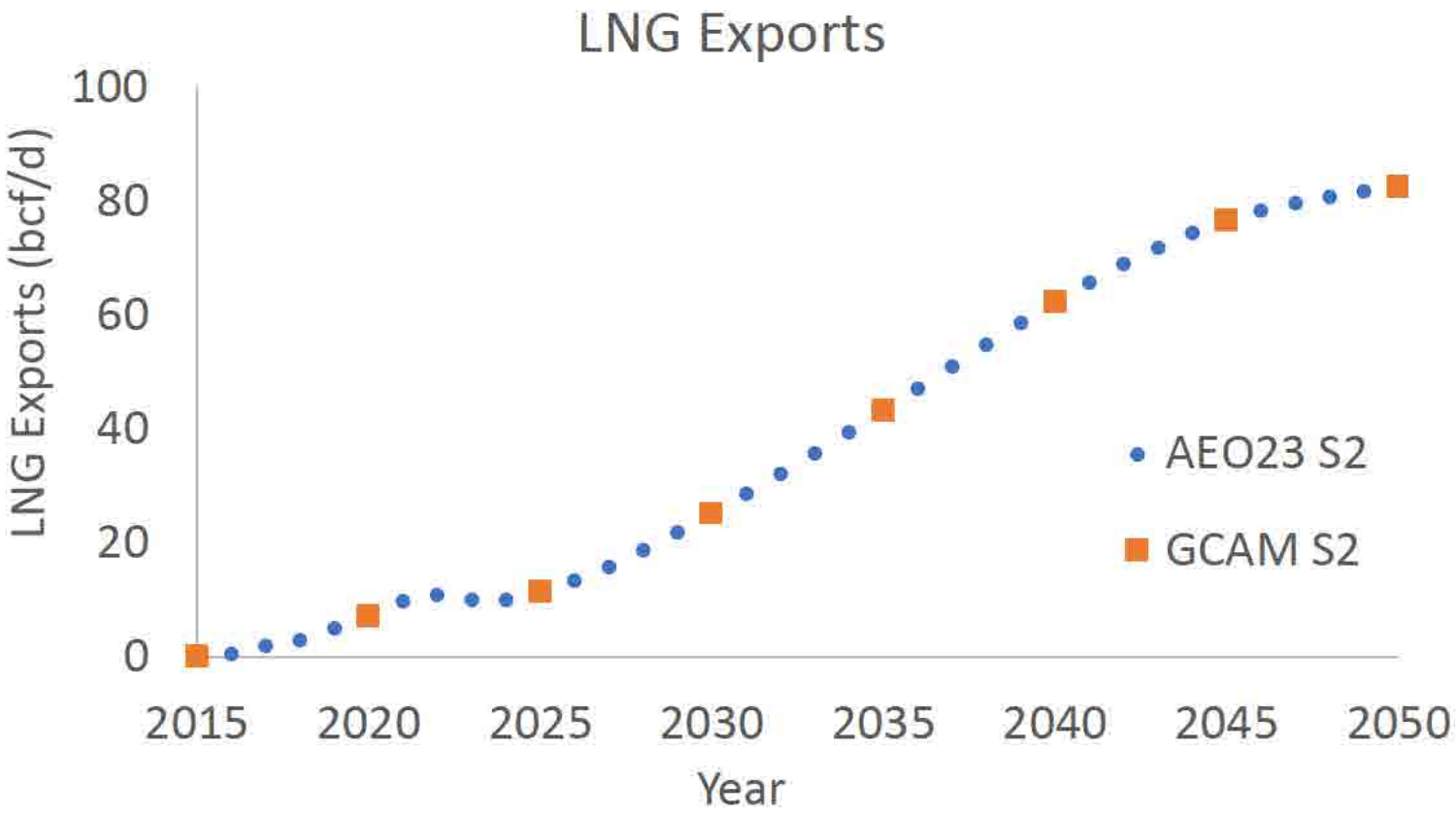
- Preliminary GCAM US LNG exports for the six scenarios. All scenarios have limited Russian export constraint
  1. Existing/Planned Capacity only (24.19 BCF/day)
  2. Unconstrained Capacity – economic solution
  3. Higher Global Demand (Higher population and economic growth)
  4. Energy Security (Limits on imports dependent on region type)
  5. Low Renewables Cost
  6. Energy Transition (1.5° C and 2° C - consistent pathways)



GCAM/NEMS Model Alignment

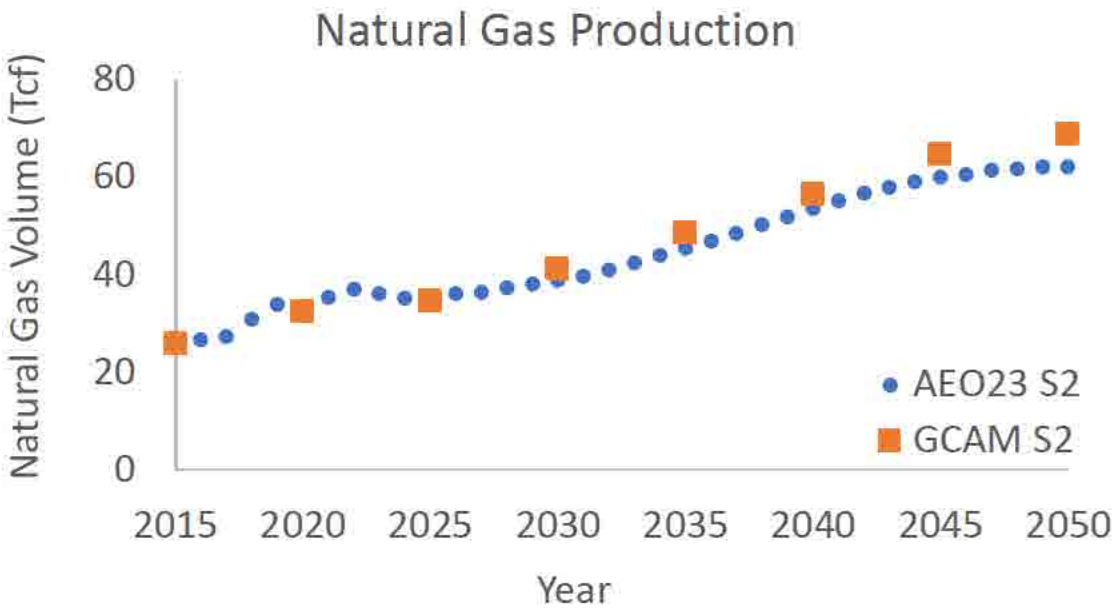
- Exogenous Variables
  - Population
  - GDP
  - Natural Gas Resource base
  - Renewable Technology Costs
  - Other IRA provisions
- Endogenous Variables
  - Natural Gas Production
  - **Natural Gas Price**
  - Electricity Consumption
  - Pipeline Imports/Exports

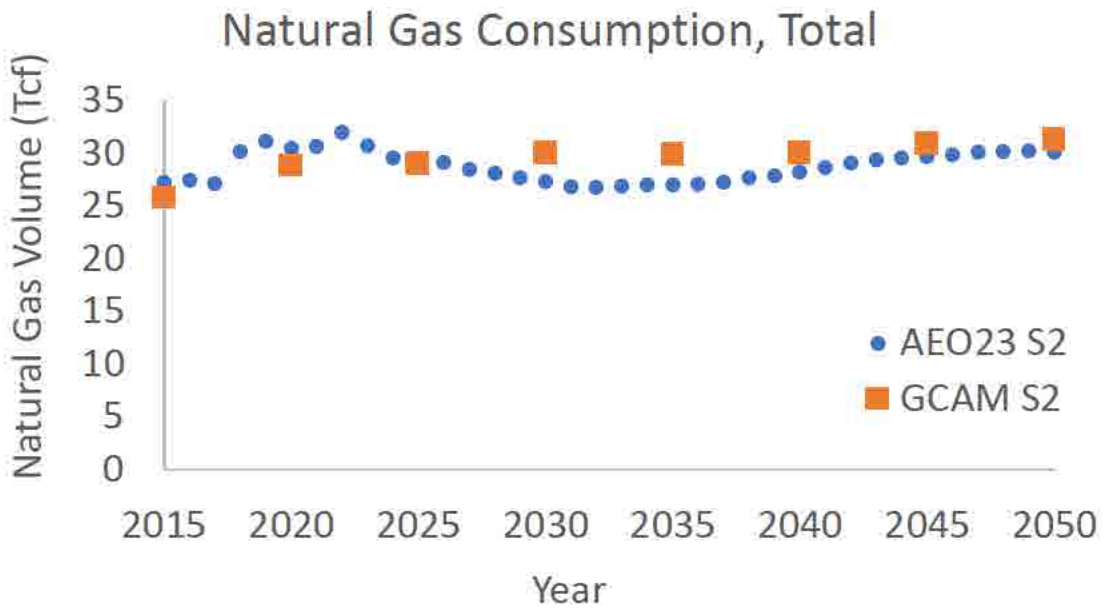
GCAM/NEMS Model Alignment



*Preliminary results from AEO23 – model is still undergoing validation

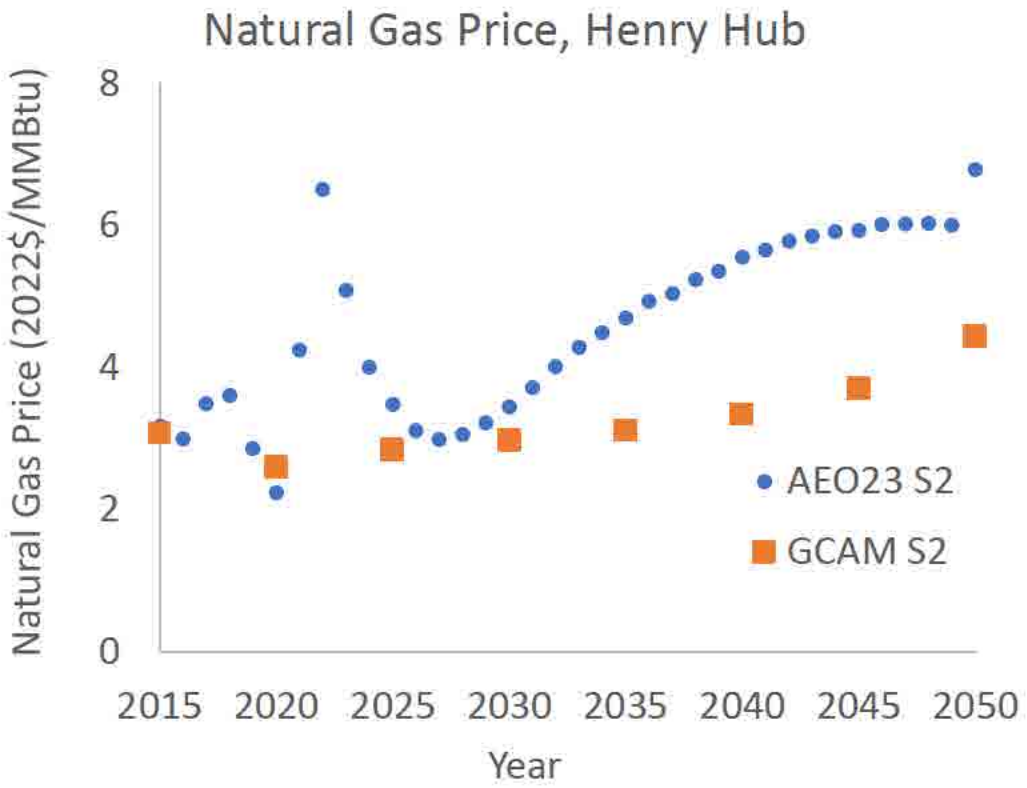
GCAM/NEMS Model Alignment

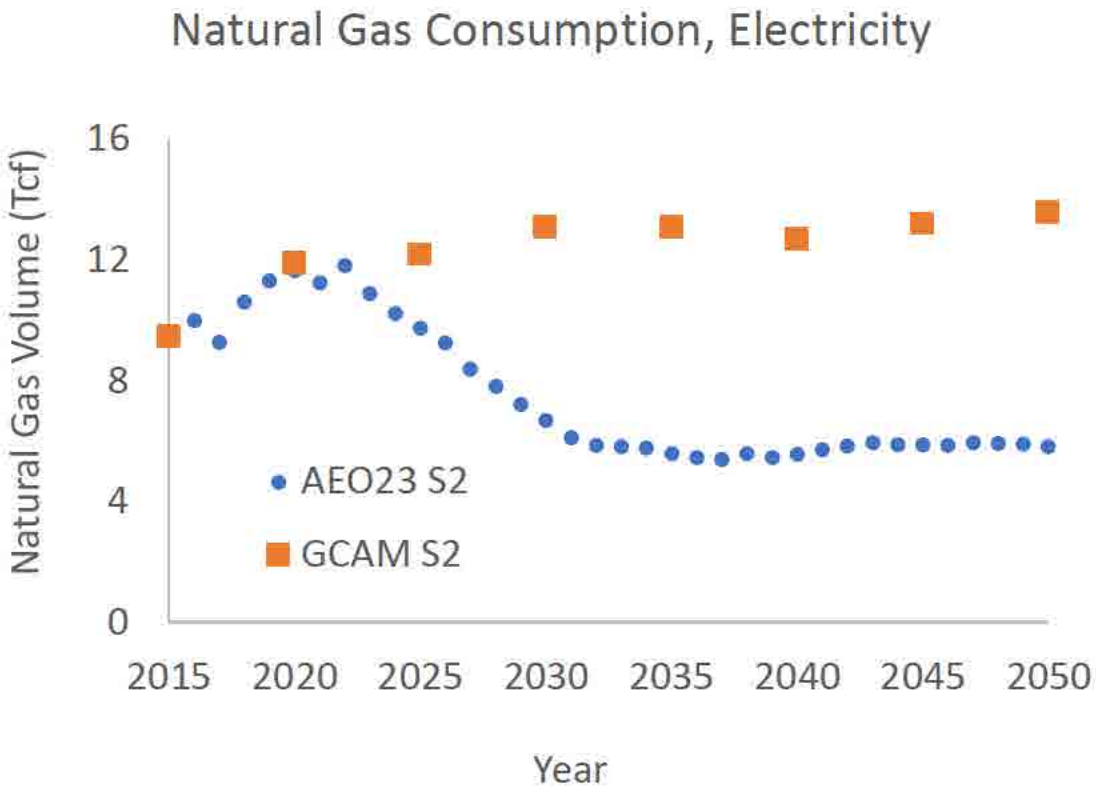




*Preliminary results from AEO23 – model is still undergoing validation

GCAM/NEMS Model Alignment





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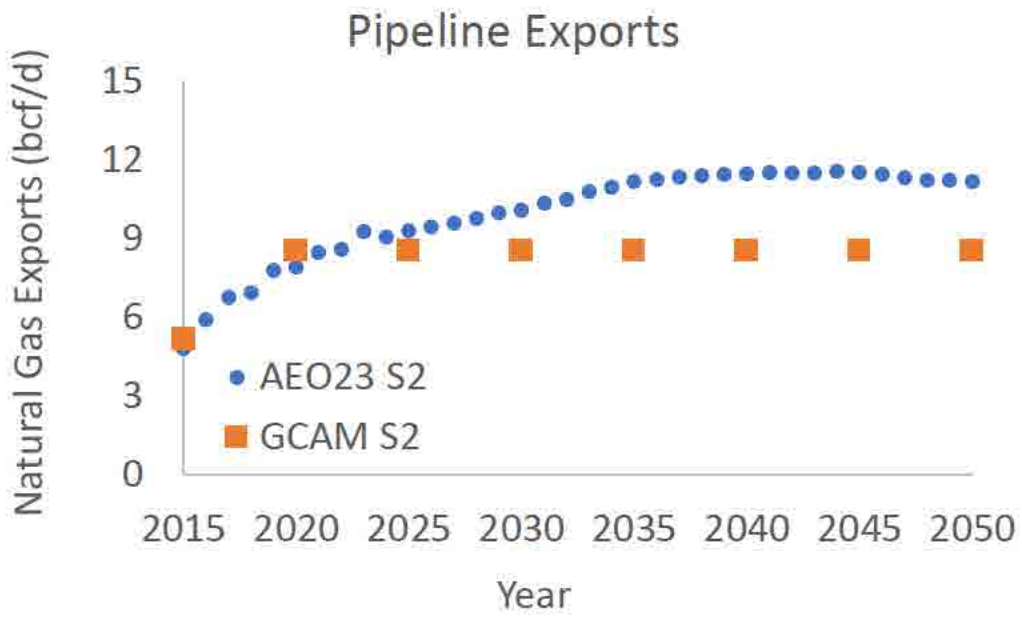
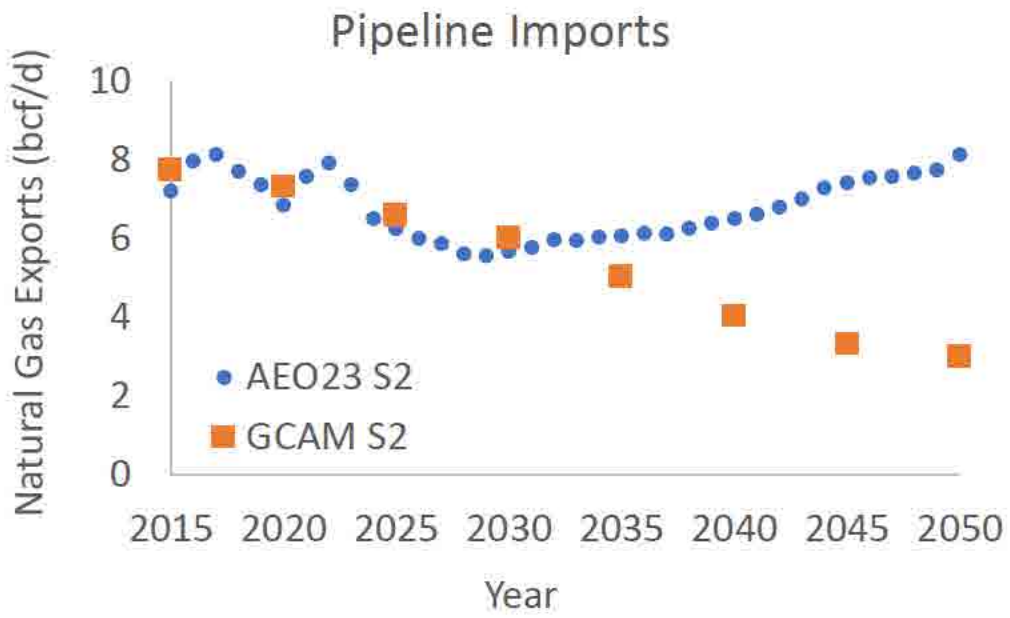
GCAM/NEMS Model Alignment





*Preliminary results from AEO23 – model is still undergoing validation

Extra Slides

FECM-NEMS 22: Details of IRA Implementation

	FECM-NEMS IRA Scenario
Macroeconomic Growth	AEO22 Low Economic Growth
Technology Assumptions-Renewables	NREL ATB Moderate case for initial costs, then endogenous learning
Technology Assumptions-Carbon Capture	NREL ATB Moderate case for initial costs, then endogenous learning; 95% capture
Technology Assumptions-Electric Vehicles	ANL Low (BAU) case for LDV EV costs, CARB costs for electric/fuel cell trucks
Light-Duty Vehicle EPA and CAFE Standards	Updated EPA and NHTSA standards thru 2026
State ZEV Mandates	Pre-existing programs, but not Advanced Clean Cars II (100% targets)
BIL Funding for Carbon Capture Demos, Transport, and Storage	Includes funding for both power and industrial carbon capture, and for CO_2 pipelines and saline injection
BIL Funding for Advanced Nuclear Demos	Two 330MW SMR plants (WA, WY)

	FECM-NEMS IRA Scenario
Power Sector	Clean electricity tax credits (5X w/ no bonus credits) thru 2050; Zero Emission Nuclear Credits; USDA rural coop programs
Buildings Sector	Renewable tax credits (5X w/ no bonus); shell and appliance tax credits and subsidies; EPA GHG Reduction Fund
Industrial Sector	Various manufacturing credits for CCS, steel, cement, and other GHG reductions
Transportation Sector	LDV tax credits (30D); commercial clean vehicle credits; and USPS clean fleets
Fuels Production	Hydrogen tax credits; biofuels tax credits; Clean Fuel Production Tech-neutral credit
45Q Sequestration Credits	Implemented for EOR, saline, and direct air capture (5X credit)
Other	Increased royalty rates for oil/gas production

Baseline Scenario Assumptions

Two IRA baseline scenarios to consider:

1. OP-NEMS Moderate IRA scenario
    - Based on the AEO2022 low economic growth case
    - Includes a mix of IRA and non-IRA assumptions including updated technology costs and transportation policies as well as additional provisions from the Bipartisan Infrastructure Law
    - OP-NEMS includes all FECM-NEMS model enhancements except for the hydrogen market module

2. FECM-NEMS IRA scenario
    - Based on the AEO2022 low economic growth case
    - Includes most of the OP-NEMS IRA and non-IRA assumptions except for differences in IRA bonus tax credits and technology costs
    - FECM-NEMS includes a new hydrogen market module that is not included in OP-NEMS

Both scenarios should be available by mid-April.

IRA Scenario Non-IRA Assumptions

	OP-NEMS Moderate IRA Scenario	FECM-NEMS IRA Scenario
Macroeconomic Growth	AEO22 Low Economic Growth	AEO22 Low Economic Growth
Technology Assumptions-Renewables	NREL ATB Moderate case costs for all projection years	NREL ATB Moderate case for initial costs, then endogenous learning
Technology Assumptions-Carbon Capture	FECM assumptions for initial costs, then endogenous learning; 95% capture	NREL ATB Moderate case for initial costs, then endogenous learning; 95% capture
Technology Assumptions-Electric Vehicles	ANL Low (BAU) case for LDV EV costs, EIA EV costs but higher MPGs for EV trucks	ANL Low (BAU) case for LDV EV costs, CARB costs for electric/fuel cell trucks
Light-Duty Vehicle EPA and CAFE Standards	Updated EPA and NHTSA standards thru 2026	Same
State ZEV Mandates	Pre-existing programs, but not Advanced Clean Cars II (100% targets)	Same
BIL Funding for Carbon Capture Demos, Transport, and Storage	Includes funding for both power and industrial carbon capture, and for CO_2 pipelines and saline injection	Same
BIL Funding for Advanced Nuclear Demos	Two 330MW SMR plants (WA, WY)	Same

IRA Scenario IRA Assumptions

	OP-NEMS Moderate IRA Scenario	FECM-NEMS IRA Scenario
Power Sector	Clean electricity tax credits (5X w/ 10% bonus credits) thru 2050; Zero Emission Nuclear Credits; USDA rural coop programs	Clean electricity tax credits (5X w/ no bonus credits) thru 2050; Zero Emission Nuclear Credits; USDA rural coop programs
Buildings Sector	Renewable tax credits (5X w/ 10% bonus); shell and appliance tax credits and subsidies; EPA GHG Reduction Fund	Renewable tax credits (5X w/ no bonus); shell and appliance tax credits and subsidies; EPA GHG Reduction Fund
Industrial Sector	Various manufacturing credits for CCS, steel, cement, and other GHG reductions	Same
Transportation Sector	LDV tax credits (30D); commercial clean vehicle credits; and USPS clean fleets	Same
Fuels Production	Hydrogen tax credits; biofuels tax credits; Clean Fuel Production Tech-neutral credit	Same
45Q Sequestration Credits	Implemented for EOR, saline, and direct air capture (5X credit)	Same
Other	Increased royalty rates for oil/gas production	Same

GCAM/NEMS Coordination: Variable Comparison

Variables that GCAM and NEMS will match to AEO22 IRA / AEO23:

- GDP
- Population
- Historic NG price

Variables that NEMS will match to GCAM:

- LNG Exports

Other variables?

- Total Natural Gas Supply
- **Total Natural Gas Consumption**
- Natural Gas Consumption in the Electric Power Sector
- Natural Gas CO_2 Emissions in the Electric Power Sector
- **Natural Gas Henry Hub Spot Price**
- Electricity Production Technology Assumptions (assuming significant differences)

GCAM/NEMS Coordination: Variable Comparison

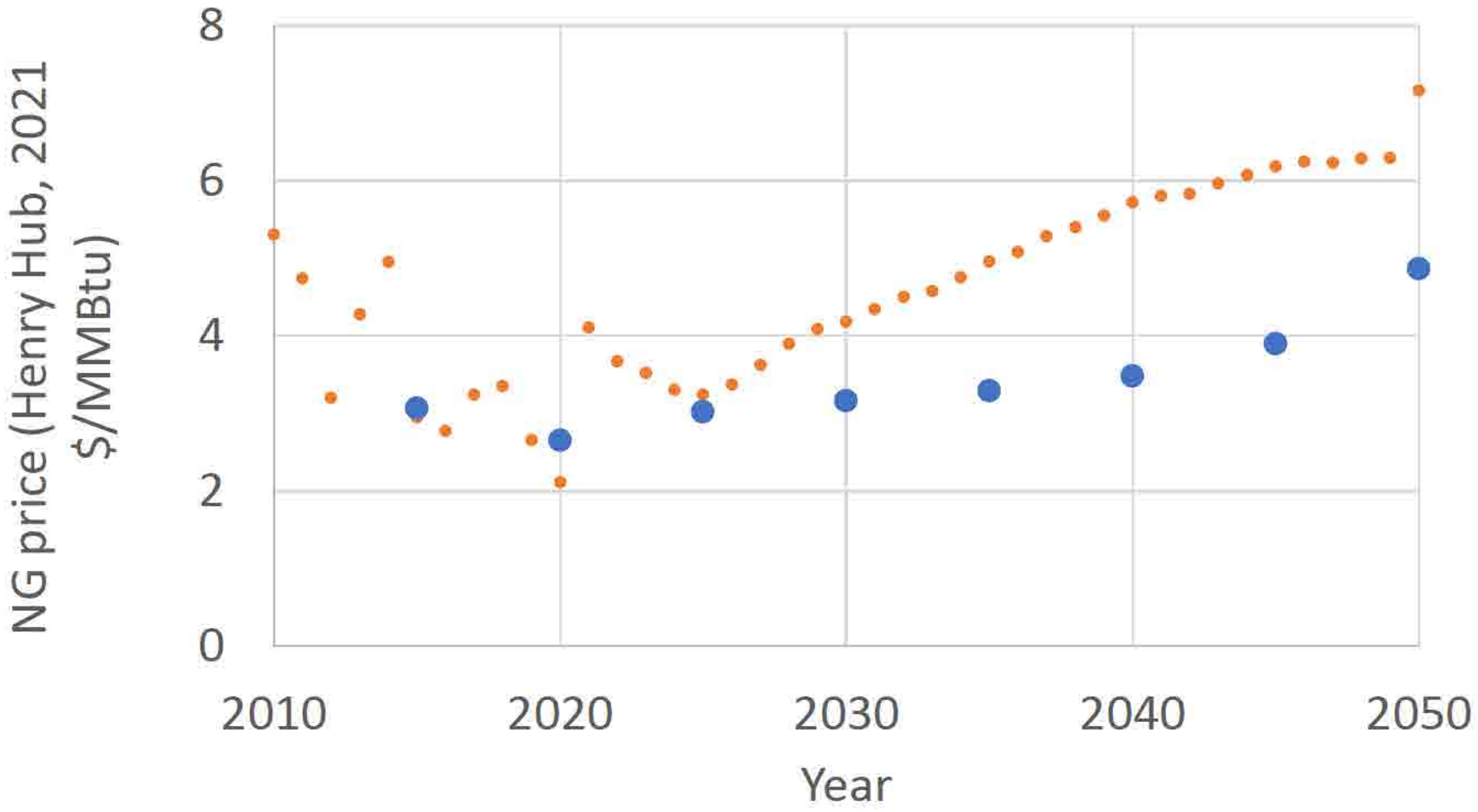
We tried a model run of AEO 2022 with low macro

- NEMS LNG Exports (model input) set equal to GCAM S2 LNG Exports (model output)
- No IRA assumptions
- Only the natural gas and oil+gas modules (limited electricity-system feedback)
- Limited CCS

Plots will compare GCAM variables with NEMS variables

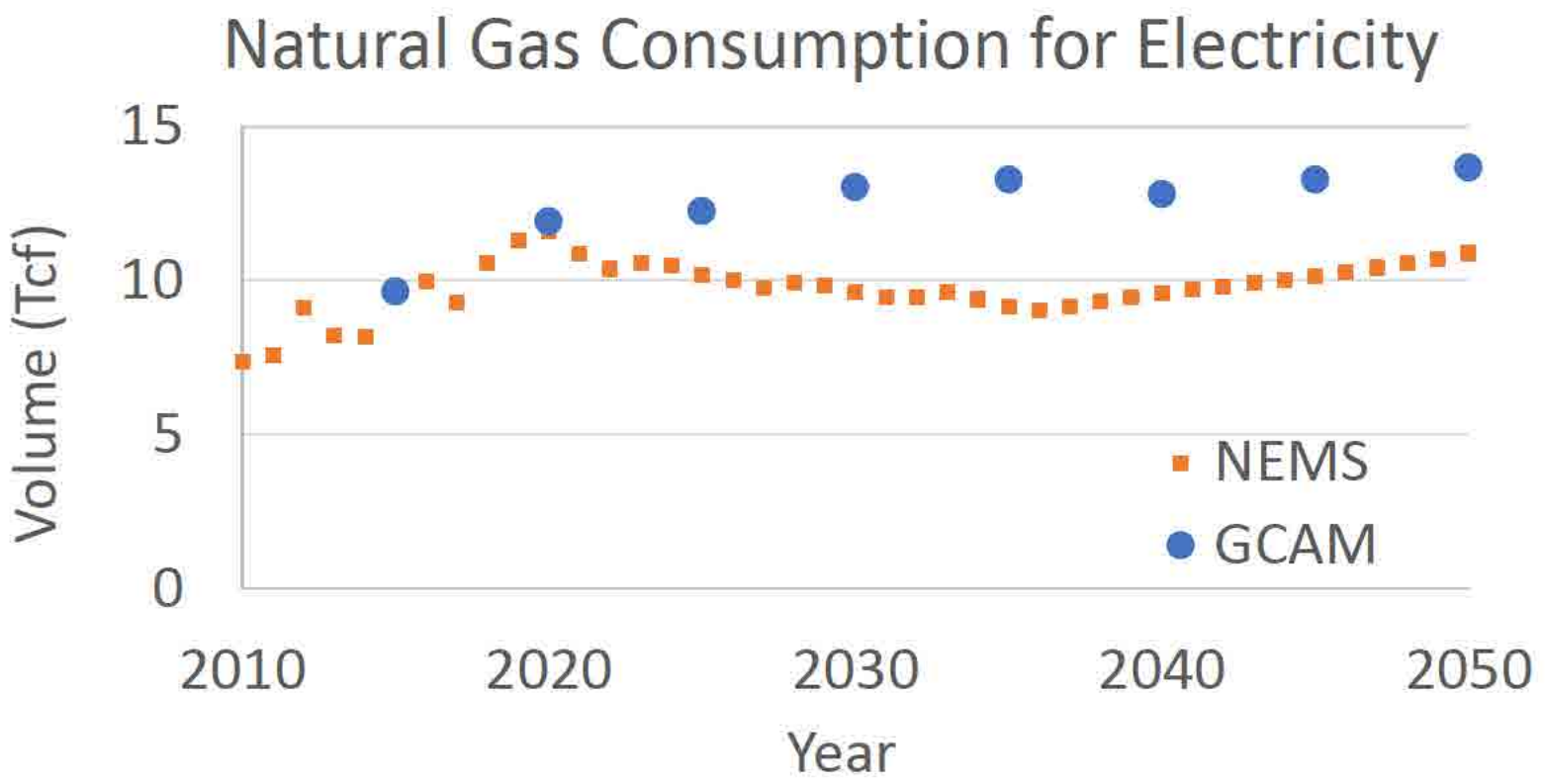
- GCAM data comes from the most recent slide deck (GCAM_progress_update_2023.04.10.pdf)

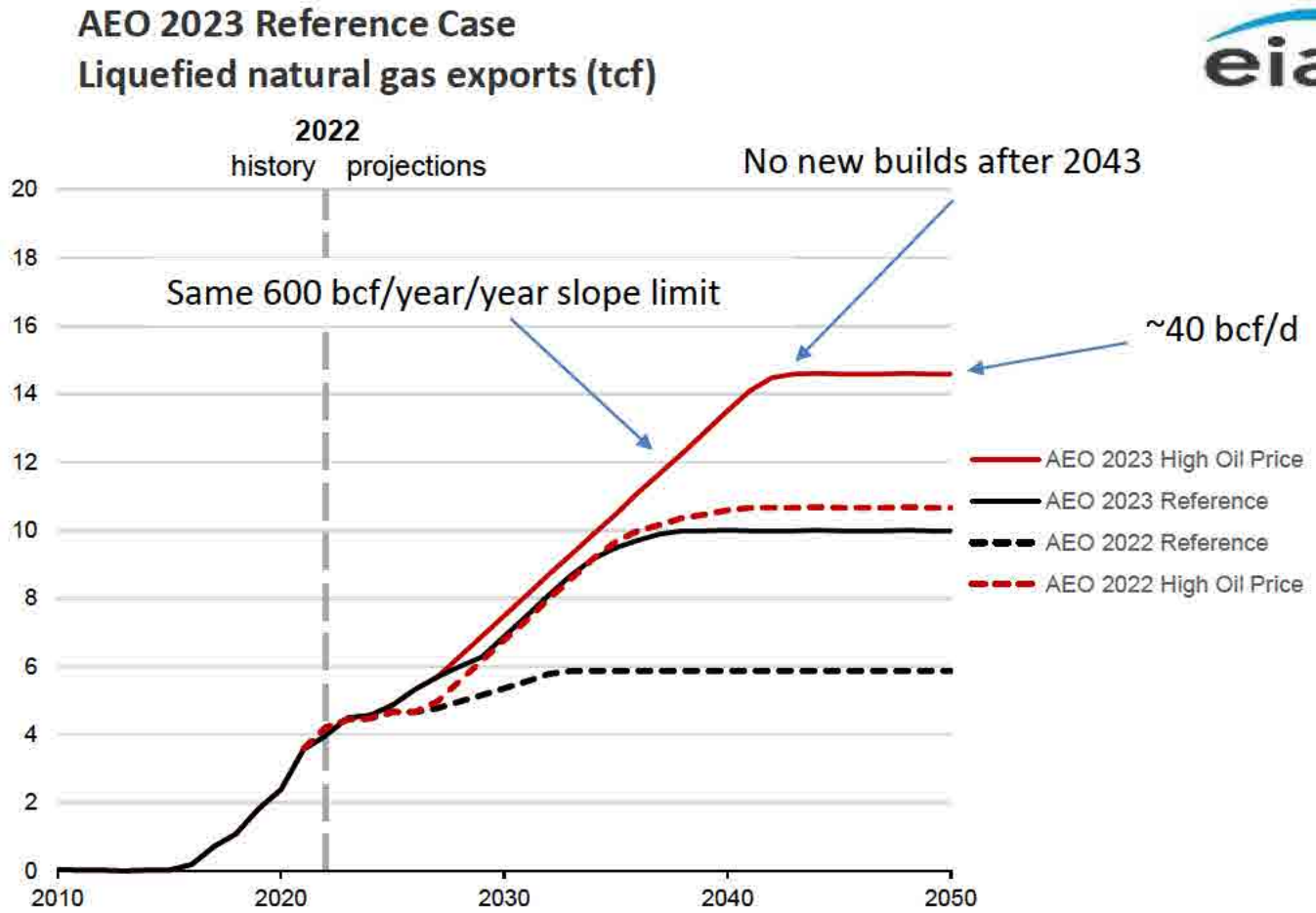
US Natural Gas Price Differs in Later Years



***This plot is based on older outputs that came from the reference macro case for both NEMS and GCAM**

Natural Gas Consumption in the Electricity Sector Differ by 2-4 Tcf





Current and planned builds (more up-to-date than AEO23)

	Capacity Online (Peak)		Capacity Under construction		TOTAL (once all expansions complete; ~2028)	
	Bcf/d	MTPA	Bcf/d	MTPA	Bcf/d	MTPA
US	14.28	109	**9.91**	76	24.19	185.6
Qatar	10.1	77	6.5	49.8	16.6	127.2

Growth rate (slope)
of 720 bcf/year/year

(GCAM slopes reach as high as 1200 bcf/year/year)

$$\textbf{Destination LNG Export Price} = (\textit{World Oil Price})^{\alpha}(\textit{Supply and Demand Balance})^{\beta}$$

From: Peter Whitman
Sent: Mon, 27 Mar 2023 12:14:46 +0000
To: Binsted, Matthew; Francisco De La Chesnaye; Iyer, Gokul; Edmonds, James A (Jae); Wolfram, Paul; Daniel Hatchell; Riera, Jefferson; Jose Bosch
Cc: Skone, Timothy; Curry, Thomas; Yarlagadda, Brinda; Sweeney, Amy; Harker-Steele, Amanda J (NETL); Robert Wallace; Agboola, Ajoke
Subject: [EXTERNAL] RE: FECM LNG Export Project Coordination
Attachments: LNG_Meeting_20230324.pdf

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Enclosed is the slide deck we presented on Friday. I have also added it to the repository.

Thank you.

Peter Whitman | **Associate Director**
ph: 703.988.5927 | ext: 307 | m: (b) (6) | onlocationinc.com

From: Binsted, Matthew T <matthew.binsted@pnnl.gov>
Sent: Friday, March 24, 2023 12:08 PM
To: Francisco De La Chesnaye <francisco.delachesnaye@onlocationinc.com>; Iyer, Gokul C <Gokul.Iyer@pnnl.gov>; Edmonds, James A (Jae) <jae@pnnl.gov>; Wolfram, Paul <paul.wolfram@pnnl.gov>; Peter Whitman <peter.whitman@onlocationinc.com>; Daniel Hatchell <daniel.hatchell@onlocationinc.com>; Jefferson Riera <jefferson.riera@onlocationinc.com>; Jose Bosch <jose.bosch@onlocationinc.com>
Cc: Skone, Timothy <timothy.skone@hq.doe.gov>; Curry, Thomas <thomas.curry@hq.doe.gov>; Yarlagadda, Brinda N <brinda.yarlagadda@pnnl.gov>; Sweeney, Amy <amy.sweeney@hq.doe.gov>; Harker-Steele, Amanda (NETL) <amanda.harkersteele@netl.doe.gov>; Robert Wallace <robert.wallace@keylogic.com>; Agboola, Ajoke <ajoke.agboola@hq.doe.gov>
Subject: RE: FECM LNG Export Project Coordination

DRAFT - DELIBERATIVE

Hi team,

Attached please find the slides we shared during today's meeting. Any additional feedback is very much appreciated.

Best,

Matthew

OnLocation
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Updated Natural Gas Regulatory Analyses

GCAM and NEMS Coordination

In support of Department of Energy
Office of Fossil Energy and Carbon Management
Office of Resource Sustainability

March 24, 2023

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Outline

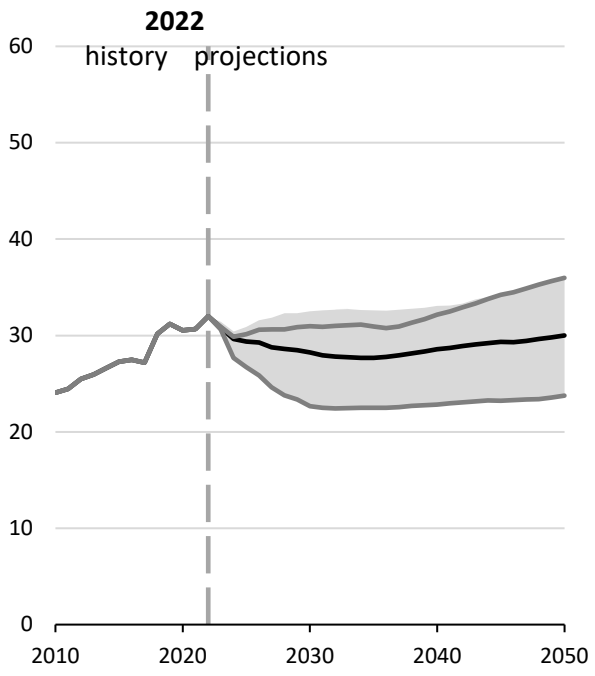
1. Administrative items
2. GCAM progress report, any other reports
3. Progress on AEO2023 stand-up
4. Progress on LCA
5. AEO 2023 results and key changes from 2022
6. GCAM/NEMS Coordination
   - Comparison Spreadsheet Key Variables
   - Options/strategy to align models
7. NEMS emissions factors

Progress on AEO23

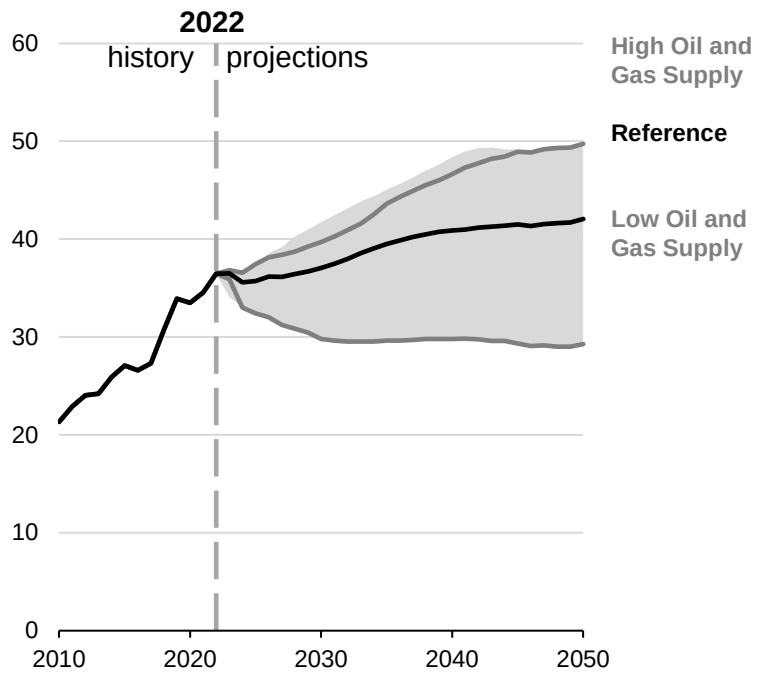
1. Imported archive and compiled
2. Run modules individually (except macro)
3. Updated to GAMS 35 (added XPRESS)
4. Waiting on new compiler to complete port
5. Starting partial integrated run for comparison with reference case

Liquefied natural gas exports drive production; domestic consumption remains stable

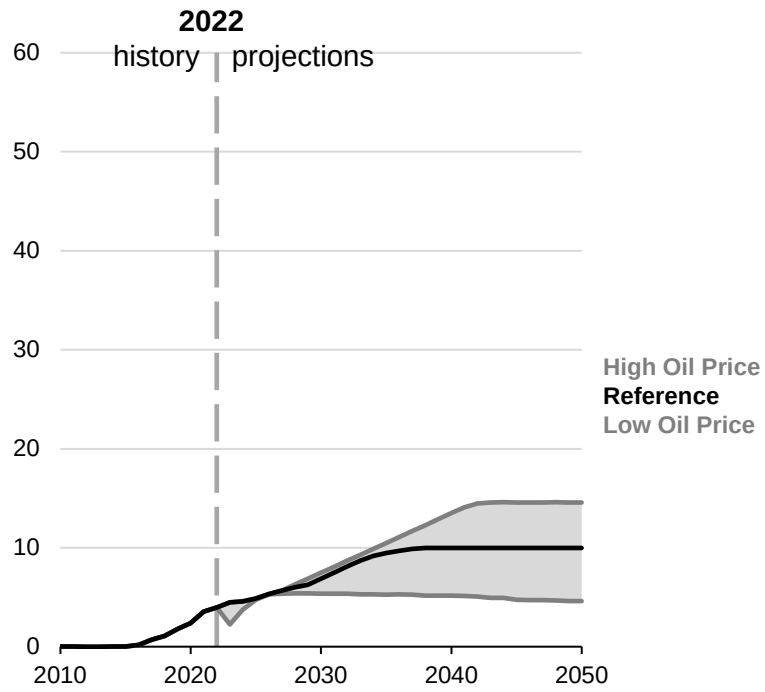
Natural gas consumption
trillion cubic feet



Dry natural gas production
trillion cubic feet



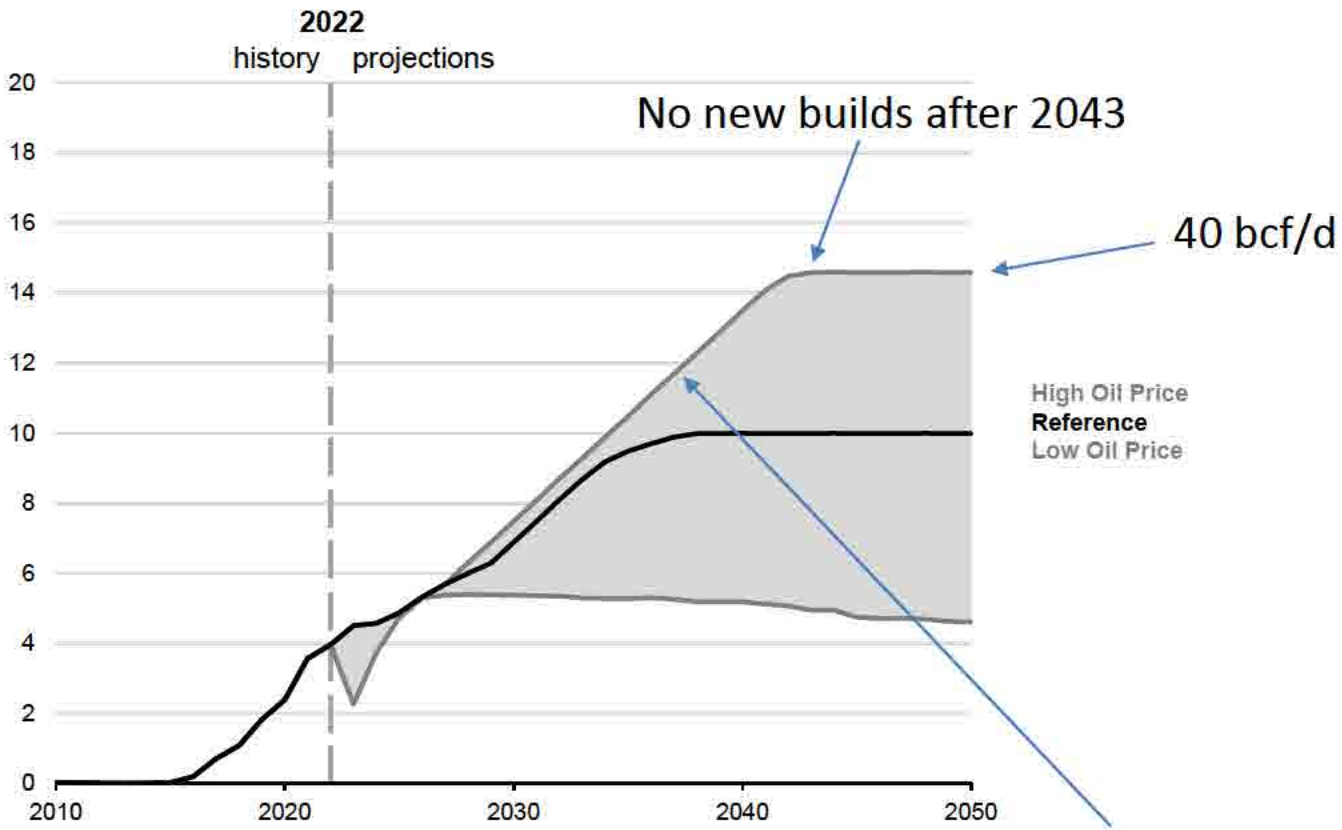
Liquefied natural gas exports
trillion cubic feet

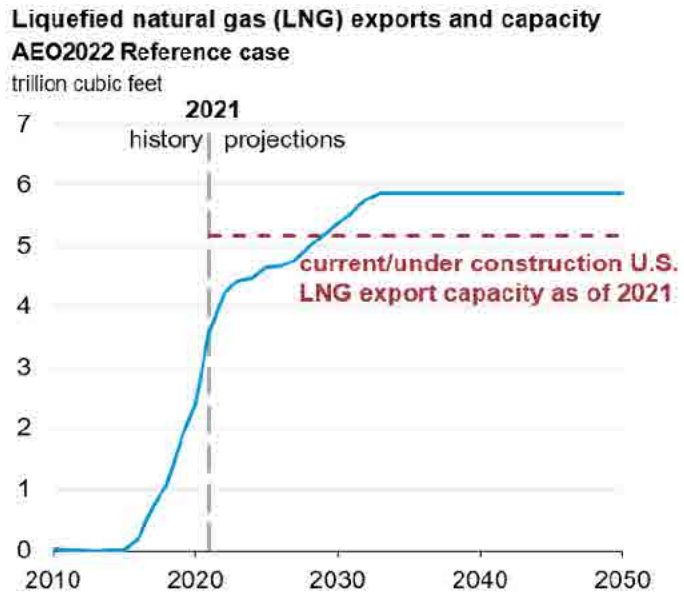


Data source: U.S. Energy Information Administration, *Annual Energy Outlook 2023* (AEO2023)
Note: Shaded regions represent maximum and minimum values for each projection year across the AEO2023 Reference case and side cases.
ZTC=Zero-Carbon Technology Cost

Liquefied natural gas exports

trillion cubic feet





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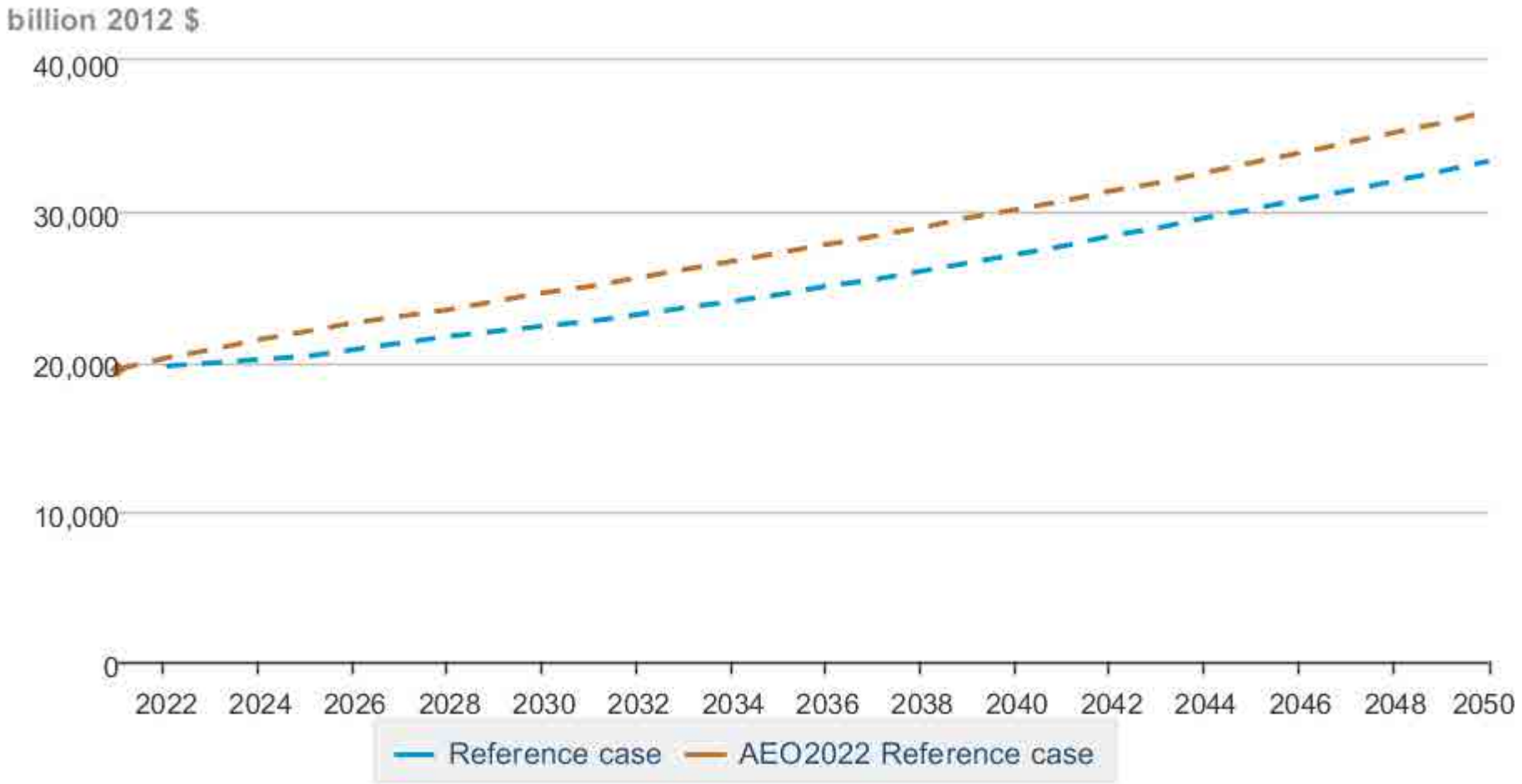
Note: Shaded regions represent maximum and minimum values for each projection year across the AEO2023 Reference case and side cases.
ZTC=Zero-Carbon Technology Cost

Macroeconomic Indicators: Real Gross Domestic Product



eia Data source: U.S. Energy Information Administration

Upcoming AEO2023 *Issues in Focus*

- **Liquefied Natural Gas (LNG) *Issues in Focus* coming next month**
  - High LNG Price case
  - Low LNG Price case
  - **Fast Builds** + High LNG Price case

GCAM/NEMS Coordination: Comparison Spreadsheet

DOE Results	GCAM Check	NEMS Check	Natural Gas			
					full name	units
1	1	1		Dry Gas Production	Natural Gas: Production: Dry Gas Production: Reference case	Tcf
1	1	1		Supplemental Natural Gas	Natural Gas: Production: Supplemental Natural Gas: Reference case	Tcf
1	1	1		Net Imports	Natural Gas: Net Imports: Reference case	Tcf
1	1			Pipeline	Natural Gas: Net Imports: Pipeline: Reference case	Tcf
1				Liquefied Natural Gas	Natural Gas: Net Imports: Liquefied Natural Gas: Reference case	Tcf
1	1	1		Total Supply	Natural Gas: Total Supply: Reference case	Tcf
1	1	1		Consumption Total	Natural Gas: Use by Sector: Total: Reference case	Tcf
	1	1		Residential	Natural Gas: Use by Sector: Residential: Reference case	Tcf
	1	1		Commercial	Natural Gas: Use by Sector: Commercial: Reference case	Tcf
	1	1		Industrial	Natural Gas: Use by Sector: Industrial: Reference case	Tcf
		1		Other Industrial	Natural Gas: Use by Sector: Industrial: Other: Reference case	Tcf
		1		Lease and Plant Fuel	Natural Gas: Use by Sector: Industrial: Lease and Plant Fuel: Reference case	Tcf
1		1		Fuel Used to Liquefy Gas for Export	Natural Gas: Use by Sector: Industrial: Liquefaction for Export: Reference case	Tcf
				Natural Gas-to-Liquids Heat and Power	Natural Gas: Use by Sector: Industrial: GTL Heat and Power: Reference case	Tcf
1		1		Natural Gas to Liquids Production	Natural Gas: Use by Sector: Industrial: GTL Liquids: Reference case	Tcf
1	1	1		Transportation	Natural Gas: Use by Sector: Transportation: Reference case	Tcf
1		1		Motor Vehicles, Trains, and Ships	Natural Gas: Use by Sector: Transportation: Vehicles: Reference case	Tcf
1		1		Pipeline and Distribution Fuel	Natural Gas: Use by Sector: Transportation: Pipeline Fuel: Reference case	Tcf
1	1	1		Electric Power	Natural Gas: Use by Sector: Electric Power: Reference case	Tcf
				Discrepancy	Natural Gas: Discrepancy: Reference case	Tcf
1	1	1		(2020 dollars per million Btu)	Natural Gas: Henry Hub Spot Price: Reference case	2020 $/MMBtu
		1		Residential	Natural Gas: Delivered Prices: Residential: Reference case	2020 $/Mcf
		1		Commercial	Natural Gas: Delivered Prices: Commercial: Reference case	2020 $/Mcf
		1		Industrial	Natural Gas: Delivered Prices: Industrial: Reference case	2020 $/Mcf
		1		Transportation	Natural Gas: Delivered Prices: Transportation: Reference case	2020 $/Mcf
		1		Electric Power	Natural Gas: Delivered Prices: Electric Power: Reference case	2020 $/Mcf
1		1		Average	Natural Gas: Delivered Prices: Average: Reference case	2020 $/Mcf
1	1	1		Imports	Natural Gas: Volumes: Imports: Reference case	Tcf
1	1	1		Pipeline Imports from Canada	Natural Gas: Volumes: Imports: Pipeline Imports from Canada: Reference case	Tcf
1	1	1		Pipeline Imports from Mexico	Natural Gas: Volumes: Imports: Pipeline Imports from Mexico: Reference case	Tcf
1	1	1		Liquefied Natural Gas Imports	Natural Gas: Volumes: Imports: Liquefied Natural Gas Imports: Reference case	Tcf
1	1	1		Exports	Natural Gas: Volumes: Exports: Reference case	Tcf
1	1	1		Pipeline Exports to Canada	Natural Gas: Volumes: Exports: Pipeline Exports to Canada: Reference case	Tcf
1	1	1		Pipeline Exports to Mexico	Natural Gas: Volumes: Exports: Pipeline Exports to Mexico: Reference case	Tcf
1	1	1		Liquefied Natural Gas Exports	Natural Gas: Volumes: Exports: Liquefied Natural Gas Exports: Reference case	Tcf
1	1	1		Net Imports	Natural Gas: Volumes: Net Imports: Reference case	Tcf
1	1	1		Canada	Natural Gas: Volumes: Net Imports: Canada: Reference case	Tcf
1	1	1		Mexico	Natural Gas: Volumes: Net Imports: Mexico: Reference case	Tcf
1	1	1		Liquefied Natural Gas	Natural Gas: Volumes: Net Imports: Liquefied Natural Gas: Reference case	Tcf

Key Variables

- Natural Gas Supply
- Natural Gas Demand
- Electricity Supply
- Electricity Demand
- Emissions

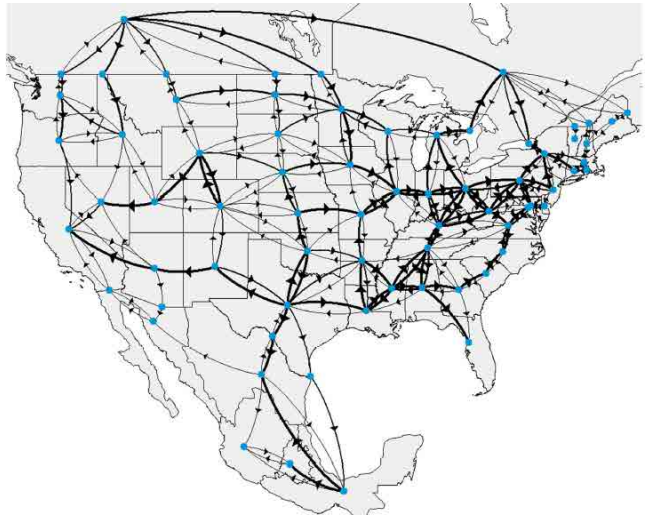
Strategies for Model Alignment

1. Force GCAM to more closely follow NEMS not just in the reference case, but across scenarios.
   - Set the NEMS parameters such that NEMS US LNG exports track GCAM
   - Define limited set of key variables for the U.S. region in GCAM that could be represented by NEMS
   - Force GCAM to follow the NEMS trajectory
   - Iterate if there are significant changes in US LNG exports
2. Don't align the models further and just document the differences
3. Run additional NEMS scenarios to show whether the differences with GCAM are substantive

Energy: Natural Gas and Petroleum Systems

	CO_2 in FECM-NEMS (MMT)	CO_2 in GHG Inventory (MMT)	CH_4 from FECM-NEMS (MMT CO_2 eq.)	CH_4 from GHG Inventory (MMT CO_2 eq.)
Natural Gas Systems	0	35.4	**156.9**	164.9
Petroleum Systems	0	30.2	0	40.2

Emissions factors applied to natural gas production and transportation flows



Region	Emissions Factor (million tonnes CH_4 per TCF)
East	0.050882513
Gulf Coast	0.147759087
Midcontinent	0.238547247
Southwest	0.168243417
Rocky Mountains	0.190587902
Northern Great Plains	0.201014497
West Coast	0.146940773
Gulf Coast	0.034954569
Pacific	0.034572237
Atlantic	0.034572237
Alaska	0.133780579
National Average for Transportation	0.028885181

2.8% decline rate in emissions per year

Emissions Factors from Fuel Consumption

$$\boldsymbol{CO_2\ emissions\ (MMT)} = Fuel\ consumption\ (quadrillion\ Btu) * CO_2\ coefficient\ (\frac{MMT}{quadrillion\ Btu}) * Combustion\ fraction$$

Ranges from 0 to 1

Fuel type	CO_2 coefficient at full combustion	Combustion fraction[a]	Adjusted emission factor
Petroleum			
Propane used as fuel	62.88	1.0	62.88
Propane used as feedstock	62.88	0.2	12.58
Ethane used as fuel	59.58	1.0	59.58
Ethane used as feedstock	59.58	0.2	11.92
Butane used as fuel	64.75	1.0	64.75
Butane used as feedstock	64.75	0.2	12.95
Isobutane used as fuel	64.94	1.0	64.94
Isobutane used as feedstock	64.94	0.2	12.99
Natural gasoline (pentanes plus) used as fuel	66.88	1.0	66.88
Natural gasoline (pentanes plus) used as feedstock	66.88	0.2	13.38
Motor gasoline (not including ethanol)	70.66	1.0	70.66
Jet fuel	72.23	1.0	72.23
Distillate fuel (not including biodiesel)	74.14	1.0	74.14
Residual fuel	75.09	1.0	75.09
Asphalt and road oil	75.35	0.0	0.0
Lubricants	74.07	0.5	37.03
Petrochemical feedstocks	70.22	0.41	28.79
Kerosene	73.19	1.0	73.19
Petroleum coke (industrial)	102.12	0.956	97.59
Petroleum coke (electric power)	102.12	1.0	102.12
Petroleum still gas	66.73	1.0	66.73
Other industrial[b]	48.89	1.0	48.89
Coal			
Residential and commercial	95.74	1.0	95.74
Metallurgical	93.83	1.0	93.83
Coke	114.14	1.0	114.14
Industrial other[c]	95.59	1.0	95.59
Electric power[d]	95.63	1.0	95.63
Natural gas			
Used as fuel	52.91	1.0	52.91
Used as feedstock	52.91	0.464	24.57
Biogenic energy sources[e]			
Biogenic waste	89.65	1.0	89.65
Ethanol	74.07	1.0	74.07

Industry Emissions

Cement and lime production process emissions calculated with an emissions factor

- 0.5-0.51 tonnes CO_2 / tonnes clinker
- Additional emissions factors for lime production:
  - 545.28 tonnes CO_2 / kilotonne coal
  - 496.71 tonnes CO_2 / kilotonne heavy fuel oil
  - 297.7 tonnes CO_2 / kilotonne natural gas

Iron, steel, and metallurgical coke production process emissions accounted for with the "combustion" of metallurgical coal

- 93.83 MMT CO_2 / Quadrillion Btu

From: Wargo, Adam
Sent: Thu, 16 Mar 2023 19:56:05 +0000
To: Crabtree, Bradford; Wilcox, Jennifer; Hooghan, Priyanka; Rasar, Kimberly; Peay, Ryan; Alleman, David; Sweeney, Amy; Deich, Noah; Ackiewicz, Mark; Anderson, Brian J (NETL); Wilson, James (NETL); Perry, Alan F.
Cc: Neville, Marcellino; Areas, Julio I.; Mathew, Roni; Brechmacher, Scott
Subject: FY24 FECM Budget presentation
Attachments: FY 2024 Budget Request Briefing (2023.03.16 1535).pptx, FY24 Alternative Uses of Coal.docx, FY24 Budget Hot topic - Domestic Fossil Fuel Production.docx, FY24 Budget Hot topic - Opposes Expansion of Offshore Drilling.docx, FY24 Budget Hot topic -Pipeline Transportation of Hydrocarbons.docx, FY24 Exporting LNG March 9 2023.docx, FY24 Hot topic Critical Mineral Supply Chains.docx, FY24 Hot topic_CCUS final.docx, FY24 Keystone XL.docx, FY24 LNG Exports (Increasing) Domestic Impact FECM March 7.docx

All,

Attached are a revised version of the FY24 Budget presentation which includes the changes recommended during the pre-briefing as well as the current hot topic papers. Please add talking points from these hot topic papers where you feel is relevant.

The attached briefing is on sharepoint for you to make any changes to the slides or talking points at: FY 2024 Budget Request Briefing

Changes to presentation based on pre-brief:

- **Slide 2: Proposed language change pulled from the FY24 FECM CJ Overview**:
    - **Proposed changes:** FECM conducts research and development (R&D) that focuses on technologies to reduce carbon emissions and other environmental impacts from fossil fuel production and use and from key industrial processes, particularly the hardest-to-decarbonize applications in the electricity and industrial sectors. Furthermore, the program advances technologies that convert and store carbon dioxide into value-added products and technologies on carbon dioxide removal to remove atmospheric and legacy emissions of carbon dioxide.
    - **Proposed changes**: FECM recognizes that broad decarbonization is essential to meeting climate goals -- 100% carbon pollution free electricity by 2035 and net-zero greenhouse gas emissions economy-wide by 2050 -- and works to engage with international colleagues to leverage expertise in these areas. FECM is also committed to improving the economic and environmental conditions of Energy Communities[1], retaining and creating good-paying jobs and supporting domestic energy and industrial production and manufacturing across our nation.

- **Slide 6: spell out acronyms, remove last three bullets policy and analysis, and STEP in talkers. Complete**

- **Slide 16: remove Net Zero focus with onsite energy sustainability. complete**

Please let the Budget Office know when you have finished reviewing/editing your slides. The Budget Office is available to meet and discuss further if needed.

Thanks,
Adam

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[1] https://energycommunities.gov/

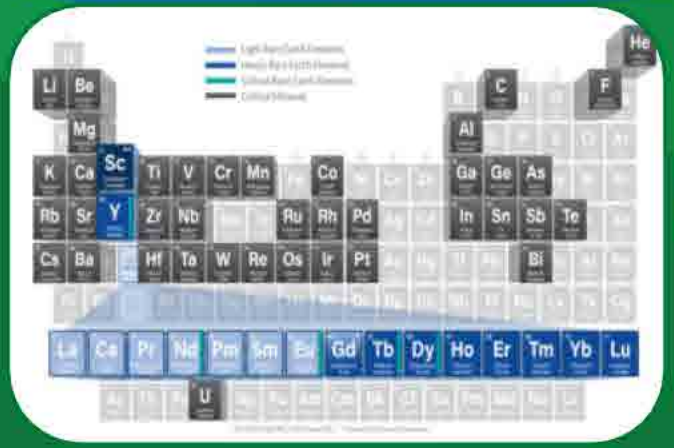
U.S. DEPARTMENT OF ENERGY
Fossil Energy and Carbon Management

FY 2024 Budget Request: Office of Fossil Energy and Carbon Management

Briefing for the Briefing for the House Energy and Water Development Staff

March 17, 2023





Fossil Energy and Carbon Management Guiding Principles

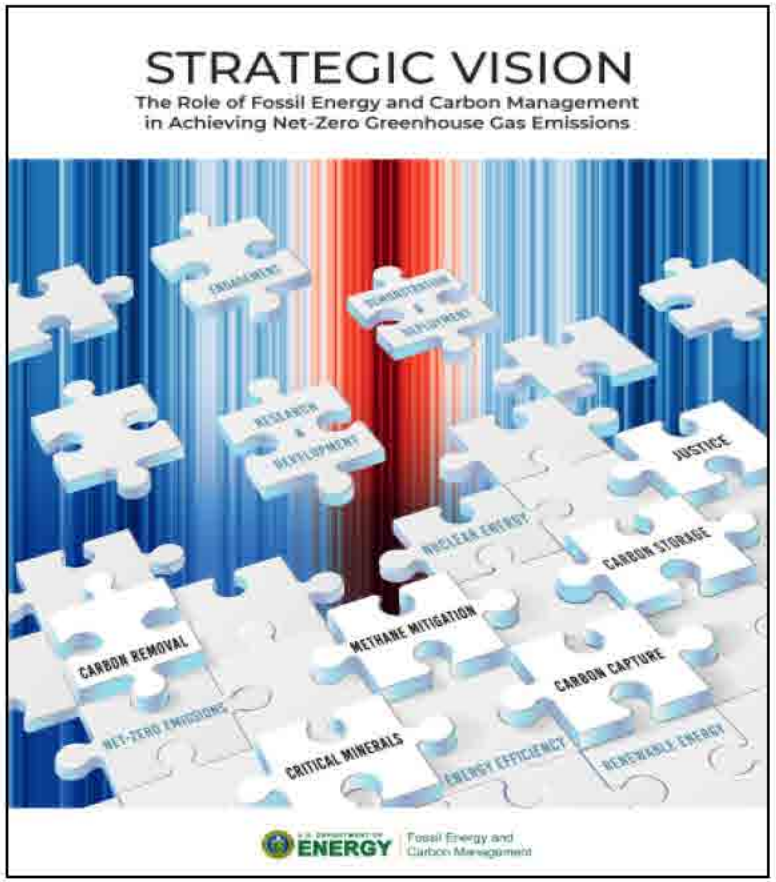
FECM's vision is to minimize the negative impacts of fossil energy and advance carbon management to enable achievement of the nation's 2050 net-zero goals.

FECM conducts research and development (R&D) that focuses on technologies to reduce carbon emissions and other environmental impacts from fossil fuel production and use and from key industrial processes, particularly the hardest-to-decarbonize applications in the electricity and industrial sectors. Furthermore, the program advances technologies that convert and store carbon dioxide into value-added products and technologies on carbon dioxide removal to remove atmospheric and legacy emissions of carbon dioxide.

FECM recognizes that broad decarbonization is essential to meeting climate goals -- 100% carbon pollution free electricity by 2035 and net-zero greenhouse gas emissions economy-wide by 2050 -- and works to engage with international colleagues to leverage expertise in these areas. FECM is also committed to improving the economic and environmental conditions of Energy Communities, retaining and creating good-paying jobs and supporting domestic energy and industrial production and manufacturing across our nation.

Fossil Energy and Carbon Management Strategic Vision

A carbon management framework that will guide FECM's engagement with offices across the Department, Federal agencies, Tribal and international governments, industry, non-governmental organizations, and communities



Advancing Carbon Management Approaches Toward Deep Decarbonization

Priorities: *Point-source carbon capture, carbon dioxide conversion, carbon dioxide removal (CDR), and reliable carbon transport and storage*

Advancing Technologies that Lead to Sustainable Energy Resources

Priorities: *Hydrogen with carbon management, domestic critical minerals (CMs) production, and methane mitigation*

Advancing Domestic Engagement and International Collaboration

Priorities: *Collaborate with domestic and international partners to engage communities and key stakeholders to help ensure that communities see tangible economic, environmental and jobs benefits from the deployment of projects and infrastructure and to help ensure project success.*

FECM FY 2024 Budget Summary

Dollars in Thousands

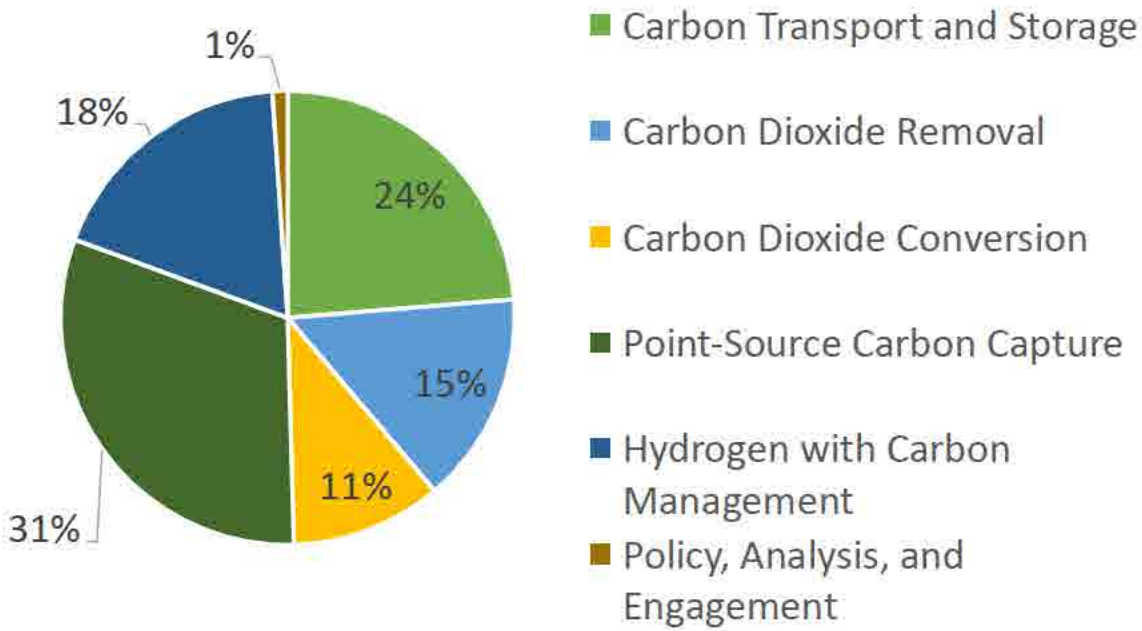
	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Request	FY 2024 Request vs FY 2023 Enacted ($)	FY 2024 Request vs FY 2023 Enacted (%)
Program					
Carbon Transport and Storage	97,000	110,000	110,000	-	0.0%
Carbon Dioxide Removal	49,000	70,000	70,000	-	0.0%
Carbon Dioxide Conversion	29,000	50,000	50,000	-	0.0%
Point-Source Carbon Capture	99,000	135,000	144,000	9,000	6.7%
Hydrogen with Carbon Management	101,000	95,000	85,000	(10,000)	-10.5%
Carbon Management - Policy, Analysis, and Engagement	3,400	-	5,000	5,000	N/A
Supercritical Transformational Electric Power (STEP)	15,000	-	-	-	N/A
Carbon Management Technologies Subtotal	**393,400**	**460,000**	**464,000**	**4,000**	**0.9%**
Advanced Remediation Technologies	55,600	55,000	13,000	(42,000)	-76.4%
Methane Mitigation Technologies	39,000	60,000	100,000	40,000	66.7%
Natural Gas Decarbonization and Hydrogen Technologies	20,000	26,000	20,000	(6,000)	-23.1%
Mineral Sustainability	53,000	54,000	45,000	(9,000)	-16.7%
Resource Sustainability - Analysis and Engagement	-	-	1,000	1,000	N/A
Resource Sustainability Subtotal	**167,600**	**195,000**	**179,000**	**(16,000)**	**-8.2%**
Energy Asset Transformation	5,000	6,000	6,000	-	0.0%
University Training and Research	13,000	13,000	19,000	6,000	46.2%
Special Recruitment Program	1,001	1,000	1,000	-	0.0%
Program Direction	66,800	70,000	92,475	22,475	32.1%
NETL Infrastructure	75,000	55,000	55,000	-	0.0%
NETL Research and Operations	83,000	87,000	89,000	2,000	2.3%
Interagency Working Group	-	3,000	-	(3,000)	-100%
Congressionally Directed Projects	20,199	-	-	N/A	N/A
FECM Total	**825,000**	**890,000**	**905,475**	**15,475**	**1.7%**

Carbon Management Technologies - FY 2024 Overview

Funding

(Dollars in Millions)	2022 Enacted	2023 Enacted	2024 Request
Carbon Transport and Storage	$97	$110	$110
Carbon Dioxide Removal (CDR)	$49	$70	$70
Carbon Dioxide Conversion (CDC)	$29	$50	$50
Point-Source Carbon Capture (PSC)	$99	$135	$144
Hydrogen with Carbon Management (HCM)	$101	$95	$85
Policy, Analysis, and Engagement	$3.4	-	$5
Supercritical Transformational Electric Power (STEP)	$15	-	-

Planned Execution



Graph shows breakdown of subprogram activities as percentage of FY 2024 program budget

Carbon Management Technologies - FY 2024 Overview (cont.)

FY 2023 Accomplishments

- **Carbon Transport and Storage** – Carbon Storage Assurance Facility Enterprise (CarbonSAFE): Completed well drilling at facilities in North Dakota, Wyoming, and Alabama. Class VI permits being prepared; Completed Phase I of Science-informed Machine learning to Accelerate Real Time Carbon Storage (SMART-CS;) CT Scans of cores.
- **Carbon Dioxide Removal** – Completed a joint FOA w/ Geothermal Technologies Office (GTO) and Nuclear Energy co-locating Direct Air Capture (DAC) facilities w/either nuclear or geothermal operations and leveraging the infrastructure or power to operate the DAC facility.
- **Carbon Dioxide Conversion** (CDC) – In coordination with carbon capture and CDR, selected national lab projects that are investing in reactive capture and conversion to minimize and intensify process steps for lower costs.
- **Point Source Carbon Capture** – Completed 4 capture Front-End Engineering Design (FEED) studies on power.
- **Hydrogen with Carbon Management** – Completed testing of (4) 1.5 kW Solid Oxide Fuel Cells (SOFC) systems – 5.6 kW of power to NETL Morgantown (MGN) grid – data center simulation. Awards for Hydrogen turbines under FOA 2400. Issue FOA 2613 on Ceramic Matrix Composites (CMCs) for Hydrogen turbines.

Carbon Management Technologies - FY 2024 Overview (cont.)

FY 2024 Planned Activities

- **Carbon Transport and Storage** – Competitive Solicitation for CarbonSAFE Phase II projects; Selection of Carbon Storage Technology and Operational Research (CarbonSTORE) facilities as field laboratories; Technical Assistance through Regional Initiatives and simulation of pipelines; Support Competitive awards and lab efforts on advanced monitoring and modeling tools.
- **Carbon Dioxide Removal** – Transformational DAC materials and components, DAC feasibility studies; expand efforts in biomass with carbon removal and storage (BiCRS) and mineralization.
- **Carbon Dioxide Conversion** – Continued development at lab-, bench-, and pilot-scale to convert carbon oxides (carbon monoxide, or CO, and carbon dioxide, or CO2) into economically valuable products manufactured in a commercially viable and environmentally and sociably beneficial manner.
- **Point Source Carbon Capture** – Continued Capture FEED and pilot projects for power and industrial applications.
- **Hydrogen with Carbon Management** – Fabrication and testing of full-size cells for reversible Solid Oxide Fuel Cells under FOA 2300 award. Novel technologies for gasification of legacy coal wastes/mixed wastes/biomass to enable net-zero hydrogen under FOA 2400 Amendment 6.
- **Policy and Analysis** – Will develop new Hydrogen Market Model in NEMS in coordination with Energy Efficiency and Renewable Energy (EERE) and Energy Information Administration (EIA); will undertake analyses to study impact of carbon management technologies in electricity markets.
- **Engagement** – Clean Energy Ministerial (CEM) CCS Initiative co-leadership.
- **Supercritical Transformational Electric Power** – Using FY 2022 funding, test the Heater and High-Temp Turbine Stop/Control Valve.
- **Policy and Analysis**: Evaluate potential economic, employment, and socioenvironmental benefits from the deployment of carbon management technologies; create and disseminate tools and information used by other external users to better understand the role of carbon management technologies in an ever-evolving energy economy.
- **Engagement**: Accelerate the advancement and responsible deployment of technologies within the carbon management R&D program portfolio globally; develop communication tools and resources for effective engagement with communities around carbon management.
- **Federal Partnerships**: Develop partnerships with other federal agencies to coordinate all carbon capture, utilization, and storage (CCUS) activities across the federal government; provide technical training to federal agency staff responsible for research and development, permitting, right of way approvals, and other requirements associated with CCUS.

Carbon Management Technologies - FY 2024 Request

Subprogram/ Control Point	FY 2023 Enacted	FY 2024 Request	$ Change from FY 2023 Enacted	% Change from FY 2023 Enacted	Impacts
Carbon Transport and Storage	$110,000	$110,000	-	0%	Funding level represents minimum needed for ensuring launch of Carbon Basin-scale Assessment and Storage Evaluation (CarbonBASE) and the selection of additional Carbon Storage Assurance Facility Enterprise (CarbonSAFE) Phase II and Carbon Storage Technology and Operational Research (CarbonSTORE) projects. Funding also continues the DOE Regional Initiative to provide technical assistance to project developers and help facilitate deployment.
Carbon Dioxide Removal	$70,000	$70,000	-	0%	The funding broadens efforts beyond Direct Air Capture (DAC) to include biomass with carbon removal and storage, and mineralization concepts. Continued focused on life cycle analysis and monitoring, reporting, and verification to validate removal.
Carbon Dioxide Conversion	$50,000	$50,000	-	0%	Funding allows for continued scale up and higher-technology readiness level field testing of promising conversion technologies, such as at the National Carbon Capture Center.
Point-Source Carbon Capture	$135,000	$144,000	$9,000	7%	The funding request reflects prioritization on key areas of transformational technologies for higher capture rates, pilot-scale tests, and Front-End Engineering Design (FEED) studies for industrial and natural gas-derived sources of carbon dioxide (CO_2).

Carbon Management Technologies - FY 2024 Request

Subprogram/ Control Point	FY 2023 Enacted	FY 2024 Request	$ Change from FY 2023 Enacted	% Change from FY 2023 Enacted	Impacts
Hydrogen with Carbon Management	$95,000	$85,000	($10,000)	-11%	Decrease reflects a lower level of effort in developing alloy compositions and manufacturing techniques to improve resistance to hydrogen embrittlement, as well as a reduced effort in basic R&D to mature Reversible Solid Oxide Fuel Cell (R-SOFC) technologies, including operating as Solid Oxide Electrolyzer Cell (SOEC).
Policy, Analysis, and Engagement	-	$5,000	$5,000	-	Conduct technoeconomic analysis for the Office of Carbon Management essential to R&D planning and for ensuring that Carbon Capture, Utilization, and Storage (CCUS) deployment is accurately reflected in DOE, US government, and global climate and energy models. (**$3.5M**). Help ensure success of carbon management technologies by working with key stakeholder including other governments to leverage R&D, address societal barriers, reduce technology risks, and address any other institutional needs that may arise. Develop engagement strategies and tools for key stakeholder groups. (**$1M**). Lead government-wide efforts to enhance interagency collaboration and build technical capacity to meet Congressional requirements across federal agencies including efficiently and effectively issuing federal permits (**$.5M**)
Total	**$460,000**	**$464,000**	**$4,000**	**1%**	

Carbon Management Technologies - FY 2023 Omnibus Execution

Dollars in Thousands

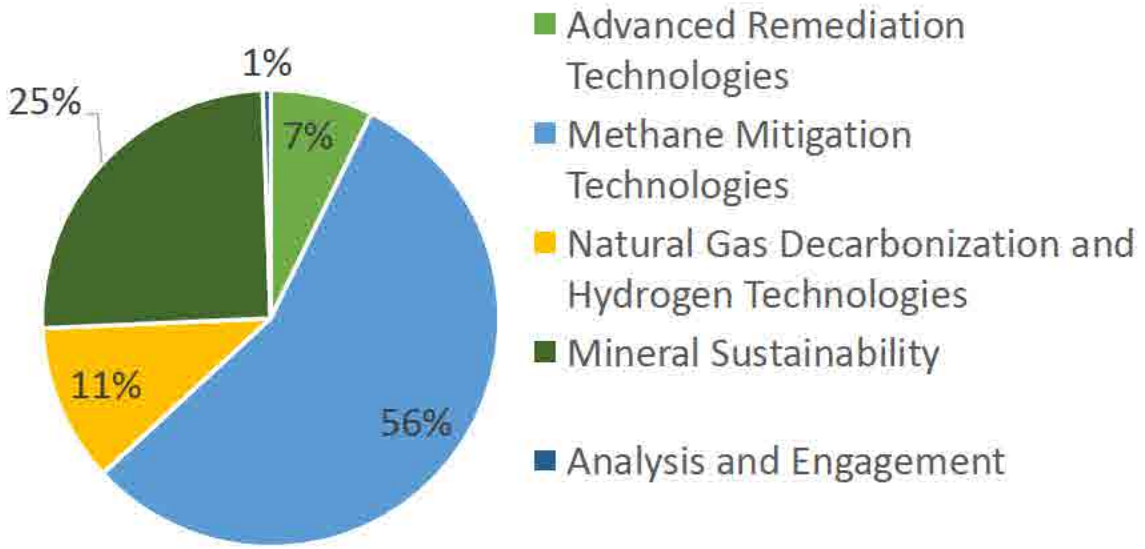
Subprogram/Control Point	FY 2023 Enacted	FY 2023 Planned Execution
Carbon Transport and Storage	$110,000	Implementing Carbon Storage Assurance Facility Enterprise (CarbonSAFE) and Regional Initiative language through competitive FOAs, including offshore carbon storage; planning FOA on transport infrastructure, consistent with appropriation language.
Carbon Dioxide Removal (CDR)	$70,000	Implementing language on marine CDR and lab methanol synthesis from Direct Air Capture (DAC)+Hydrogen; broadening portfolio beyond DAC (Biomass with carbon removal and storage (biCRS), mineralization).
Carbon Dioxide Conversion	$50,000	Implementing language on algae via prior (FY22) joint FOA with Bioenergy Technologies Office (BETO) and new FOA/topic area; expanding R&D portfolio to include scale-up of technologies - funding National Carbon Capture Center (NCCC).
Point-Source Carbon Capture	$135,000	In process of executing language on industrial and natural gas R&D, and Front End Engineering Designs (FEEDs); funding NCCC.
Hydrogen with Carbon Management	$95,000	1. Gas turbine combustor system development for hydrogen and zero-carbon fuels. 2. Development of Ceramic Matrix Composites (CMC) materials and manufacturing techniques for hydrogen turbine components. 3. Syngas cleanup R&D for hydrogen purity requirements of net-zero carbon fuels and chemicals. 4. Novel material R&D to improve Reversible Solid Oxide Fuel Cell (R-SOFC) performance and durability for hydrogen/electricity.
Total	**$460,000**	

Resource Sustainability - FY 2024 Overview

Funding

(Dollars in Millions)	2022 Enacted	2023 Enacted	2024 Request
Advanced Remediation Technologies	$55.6	$55	$13
Methane Mitigation Technologies	$39	$60	$100
Natural Gas Decarbonization and Hydrogen Technologies	$20	$26	$20
Mineral Sustainability	$53	$54	$45
Analysis and Engagement	-	-	$1

Planned Execution



Graph shows breakdown of subprogram activities as percentage of FY 2024 program budget

Resource Sustainability - FY 2024 Overview (cont.)

FY 2023 Accomplishments

- Launched a free online tool, the National Energy Water Treatment and Speciation (NEWTS) Database, which can be utilized by community leaders and water researchers to better understand the composition of energy-related wastewater streams.
- Established the Methane Emissions Test and Evaluation Center (METEC) as the gold standard for methane emissions sensing verification and used it to educate stakeholders on state-of-the-art technology.
- Completed a study on the viability, safety, and reliability of storing pure hydrogen or hydrogen/natural gas blends in the Subsurface Hydrogen Assessment, Storage, and Technology Acceleration (SHASTA) Project.
- Completed construction and began operations of an acid mine drainage remediation and rare earth element recovery pilot facility in Mt. Storm, WV, successfully producing high purity (>75%) mixed rare earth oxides.
- Backpack-sized laser system developed to find rare earth elements in coal feedstocks in the field.

FY 2024 Planned Activities

- Advanced Remediation Technologies: Research and technologies to address the environmental impacts of fossil energy development and continue implementation of a re-designed field test program.
- Methane Mitigation Technologies: Develop and validate advanced sensor technologies to detect and measure methane emissions across fossil energy infrastructure; data collection, dissemination, and analysis of methane emissions data.
- Natural Gas Decarbonization and Hydrogen Technologies: Develop and advance technologies for the production, transportation, and storage of domestically produced clean hydrogen.
- Mineral Sustainability: Enable at-scale processing, separation pilot-projects. Develop improved characterization of feedstocks; regional basin projects (the Carbon Ore, Rare Earth and Critical Minerals (CORE-CM) Initiative); and machine learning and optimization modeling.
- Analysis and Engagement: Focus on analysis and studies that support environmentally prudent production and use of domestic fossil fuels with an understanding of their role as a strategic asset for the U.S. and its allies for global energy security and provides evidence-based, portfolio-wide analysis for decision-makers.

Resource Sustainability - FY 2024 Request

Dollars in Thousands

Subprogram/Control Point	FY 2023 Enacted	FY 2024 Request	$ Change from FY 2023 Enacted	% Change from FY 2023 Enacted	Impacts
Advanced Remediation Technologies	$55,000	$13,000	($42,000)	-76%	Improve environmental performance of oil and natural gas development related to drinking water protection and beneficial use of produced water **($7M);** reduced seismicity **($2M);** and reduced offshore oil spills **($4M).**
Methane Mitigation Technologies	$60,000	$100,000	$40,000	67%	Develop advanced technologies in: • Development of direct and remote measurement sensors for the collection, dissemination, and analysis of emissions data including support to the Environmental Protection Agency's (EPA) Greenhouse Gas Inventory. **$35M** • Funding for advanced remote detection technologies for natural gas infrastructure. **$25M** • Collecting and analyzing emissions data to inform efforts on Life Cycle Analysis studies, and the EPA's Greenhouse Gas Inventory. **$15M** • Development of modular methane emissions remediation materials and solutions. **$10M** • Modular technologies for utilizing otherwise flared, vented, or stranded natural gas. **$8M** • Funding to develop technologies in advanced materials, data management tools, in-pipe inspection, repair technologies, and dynamic compressor research and development. **$7M**
Natural Gas Decarbonization and Hydrogen Technologies	$26,000	$20,000	($6,000)	-23%	Decreased funding reflects transitory level of effort in research on underground hydrogen storage for FY 2024 and to allow continued focus on other program areas within the Requested budget. **$20M**
Mineral Sustainability	$54,000	$45,000	($9,000)	-17%	Improve domestic production of Critical Minerals (CM) and Rare Earth Elements (REE) from waste materials, and development transformational technologies **($45M).** This decrease reflects reduced funding for coal-based building products composed of carbon ore.
Analysis and Engagement	-	$1,000	$1,000	N/A	This activity will focus on analysis and studies that support environmentally prudent production and use of domestic fossil fuels with an understanding of their role as a strategic asset for the U.S. and its allies for global energy security and provides evidence-based, portfolio-wide analysis for decision-makers. **$1M**
Total	**$195,000**	**$179,000**	**($16,000)**	**-8%**	

Resource Sustainability - FY 2023 Omnibus Execution

Dollars in Thousands

Subprogram/Control Point	FY 2023 Enacted	FY 2023 Planned Execution
Advanced Remediation Technologies	$55,000	• **Produce Water**: Issue FOA for produced water treatment, management, and characterization research with universities. **$8M** • **Produced Water:** NETL and other National Lab research on produced water research, and research to reduce environmental impacts. **$2M** • **Field Test Sites:** FOA in FY 2023 for field test sites with research on carbon dioxide (CO_2) Enhanced Oil Recovery (EOR) in unconventional wells with CO_2 storage at the completion of production and National lab research to support Field Test Sites. **$19M** • **Methane Hydrates:** Fully fund the Gulf of Mexico (GOM) project, including National Lab supporting research. **$20M** • **RBDMS:** Risk Based Data Management, including FracFocus. **$3M** • **OESI:** Oil spill prevention research through the Offshore Environment and Safety Institute (OESI). **$2M**
Methane Mitigation Technologies	$60,000	• **Orphan Wells:** FOA focused on well characterization, materials to improve plugging, and monitoring technologies as well as biofilm research for undocumented orphaned wells. **$10M** • **Methane Monitoring and Measurement:** FOA-2616 (Innovative Methane Measurement, Monitoring, and Mitigation Technologies) to advance methane mitigation technologies from point sources along the oil and natural gas supply chain, develop integrated methane monitoring platforms, better inform top-down (Satellites) and bottom-up analysis methods, and support emission inventory improvement. **$20M** • **Methane Monitoring and Measurement:** Continue advanced technology development at NETL, PNNL, SNL, and expanded support for the Methane Emissions Technology Evaluation Center (METEC) to continue investigating and field-testing methane mitigation and quantification technologies. **$15M** • **Venting and Flaring:** Release forthcoming FOA focused on reducing flaring and non-safety related venting from the well pad and emphasize pilot-scale flaring mitigation technologies. **$15M**

Resource Sustainability - FY 2023 Omnibus Execution (cont.)

Dollars in Thousands

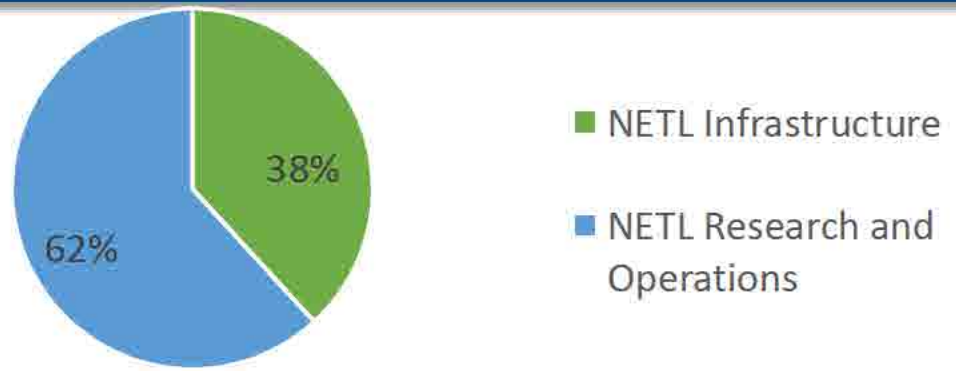
Subprogram/Control Point	FY 2023 Enacted	FY 2023 Planned Execution
Natural Gas Decarbonization and Hydrogen Technologies	$26,000	• **Hydrogen from Produced Water:** FOA for demonstration project for producing hydrogen from produced water **up to $10M.** • **Hydrogen Transportation**: FOA for development of pipeline transport of hydrogen and natural gas blends by advancing technologies that emphasize sensors and sensing capabilities that can detect low concentrations of hydrogen and quantify emissions during transport. **$3M** • **Subsurface Storage:** FOA for research on subsurface storage technologies to reliably inject and withdraw hydrogen and natural gas blends within characterized geologic systems including depleted oil and natural gas reservoirs, salt caverns, hard rock caverns, and saline aquifers. **$4M** • **Subsurface Storage:** National Lab research on subsurface geo-chemistry and geo-mechanics related to understanding potential hydrogen injection (including Subsurface Hydrogen Assessment, Storage, and Technology Acceleration (SHASTA)). **$6M** • **Center for Sustainable Fuels and Chemicals:** FECM will establish the Center for Sustainable Fuels and Chemicals at the NETL. **$3M**
Mineral Sustainability	$54,000	• **Report to Congress:** The Draft Report will be submitted for internal DOE review in March. • **Domestic Supply Chain**: FOA on advancing technology development for securing a domestic supply of critical minerals and materials. **$6M** • **Carbon Ore, Rare Earth and Critical Minerals (CORE-CM):** Phase II FOA to establish regional centers for processing of rare earth elements and other critical materials from coal and coal byproducts. **$33M** • **Coal And Coal Byproducts:** NETL and other National Laboratory research to support processing of rare earth elements and other critical materials from coal and coal byproducts. **$5M** • **Carbon Fiber Technology Facility:** FECM will provide funding to the Carbon Fiber Technology Facility for research using coal as a precursor for high-value added products. **$10M**
Total	**$195,000**	

NETL - FY 2024 Overview

Funding

(Dollars in Millions)	2022 Enacted	2023 Enacted	2024 Request
NETL Infrastructure	$75	$55	$55
NETL Research and Operations	$83	$87	$89
Interagency Working Group on Coal, Oil and Gas, and other Power Plant Communities and Economic Revitalization	-	$3	-

Planned Execution



Graph shows breakdown of subprogram activities as percentage of FY 2024 program budget

FY 2023 Accomplishments

- The Energy Data eXchange (EDX), NETL's flagship R&D data curation and collaboration platform, received the Secretary of Energy's Achievement Award.
- Microwave catalysts developed by NETL researchers reduce associated carbon dioxide emissions by nearly 200% compared to state-of-the-art methods.
- NETL advanced sensor technologies for natural gas pipeline reliability, resiliency, and methane emissions reduction.
- New high-performance computer 4-year lease increases performance 3x to 8+ Peta Floating-Point Operations Per Second (PFLOPs).
- Executing ~$20B of Bipartisan Infrastructure Law (BIL) provisions and $150M of Inflation Reduction Act (IRA) Infrastructure investments in addition to annual appropriations.

FY 2024 Planned Activities

- Oversight of a $5B+ base financial assistance portfolio comprised of more than 1,000 projects in 50 states.
- Execution of a $200M in-house research portfolio comprised of more than 200 projects.
- Increased focus on Artificial Intelligence initiatives to achieve ambitious research goals drive innovation across the FECM research portfolio.
- Continued focus on onsite energy sustainability Laboratory investment opportunities, deferred maintenance management, and information technology modernization, in addition to IRA construction projects to enhance capabilities in alloy development, computation, and process development.

NETL - FY 2024 Request

Dollars in Thousands

Subprogram/ Control Point	FY 2023 Enacted	FY 2024 Request	$ Change from FY 2023 Enacted	% Change from FY 2023 Enacted	Impacts
NETL Infrastructure	$55,000	$55,000	-	0%	Provides funding to maintain infrastructure at three research sites, invest in onsite energy sustainability and Artificial Intelligence (AI) initiaitves, continue High-Performance Computer (HPC) lease and cover fixed operational costs and Laboratory-Directed Research & Development (LDRD) component.
NETL Research and Operations	$87,000	$89,000	$2,000	2%	Provides funding for federal scientists and engineers performing on-site research and project management activities and cover variable operating costs and LDRD component.
Interagency Working Group (IWG)	$3,000	-	($3,000)	-100%	IWG funding request shifted to the Office of State and Community Energy Programs (SCEP).
Total	**$145,000**	**$144,000**	**($1,000)**	**-1%**	

NETL - FY 2023 Omnibus Execution

Dollars in Thousands

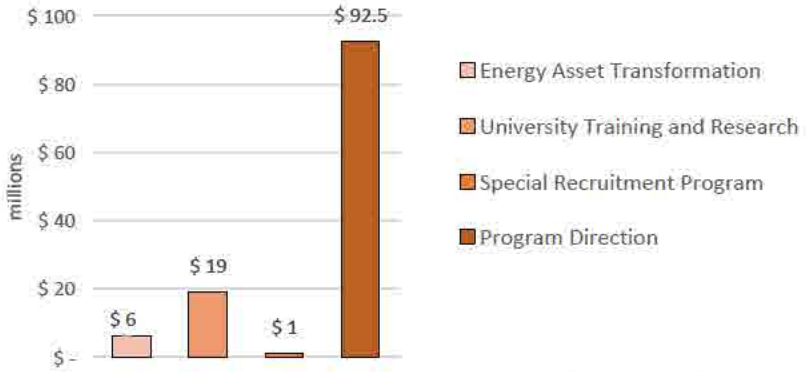
Subprogram/ Control Point	FY 2023 Enacted	FY 2023 Planned Execution
NETL Infrastructure	$55,000	Consistent with Congressional direction, NETL is utilizing funding for the continuation of NETL's High-Performance Computer lease, the final phase of our Center for Artificial Intelligence and Machine Learning, sitewide safety, and deferred maintenance management.
NETL Research and Operations	$87,000	On-site research in support of FECM mission, project management and contract oversight of extensive extramural research portfolio, and variable operating costs across 240-acres laboratory complex.
Interagency Working Group	$3,000	Targeted investments across the federal government to help communities impacted by the climate crisis and shift to a clean energy economy.
Total	**$145,000**	

Other FECM Programs - FY 2024 Overview

Funding

(Dollars in Millions)	2022 Enacted	2023 Enacted	2024 Request
Energy Asset Transformation	$5	$6	$6
University Training and Research (UTR)	$13	$13	$19
Special Recruitment Program	$1	$1	$1
Program Direction	$66.8	$70	$92.5

Planned Execution



Bar chart used because subprograms shown are not parts of a single larger program.

FY 2023 Accomplishments

- Selected three Phase II projects to move forward on Energy storage to aid in repurposing fossil assets.
- The Office of Energy Efficiency & Renewable Energy (EERE) and the Hydrogen and Fuel Cell Technologies Offices (HFTO) leveraged the Historically Black Colleges and Universities and Other Minority Institutions (HBCU-OMI) FOA 2598 (Amendment) within UTR program to support research opportunities valued at $2M for underrepresented and structurally marginalized communities.
- Initiated a new FECM student highlight Series titled "In Their Own Words: The HBCU-OMI Program Student Experience."
- Conducted "HBCU-OMI FECM Webinar" to amplify research opportunities within FECM.
- Hosted 50 Science, Technology, Engineering, and Math (STEM) interns under Mickey Leland Energy Fellowship program from 43 educational institutions and minority-serving institution (MSIs) from across the Nation.
- As of FY 2022 Q1, 43 UTR projects were active, valued at over $18M and approximately 100 students currently affiliated with the program.

FY 2024 Planned Activities

- Support curriculum design, research on successful recruitment and retention methods, development of outreach or mentorship programs, fellowships, and building science, engineering research, and education capacity.
- Recruit and select a diverse group of undergraduate, graduate, and post-graduate students in STEM majors to participate in the Office of Fossil Energy and Carbon Management and DOE educational programs.
- Program direction is for salaries and benefits (including bonuses and pay raises), travel, support services, and other expenses. The funding supports Headquarters Federal staff who provide monitoring (oversight and audit) activities for the FECM R&D portfolio. The funding supports Federal staff at NETL for management of the Lab, communications, legal, acquisition, and finance activities.

Other FECM Programs - FY 2024 Request

Dollars in Thousands

Subprogram/ Control Point	FY 2023 Enacted	FY 2024 Request	$ Change from FY 2023 Enacted	% Change from FY 2023 Enacted	Impacts
Energy Asset Transformation	$6,000	$6,000	-	0%	Additional funding will support the development of case studies that are crucial to implementing this program. (**$6M**)
University Training and Research	$13,000	$19,000	$6,000	46%	Funding supports 1) education and training the next generation of students to equip them with cutting-edge, translatable skillsets to foster a highly-skilled, inclusive, and competitive US workforce and economy; 2) novel, early-stage research at US colleges and universities that advance the FECM mission (**$6M**). In addition to the above, funding supports the enhancement of science, research, and education capacity at Historically Black Colleges and Universities (HBCUs) and other Minority Serving Institutions (MSIs). (**$13M**)
Special Recruitment	$1,000	$1,000	-	0%	Funding supports nation-wide recruitment at HBCUs and other MSIs for research internships (with stipend and housing/travel allowance) for undergraduate and graduate students in Science, Technology, Engineering, and Math (STEM) disciplines to educate and train the next generation of engineers and scientists in preparation to enter an increasingly diverse and inclusive STEM workforce. (**$1M**)
Program Direction	$70,000	$92,475	$22,475	32%	An increase in federal staffing level is required to maintain appropriate program oversight and administration of FECM programs, including support efforts at NETL to oversee, award, manage, and closeout R&D programs and projects. (**$92.5M**)

Other FECM Programs - FY 2023 Omnibus Execution

Dollars in Thousands

Subprogram/ Control Point	FY 2023 Enacted	FY 2023 Planned Execution
Energy Asset Transformation	$6,000	Supports the Department's goals to develop case studies for transition of fossil fuel assets that are crucial to implementing this program.
University Training and Research	$13,000	Support curriculum design; research on successful recruitment and retention methods; and development of outreach or mentorship programs, fellowships, and building science, engineering research, and education capacity. Help develop the next generation of workforce for the decarbonized future.
Special Recruitment	$1,000	Recruit and select a diverse group of undergraduate, graduate, and post-graduate students in Science, Technology, Engineering, and Math (STEM) majors to participate in FECM and DOE educational programs.
Program Direction	$70,000	Fossil Energy & Carbon Management's Program Direction provides for the Headquarters workforce responsible for the oversight and administration of the FECM Research and Development program, the technical staff at the NETL (procurement, finance, legal functions, contractor support), and the Import/Export authorization office managed the Division of Natural Gas Regulatory Activities within the Office of Resource Sustainability.

Questions?

Alternative Uses of Coal

FECM FY 2024 Budget Overview

Base Appropriations ($ in thousands)	FY23 Enacted	FY24 Request	FY24 Request vs. FY24 Enacted	
			$	%
Minerals Sustainability (Carbon Ore Processing)	$10,000	$4,000	-$6,000	-60%

Top Line Messages:

- The raw materials from coal and coal waste can be used to create a variety of high value carbon-based products needed for a clean energy-based, modern economy, especially graphite, which currently has no domestic supply.

- DOE investments this year have ~~enabled researchers to create~~resulted in the first battery anodes from coal waste, ~~the National Energy Technology Laboratory (NETL) to~~ improved carbon-based supercapacitor longevity and performance by 80% (NETL), and ~~Ohio University to produce~~ coal-based decking materials with lower energy use and emissions than traditional materials (Ohio University).~~.~~

- High value carbon products from coal and coal wastes will help transition~~ing~~ coal and power plant communities, create job opportunities through a new, clean use for these resources, ~~while~~ and reclaim~~ing~~ land and water.

- In FY24, ~~through continued~~ DOE investments will improve~~, improvements will be made in~~ the generation of battery grade graphite from coal waste~~,~~ and generate carbon fiber ~~will be generated~~ from coal and coal waste feedstocks on a large scale.

Background

- Work in the Carbon Ore Processing Program supports research, development, and demonstration (RD&D) to transform the carbon from coal and coal wastes into value-added carbon products and complements the $25M authorized (but not appropriated) in the Creating Helpful Incentives to Produce Semiconductors for America (CHIPS) Act to support carbon products from coal.

- The bountiful supply of coal and coal waste (millions and perhaps billions of tons of carbon in coal wastes) can provide a secure domestic resource for battery grade graphite, as well as greener building materials and carbon fiber, which have larger markets.

- Coal is an extremely diverse material, containing almost every element in the periodic table. This presents opportunities for co-producing valuable materials, such as rare earth elements, ~~but~~ and includes challenges in ensuring that harmful impurities do not impact worker safety or product performance.

- ~~Additional r~~Research challenges include developing approaches that take advantage of the natural variations in domestic coals, and in developing technological approaches to control, optimize, and tailor the carbon material to specific end uses.

Highlights of Program Office Achievements

- Oak Ridge National Laboratory (ORNL) and the University of Kentucky received over $5M in FY23 to continue their research and development on generating carbon fiber from coal and coal waste feedstocks.

- The University of Illinois was awarded $1M to develop high-value supercapacitor materials from domestic coal in a cost-effective manner.

- Ohio University was awarded nearly $2M to develop a cost-effective process for generating graphene and carbon quantum dots from coal and coal waste, and to develop carbon metal composites ~~(CMCs)~~ to improve the efficiency and reduce the greenhouse gas emissions from electric motors. This is in addition to their ~~work to date on~~ advancing the technology for high quality, low emissions decking materials towards commercialization.

- Tennessee Technological University, a minority serving institution, was recently awarded $1M to develop graphene-copper nanocomposites from coal to improve the conductivity, strength, and heat resistance of copper wires.

- The University of Delaware was recently awarded $1M to develop a lab-scale additive manufacturing process for carbon-copper composites to make more heat resistant materials for electrical applications.

Domestic Fossil Fuel Production

FECM FY 2024 Budget Overview

Base Appropriations ($ in thousands)	FY23 Enacted	FY24 Request	FY24 Request vs. FY24 Enacted	
			$	%
Advanced Remediation Technologies	$55,000	$13,000	-$42,000	-76.4%

Top Line Messages:

- Fossil fuels have contributed to America's economy and have provided fuel for electricity generation, vehicles, heat for homes, industrial products, plastics, and other important products. ~~Although there are many benefits from oil, natural gas, and coal, these~~ These benefits come with risks to the environment.

- The FY24 budget request for Advanced Remediation Technologies is based on investments to support research, development, demonstration, and deployment (RDD&D) programs that are focused on reducing the environmental impacts from the development, transportation, distribution, and storage of fossil energy resources.

- ~~Additionally, as we will continue to depend on fossil fuels in the near future~~ the ~~years ahead~~The FY24 budget request is aligned with our domestic energy security and the security of our allies.

Background

- The FY24 budget is distinct from Bi-partisan Infrastructure Law (BIL) investments.

- The Advanced Remediation Technologies Division supports research that leads to the development and advancement of technologies to remediate and prevent environmental impacts from the recovery of fossil energy resources. The program invests in RDD&D activities to address wellbore integrity, induced seismicity, water use, produced water treatment, offshore safety and spill prevention.

Highlights of Program Office Achievements

- Our research on the development of safe and cost effective well plugging materials is changing well plugging practices in Pennsylvania ~~(PA)~~ to reduce methane emissions and protect ground water resources.

- The results of our research will be used to modify regulations for plugging orphaned and abandoned wells in Pennsylvania. ~~The PA~~Their Department of Environmental Protection is incorporating our plugging materials and process recommendations in ~30 different contracts with plugging operators as part of their plan to plug 300-400 wells in Pennsylvania.

- Our research on offshore safety has provided regional insights into environmental and operational stressors that contribute to structural integrity loss over time for offshore platforms. This work will help to improve safety and will reduce the potential for spills.

Opposes Expansion of Offshore Drilling

FECM FY 2024 Budget Overview

NO FUNDING TABLE; TALKING POINTS ONLY

Top Line Messages:

- ~~President Biden was clear during his State of the Union address:~~ oil and gas will remain a part of our energy mix in the years ahead.
- While the Department of Interior is responsible for offshore oil and gas leasing as well as drilling permits, the Department of Energy's (DOE) Office of Fossil Energy and Carbon Management is providing expertise and sharing the results of its previous work to help reduce oil spills while offshore oil and gas activities continue.

Commented [CB1]: We should not reference the SOTU. It was not clear and created an avoidable debate.

Background
N/A

Highlights of Program Office Achievements

- DOE's work has helped to reduce spills that may occur during drilling by predicting the occurrence of sudden pressure changes, or "kicks" in the subsurface, and by identifying sea floor hazards that may result in sea-floor landslides that could damage wells during production operations.

Pipeline Expansion for Hydrocarbons

FECM FY 2024 Budget Overview

Base Appropriations ($ in thousands)	FY23 Enacted	FY24 Request	FY24 Request vs. FY24 Enacted	
			$	%
Methane Mitigation	$100,000	$60,000	-$40,000	-40%

Top Line Messages:

- The U.S. has the most extensive natural gas production, gathering, processing, storage, and delivery infrastructure systems in the world.
- The United States continues to produce and use fossil energy, specifically oil and natural gas, at historically high rates.
- ~~As noted by President Biden in the State of the Union address,~~ oil and gas will remain a part of our energy mix in the years ahead, and the Department of Energy (DOE) is doing its part to reduce the greenhouse gas emissions from the existing natural gas supply chain, including pipelines.
- DOE is aggressively pursuing research to reduce emissions from natural gas pipelines by developing better sensors to detect leaks, new technology to eliminate leaks from related equipment such as compressors, and new pipeline coatings that can prevent leaks.

Commented [CB1]: Again, S1 should not reference the SOTU. The ten-year reference hurts us. We already got this removed from S1s CERAWeek TPs and speech through David Bloom.

Background
N/A

Highlights of Program Office Achievements

- DOE has developed new retrofit equipment that can be installed on existing compressors that are powered by natural gas to minimize the unburned methane that can escape in the exhaust system.

Liquefied Natural Gas (LNG) Exports

FECM FY 2024 Budget Overview

Top Line Messages:

- LNG exports from the U.S. are expected to average approximately 12 billion cubic feet per day. LNG exports are expected to reach 14 billion cubic feet per day by late 2024 as additional capacity comes online.
- In 2023, approximately two-thirds of ~~of~~ U.S. LNG exports went to Europe.
- There are currently seven LNG export projects operating, with two more, Golden Pass and Plaquemines, expected to come online in late 2024. One other project is also currently constructing an expansion that may be online by late 2024 as well.
- Once all the LNG export capacity under construction is completed, U.S. LNG export capacity will be approximately 20 billion cubic feet per day (Bcf/d), more than any other country.
- There are several additional LNG projects that have full permitting from the Department of Energy (DOE) and the Federal Energy Regulatory Commission (FERC) that are awaiting a final investment decision. Current exports of 49 million cubic feet per day authorized by DOE exceed present U.S.LNG production fourfold.
- The market ultimately determines the amount of LNG exported.
- The Energy Information Administration's (EIAs) 2023 Annual Energy Outlook expects that U.S. LNG exports will increase to approximately 20 Bcf/d by 2030 and remain near that level through 2050.
- DOE is focused on ~~driving down~~reducing methane emissions in the oil and gas sector, leveraging the deep technical expertise of FECM and the National Energy Technology Laboratory (NETL), and the diplomatic efforts of International Affairs.

Background:

- Via DOE's regulatory role over natural gas and LNG imports and exports under the Natural Gas Act ~~(NGA)~~, DOE must review and approve applications to export LNG.
- Applications for exports to countries that have a free trade agreement (FTA) with the U.S. receive automatic approval under Section 3(c) of the ~~NGA~~Natural Gas Act. ~~, while~~ If applications are for exports to non-FTA countries, DOE must make a finding under Section 3(a) of the NGA that such applications are not inconsistent with the public interest~~ for exports to non-FTA countries~~.
- FERC leads review for the siting, construction, and operation of LNG export terminals, including the National Environmental Policy Act (NEPA) review, and DOE makes a finding on non-FTA applications ~~once~~ after the FERC review is complete.

Commented [CB1]: Amy has this in the Q&A response section below, but it should probably be in the toplines to head of a question suggesting that we are not permitting projects.

Congressional Interactions:

- There is strong support for LNG exports from both Senate Energy and Natural Resources (SENR) Chairman Manchin and Ranking Member Barrasso, as well as from the Congressional representatives along the Gulf Coast where most LNG export projects are located.

- Recent legislation was introduced by House Republicans to eliminate DOE's role over LNG export reviews under the Natural Gas Act.

Q&A:

- Question: I understand DOE is withholding LNG export permits that do not need review from any further agencies. In light of what is going on, how can you justify not acting?

    - Suggested Answer: DOE has issued seven ~~non-free free trade~~LNG ~~agreement~~ export authorizations for exports to non-free trade agreement (non-FTA) countries over the past year, the most recent issued in March 2023. With these issuances, each of the operating LNG export projects has approval from DOE to export its full FERC-authorized capacity to any country not prohibited by U.S. law or policy. Additionally, while current LNG export levels are expected to average 12 billion cubic feet per day in 2023, authorized exports are for more than four times export levels, with over 49 billion cubic feet per day of U.S. natural gas approved for export to non-FTA countries.

- Question: When might DOE issue further authorizations?

    - Suggested Answer: DOE does not announce the timing of LNG export orders, but we continue to act on applications to export LNG to non-free trade agreement countries ~~once~~ after the FERC review is complete.

Prepared by: Amy Sweeney, Fossil Energy and Carbon Management, 202-586-2627
Prepared on: March 9, 2023
Reviewed by: Ryan Peay, Fossil Energy and Carbon Management, 202-287-6701

Creating a domestic rare earth and critical mineral supply chain

FECM FY 2024 Budget Overview

Base Appropriations ($ in thousands)	FY23 Enacted	FY24 Request	FY24 Request vs. FY24 Enacted	
			$	%
Minerals Sustainability (Advanced Characterization and Critical Minerals Processing)	$44,000	$40,000	-$4,000	-9.1%

Include BIL Table, if applicable:

Bi-partisan Infrastructure Law (BIL) Section	$ (thousands)
BIL Sec 40205. REE Demo Facility	$140,000*
BIL Sec 41003, b. RE Minerals Security	$127,000
BIL Sec 41003, c. Critical Materials Innovation, Efficiencies, and Alternatives	$600,000
BIL Sec 41003, d. Critical Materials Supply Chain Research Facility	$75,000

*Going to Manufacturing Energy Supply Chain (MESC)

Top Line Messages:

- The U.S. must increase domestic production and processing capacity to build critical minerals and rare earth elements supply chains here at home. FECM will focus on the characterization of critical minerals and rare earth elements as well as the sustainable production and processing of critical minerals using unconventional resources such as coal waste and byproducts from the industry.

- This work will help support communities and regions of the U.S. that are heavily dependent on this industry today.

- The Department of Energy (DOE) has had major successes over the past few years in producing research, development, and demonstration (RD&D) that ~~leads toward~~enables the development of~~ing~~ rare earth elements ~~(REE)~~ and other critical minerals ~~(CM)~~ from unconventional and secondary sources, including pilot projects collecting high purity rare earth oxides from coal, coal waste, coal ash, and acid mine drainage.

- These annual program successes will be complemented by Bipartisan Infrastructure Law ~~BIL~~ funding for a ~~REE~~ Rare Earth Element Demo Facility and inform next stage of development to broadly move the extraction of rare earth

elements and other ~~Critical~~ critical ~~Minerals~~ minerals from unconventional feedstocks toward a substantial commercial industry.

- In FY24, the Office of Fossil Energy and Carbon Management (-FECM) will begin Phase II of the Carbon Ore, Rare Earth and Critical Minerals (referred to as CORE-CM) iInitiative, using a place-based approach for U.S. basins to catalyze regional economic growth and job creation by realizing the full potential value of critical mineral supply chains.

- FECM will continue to demonstrate critical mineral extraction, processing, and refining to build strong domestic supply chains and reduce our dependence on other countries for these critical building blocks of a clean energy and industrial economy.

- FECM will also work with other U.S. agencies and international partners to establish strong and environmentally responsible standards for world-wide rare earth elements and other critical minerals production and refining. ~~across the world~~.

Background

- The ~~BIL~~ Bipartisan Infrastructure Law funding is not duplicative of annual appropriations and . ~~The BIL funding~~ is focused on establishing a demonstration project for rare earth element refining from waste sources, including coal waste sources. The FY23 annual funding is focused on Phase II of the Carbon Ore, Rare Earth, and Critical Minerals ~~CORE-CM~~ ~~Initiative~~initiative, as well as new technologies for characterizing unconventional resources for improved REE recovery.

- ~~CORE-CM~~The Carbon Ore, Rare Earth, and Critical Minerals (CORE-CM) initiative ~~has been~~is designed to address the upstream and midstream critical minerals supply chain to accelerate the realization of full potential for critical minerals within the U.S. basins. ~~The~~A total of $25.5M has been awarded to thirteen CORE-CM Regional Coalitions that will generate the information needed to understand how substantial the unconventional domestic resource will be for key energy-related critical minerals, like cobalt, lithium, nickel, and graphite.

- Since 2016, FECM has invested approximately $42M to begin the establishment of four first-of-a-kind bench-scale and small-scale domestic pilot facilities that have produced kilograms of mixed r~~R~~are e~~E~~arth e~~E~~lements ~~(MREO)~~ and ~~CM~~critical minerals, including individual separation of scandium, yttrium, cobalt, manganese, gallium, and nickel oxides. These pilots demonstrated the capability to remediate legacy waste while producing ~~MREO~~mixed rare earth elements and other critical minerals. ~~CMs.~~

- Critical materials, including several rare earth elements, possess unique magnetic and catalytic properties and are critical for future advances in energy storage, turbines, lithium batteries, high temperature alloys and fuel cells, and are important in national defense technologies.

- The International Energy Agency (IEA) finds that with a global clean energy transition like the one President Biden envisions, demand for key minerals would explode beyond current usage ~~such as~~by 2040 (e.g., lithium (42 times),~~,~~ graphite (25 times), nickel (19 times), and rare-earth metals (7 times). ~~would explode, rising by 42X, 25X, 19X and 7X current usage, respectively, by 2040.~~ Recycling cannot meet this demand in the near term. Conventional mining takes too long, and shortfalls are projected.

- ~~Since 2016, FECM has invested approximately $42M to begin the establishment of four first-of-a-kind bench-scale and small-scale domestic pilot facilities that have produced kilograms of mixed Rare Earth Elements (MREO) and CMs, including individual separation of scandium, yttrium, cobalt, manganese, gallium, and nickel oxides. These pilots demonstrated the capability to remediate legacy waste while producing MREO and other CMs.~~

- ~~Critical materials, including several rare earth elements, possess unique magnetic and catalytic properties and are critical for future advances in energy storage, turbines, lithium batteries, high temperature alloys and fuel cells, and are important in national defense technologies.~~

- ~~CORE-CM has been designed to address the upstream and midstream critical minerals supply chain to accelerate the realization of full potential for critical minerals within the U.S. basins. The CORE-CM Regional Coalitions will generate the information needed to understand how substantial the unconventional domestic resource will be for key energy-related critical minerals, like cobalt, lithium, nickel, and graphite.~~

Highlights of Program Office Achievements

- ~~Completed construction and began operations of an~~ An acid mine drainage remediation and rare earth element recovery pilot facility in Mt. Storm, WV~~,~~ was constructed and began operations. It successfully produce~~s~~~~ing~~ high purity (>75%) mixed rare earth oxides. This is one of five small scale pilots from coal-based feedstocks.

- A backpack-sized laser system was developed to find rare earth elements in coal feedstocks in the field, helping accelerate characterization of secondary feedstocks and ultimately time to recovery.

- In FY23, an additional $6.5M was awarded to the 13 carbon ore, rare earth elements, and critical minerals regional ~~CORE-CM~~ coalitions, bringing the total to $25.5M for Phase I. This will lead to the development of a national prospectus on critical minerals from unconventional and secondary sources. These awards go to:
    - The Pennsylvania State University
    - Virginia Tech
    - Collaborative Composite Solutions Corp, Knoxville, TN
    - New Mexico Institute of Mining and Technology
    - University of Illinois
    - University of North Dakota
    - University of Wyoming
    - University of Utah
    - University of Texas at Austin
    - University of Alaska Fairbanks
    - West Virginia University

Carbon Capture, Utilization, and Storage (CCUS)

FECM FY 2024 Budget Overview

Base Appropriations ($ in thousands)	FY23 Enacted	FY24 Request	FY24 Request vs. FY23 Enacted	
			$	%
Point-Source Carbon Capture	135,000	144,000	+9,000	+6.7
Carbon Dioxide Conversion (renamed, formerly Carbon Utilization)	50,000	50,000	0	0
Carbon Transport and Storage	110,000	110,000	0	0
Carbon Management - Policy, Analysis, and Engagement	0	5,000	+5,000	N/A
Total	**295,000**	**309,000**	**+14,000**	**+4.7%**

Include BIL Table, if applicable:

Bi-partisan Infrastructure Law (BIL) Section	$ (thousands)
Section 40302: Carbon Utilization Grants Program	66,563
Section 40303: Carbon Capture Technology Program	20,000
Section 40305: Carbon Storage Validation and Testing	500,000
Section 41004(a): Carbon Capture Large-Scale Pilot Projects	200,000*
Section 41004(b): Carbon Capture Demonstration Projects	500,000*

*Going to Office of Clean Energy Demonstrations (OCED)

Top Line Messages:

- The FY24 budget request for CCUS supports research and development investments that enable the demonstration, and deployment for the power and industrial sectors to enable wider, strategic commercial deployment to meet goals of carbon pollution-free electricity by 2035 and economy wide net-zero greenhouse gas emissions by 2050.
- Point-Source Carbon Capture invests in technologies that are focused on reducing the cost and improving the performance of technologies that can mitigate emissions from the industrial and power sectors.
- Carbon Conversion focuses on the conversion of carbon oxides (such as carbon dioxide (CO_2) and carbon monoxide (CO)) to useful and value-added products, such as fuels, chemicals, and building materials.
- Carbon Transport and Storage is making key investments in strategies to develop the infrastructure for reliable carbon storage, RDD&D to improve performance and reduce

costs, educational partnerships to grow the workforce, technology transfer, and technical assistance to stakeholders.
- Policy, Analysis, and Engagement is conducting critical analysis and engagement work to improve our understanding of the role of carbon management technologies and address non-technical challenges associated with CCUS deployment.

Background

- The FY24 budget request complements the Bipartisan Infrastructure Law (BIL) efforts in several ways:
    - The FY24 Carbon Dioxide Conversion request is to invest in advanced technologies (technology push) whereas the BIL Carbon Utilization Grant Program provides grants to state and local governments and public utilities to purchase products derived from carbon oxides such as carbon dioxide (market pull).
    - The FY24 Point-Source Carbon Capture request is to invest in advanced technologies that can help lower the costs and optimize the process while the BIL funding is primarily focused on large-scale demonstration and deployment of projects.
    - The FY24 Carbon Transport and Storage request is to invest in advanced monitoring and characterization technologies; modeling and simulation tools to support basin-scale decision-making for multiple projects; and field laboratories that leverage investments in activities such as the Carbon Storage Assurance Facility Enterprise (CarbonSAFE) initiative supported under the BIL.
    - The FY24 Policy, Analysis, and Engagement request is to invest in technoeconomic analysis, domestic and international engagement, and government-wide efforts to build technical capacity and enhance interagency collaboration.

Highlights of Program Office Achievements

- Implemented bipartisan-supported efforts for carbon capture at natural gas and industrial facilities by awarding front-end engineering design studies for cement plants in Texas and Indiana; an iron plant in Texas; and natural gas combined cycle plants in Kentucky and Florida. FY24 investments will continue to explore a broader range of industrial sources and leverage these learnings to facilitate advanced technologies that can achieve higher rates of capture (>97%).
- The CarbonSAFE Phase III projects have made significant progress in their efforts to characterize geologic storage complexes, collectively capable of storing at least 975 million metric tons of carbon dioxide over 20 years. These CarbonSAFE projects have characterized six storage complexes (two in Illinois, one in North Dakota, one in New Mexico, one in Mississippi, and one in Wyoming).
- Currently implementing a number of Congressionally directed efforts such as methanol synthesis from atmospheric carbon dioxide and low-carbon hydrogen, and regional activities to accelerate carbon capture and storage.

Cancellation of Keystone XL

FECM FY 2024 Budget Overview

Top Line Messages:

The U.S. Department of Energy (DOE) released a report evaluating existing analysis on economic and job effects of the export limited (XL) portion of Keystone pipeline. It concluded there were limited job impacts, with only approximately 50 permanent jobs that were estimated to have been created ~~were~~ if the pipeline were operational. Additionally, the consumer impacts associated with the revocation of the permit for the Keystone XL pipeline remain inconclusive considering the changes that have occurred in Canadian and U.S. crude oil markets since the Keystone XL pipeline was proposed.

Background Points

- The President revoked the Presidential Permit for the Keystone XL pipeline because it would have had limited jobs impact and ~~,~~ an uncertain impact on consumer prices.~~, and the market case for it deteriorated. Low oil prices led Shell, Exxon, Equinor (then Statoil), and Total to either sell their tar sands assets or whittle them down. it was primarily for crude oil from Canadian oil sands, which have a high climate impact compared to other forms of crude oil production.~~

- DOE's report shows that there are only approximately 50 permanent jobs associated with the pipeline ~~once~~ if it ~~is~~ became operational.

- And the impact to consumer prices is unclear. The Keystone XL pipeline was proposed before the increase in U.S. shale production really took off, and past studies have shown that it would have no significant change in total U.S. refining activity.

- The sponsor of Keystone XL, Canada's TC Energy, has said publicly that they no longer wish to pursue the project.

Congressional Interactions:

- In December 2022, DOE released *Keystone XL Extension Permit Revocation: Energy Costs and Job Impacts* pursuant to section 40434 of the Infrastructure Investment and Jobs Act (Pub. L. No. 117-58). DOE prepared this report to estimate the job losses and consumer impacts associated with the revocation of the Keystone XL pipeline permit.

- There was minimal reaction to the report, though Senators Daines -and Risch released a statement highlighting the negative impacts associated with the total expected investment and construction jobs associated with the project had it been completed.

Q&A

- Question: How can the Biden Administration justify the cancellation of this key piece of infrastructure when you are touting permitting reform?
    - Answer: DOE's report shows that the impact on the cancellation of Keystone XL on consumer prices is unclear. The Keystone XL pipeline was proposed before the increase in U.S. shale production really took off, and past studies have shown that it would have no significant change in total U.S. refining activity. Additionally, the sponsor of Keystone XL, Canada's TC Energy, has said publicly that they no longer wish to pursue the project.

Prepared by: Amy Sweeney, Fossil Energy and Carbon Management, 202-586-2627
Prepared on: March 9, 2023
Reviewed by: Ryan Peay, Fossil Energy and Carbon Management, 202-287-6701

Liquefied Natural Gas (LNG) Exports (Increasing) and Domestic Impact

FECM FY 2024 Budget Overview

Top Line Messages:

- The U.S. has a well-supplied and transparent natural gas market with production far exceeding current demand—a trend that is expected to continue according to the Energy Information Agency's (EIA's) latest projections through 2050 in the Annual Energy Outlook 2023.

- Natural gas prices increased significantly in 2021 and 2022 when production did not keep pace with demand, but have receded to below $3 in recent months, and are expected to average under $3.50 this year amid record production.

- In their latest Short-Term Energy Outlook (STEO, March 7, 2023), EIA forecasts that prices will average below $3.20/MMBtu this year and average around $4 in 2024, despite expecting rising LNG exports during that period.

-

- ~~Portions~~ Some areas of the U.S. that have natural gas supply constraints, such as New England, and may continue to experience above-average prices for natural gas since the pipeline constraints into the region are the main driver of their higher prices.

- An increase or reduction in LNG exports is unlikely to impact those prices.
- ~~, but reduced LNG exports are unlikely to mitigate those higher prices since the pipeline constraints into the region are the main driver of their higher prices.~~

Background:

- There have been concerns by members of Congress, particular in the northeast, that the Department of Energy (DOE) should slow down or curtail LNG exports to help keep domestic prices down.

    - These concerns were heightened in late 2021 when LNG exports were rising along with domestic prices and EIA's 2021-2022 Winter Fuels Outlook showed that U.S. households would pay 30% more for their winter heating bills with price ~~vs~~ versus weather being the primary driver of the increase.

- Industrial consumers of natural gas represented by the Industrial Energy Consumers of America have also continued to raise concerns that LNG exports are ~~causing~~ costing U.S. manufacturers a competitive edge if global competitors are able to use less expensive U.S. natural gas.

    - The domestic manufacturing sector continues to grow.

- DOE's studies on the economic impacts of LNG exports do not support this conclusion and show little, to any, slowing of growth of the U.S. manufacturing sector with rising LNG exports.

Congressional Interactions:

- Since the Russian invasion of Ukraine, most Congressional interaction regarding LNG exports have been regarding permitting concerns~~,~~ .
- ~~with l~~Legislation was introduced in early 2023 to remove DOE's authority to review applications to export natural gas under the Natural Gas Act.
- ~~Concerns~~ Recently, concerns about domestic price impacts from LNG exports ~~have not been raised~~have lessened ~~as much recently~~ as prices have receded, but New England continues to pursue questions about Jones Act waivers for imports of domestically produced LNG into New England.
- New England is ~~as they are~~ exposed to global LNG import prices for any LNG they need to source outside of ~~of~~ their long-term contract with Atlantic LNG in Trinidad and Tobago.
- The Atlantic LNG contract ~~which~~ is set to expire in May 2024.

Q&A

- Question: Would DOE support Jones Act waivers to allow domestic LNG to be brought to New England for price relief?
  - Answer: Jones Act Waiver decisions are made by ~~DHS~~the Department of Homeland Security, but DOE assists in providing analysis for LNG-related waivers. DOE has closely coordinated with New England governors over fuel supply concerns this past winter. While natural gas supplies to the region continue to be a concern due to limited pipeline connectivity into the region, no requests have been made for waivers for LNG for New England.

Prepared by: Amy Sweeney, Fossil Energy and Carbon Management, 202-586-2627
Prepared on: March 9, 2023
Reviewed by: Ryan Peay, Fossil Energy and Carbon Management, 202-287-6701

From: Daniel Hatchell
Sent: Mon, 3 Apr 2023 18:21:41 +0000
To: Francisco De La Chesnaye; Iyer, Gokul; Edmonds, James A (Jae); Binsted, Matthew; Wolfram, Paul; Whitman, Peter C; Riera, Jefferson; Jose Bosch
Cc: Curry, Thomas; Skone, Timothy; Yarlagadda, Brinda; Sweeney, Amy; Harker-Steele, Amanda J (NETL); Robert Wallace; Agboola, Ajoke
Subject: [EXTERNAL] RE: FECM LNG Export Project Coordination
Attachments: LNG_Meeting_20230330.pdf

Hi everyone,

Attached are our slides from last week's LNG meeting.

Cheers,
Daniel

Daniel Hatchell | **Consultant**
ph: 703.988.5927 | ext: 310 | onlocationinc.com

-----Original Appointment-----
From: Francisco De La Chesnaye <francisco.delachesnaye@onlocationinc.com>
Sent: Tuesday, January 31, 2023 4:22 PM
To: Francisco De La Chesnaye; Iyer, Gokul C; Edmonds, James A (Jae); Binsted, Matthew T; Wolfram, Paul; Peter Whitman; Daniel Hatchell; Jefferson Riera; Jose Bosch
Cc: Curry, Thomas; Skone, Timothy; Yarlagadda, Brinda N; Sweeney, Amy; Harker Steele, Amanda J.; Robert Wallace; Agboola, Ajoke
Subject: FECM LNG Export Project Coordination
When: Thursday, March 30, 2023 2:00 PM-3:00 PM (UTC-05:00) Eastern Time (US & Canada).
Where: Microsoft Teams Meeting

Adjusting at FECMs' request. Alternative is for before 12 pm on 3/31. Let me know which works best.

Microsoft Teams meeting

Join on your computer, mobile app or room device
Click here to join the meeting

Meeting ID: (b) (6)
Passcode: (b) (6)
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Updated Natural Gas Regulatory Analyses

GCAM and NEMS Coordination

In support of Department of Energy
Office of Fossil Energy and Carbon Management
Office of Resource Sustainability

March 30, 2023

DRAFT*DELIBERATIVE*PRE-DECISIONAL

Outline

1. Administrative items
2. Baseline scenario assumptions
3. GCAM progress report
4. GCAM/NEMS Coordination
   - Comparison Spreadsheet Key Variables
   - AEO 2023 Changes
   - Options/strategy to align models

Baseline Scenario Assumptions

Two IRA baseline scenarios to consider:

1. OP-NEMS Moderate IRA scenario
    - Based on the AEO2022 low economic growth case
    - Includes a mix of IRA and non-IRA assumptions including updated technology costs and transportation policies as well as additional provisions from the Bipartisan Infrastructure Law
    - OP-NEMS includes all FECM-NEMS model enhancements except for the hydrogen market module

2. FECM-NEMS IRA scenario
    - Based on the AEO2022 low economic growth case
    - Includes most of the OP-NEMS IRA and non-IRA assumptions except for differences in IRA bonus tax credits and technology costs
    - FECM-NEMS includes a new hydrogen market module that is not included in OP-NEMS

Both scenarios should be available by mid-April.

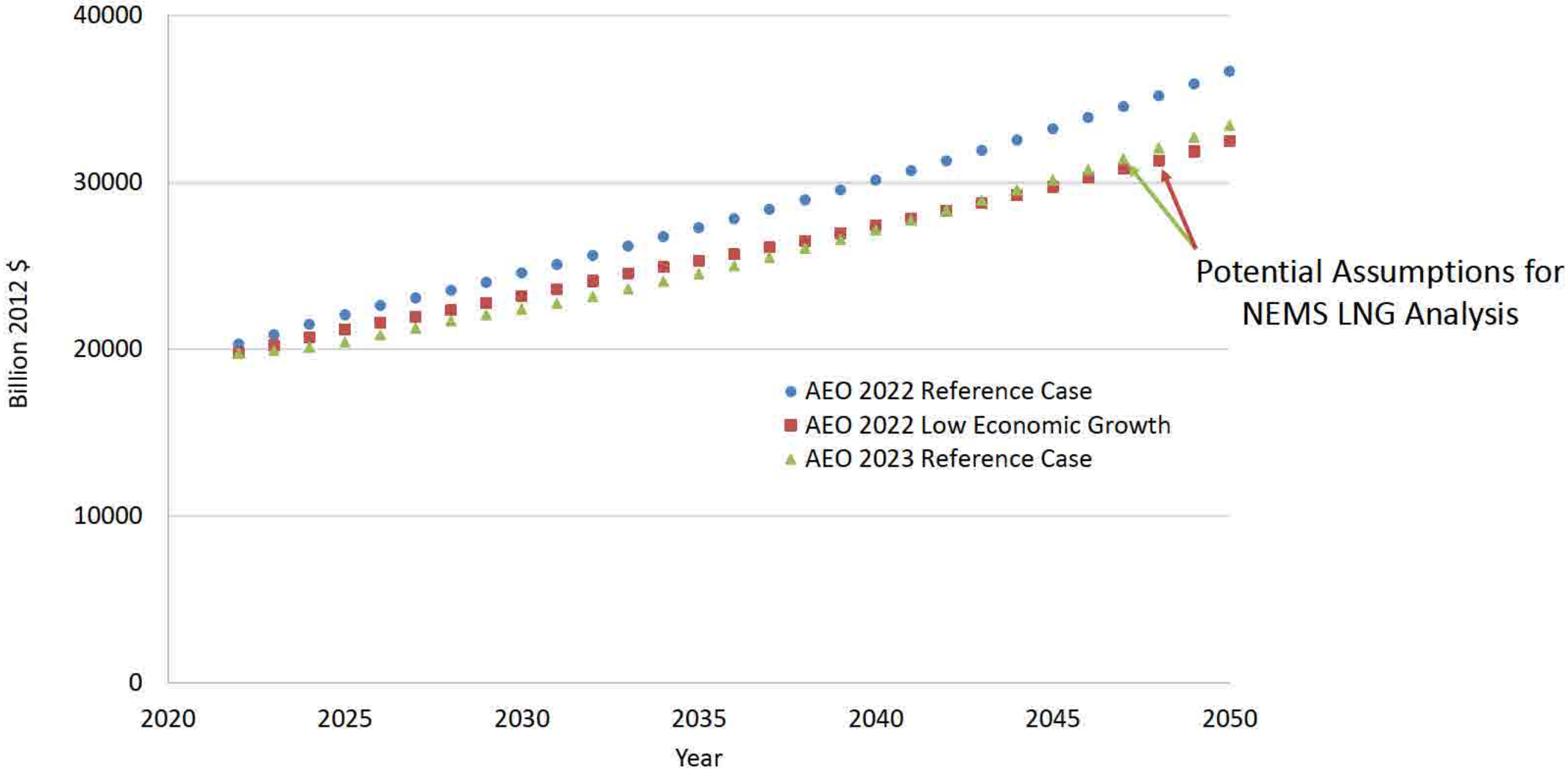
IRA Scenario Non-IRA Assumptions

	OP-NEMS Moderate IRA Scenario	FECM-NEMS IRA Scenario
Macroeconomic Growth	AEO22 Low Economic Growth	AEO22 Low Economic Growth
Technology Assumptions-Renewables	NREL ATB Moderate case costs for all projection years	NREL ATB Moderate case for initial costs, then endogenous learning
Technology Assumptions-Carbon Capture	FECM assumptions for initial costs, then endogenous learning; 95% capture	NREL ATB Moderate case for initial costs, then endogenous learning; 95% capture
Technology Assumptions-Electric Vehicles	ANL Low (BAU) case for LDV EV costs, EIA EV costs but higher MPGs for EV trucks	ANL Low (BAU) case for LDV EV costs, CARB costs for electric/fuel cell trucks
Light-Duty Vehicle EPA and CAFE Standards	Updated EPA and NHTSA standards thru 2026	Same
State ZEV Mandates	Pre-existing programs, but not Advanced Clean Cars II (100% targets)	Same
BIL Funding for Carbon Capture Demos, Transport, and Storage	Includes funding for both power and industrial carbon capture, and for CO_2 pipelines and saline injection	Same
BIL Funding for Advanced Nuclear Demos	Two 330MW SMR plants (WA, WY)	Same

IRA Scenario IRA Assumptions

	OP-NEMS Moderate IRA Scenario	FECM-NEMS IRA Scenario
Power Sector	Clean electricity tax credits (5X w/ 10% bonus credits) thru 2050; Zero Emission Nuclear Credits; USDA rural coop programs	Clean electricity tax credits (5X w/ no bonus credits) thru 2050; Zero Emission Nuclear Credits; USDA rural coop programs
Buildings Sector	Renewable tax credits (5X w/ 10% bonus); shell and appliance tax credits and subsidies; EPA GHG Reduction Fund	Renewable tax credits (5X w/ no bonus); shell and appliance tax credits and subsidies; EPA GHG Reduction Fund
Industrial Sector	Various manufacturing credits for CCS, steel, cement, and other GHG reductions	Same
Transportation Sector	LDV tax credits (30D); commercial clean vehicle credits; and USPS clean fleets	Same
Fuels Production	Hydrogen tax credits; biofuels tax credits; Clean Fuel Production Tech-neutral credit	Same
45Q Sequestration Credits	Implemented for EOR, saline, and direct air capture (5X credit)	Same
Other	Increased royalty rates for oil/gas production	Same

Real GDP

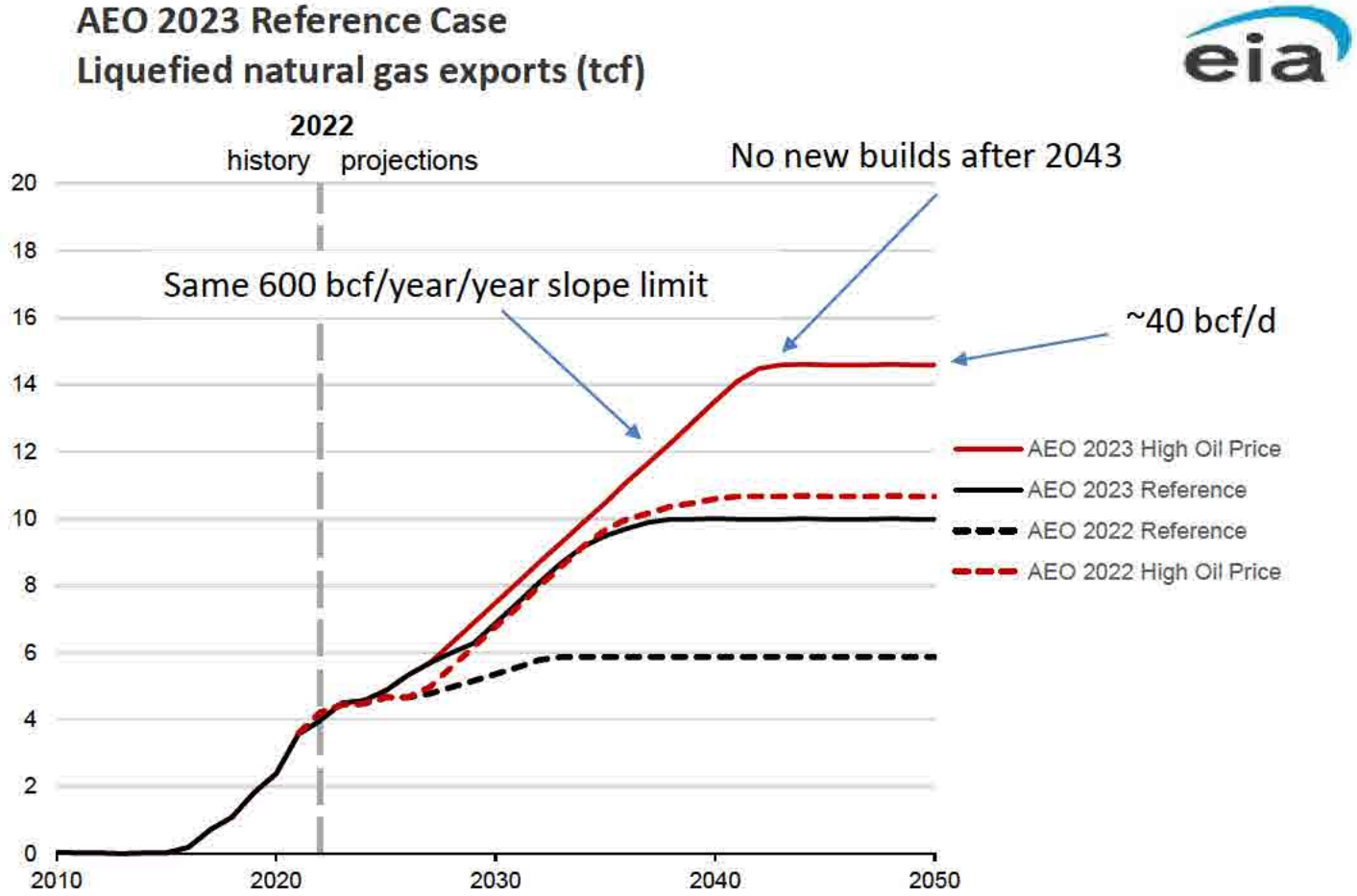

40000
30000
20000
10000
0
Billion 2012 $
2020
2025
2030
2035
2040
2045
2050
Year
AEO 2022 Reference Case
AEO 2022 Low Economic Growth
AEO 2023 Reference Case
Potential Assumptions for NEMS LNG Analysis

GCAM/NEMS Coordination: Variable Comparison

Key variables that GCAM and NEMS both report:

- Total Natural Gas Supply
- Total Natural Gas Consumption
- Natural Gas Consumption in the Electric Power Sector
- Natural Gas CO_2 Emissions in the Electric Power Sector
- **Natural Gas Henry Hub Spot Price**
- **LNG Export Volume**
- **GDP**

- Electricity Production Technology Assumptions (assuming significant differences)



Planned Builds

	Capacity Online (Peak)		Capacity Under construction		TOTAL (once all expansions complete; ~2028)	
	Bcf/d	MTPA	Bcf/d	MTPA	Bcf/d	MTPA
US	14.28	109	**9.91**	76	24.19	185.6
Qatar	10.1	77	6.5	49.8	16.6	127.2

Growth rate (slope) of 720 bcf/year/year

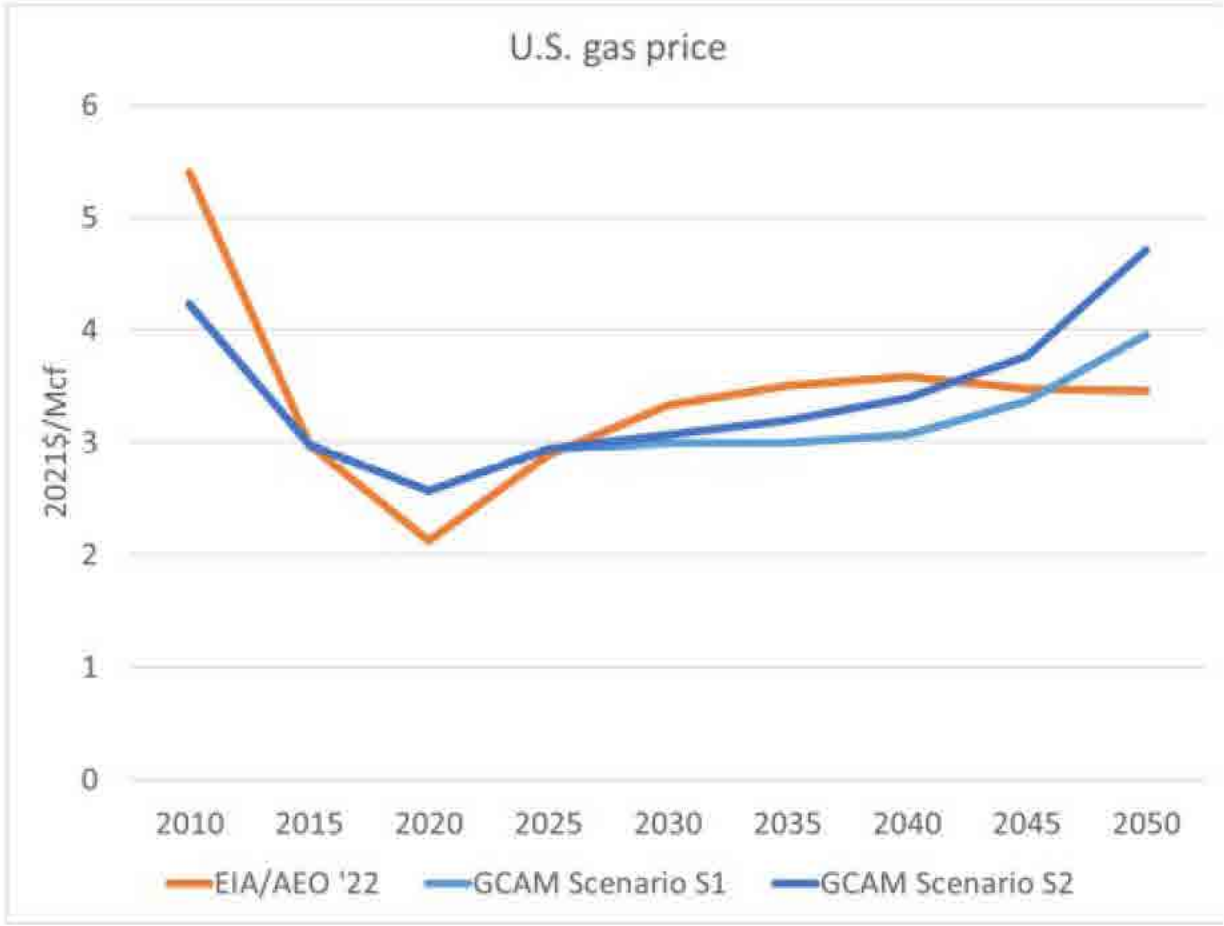
(GCAM slopes reach as high as 1200 bcf/year/year)

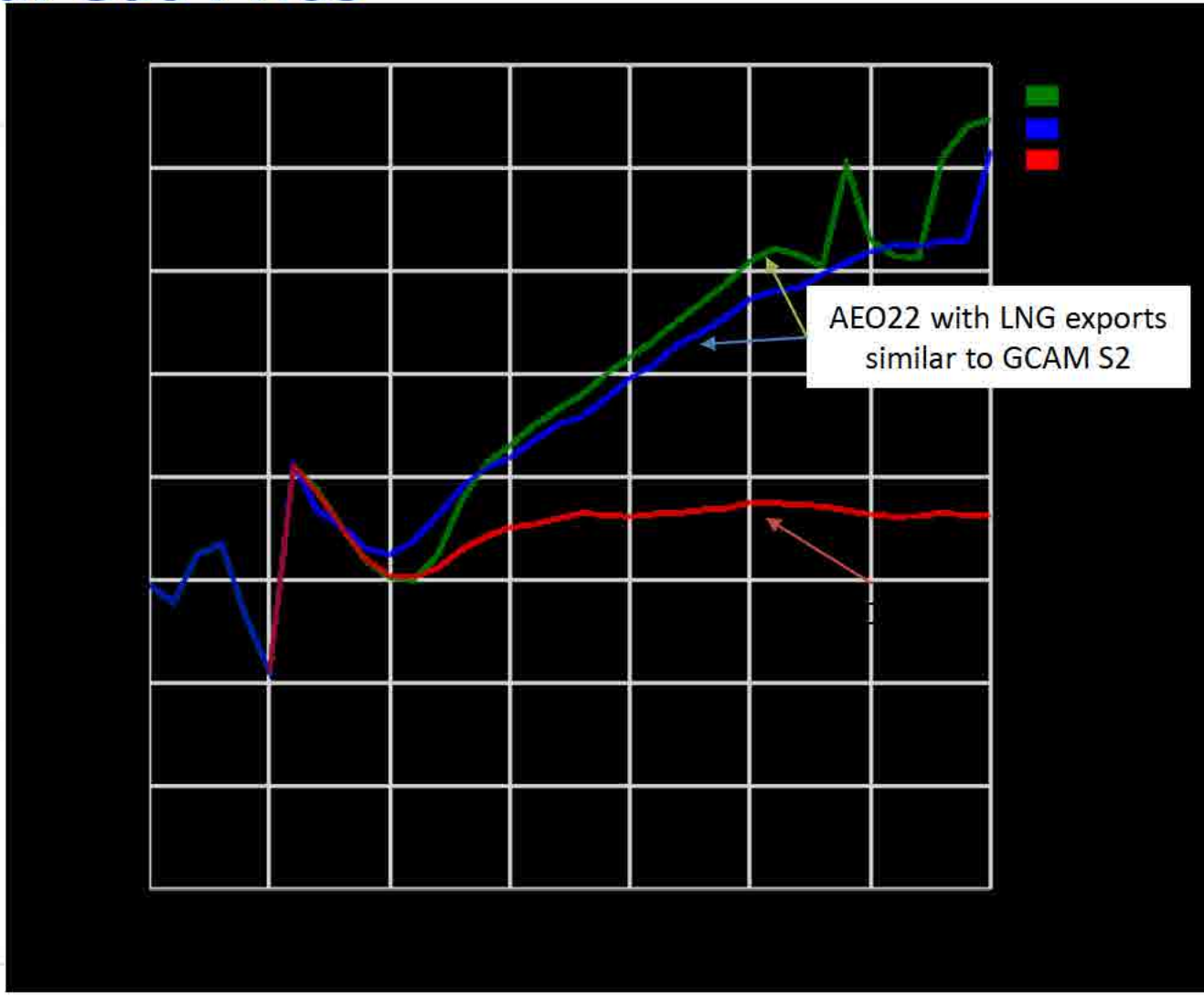
$$\textbf{LNG Export Price} = (\textit{World Oil Price})^{\alpha}(\textit{Supply and Demand Balance})^{\beta}$$

Upcoming AEO2023 *Issues in Focus*

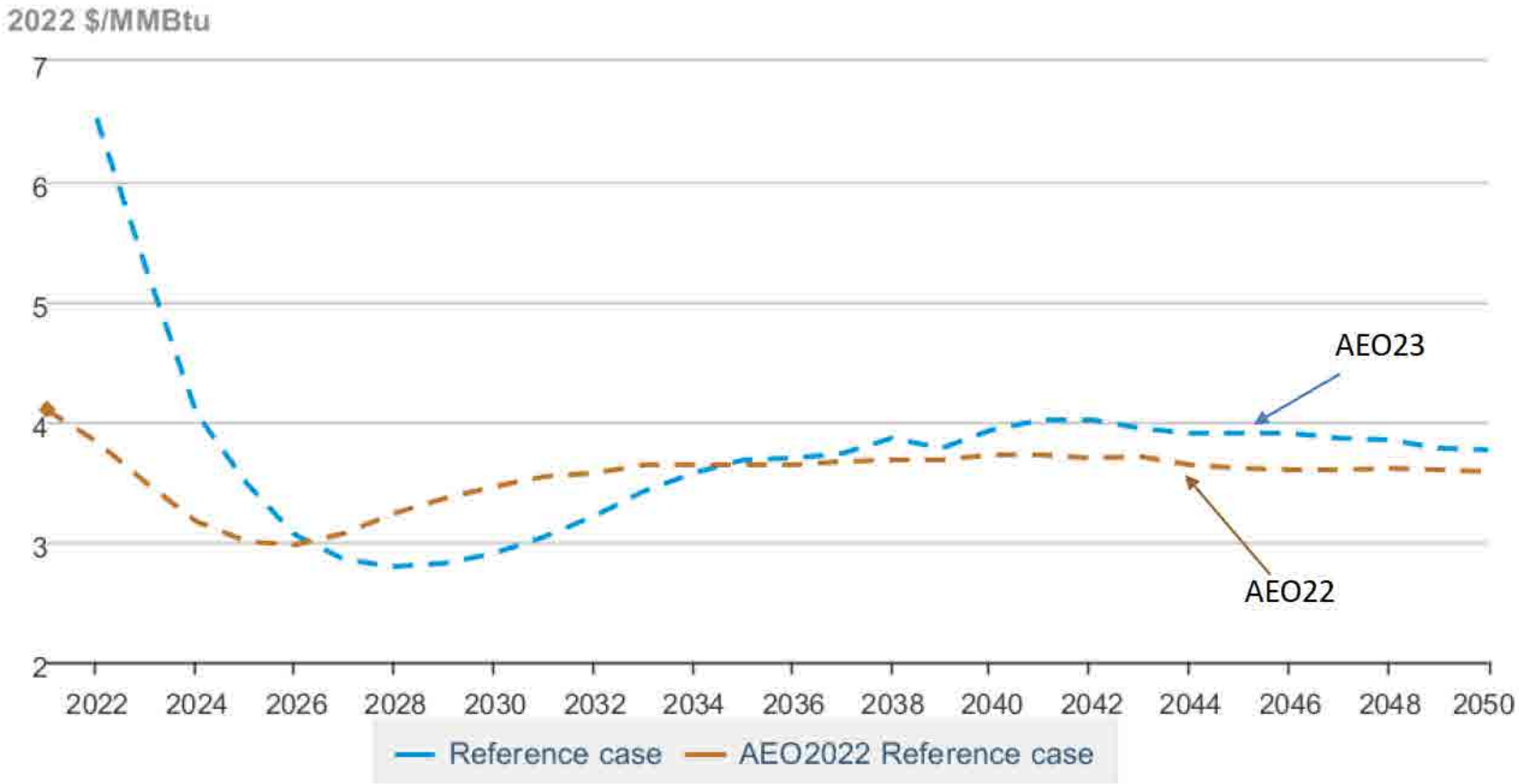
- **Liquefied Natural Gas (LNG) *Issues in Focus* coming next month**
  - High LNG Price case
  - Low LNG Price case
  - **Fast Builds** + High LNG Price case

US Natural Gas Price





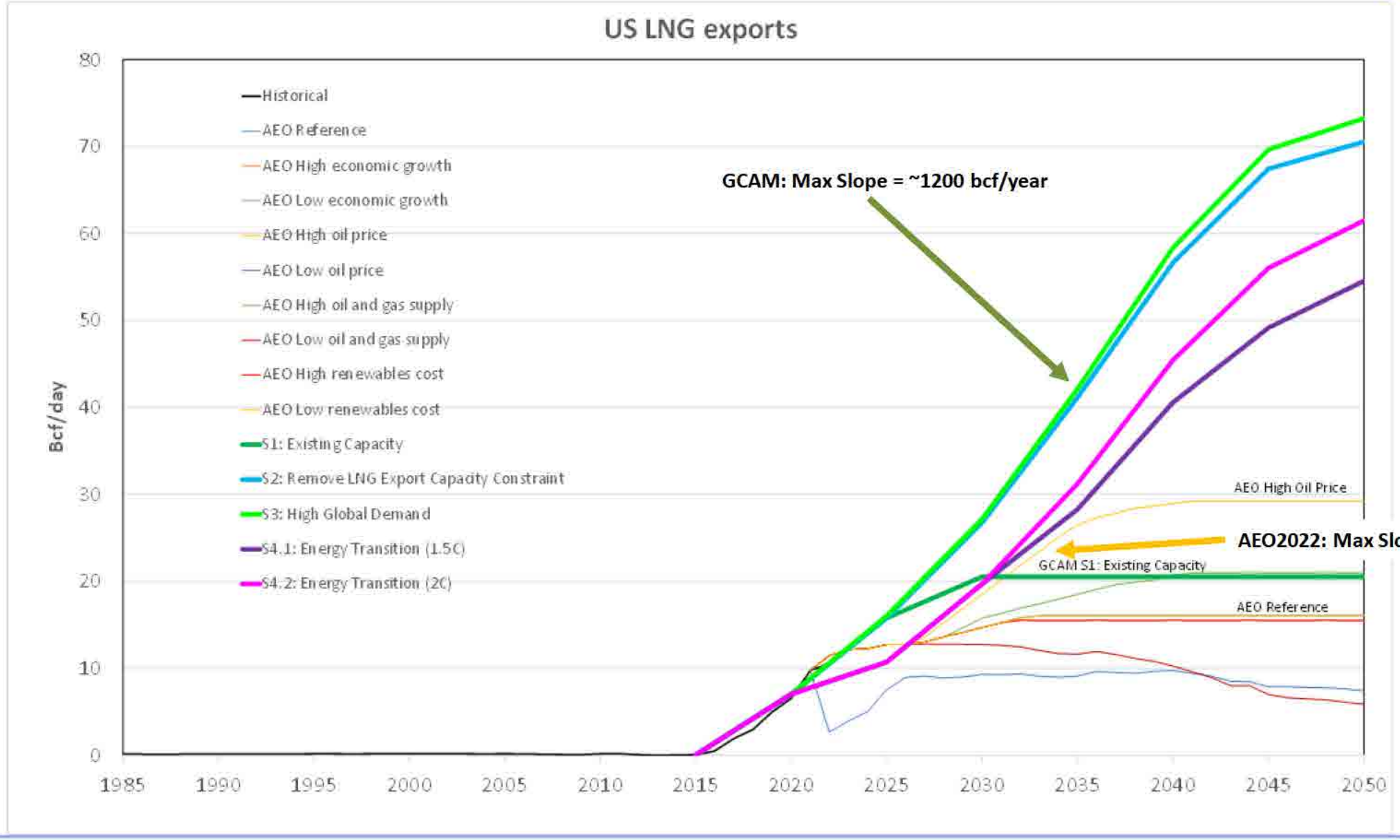
Natural Gas: Henry Hub Spot Price



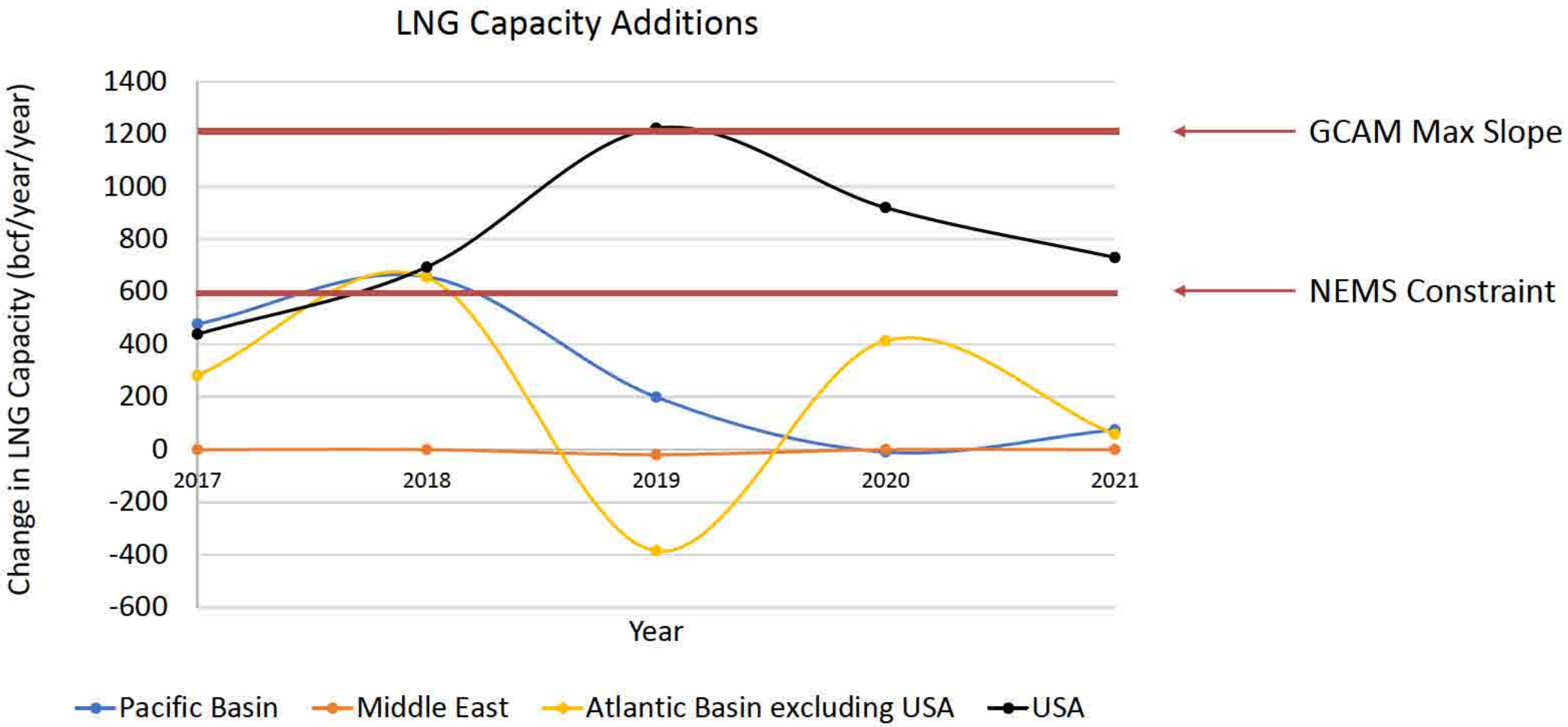
eia Data source: U.S. Energy Information Administration

Extra Slides

LNG Capacity Expansion Rate



Slope of Capacity Additions



Calculate World LNG Prices

Controls influence of world oil price

Controls influence of supply/demand ratio change

$$PRICE\_LNG_{(yr+lookyr),d} = (WOP_{(yr+lookyr)})^{\alpha_d} * \left(\frac{\left(\frac{FLEX_{(yr+lookyr)} + LNG\_USA_{(yr+lookyr)} + LNG\_ADD}{Q\_LNG_{(yr+lookyr),d}} \right)}{\left(\frac{FLEX_{lhyr} + LNG\_USA_{lhyr} + LNG\_ADD}{Q\_LNG_{lhyr,d}} \right)} \right)^{\beta_d}$$

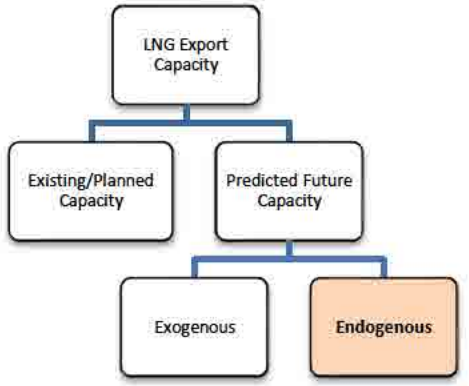
World oil price

Supply/demand ratio change

$$\left(\frac{\frac{Global\ Supply_{\ Calculation\ year}}{Regional\ Demand_{\ Calculation\ year}}}{\frac{Global\ Supply_{\ 2018}}{Regional\ Demand_{\ 2018}}} \right)$$

Potential capacity expansion; affects future prices

"Historic" potential capacity doesn't exist; equals zero



- Future prices are then discounted at a 10% discount rate

From: Peter Whitman
Sent: Fri, 26 May 2023 20:39:07 +0000
To: Francisco De La Chesnaye; Iyer, Gokul; Edmonds, James A (Jae); Binsted, Matthew; Wolfram, Paul; Daniel Hatchell; Riera, Jefferson
Cc: Curry, Thomas; Yarlagadda, Brinda; Sweeney, Amy; Harker-Steele, Amanda J (NETL); Robert Wallace; Agboola, Ajoke; Jamieson, Matthew B.; Michael Blackhurst; Skone, Timothy
Subject: [EXTERNAL] FECM LNG Export Project Coordination
Attachments: LNG_Meeting_20230526.pdf

DRAFT – DELIBERATIVE – PRE-DECISIONAL

Please see the enclosed slides from today's meeting.

Peter Whitman | **Associate Director**
ph: 703.988.5927 | ext: 307 | m: (b) (6) | onlocationinc.com

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Updated Natural Gas Regulatory Analyses

GCAM and NEMS Scenario Comparison

In support of Department of Energy
Office of Fossil Energy and Carbon Management
Office of Resource Sustainability

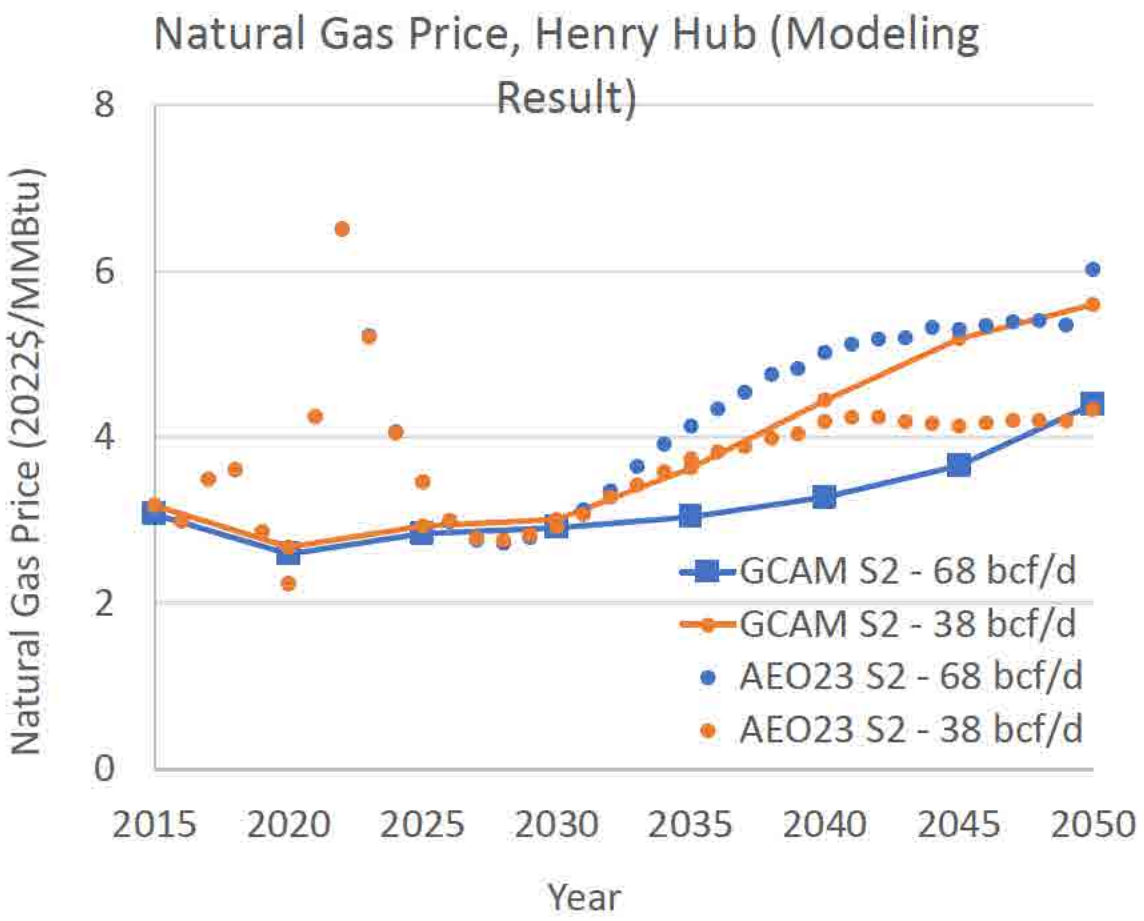
May 26, 2023

DRAFT*DELIBERATIVE*PRE-DECISIONAL

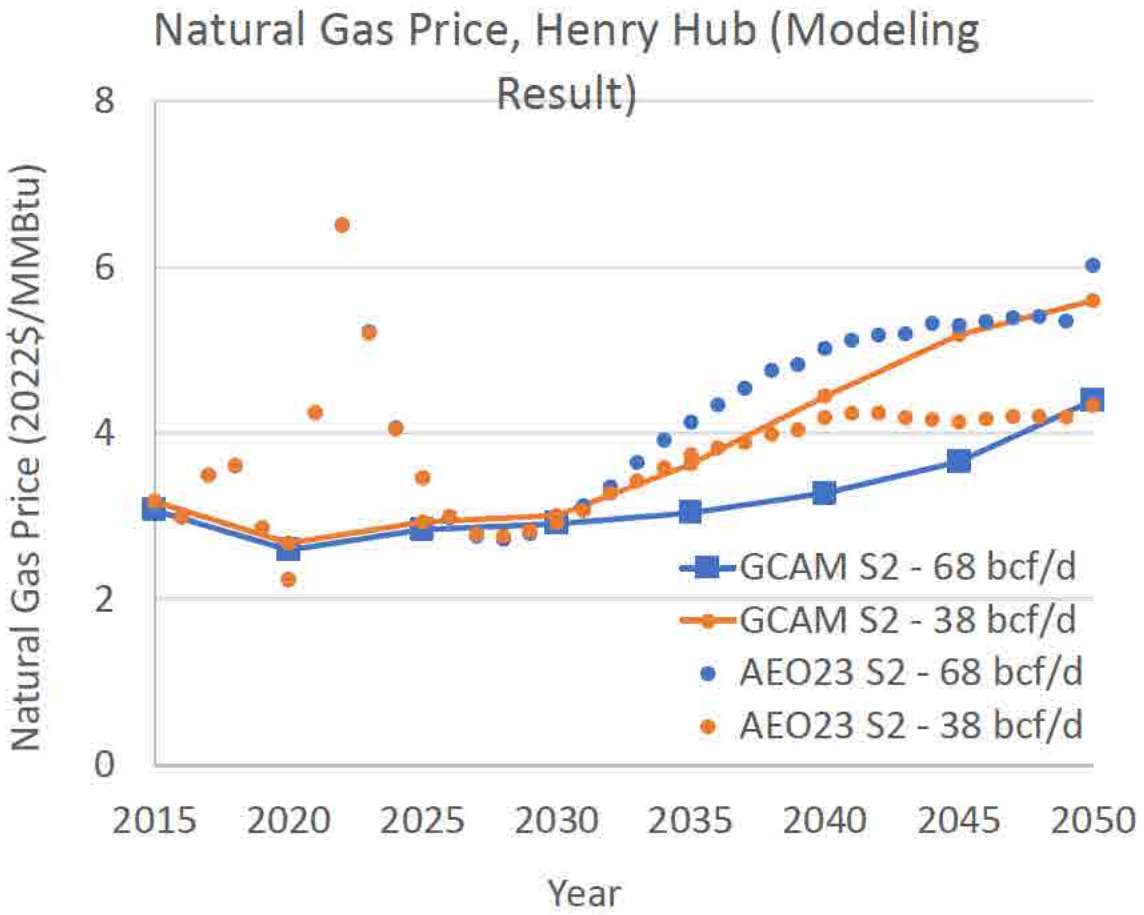
Meeting Agenda

- Natural Gas Price Curve Alignment
  - Comparison to EIA Issues in Focus – LNG
- Scenario 6 Net Zero Alignment
  - Emissions comparison
  - DAC Technology Assumptions

NG Price Curves: S2

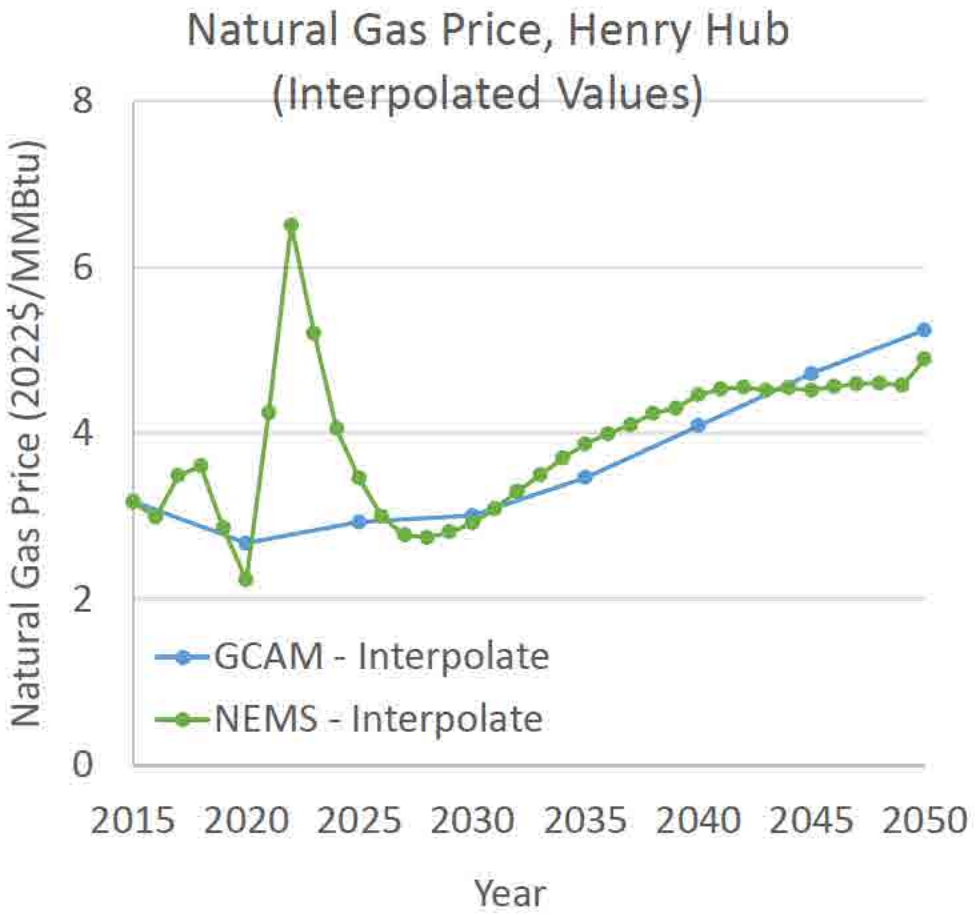


NG Price Curves: S2



Linear Interpolation

48 bcf/d



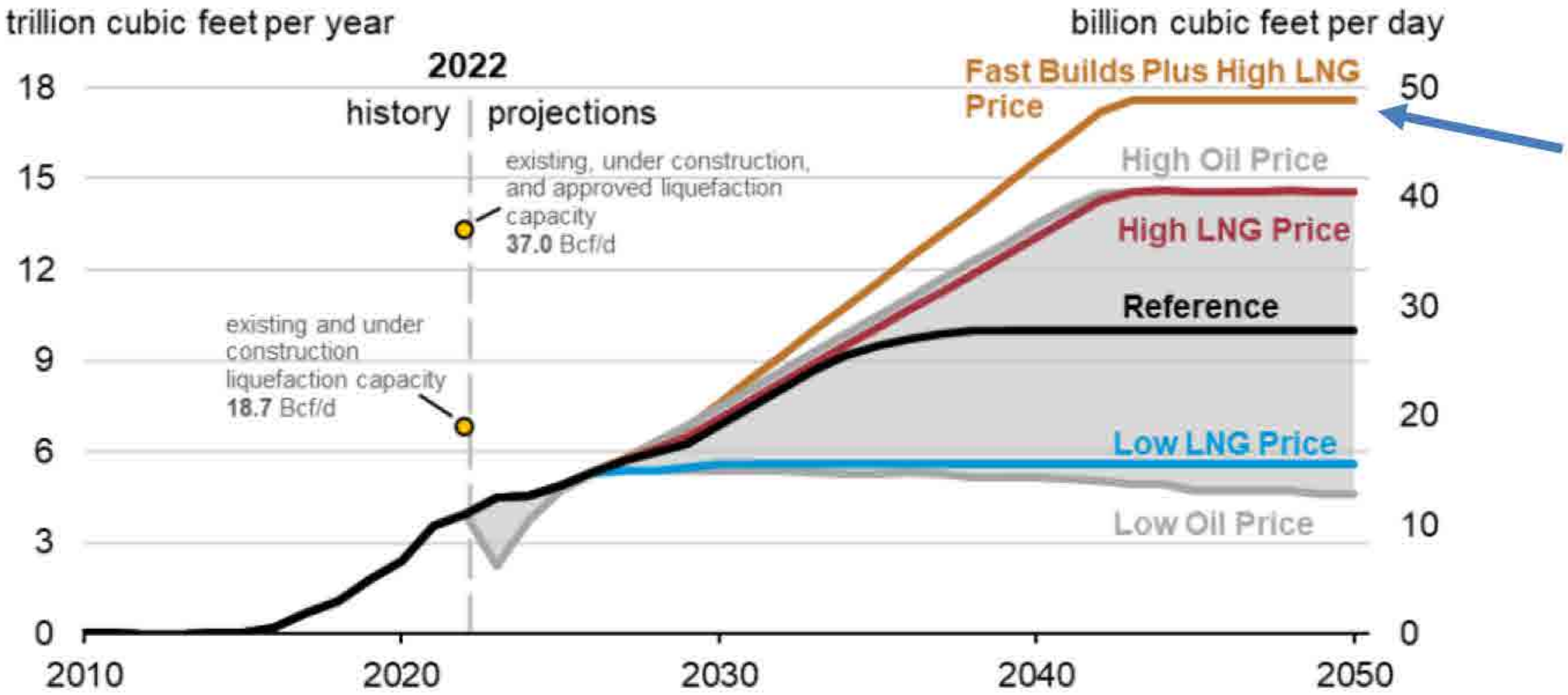
EIA Issues in Focus: LNG

Four cases, run endogenously based on AEO2023

Case	International LNG Price	LNG Maximum Build Rate
AEO2023 Reference	+/- 0%	600 bcf/year/year
High LNG Price	+ 25%	600 bcf/year/year
Low LNG Price	- 20%	600 bcf/year/year
Fast Builds + High LNG Price	+ 25%	**800 bcf/year/year**

EIA Issues in Focus: LNG

Figure 1. U.S. liquefied natural gas (LNG) exports, AEO2023



Data source: U.S. Energy Information Administration, *Annual Energy Outlook 2023 (AEO2023)* and LNG Capacity Tracker

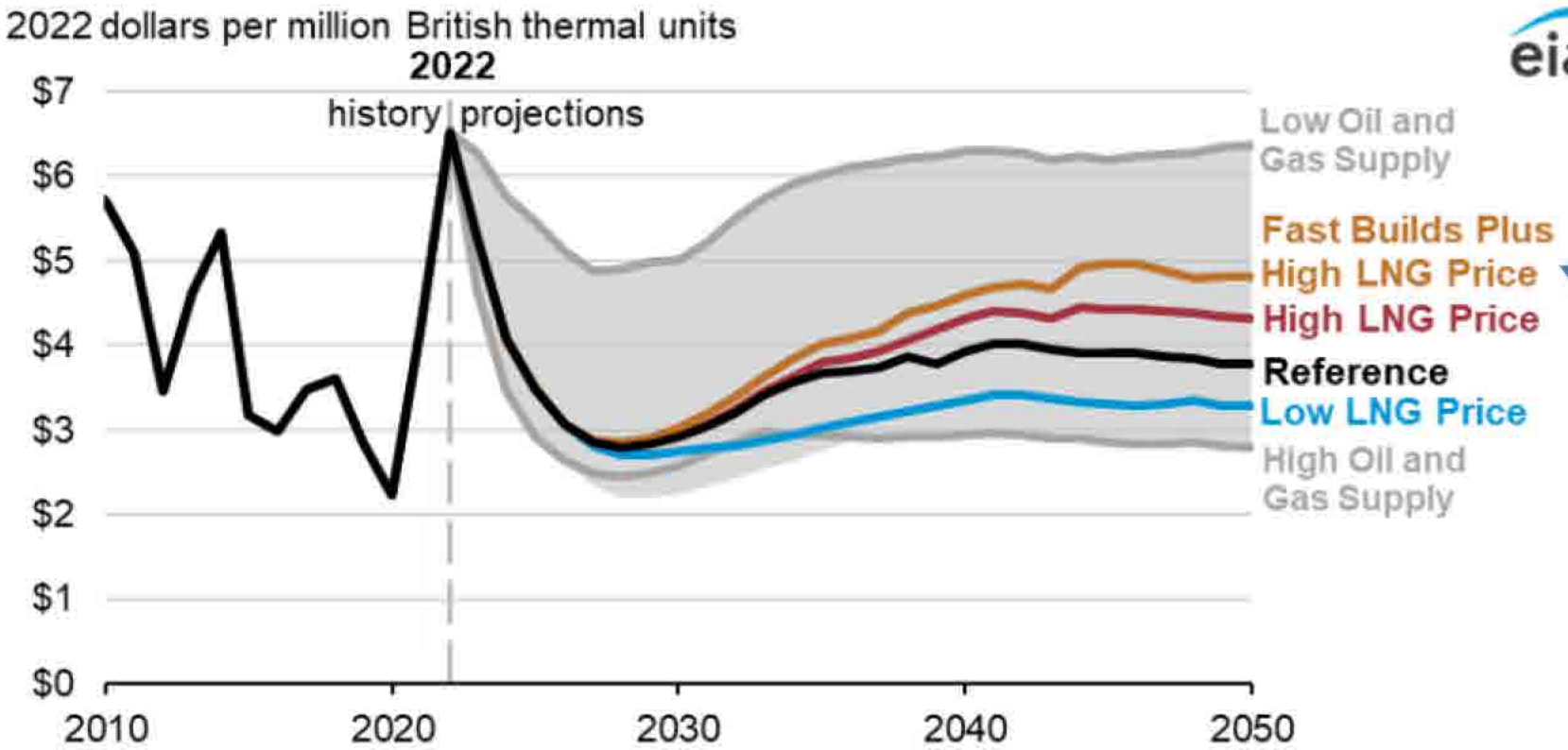
Note: Existing, under construction, and approved LNG capacities are baseload capacities. Shaded regions represent maximum and minimum values for each projection year across the AEO2023 Reference case and side cases.

At 48 bcf/d, this could end up close to our NG price alignment run.

Maximum slope here (800 bcf/year/year) is similar to the maximum year-to-year change from the NEMS 48 bcf/d case (807 bcf/year/year)

EIA Issues in Focus: LNG

Figure 2. Natural gas spot price at the Henry Hub, AEO2023

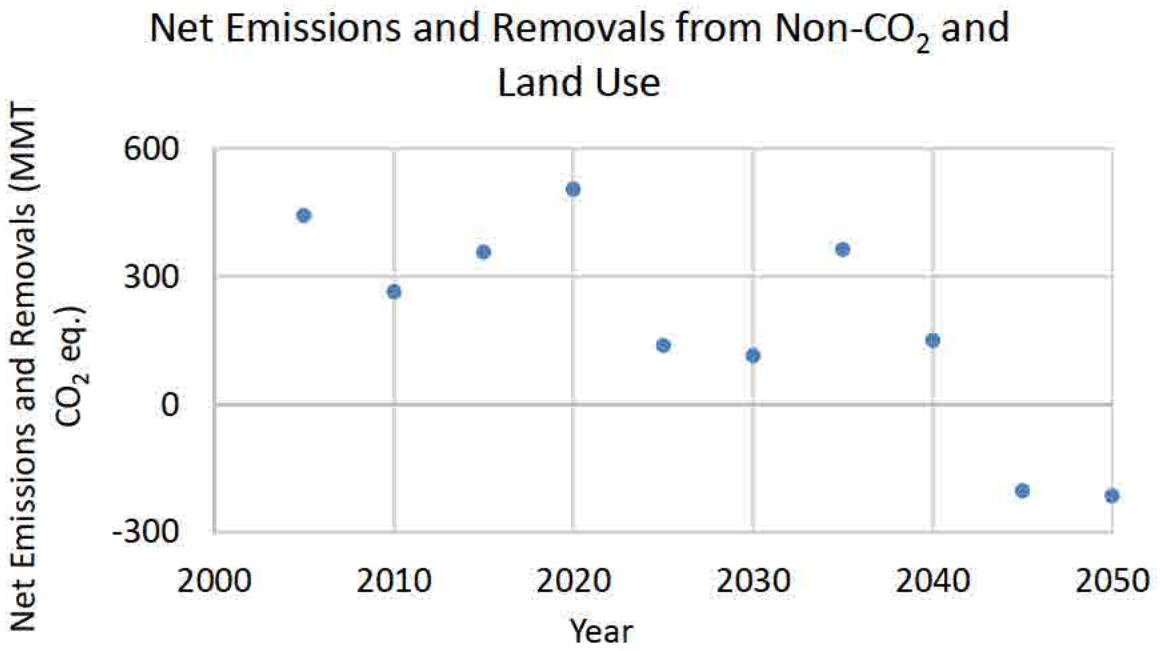


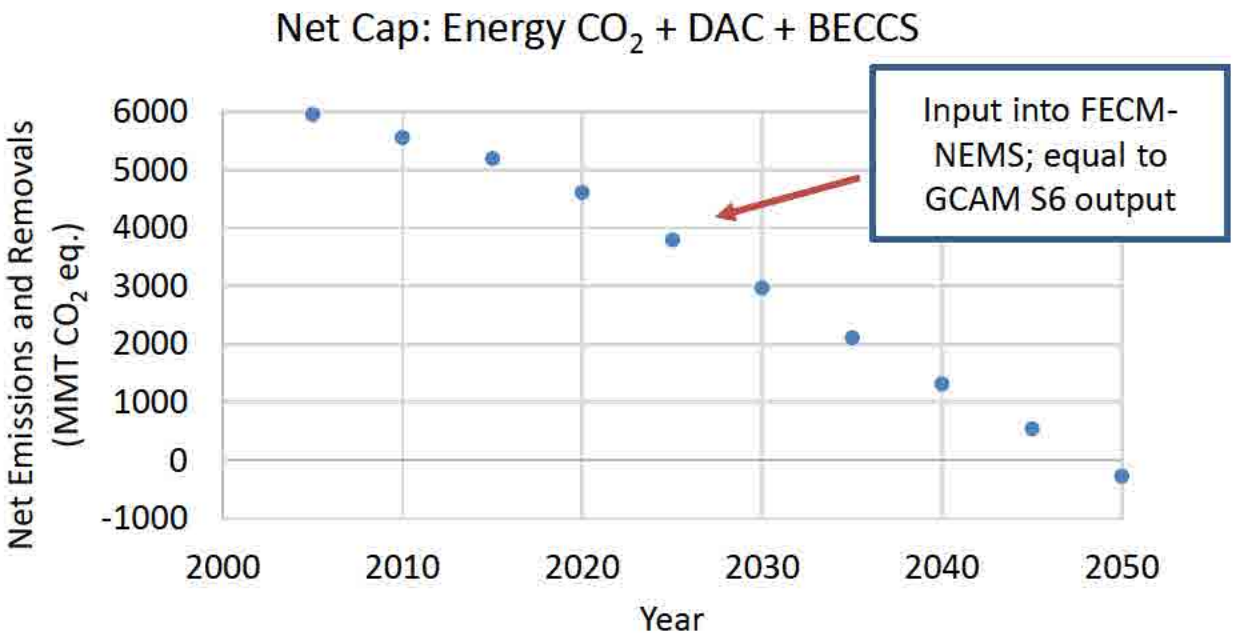
Data source: U.S. Energy Information Administration, *Annual Energy Outlook 2023* (AEO2023)
Note: Shaded regions represent maximum and minimum values for each projection year across the AEO2023 Reference case and side cases.

End price ($2022 4.81/MMBtu) is likewise similar to 48 bcf/d case in NEMS ($2022 4.86/MMBtu)

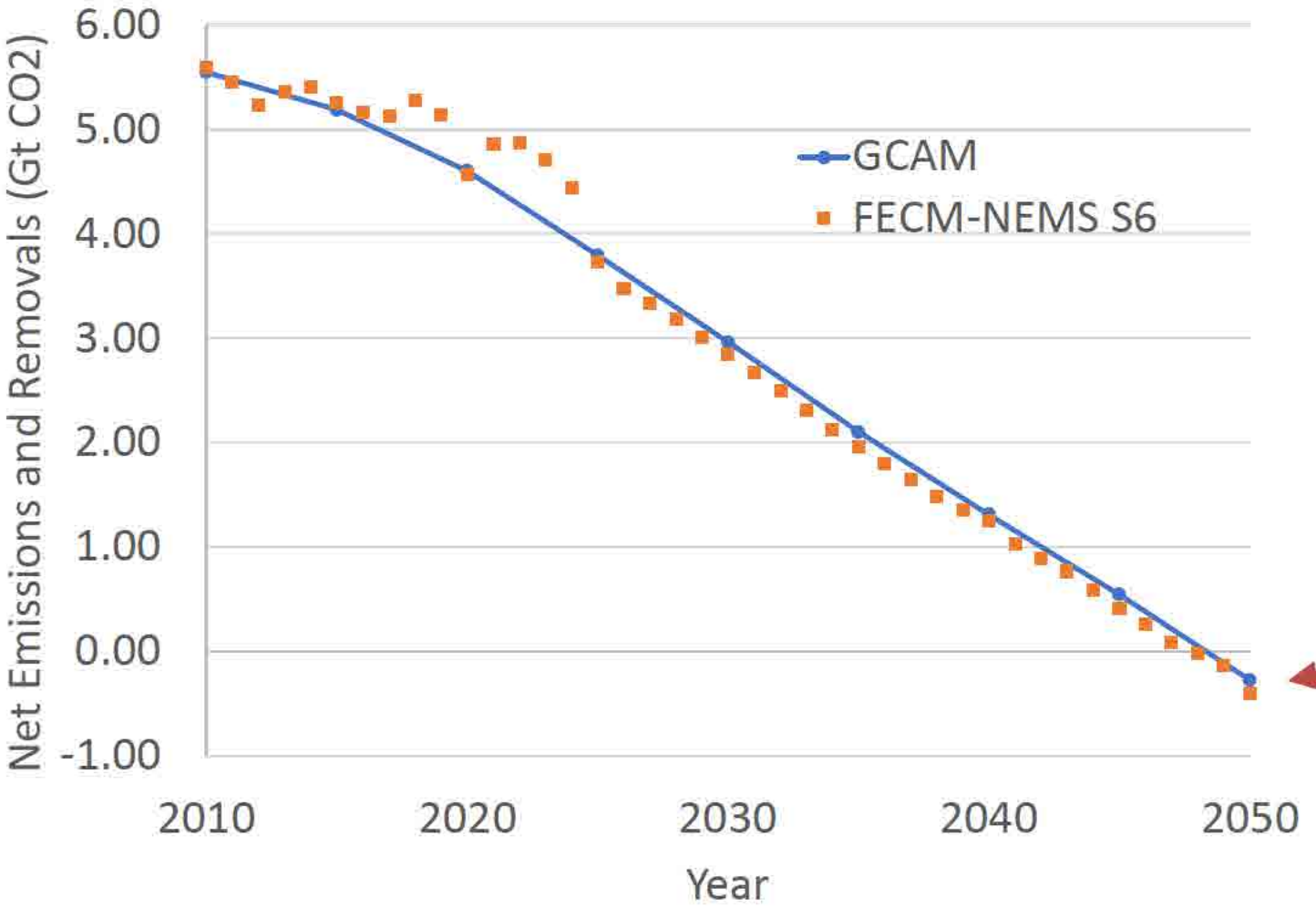
GHG Emissions Cap

- The left-hand chart illustrates the net emissions from the other gases and land use based on GCAM outputs. FECM-NEMS does not model these values.
- The right-hand chart is the Net Cap used in modeling.
- The sum of the two plots should equal 0 in 2050 (we overshot slightly)



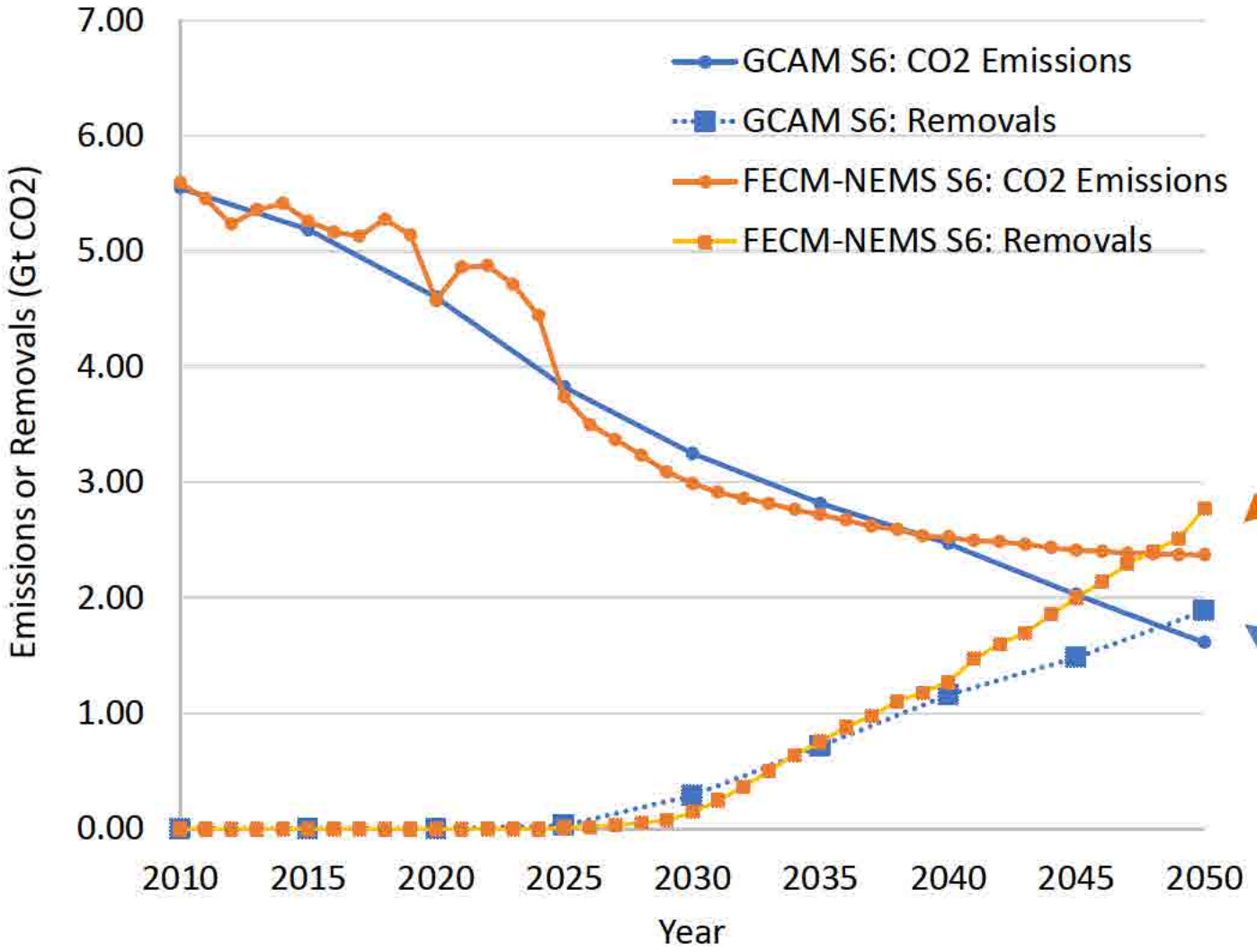


GHG Emissions Cap – Actual Net Emissions (Output)



Small difference – we accidentally left in CH_4 from natural gas

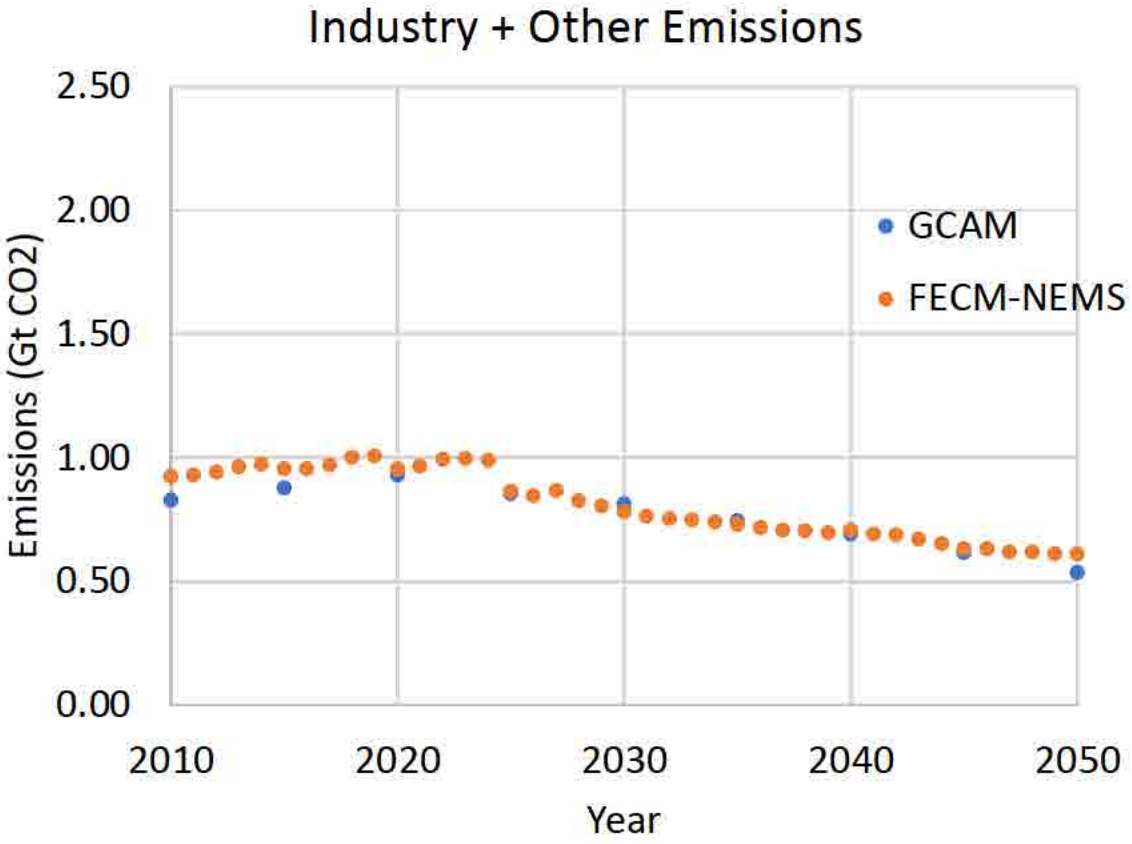
Emissions and Removals Comparison

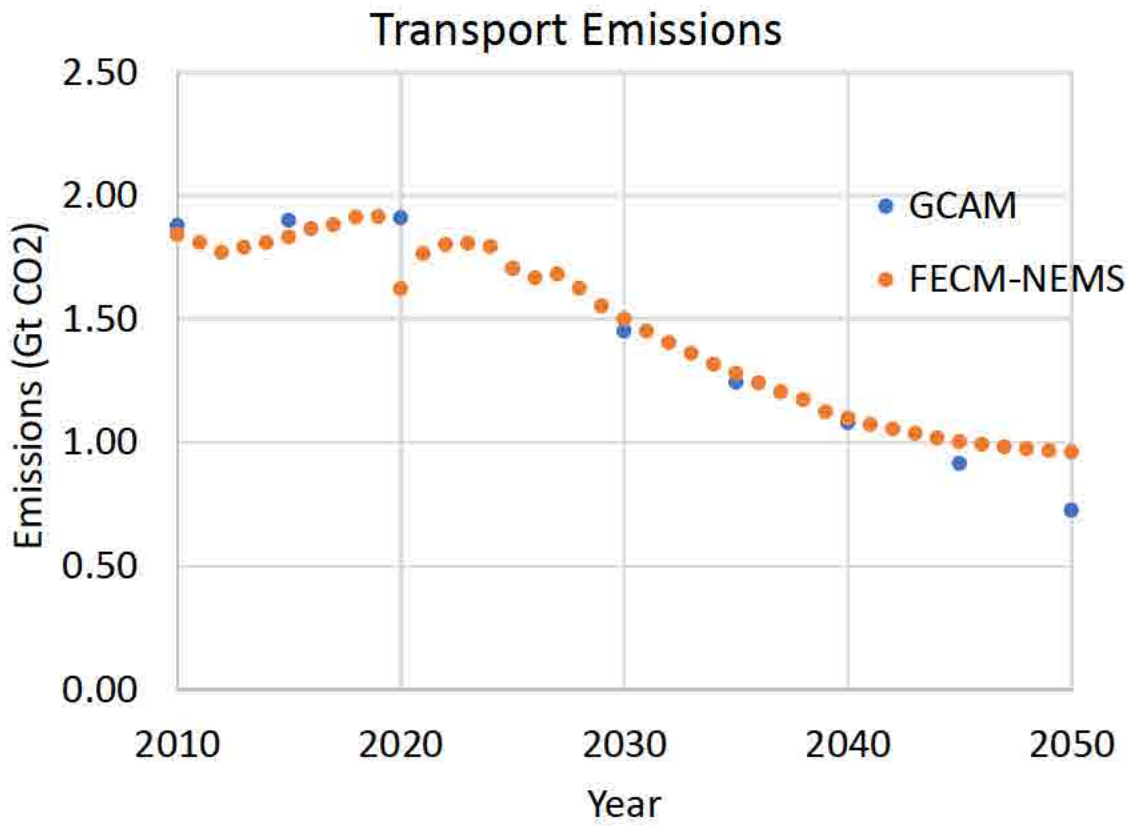


Removals and emissions intersect at this point for FECM22 S6. There are slightly more removals than emissions, satisfying the net-zero criteria.
Note: Removals in FECM-NEMS 90% DAC, 2% BECCS, and 8% H2 Biomass

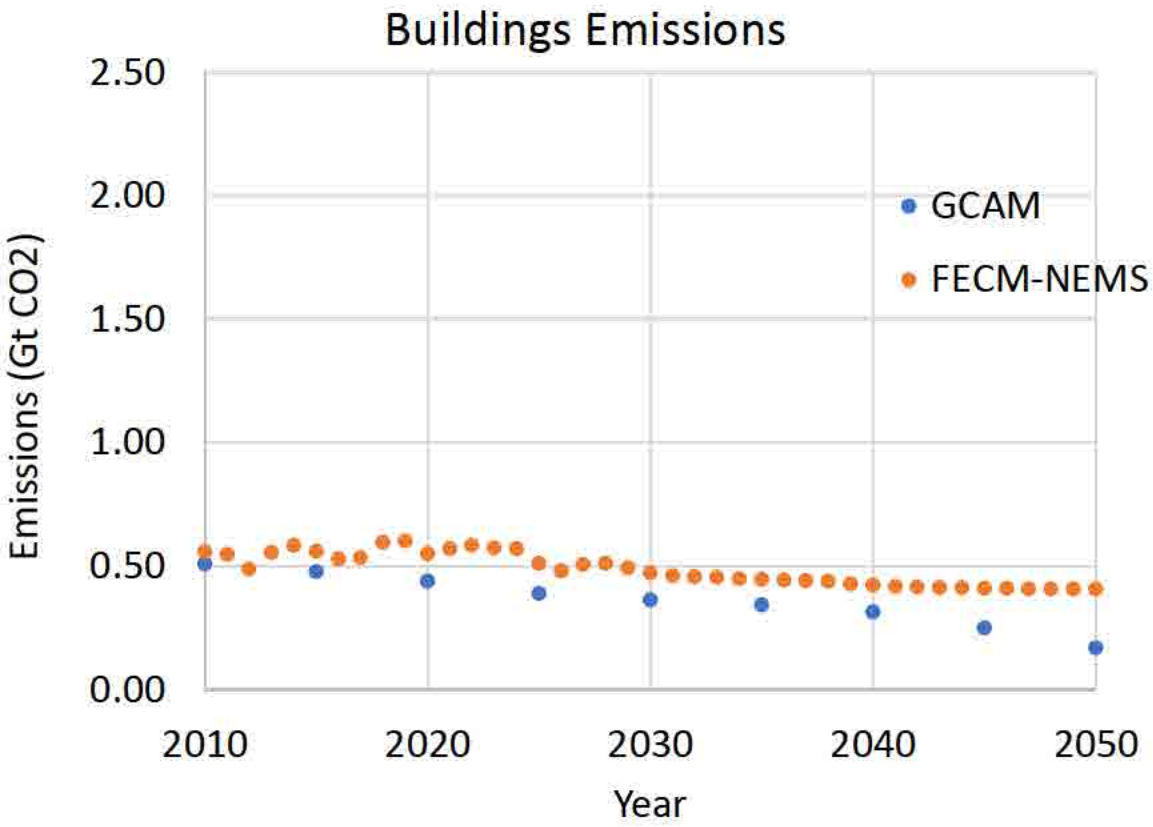
The GCAM S6 has a similar emissions/removal delta, but the intersection occurs lower, which means fewer emissions and fewer removals to reach net-zero.
Note: Removals in GCAM are 43% DAC + 57% BECCS

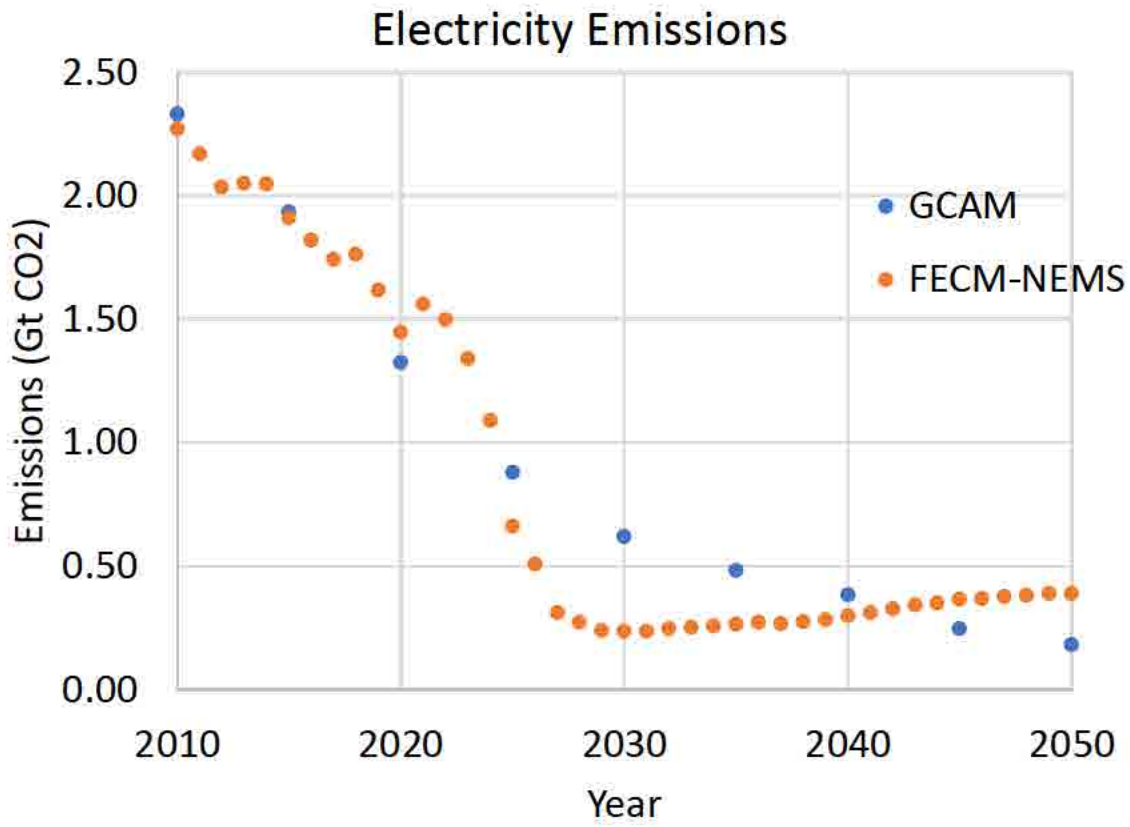
GCAM vs FECM-NEMS Emissions Comparison: Industry and Electricity are Similar



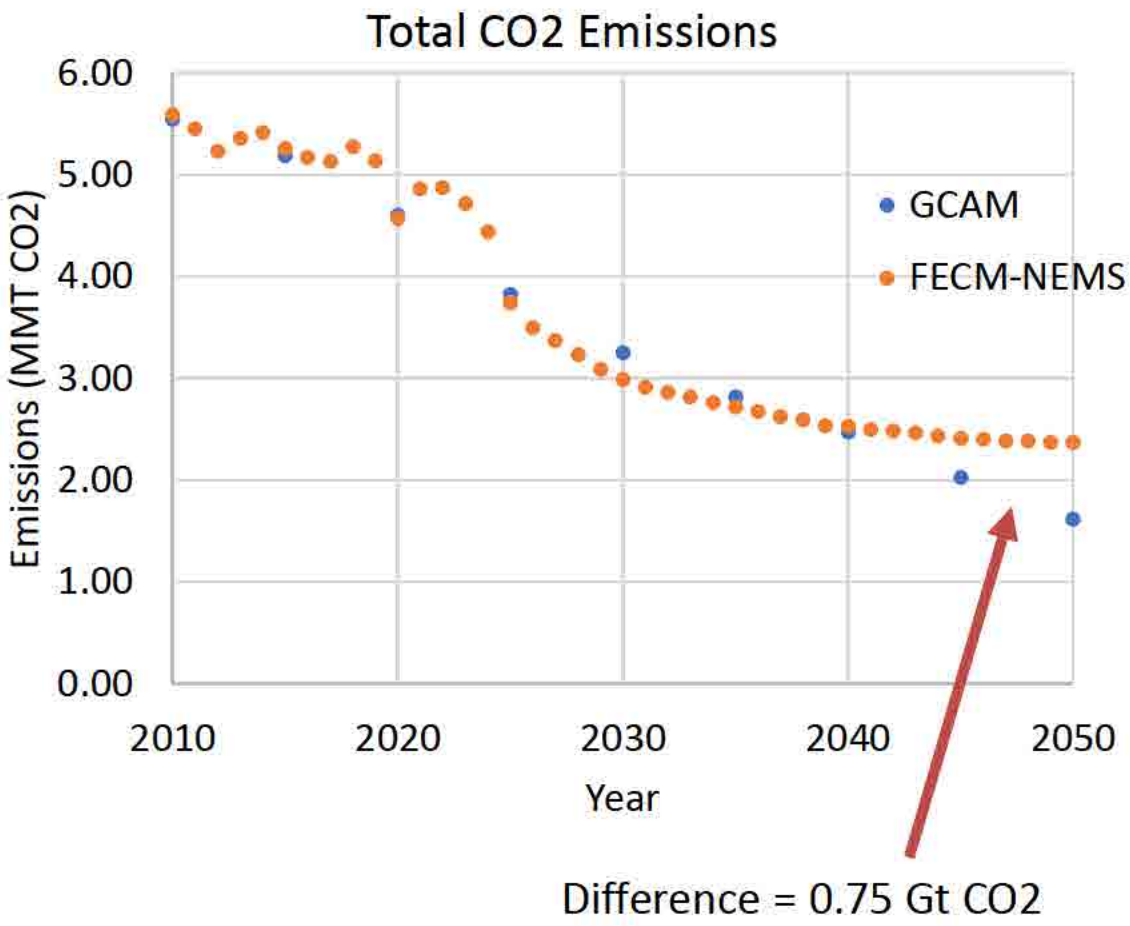


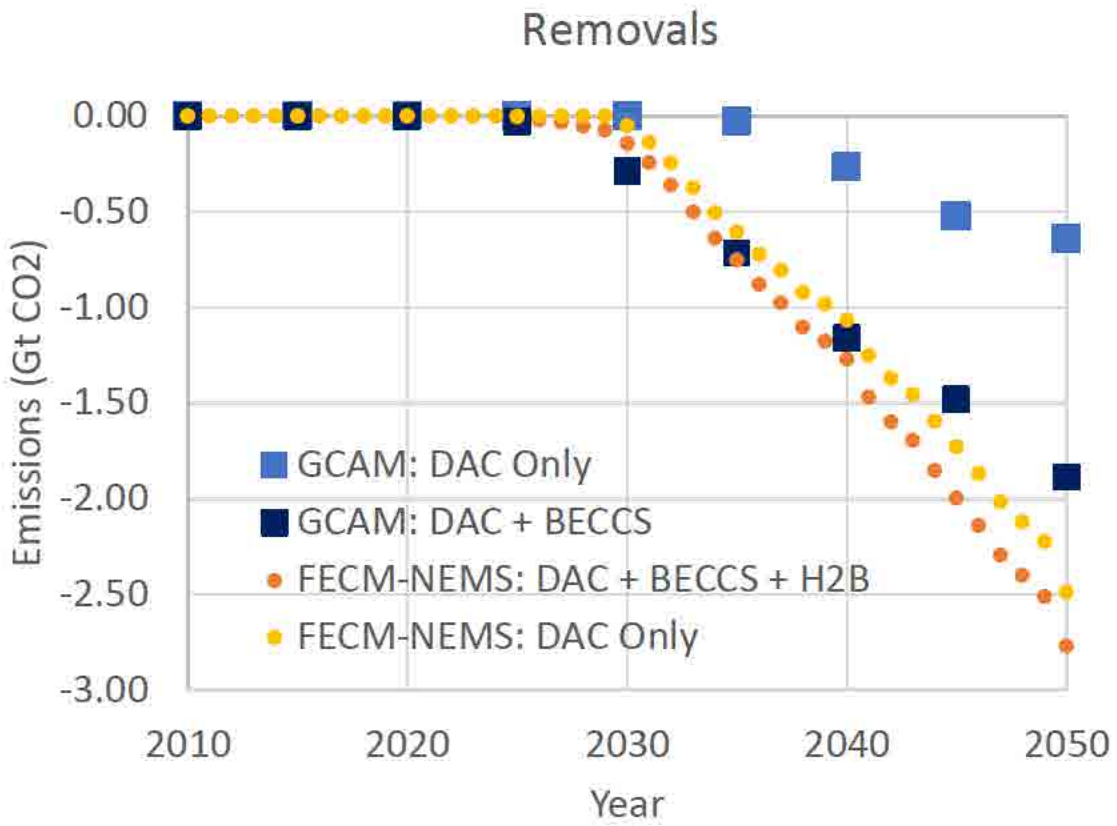
GCAM vs FECM-NEMS Emissions Comparison: Differences Between Buildings (Residential + Commercial) and Electricity



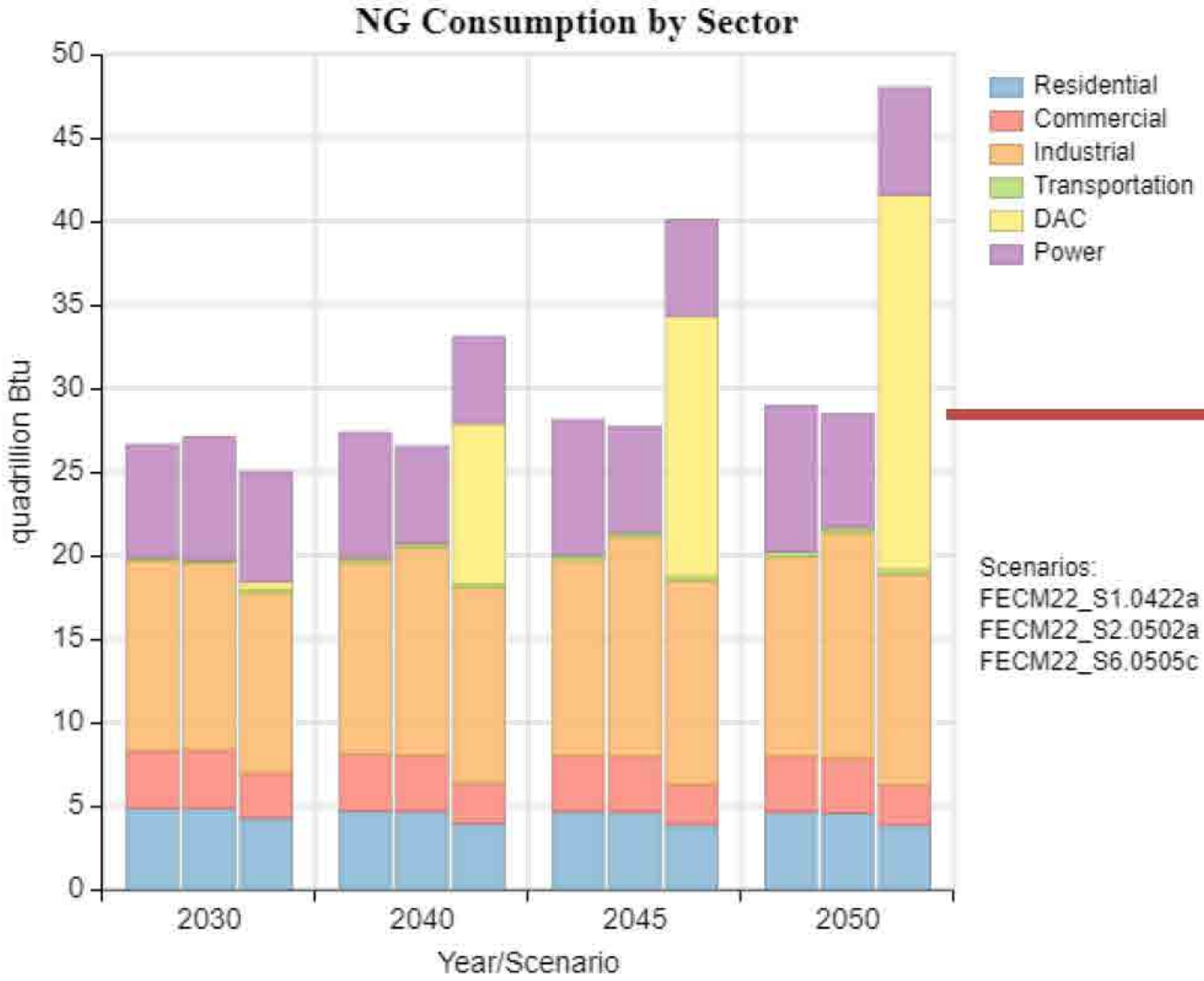


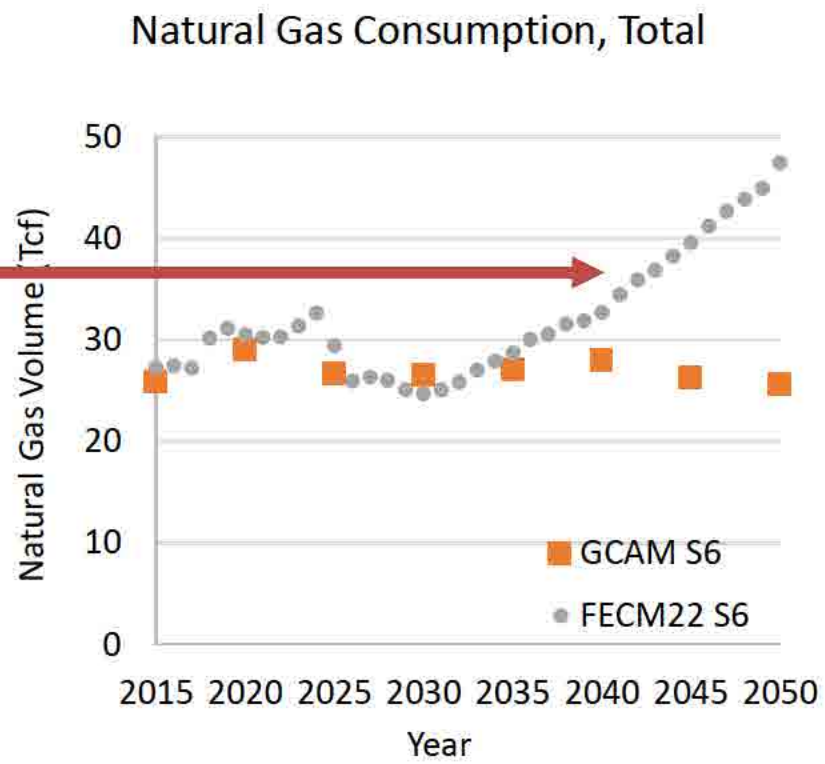
GCAM vs FECM-NEMS Emissions Comparison: Differences Between Buildings (Residential + Commercial) and Electricity





Natural Gas Price, GCAM and FECM Comparison





*Left to right: FECM22 S1, FECM22 S2, FECM22 S6

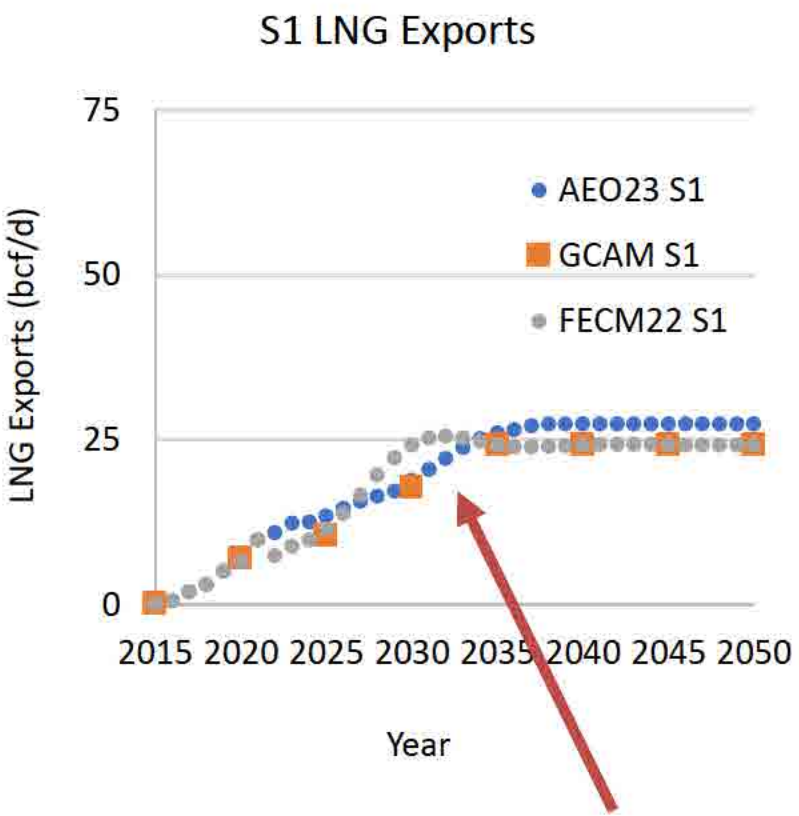
DAC Technology Comparison

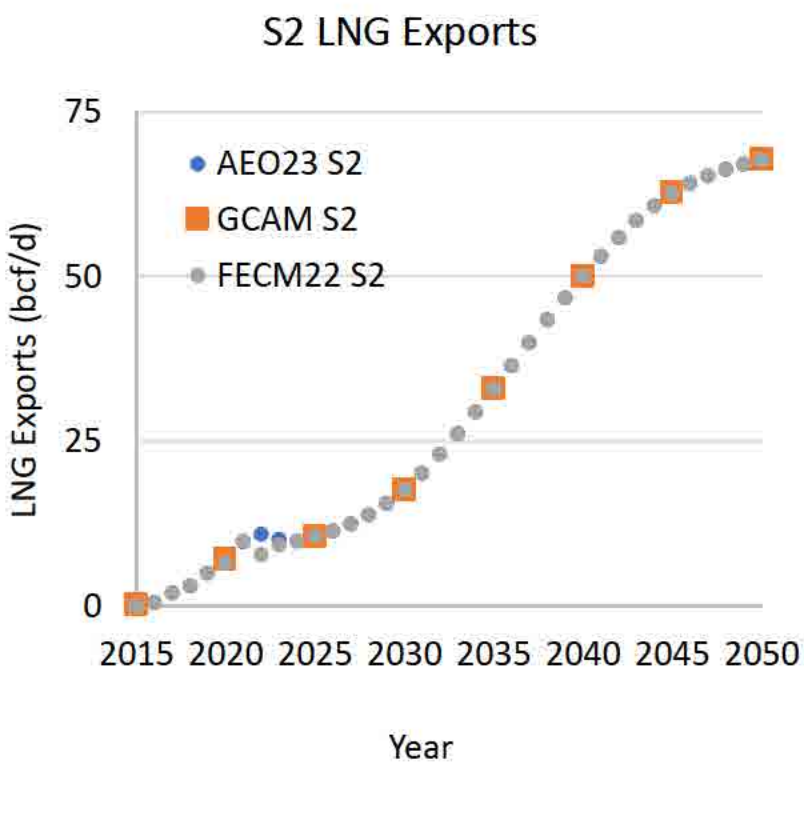
Tech	Capex $/ton year	CRF	Capex $/ton	Opex $ton	Electricity demand kwhr/ton	Heat/fuel demand MMBTU/Ton	Recalculated GCAM Non Energy Cost	Comment / Reference
HT GCAM	$1,146	13%	$143	$42	361.11	5.6	$185	Intermediate estimate for HT DAC using natural gas (2030 values for SSP1, SSP2) Energy in GJ/ton converted to kwhr/ton and MMBTU/ton
HT GCAM Fully electric	$1,146	13%	$143	$42	1416.67	-	$101	Intermediate estimate for fully-electric HT DAC (2030 values for SSP1, SSP2) Energy in GJ/ton converted to kwhr/ton
FECM grid	$1,300	7.1%	$112	$71	450	8.75		Total of Fixed and Variable O&M; Capex includes other factors
FECM NG only	$1,500	7.1%	$129	83.6	0	9.27		Total of Fixed and Variable O&M ; Capex includes other factors

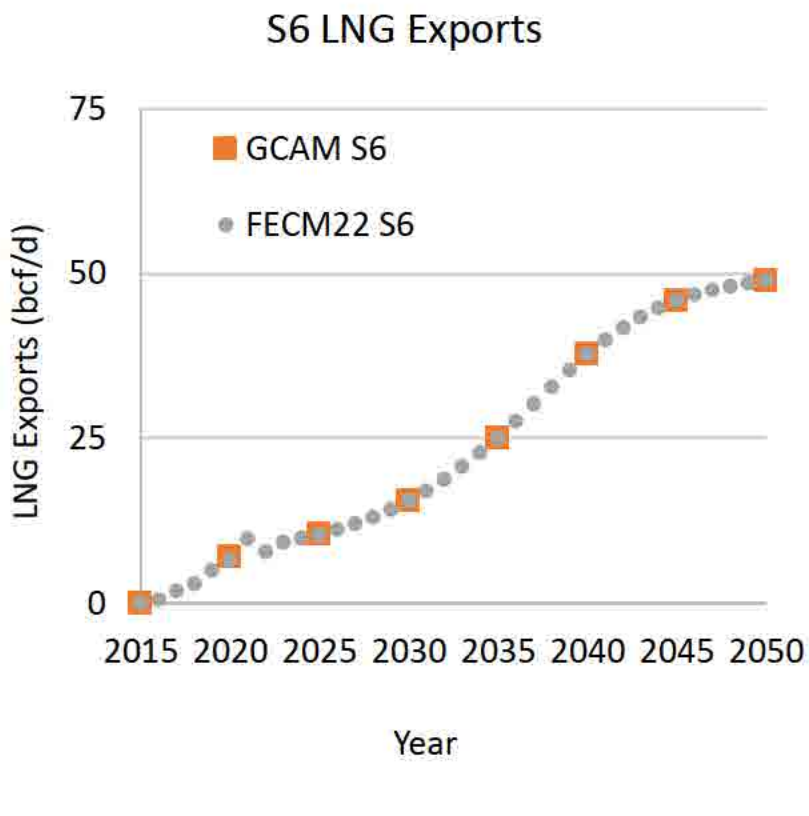
Extra Slides

Note: These results are older and use the old NG supply curve

LNG Exports (exogenous input)



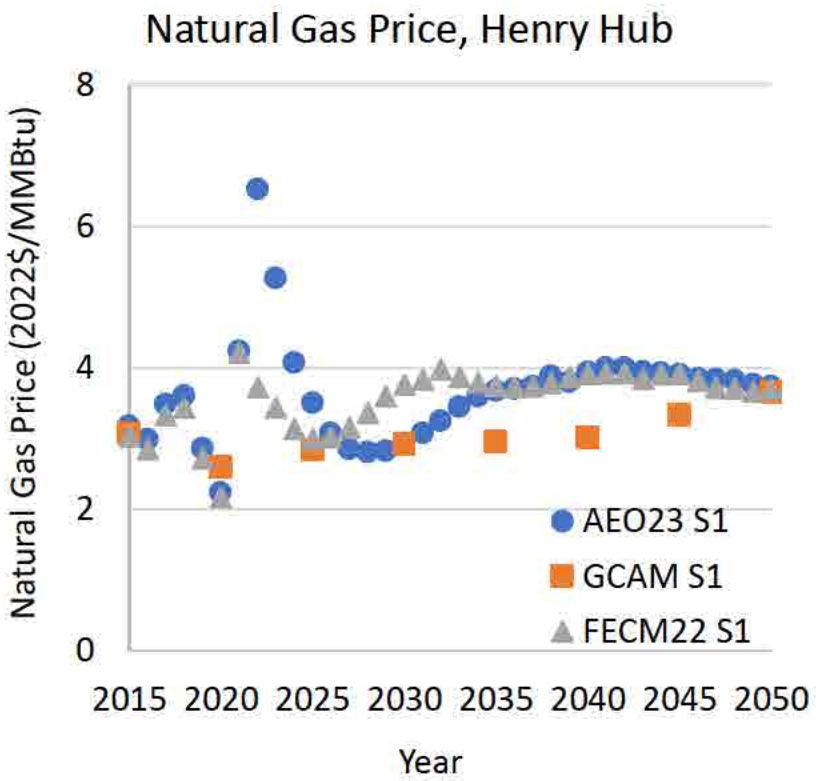


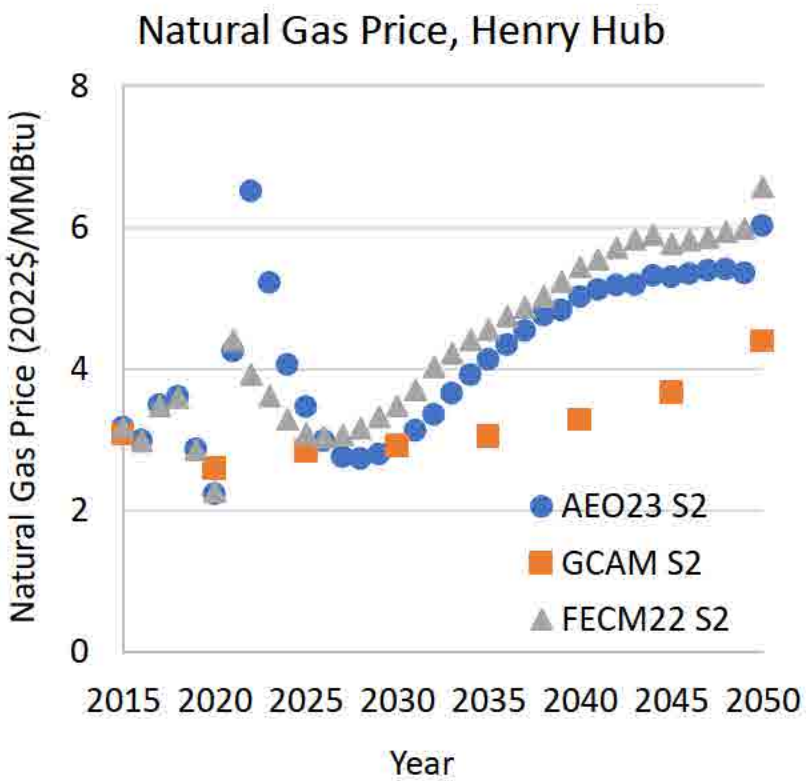


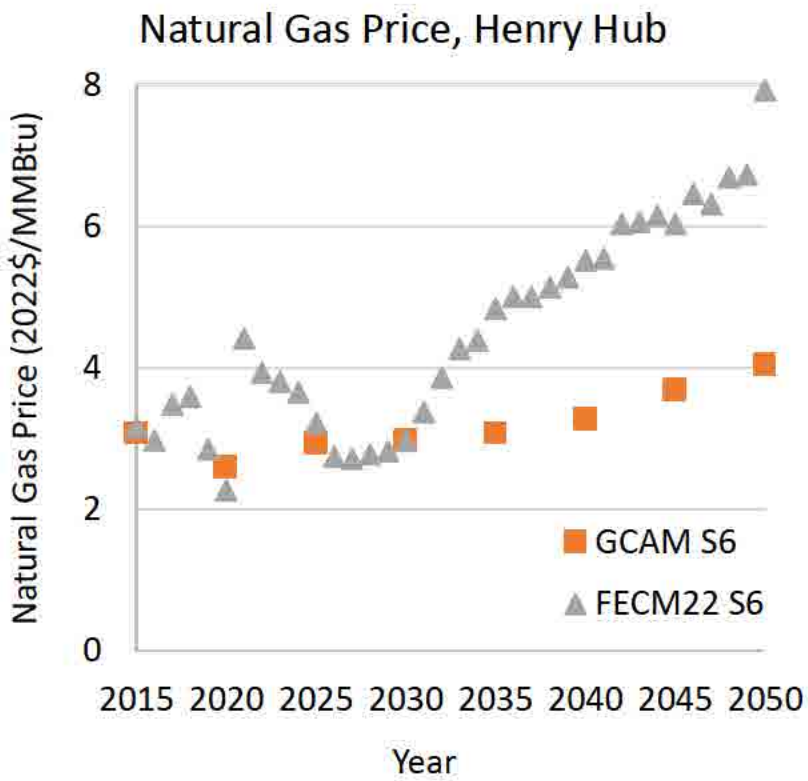
*Slight difference for FECM22 S1 – haven't updated to new S1 definition (27.34 bcf/d) yet

Note: These results are older and use the old NG supply curve

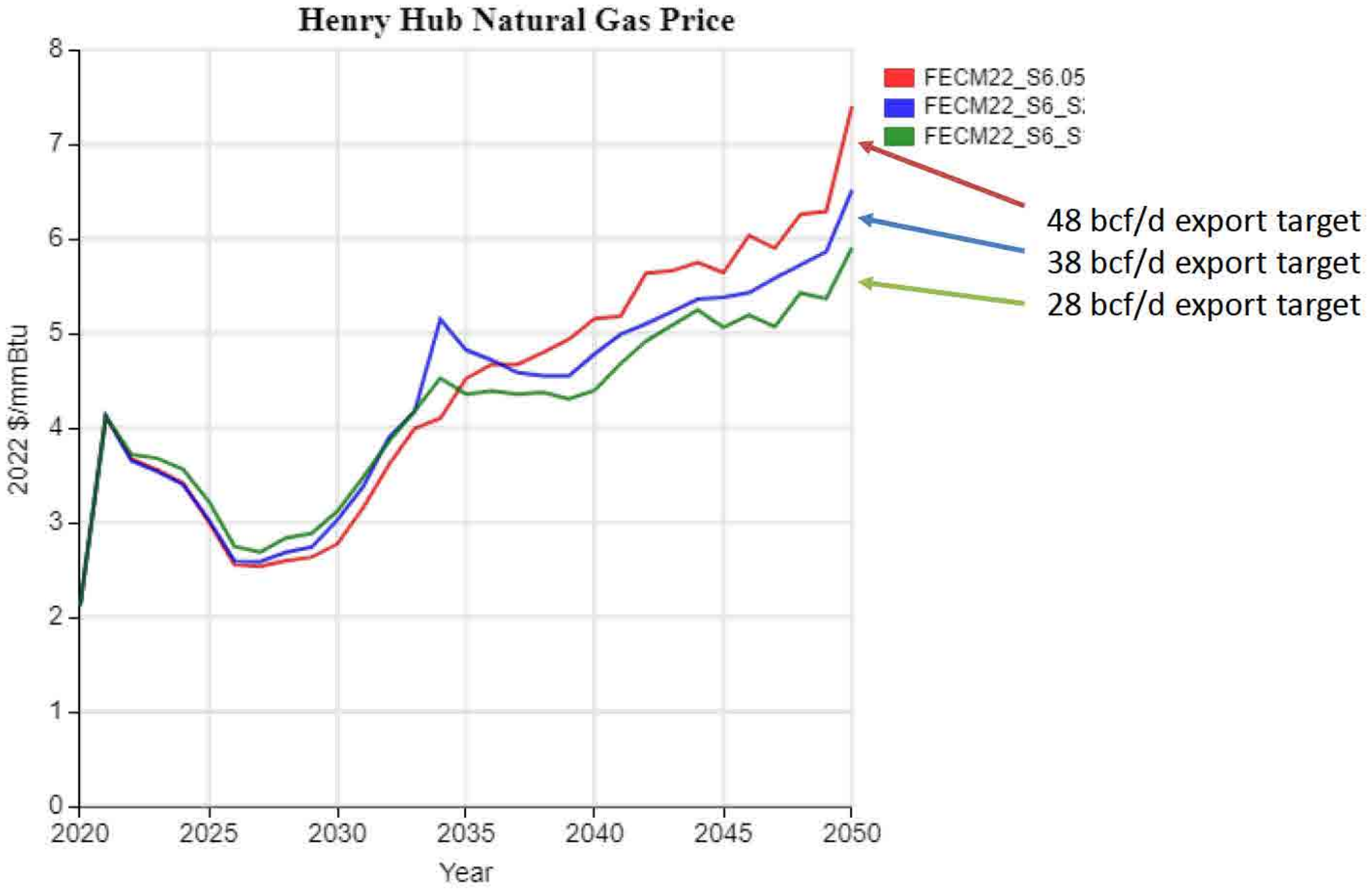
Natural Gas Price





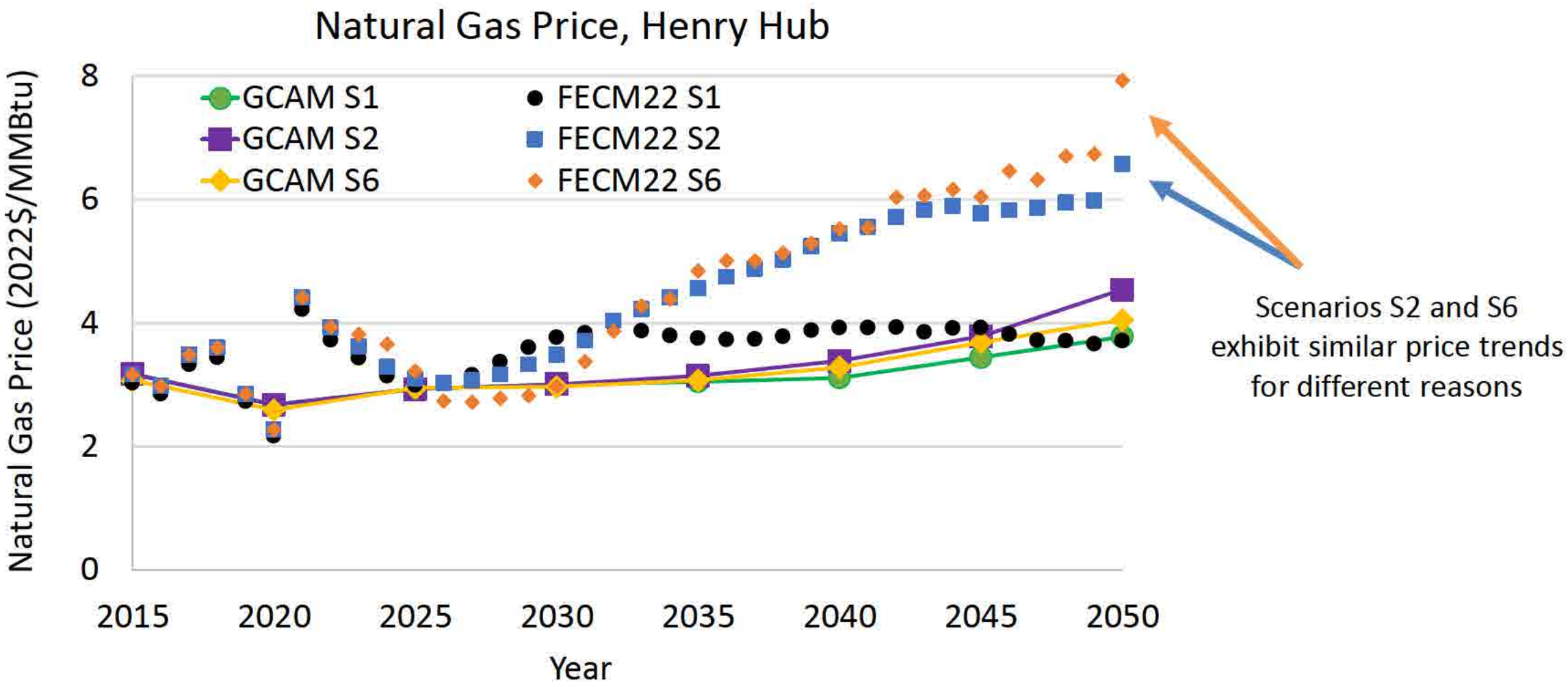


*No net-zero case for the AEO23 model


Henry Hub Natural Gas Price
2022 $/mmBtu
Year
0
1
2
3
4
5
6
7
8
2020
2025
2030
2035
2040
2045
2050
FECM22_S6.05
FECM22_S6_S
FECM22_S6_S
48 bcf/d export target
38 bcf/d export target
28 bcf/d export target

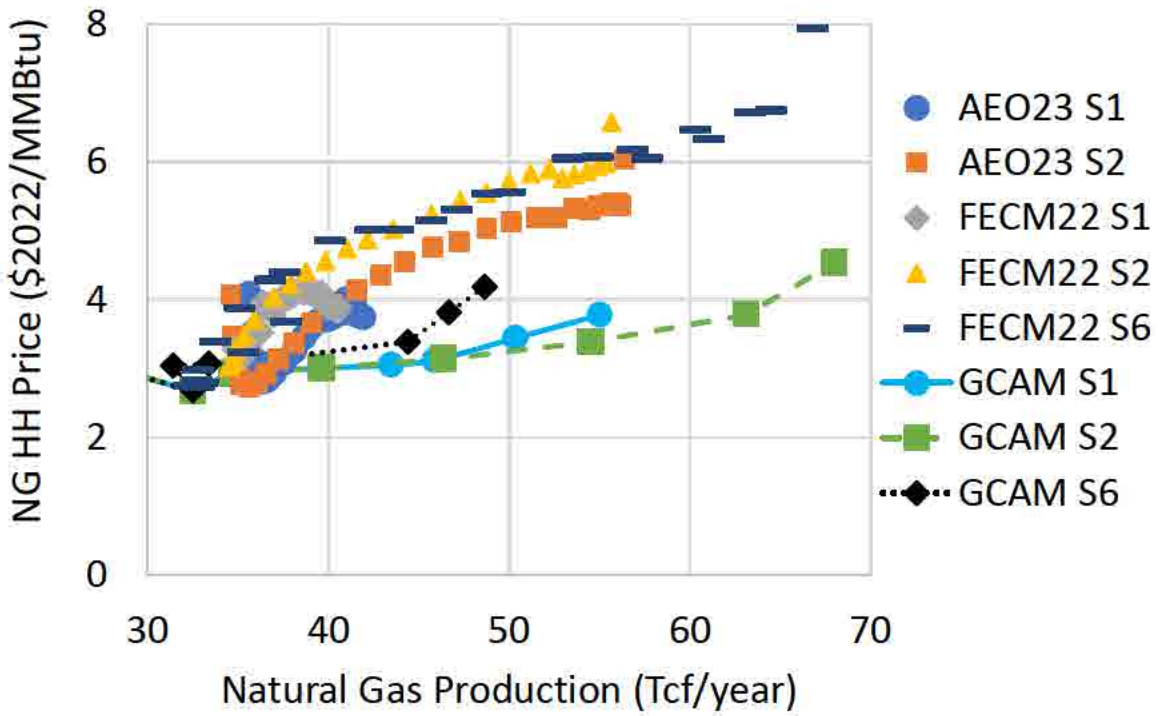
Note: These results are older and use the old NG supply curve

Natural Gas Price, GCAM and FECM Comparison

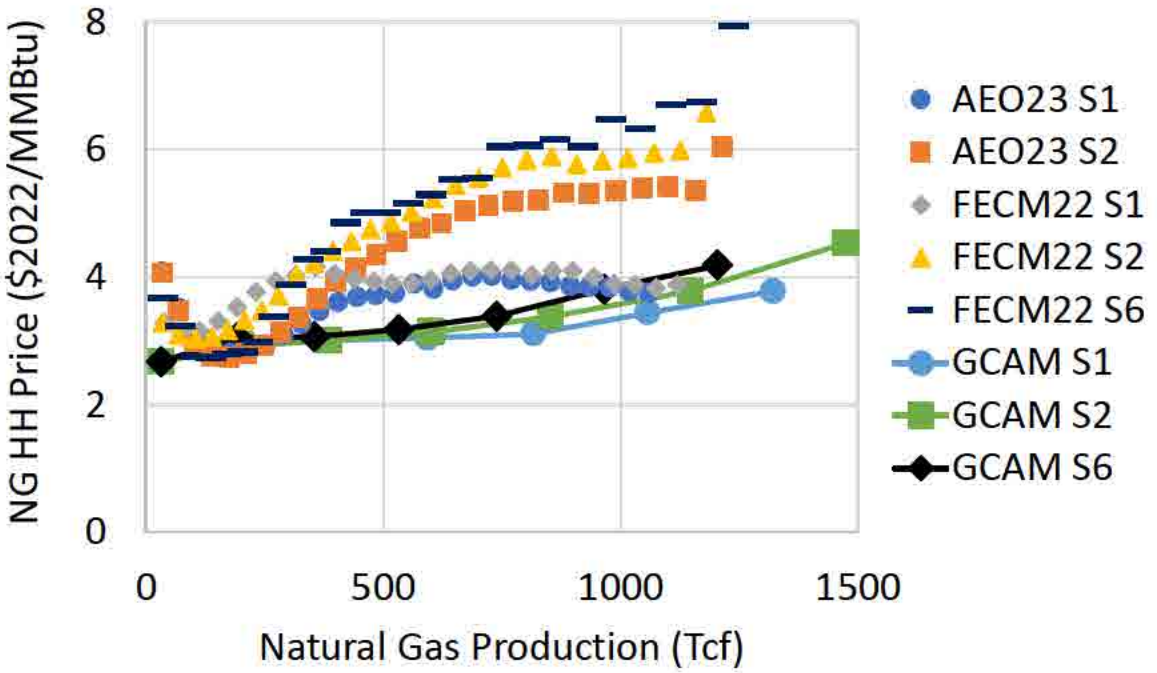


Natural Gas Price/Supply Curve, Scenario Comparison

NG supply curve by model (Starting in 2024 to exclude historical and STEO years)



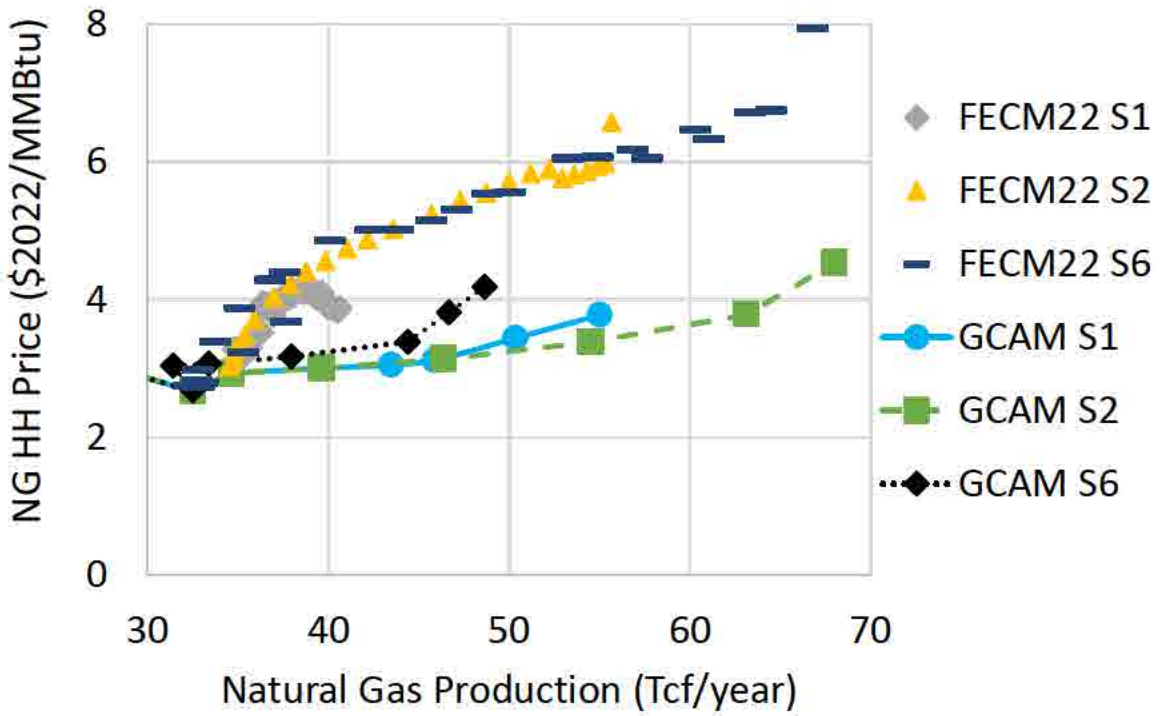
NG cumulative supply curve by model (Starting in 2024 to exclude historical and STEO years)



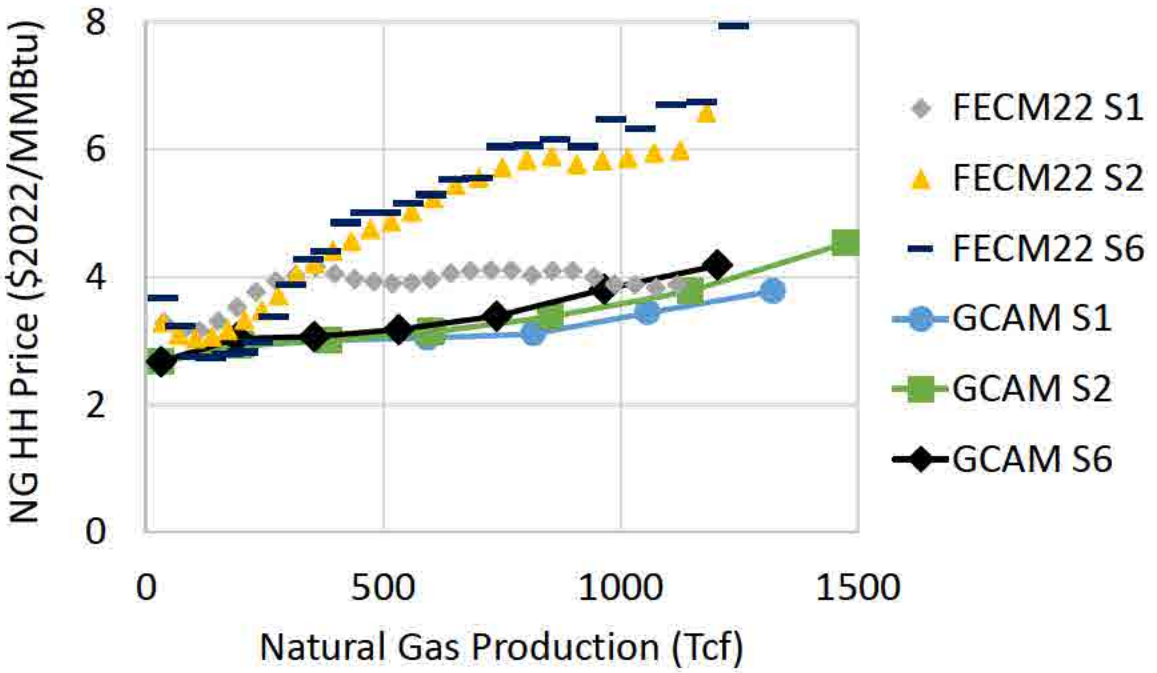
Note: These results are older and use the old NG supply curve

Natural Gas Price/Supply Curve, Scenario Comparison

NG supply curve by model (Starting in 2024 to exclude historical and STEO years)



NG cumulative supply curve by model (Starting in 2024 to exclude historical and STEO years)



Note: These results are older and use the old NG supply curve

Inflation Reduction Act in FECM-22

Overview

- The Inflation Reduction Act (IRA) was passed in August 2022
  - Includes many important energy and climate provisions
- FECM-NEMS scenario includes the following:
  - Based on the AEO2022 low economic growth case
  - Includes many IRA provisions as well as several non-IRA policy and technology assumptions
  - FECM-NEMS includes many model enhancements to carbon management technologies including the addition of DAC and a hydrogen market module

FECM Reference Scenario Assumption Summary

	Technology & Pre-IRA Policy Updates	IRA Provisions
Economic Growth	AEO 2022 macroeconomic growth (real GDP average growth of 1.8%/year to 2050)	
Technology		
Power (renewables and CCS)	NREL ATB Mod: Initial year (2027) and endogenous learning; Update on CCS retrofits (not yet received)	
Transportation	Harmonized ANL Low (BAU): Initial year (2025) and endogenous learning	
Policy		
Power	BIL CCS demonstration plants (includes subsidies for CO_2 pipelines and storage)	Clean Elec Credits (5X with no bonus credits), Zero Emission Nuclear Credits, 45Q
Hydrogen	none	45V credits
Transportation	CAFE standards through 2026 EPA LDV stds & ZEV waiver	30D, 45W, 70002 USPS Clean fleets
Buildings	none	25C, 25D, 45L, 48D, 179D IRA 50121, 50122, 50131
Industry	BIL CCS demonstration plants for cement	48D, 45Q, 50161 + 48C

Key Provisions of the Inflation Reduction Act

- The FECM-NEMS Baseline case includes major IRA energy-related provisions in each energy sector:
  - Power sector (e.g., clean energy PTC and ITC; zero emission nuclear credits)
  - Buildings sector (e.g., energy efficient home tax credits and rebate programs; building codes; PV credits)
  - Transportation sector (e.g., clean vehicle tax credits)
  - Refinery sector (e.g., extension of incentives for biofuels)
  - Hydrogen tax credits
  - Industrial sector (e.g., CCS and electrification options for cement, steel, glass, paper and aluminum)
  - Oil and gas royalty rate increases
  - Cross-cutting programs (extension of 45Q sequestration credits, EPA green bank, USDA programs)
- There are a few other energy-related provisions are more difficult to model, are not well defined, or impact technologies not currently represented in the model, so they were not included in the IRA case.
  - This may lead to an underestimation of the IRA impact.
  - On the other hand, the modeling may not reflect all the institutional and regulatory frictions that might slow or reduce the IRA impact, and thus lead to an overestimate of the impact.

Non-IRA Modeling Updates

- The FECM-NEMS Baseline case includes the following non-IRA policy and technology assumptions that were not included in the AEO 2022:
  - Provisions from the Bipartisan Infrastructure Law (BIL):
    - Funding for carbon capture demos, and CO_2 transport and storage infrastructure
    - Advanced reactor demos – small modular reactors
  - Updated EPA/NHTSA CAFE standards
  - Updated state-based Zero-Emission Vehicle (ZEV) requirements to reflect the end of the moratorium on state programs (16 states)
  - Updated technology costs for power sector and electric vehicles with endogenous learning
- In addition, the Baseline case also uses FECM technologies and assumptions that include:
  - Industrial CCS with options to send captured CO_2 to EOR or saline storage
    - Industrial sources are ethanol, natural gas processing, hydrogen in refineries, and cement
  - BECCS retrofit option (coal with carbon capture and up to 49% biomass cofiring)
  - Direct Air Capture (DAC) technologies using electricity and natural gas or natural gas only
  - Updated coal and natural gas CCS capital costs and 95% carbon capture rate

FECM-NEMS Enhancements in Completed Merged Model

- Industrial carbon capture, utilization and storage (CCUS) enhancements
  - Endogenous CO_2 capture at ethanol, hydrogen production at refineries, and natural gas processing
  - Cement Carbon Management
  - Updated Industrial CO_2 Resource and capture costs
- Direct Air Capture (DAC)
- CTUS enhancements
  - New pipeline network representation and updated pipeline and storage costs
- Coal retrofit with biomass cofiring and carbon capture and storage (BECCS)
- Representation of methane emissions associated with natural gas production and delivery
- Inclusion of fixed indirect GHG emissions vectors
- Addition of hydrogen as a fuel source
  - Creation of the Hydrogen Market Module (HMM)
  - Modifications to various sectoral modules to represent potential hydrogen use
  - Updates to CTUS to include the new HMM capture sites
- Policy updates for Bipartisan Infrastructure Law (BIL) and Inflation Reduction Act (IRA)

Technology Assumptions

	FECM-NEMS Baseline IRA Case	AEO 2023 Reference IRA
Macroeconomic Growth	AEO 2022 low macroeconomic growth (real GDP average growth of 1.8%/year to 2050)	AEO 2023 macroeconomic growth (1.9%/year average growth)
Power Sector:		
Renewable technologies	NREL ATB 2022 Moderate case initial costs and endogenous learning (lower than AEO 2022)	Similar to AEO 2022
New coal and gas CCS	NREL ATB 2022 Mid-Year Update Moderate case initial costs and endogenous learning (lower than AEO 2022)	Similar to AEO 2022
EV charging load shape	more daytime charging than AEO 2022	Same as AEO 2022 *
Coal power plant planned retirements	EPA NEEDS database (Oct 2022)	Form EIA-860, Annual Electric Generator Report (Sept 2022)
Transportation:		
Light-duty vehicles (LDV)	Harmonized initial EV costs with ANL Low (BAU) case	Similar to AEO 2022*
Medium/Heavy vehicles (MHDV)	CARB base truck costs for fuel cell vehicles, EVs, diesel, CNG, E85, and gasoline (but using EIA battery costs), improved fuel economy ratio for EV and fuel cell relative to diesel vehicles based on ANL Low case	Similar to AEO 2022*

* Still checking

Non-IRA Policy Assumptions

	FECM-NEMS Baseline IRA Case	AEO 2023 Reference IRA
Transportation Policies:		
LDV EPA and CAFE standards	Updated EPA and NHTSA thru 2026	Same as FECM IRA case
State ZEV mandates	Pre-existing program, but not Advanced Clean Cars II (100% targets)	Same as FECM IRA case
Bipartisan Infrastructure Law:		
CO2 pipeline and saline subsidies	Lower transport and storage costs	Not included
CCS demos - industry	Applied to cement (1/3 of total funding)	Not included
CCS demos - power	Funding for coal retrofits and new gas CCS (50% cost share)	Not included
Advanced nuclear demos	Two 330MW SMR plants (WA, WY)	Not included
Civil Nuclear Credits	Included as in AEO 2022	Same as AEO 2022
Strategic Petroleum Reserve (SPR)	Included as in AEO 2022	Same as AEO 2022

IRA Policy Assumptions

	FECM-NEMS Baseline IRA Case	AEO 2023 Reference IRA
Power Sector:		
Clean Tech PTC and ITC credits	5x credits, no extra bonus	Same as FECM IRA case
Zero Emission Nuclear Credits	Production tax credits available thru 2032	Same as FECM IRA case
USDA rural coop programs	Funding for solar, wind, and CCS	Not included
Buildings:		
Residential RE credits	ITC credits available thru 2034	Same as FECM IRA case
Commercial RE and CHP credits	5x ITC credits, no extra bonus	Same as FECM IRA case
Residential sector tax credits and subsidies	25C, 25D, 45L, 50121, 50122, 50131	25C, 25D, 45L
Commercial sector tax credits and subsidies	179D tax credits	Not included
EPA GHG Reduction Fund	Building retrofits and rooftop PV	Not included
Industry:		
Industrial tax credits and subsidies	Various manufacturing credits for CCS, steel, cement, and other GHG reductions (48C, 50161, and Low-Carbon Procurement Provisions)	Not included
Battery manufacturing credit (45X)	Not included	Not included

IRA Policy Assumptions

	FECM-NEMS Baseline IRA Case	AEO 2023 Reference IRA
Transportation:		
LDV EV tax credits (30D)	Weighted credit (not all qualify)	Exogenous based on offline analysis
Commercial clean vehicle credit (45W) - freight trucks	Credits for EV and Fuel Cell Vehicles	Not included
Commercial clean vehicle credit (45W) - electric buses	Exogenous shares for electric school buses based on ICCT Moderate case	Not included
70002 USPS Clean fleets	Included (exogenous min EV sales)	Not included
Fuel Production:		
Hydrogen tax credits (45V)	Full 5X value	Not included
Biofuel tax credits	Extended thru 2024 (replaced by 45Z)	Extended thru 2027
45Z Clean Fuel Production Tech-neutral credit	2025 thru 2027	Simplified version for certain fuels
Sustainable Aviation Fuel Credit	Not included	Simplified version through 2027
Sectoral Cross-Cutting Programs:		
45Q credits (EOR/saline/DAC)	$60 EOR/$85 saline/$180 DAC	$60 EOR/$85 saline (no DAC)
Oil/Gas Production:		
Increased royalty rates	Implemented	Implemented
Completion of OCS leasing program by 2022	Not included	Implemented

Schedule

Complete for Internal DOE Review by Mid July

Final Inter-agency Review by End Aug

Final Report by End Sep

		PPNL and OL Teams	
weeks	w/o	Modeling efforts	Report Writing
1	4/17/2023	Decide on scenarios and align on key variables	
2	4/24/2023	GCAM and NEMS (AEO23 & FECM) coordination	D: Introduction and Scenario Design
3	5/1/2023	GCAM Run on Sce 1 to 6	
4	5/8/2023	GCAM Run on Sce 1 to 6 and Review	D: Study Methodology & Key Assumptions
5	5/15/2023	PNNL pass results to OL and start NEMS runs	**D: International GHG Outcomes**
6	5/22/2023	NEMS Runs on Sce 1 - 6	
7	5/29/2023	NEMS Runs on Sce 1 - 6	
8	6/5/2023	NEMS Runs on Sce 1 - 6	**D: U.S. Natural Gas Market Results**
9	6/12/2023	Review and comparison of NEMS and GCAM results	**D: U.S. GHG Outcomes & Econ??**
10	6/19/2023	Review and comparison of NEMS and GCAM results	
11	6/26/2023	Possible model adjustments and new runs	
12	7/3/2023	Possible model adjustments and new runs	
13	7/10/2023	GCAM and NEMS Final Results	Final Drafts
14	7/17/2023		
			Appendices and Data Annexes

Key issues / items to consider / Action Items as of April 24, 2023

- Set up meeting with Michael Blackhurst to review more details on technology and GHG results
- Write draft rational for using LNG export capacity figures in Scenario 1 for AEO 2023 and FECM-NEMS.
- Draft annotated outline for Modeling Report for NEMS and GCAM and share with PNNL and LCA Teams
- Coordinate on key data results across scenarios 2-5.
- Align on natural gas between NEMS and GCAM in Scenario 1
- Evaluate between scenarios 3 to 5, for high and low LNG Export
- Align in IRA assumption across GCAM, AEO 23, and FECM-NEMS (FECM acknowledge/confirm IRA implementation)
- Align on tech assumptions (NREL Low Cost ATB) on #5 between GCAM and FECM-NEMS
- Evaluate GCAM global and regional GHG emission changes across scenarios
- Careful coordination and consideration on #6 between GCAM and FECM-NEMS (H_2, DAC, non-NEMS GHGs, others?) and GCAM inputs to NEMS on scenario 6 for non-CO Non-CO2 & Landuse

From: Iyer, Gokul C
Sent: Fri, 7 Jul 2023 19:53:31 +0000
To: Curry, Thomas; Harker-Steele, Amanda J (NETL); Francisco De La Chesnaye; Edmonds, James A (Jae); Binsted, Matthew; Wolfram, Paul; Whitman, Peter C; Daniel Hatchell; Riera, Jefferson
Cc: Yarlagadda, Brinda; Sweeney, Amy; Robert Wallace; Agboola, Ajoke; Jamieson, Matthew B.; Wallace, Robert T. (CONTR); Scott Matthews; Matthews, Howard Scott (CONTR)
Subject: RE: FECM LNG Export Project Coordination
Attachments: Progress_update06302023_final.pdf

Hi Tom,

Attached are the slides from last week. Please let me know if you have any questions.

Gokul

From: Curry, Thomas <thomas.curry@hq.doe.gov>
Sent: Friday, July 7, 2023 11:01 AM
To: Harker-Steele, Amanda (NETL) <amanda.harkersteele@netl.doe.gov>; Francisco De La Chesnaye <francisco.delachesnaye@onlocationinc.com>; Iyer, Gokul C <Gokul.Iyer@pnnl.gov>; Edmonds, James A (Jae) <jae@pnnl.gov>; Binsted, Matthew T <matthew.binsted@pnnl.gov>; Wolfram, Paul <paul.wolfram@pnnl.gov>; Whitman, Peter C <peter.whitman@onlocationinc.com>; Daniel Hatchell <daniel.hatchell@onlocationinc.com>; Riera, Jefferson <jefferson.riera@onlocationinc.com>
Cc: Yarlagadda, Brinda N <brinda.yarlagadda@pnnl.gov>; Sweeney, Amy <amy.sweeney@hq.doe.gov>; Robert Wallace <robert.wallace@keylogic.com>; Agboola, Ajoke <ajoke.agboola@hq.doe.gov>; Jamieson, Matthew B. <matthew.jamieson@netl.doe.gov>; Wallace, Robert T. (CONTR) <Robert.Wallace@NETL.DOE.GOV>; Scott Matthews <scott.matthews@keylogic.com>; Matthews, Howard Scott (CONTR) <scott.matthews@netl.doe.gov>
Subject: RE: FECM LNG Export Project Coordination

DRAFT – DELIBERATIVE – PRE-DECISIONAL

Agree with Amanda on the focus for the call starting now.

We can skip the 12pm call.

Gokul and Matthew, can you send me slides with the update from last week with the final international pricing and with the 6A/B results?

Thank you.
Tom

From: Harker Steele, Amanda J. <Amanda.HarkerSteele@netl.doe.gov>
Sent: Friday, July 7, 2023 10:32 AM
To: Francisco De La Chesnaye <francisco.delachesnaye@onlocationinc.com>; Iyer, Gokul <gokul.iyer@pnnl.gov>; Edmonds, James A (Jae) <jae@pnnl.gov>; Binsted, Matthew <matthew.binsted@pnnl.gov>; Wolfram, Paul <paul.wolfram@pnnl.gov>; Whitman, Peter C <peter.whitman@onlocationinc.com>; Daniel Hatchell <daniel.hatchell@onlocationinc.com>; Riera,

Jefferson <jefferson.riera@onlocationinc.com>
Cc: Curry, Thomas <thomas.curry@hq.doe.gov>; Yarlagadda, Brinda <brinda.yarlagadda@pnnl.gov>; Sweeney, Amy <amy.sweeney@hq.doe.gov>; Robert Wallace <robert.wallace@keylogic.com>; Agboola, Ajoke <ajoke.agboola@hq.doe.gov>; Jamieson, Matthew B. <matthew.jamieson@netl.doe.gov>; Wallace, Robert T. (CONTR) <Robert.Wallace@NETL.DOE.GOV>; Scott Matthews <scott.matthews@keylogic.com>; Matthews, Howard Scott (CONTR) <scott.matthews@netl.doe.gov>
Subject: RE: FECM LNG Export Project Coordination

Hi Paco,

I will defer to the Task 1 & 2 teams.

For clarity, the 11am meeting is dedicated solely to Task 4. I expect this meeting could run long so having the extra time on calendars for HQ folks would be good fur us in the event that the original 12 pm meeting isn't needed.

Sincerely,
Amanda J. Harker Steele, Ph.D. (she/her)
Research Economist – EMAT, SSAE
National Energy Technology Laboratory (NETL)
Department of Energy
3610 Collins Ferry Rd.
Morgantown, WV 26508
Amanda.HarkerSteele@netl.doe.gov
304-285-0207

From: Francisco De La Chesnaye <francisco.delachesnaye@onlocationinc.com>
Sent: Friday, July 7, 2023 10:27 AM
To: Iyer, Gokul C <Gokul.Iyer@pnnl.gov>; Edmonds, James A (Jae) <jae@pnnl.gov>; Binsted, Matthew T <matthew.binsted@pnnl.gov>; Wolfram, Paul <paul.wolfram@pnnl.gov>; Peter Whitman <peter.whitman@onlocationinc.com>; Daniel Hatchell <daniel.hatchell@onlocationinc.com>; Jefferson Riera <jefferson.riera@onlocationinc.com>
Cc: Curry, Thomas <thomas.curry@hq.doe.gov>; Yarlagadda, Brinda N <brinda.yarlagadda@pnnl.gov>; Sweeney, Amy R <amy.sweeney@hq.doe.gov>; Harker Steele, Amanda J. <Amanda.HarkerSteele@netl.doe.gov>; Robert Wallace <robert.wallace@keylogic.com>; Agboola, Ajoke <ajoke.agboola@hq.doe.gov>; Jamieson, Matthew B. <Matthew.Jamieson@NETL.DOE.GOV>; Wallace, Robert T. (CONTR) <Robert.Wallace@NETL.DOE.GOV>; Scott Matthews <scott.matthews@keylogic.com>; Matthews, Howard Scott (CONTR) <Scott.Matthews@netl.doe.gov>
Subject: [EXTERNAL] FECM LNG Export Project Coordination

All,

Wondering if we need this meeting today.

The Task 1 and 2 teams met earlier this week to “lock down” all the key assumption, etc., on the models and to update the Report Outlines and Schedules so we are good there. Daniel may have some follow up on results presentation in tables and charts, but he can do that directly with PNNL.

On Task 3, Tim is out this week, and we are looking for a time to re-connect early next week.

On Tasks 3 and 4, we have a meeting at 11 am where will update progress then.

Let me know if there are items to cover and if we do need the 12 pm meeting.

Best, Paco

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Long-term scenarios of U.S. and global liquefied natural gas markets

July 7, 2023

Gokul Iyer, Matthew Binsted,
Brinda Yarlagadda,
Paul Wolfram, Jae Edmonds

U.S. DEPARTMENT OF ENERGY BATTELLE

PNNL is operated by Battelle for the U.S. Department of Energy

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Progress updates 06/30/2023

- We have the international prices in
  - We also have a version of S6 with the US LNG export constraint
  - For now, we're calling it S7: Energy transition (1.5C) w/ US LNG export constraint
- Begun drafting report sections
  - Feedback on Figure format would be appreciated
- Contributed to briefing
  - We have put together slides on better communicating the assumptions within S6
- Responding to questions from LCA team

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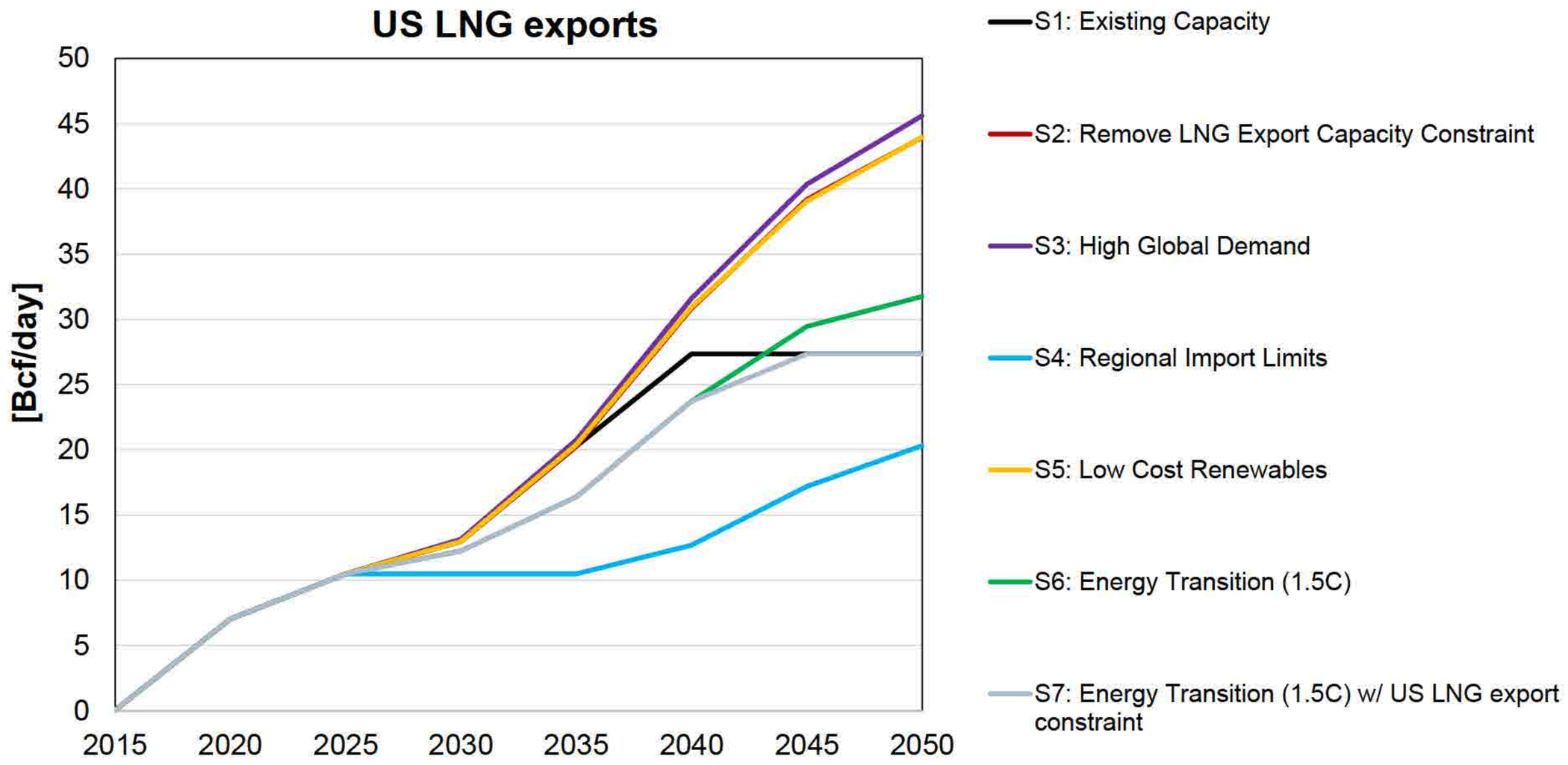
US LNG exports



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Scenarios for the rest of the presentation

	US LNG export constraint	Remove US LNG export constraint
No emission constraint	S1: Existing Capacity	S2: Remove LNG export capacity constraint
Transition toward 1.5C	S7: Energy transition (1.5C) w/ US LNG export constraint	S6: Energy transition (1.5C)

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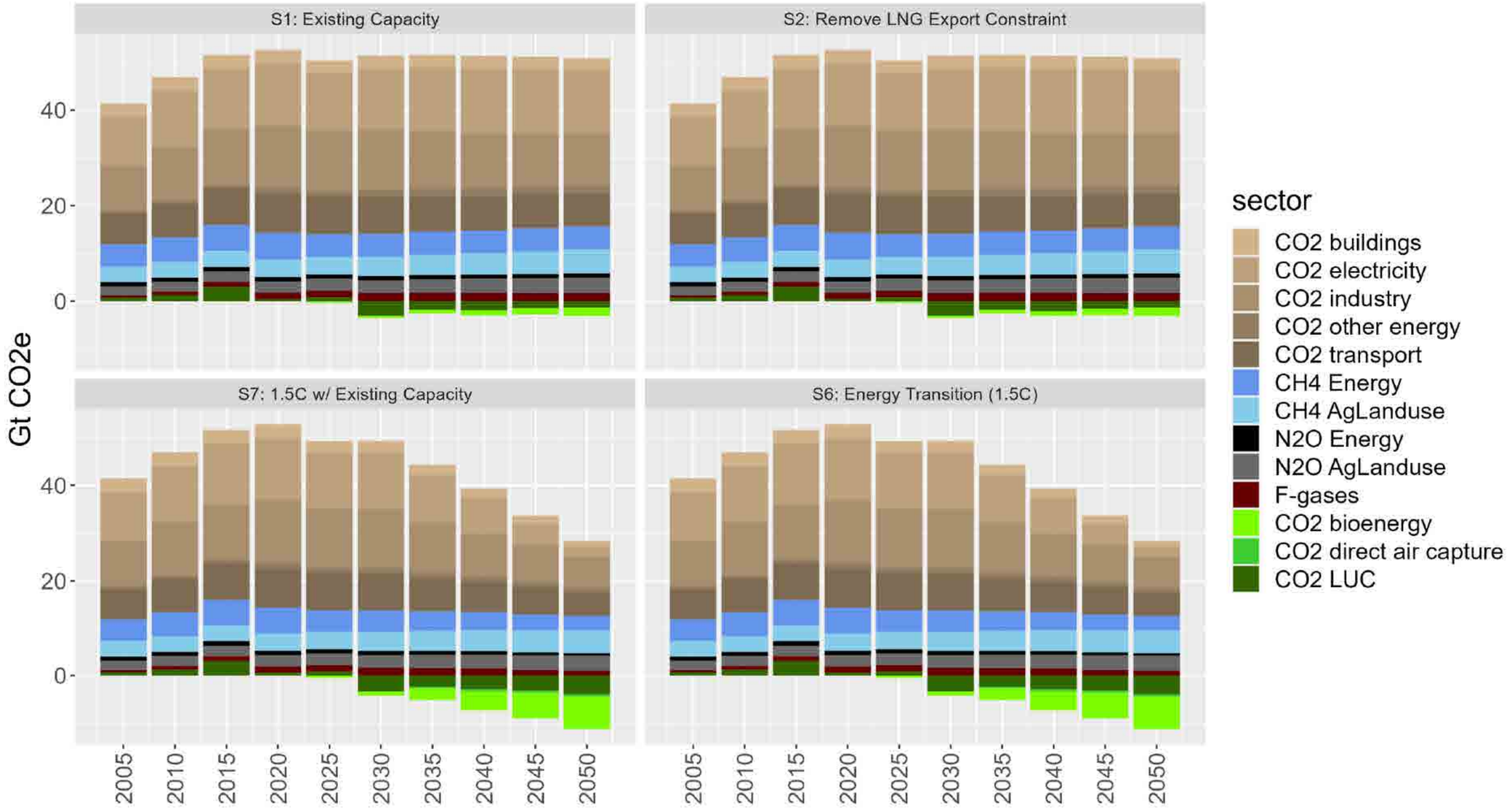
Global Greenhouse gas emissions by sector



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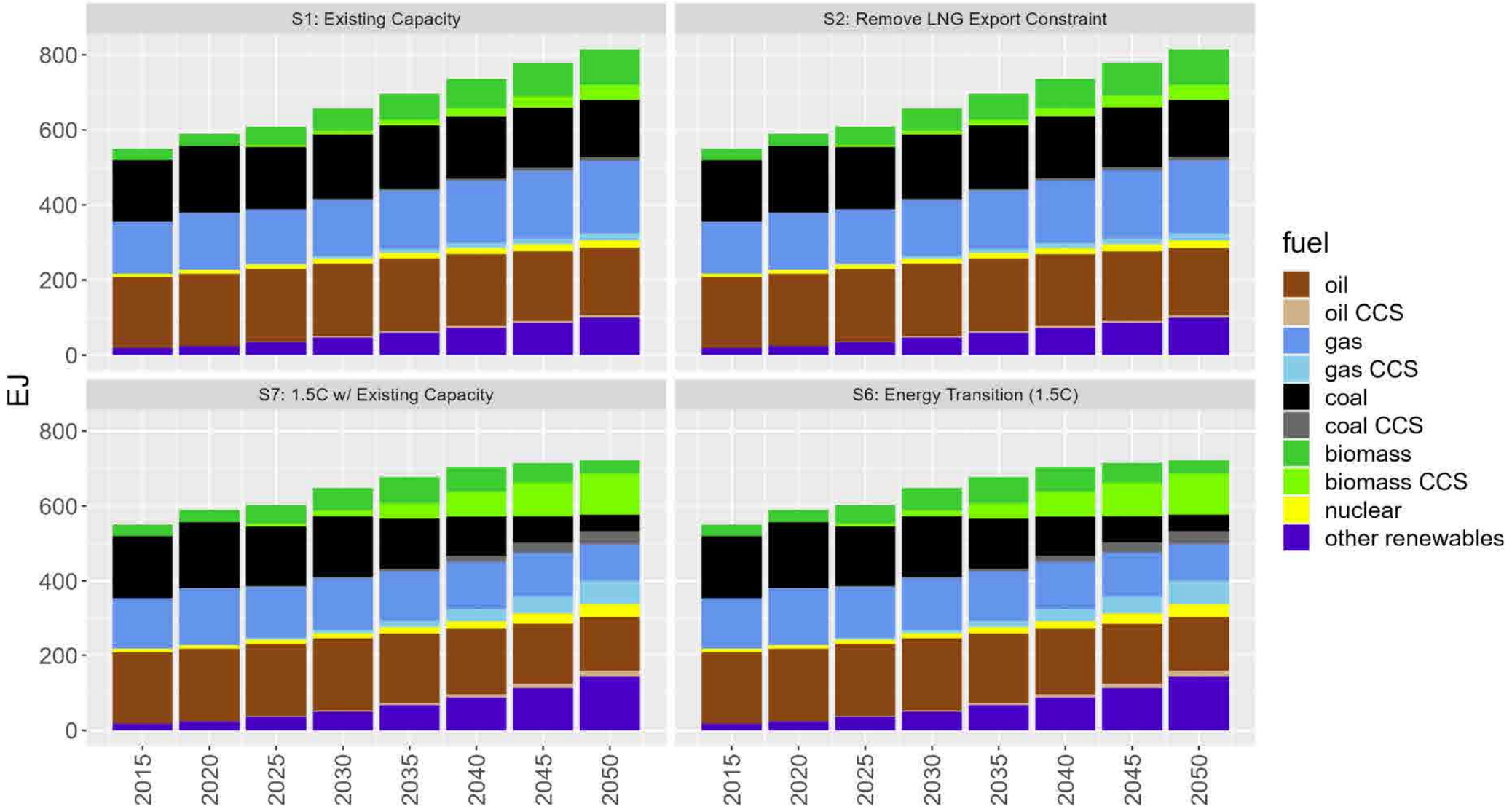
Primary energy consumption



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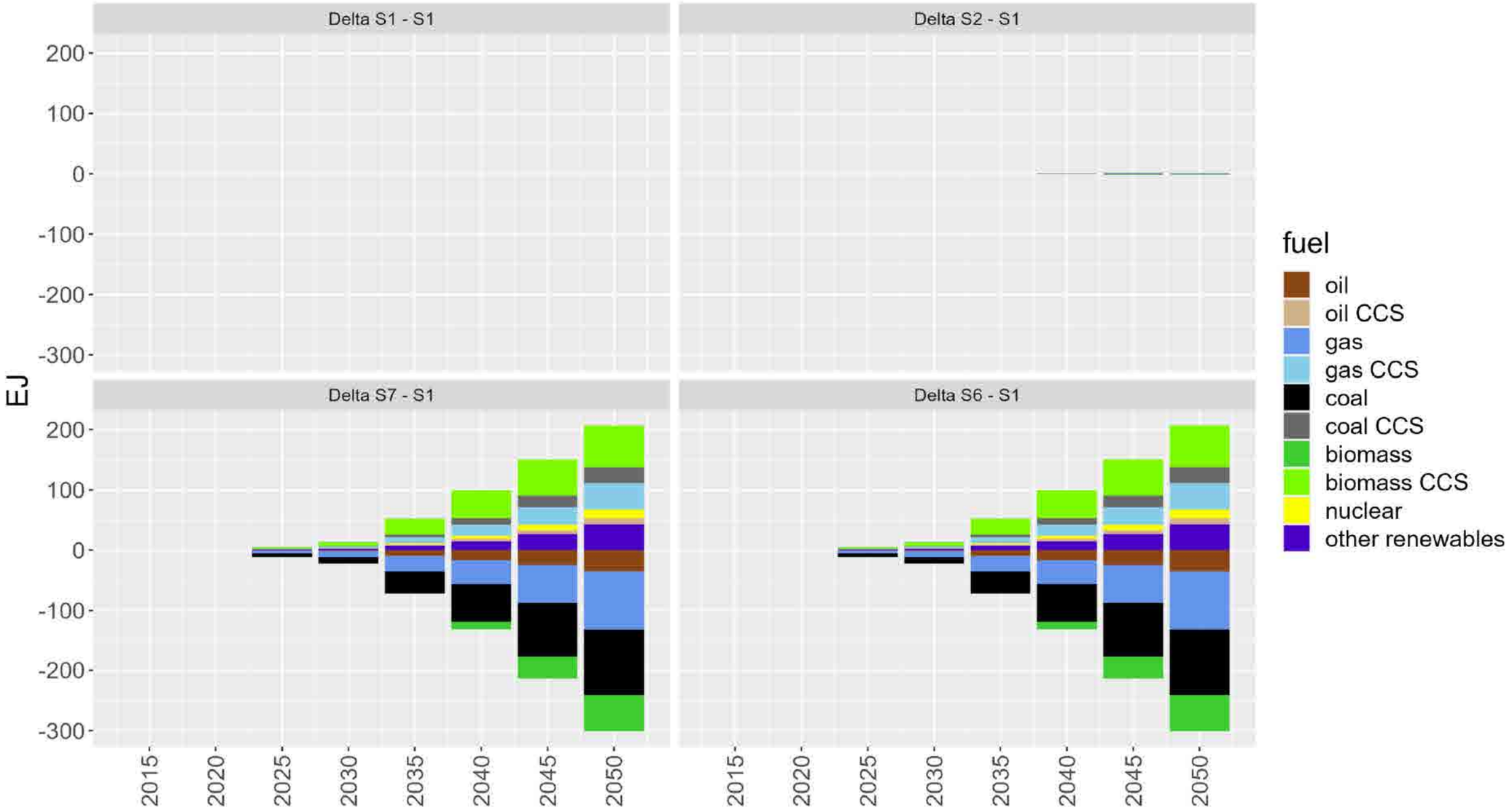
Primary energy consumption: differences from S1



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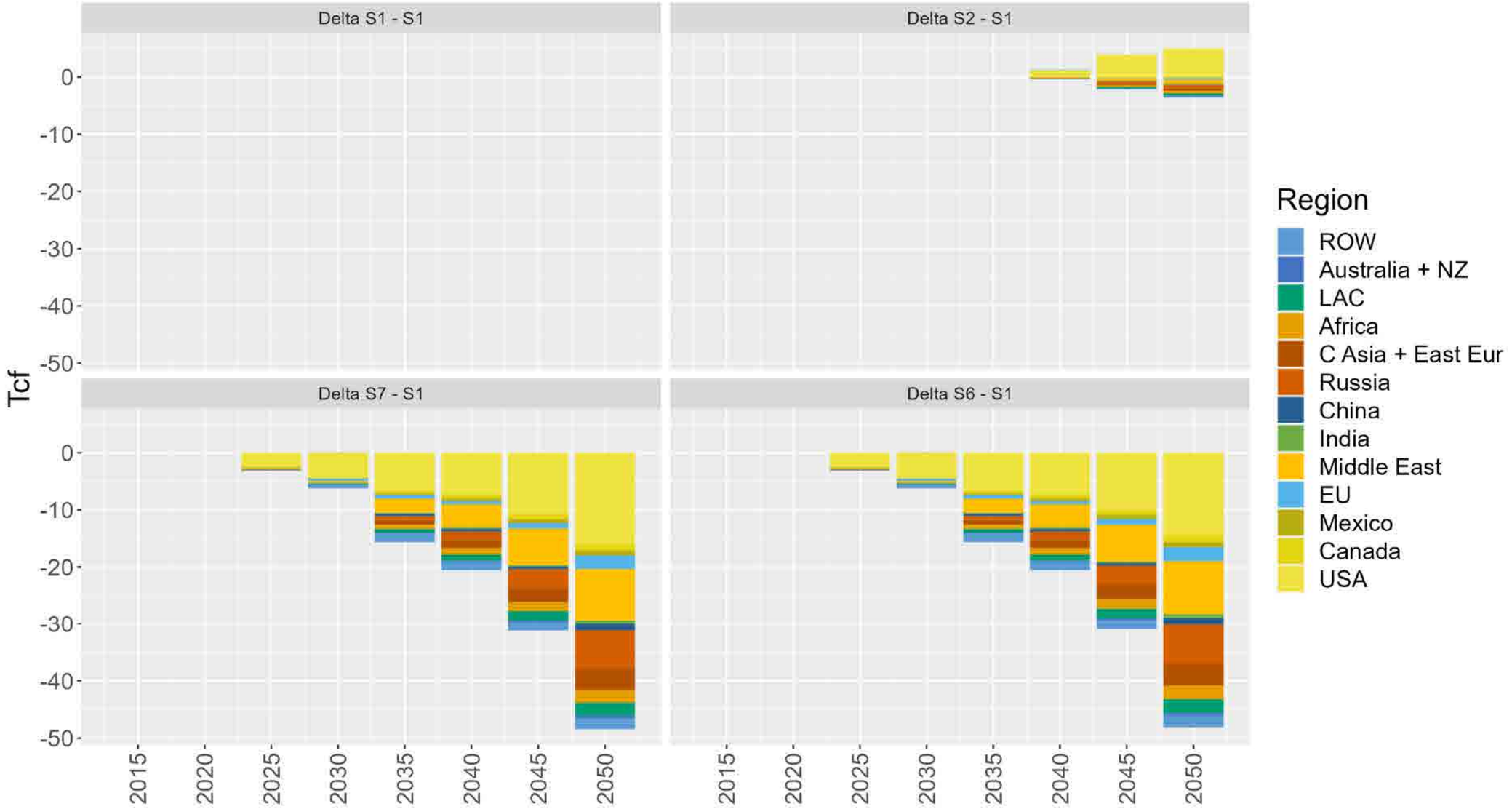
Natural gas production : differences from S1



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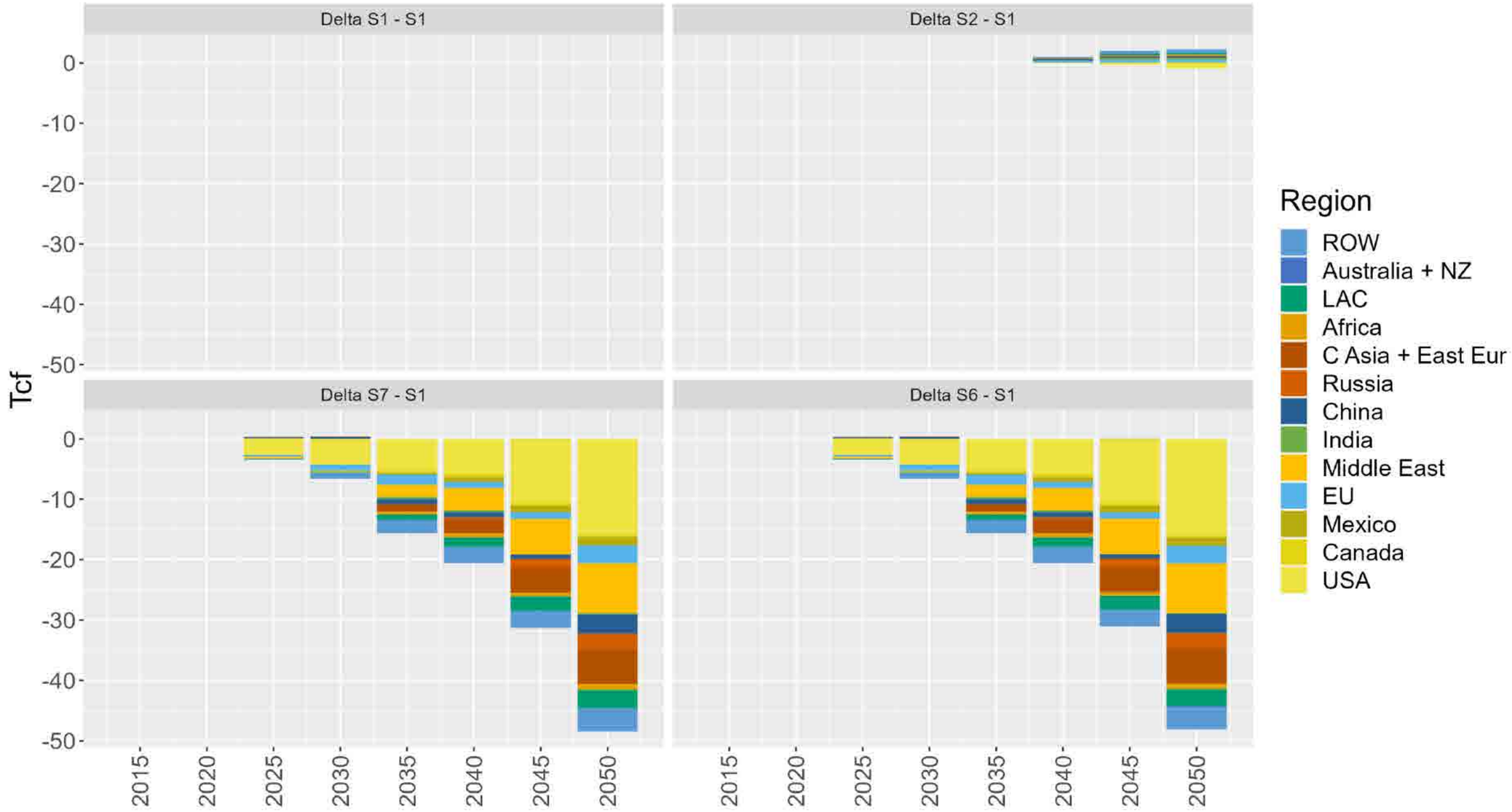
Natural gas consumption: differences from S1



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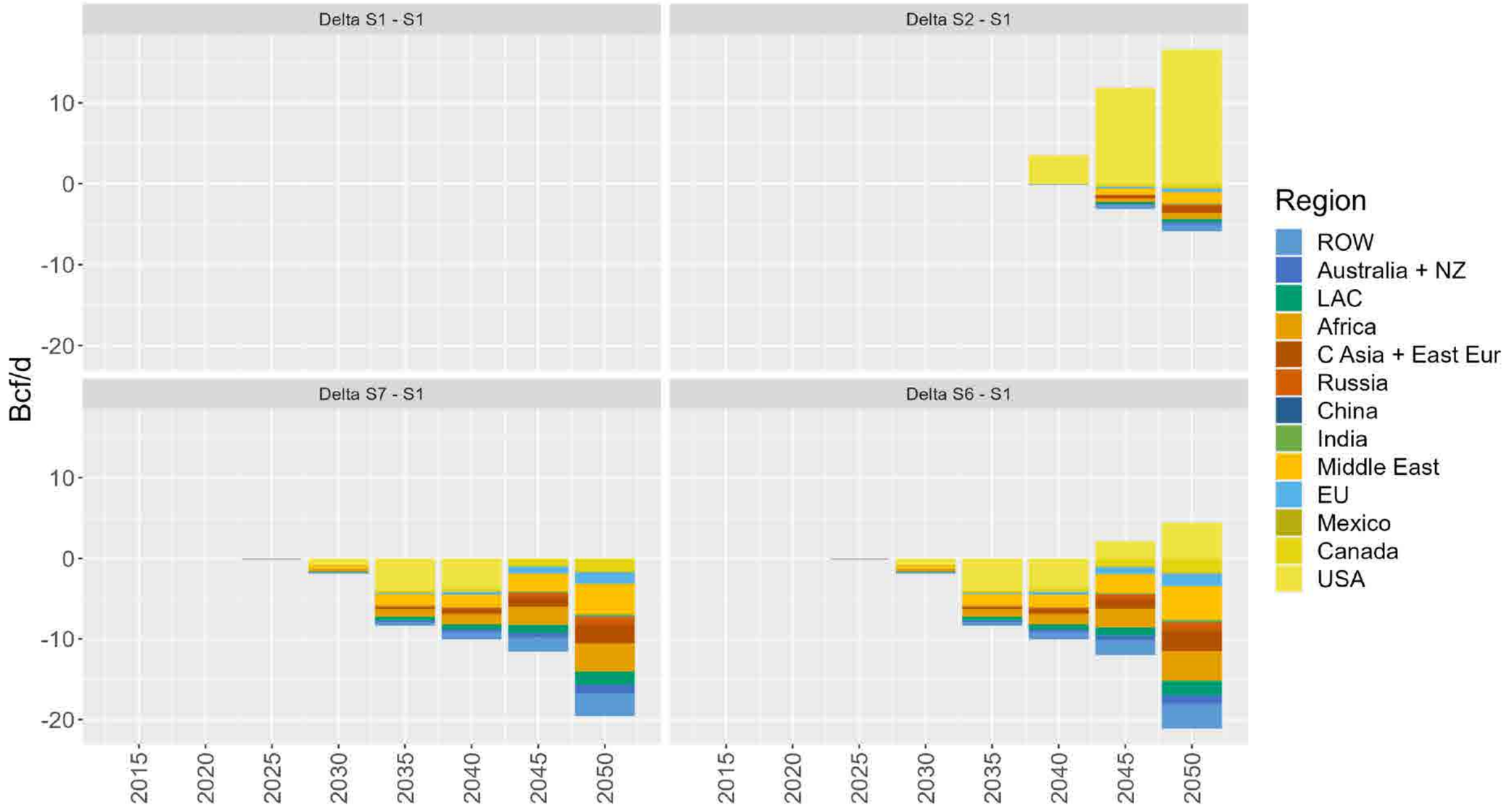
LNG exports: differences from S1



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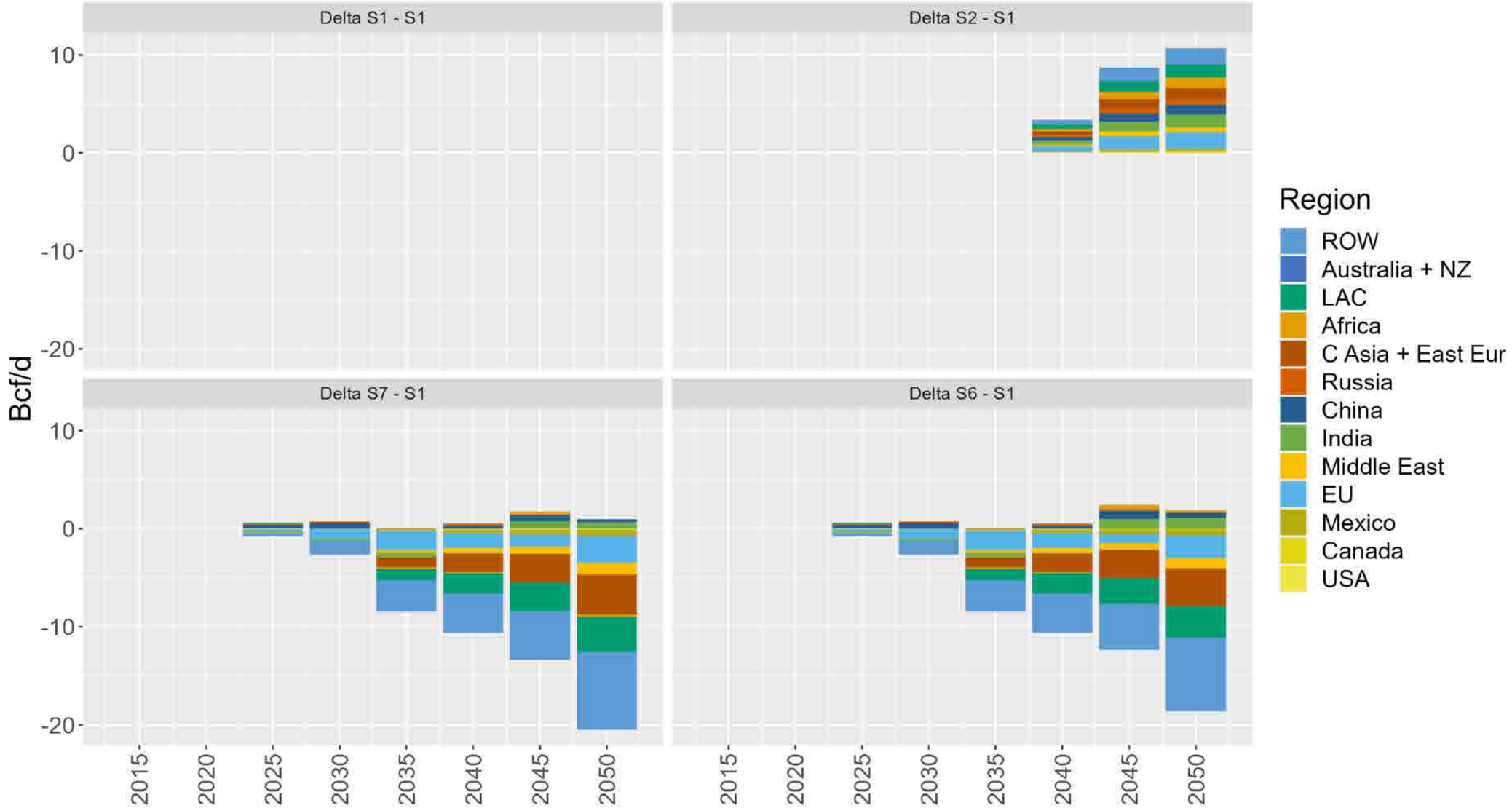
LNG imports: differences from S1



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Next steps

- Share US LNG exports and CO2 emissions data w/ OnLocation
- Continue writing

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Scenario 6 (Energy Transition): Detailed assumptions

- To construct the Energy Transition scenario, we begin with countries' most recent commitments and pledges
- Through 2030:
  - Countries are assumed to achieve their nationally determined contributions (NDCs)
- Beyond 2030:
  - Countries without official UNFCCC net-zero pledges or long-term strategies (LTSs) are assumed to achieve the same level of decarbonization rate as the rate between 2015 and 2030 or a minimum rate if their decarbonization rate is below this minimum rate
  - Countries with official net-zero pledges and LTSs are assumed to follow their net-zero pledges and LTSs till the target year, followed by the path defined by the minimum decarbonization rate
- We assume a minimum threshold for the post-2030 decarbonization rate (measured in terms of GHG emissions per unit of GDP) of 8% per year
  - The 8% minimum decarbonization rate assumption suggests strong mitigation policies and significant departure from historically observed decarbonization rates (next slide)
- Globally the resulting emissions pathway is consistent with limiting global warming to less than 1.5°C by 2100
- The methodology and assumptions are based on published peer-reviewed literature: Fawcett et al., 2015, *Science*; Ou & Iyer et al. 2021, *Science*; Iyer & Ou et al. 2022, *Nature Climate Change*

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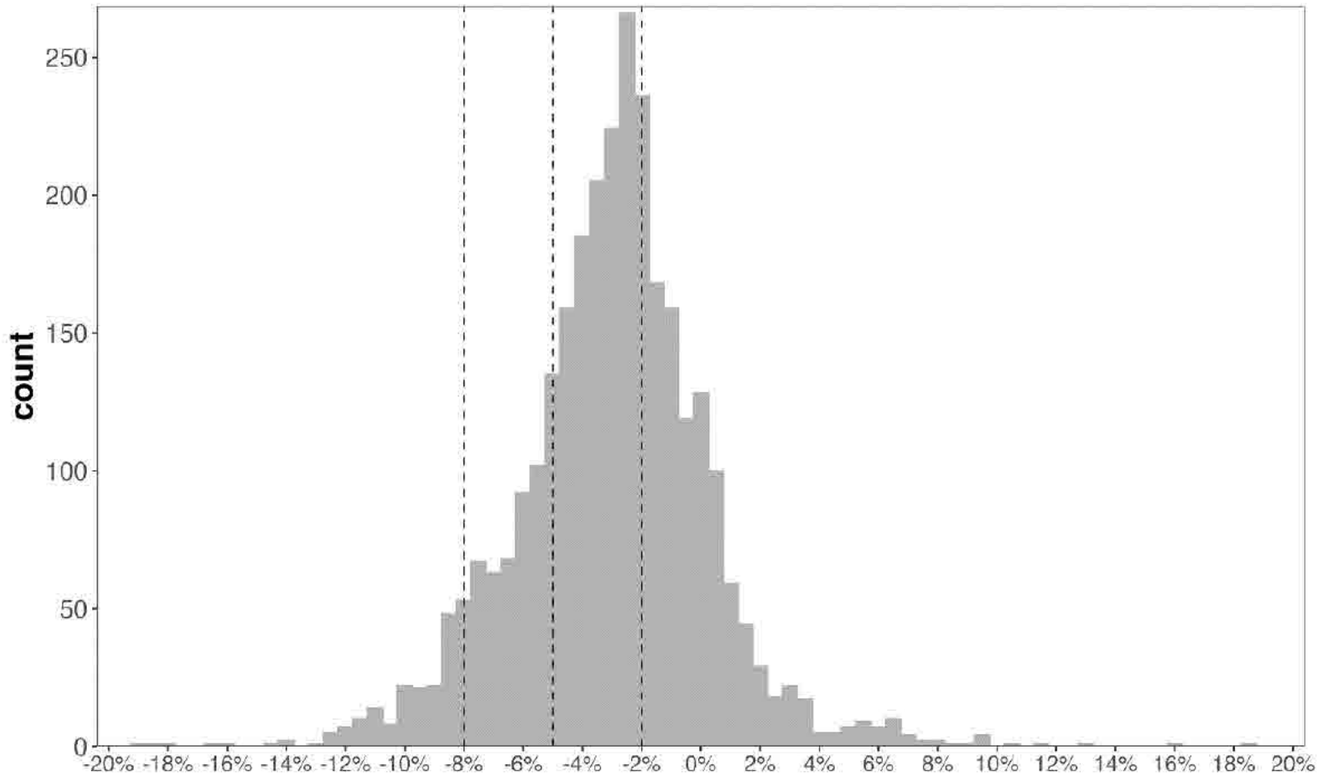
Historical distribution of decarbonization rates

Historical distribution of 10 year running average of country level rates of change in GHG/GDP (1990-2018). Negative rates of change are referred to as "decarbonization rates".



Iyer & Ou et al. 2022, Nature Climate Change

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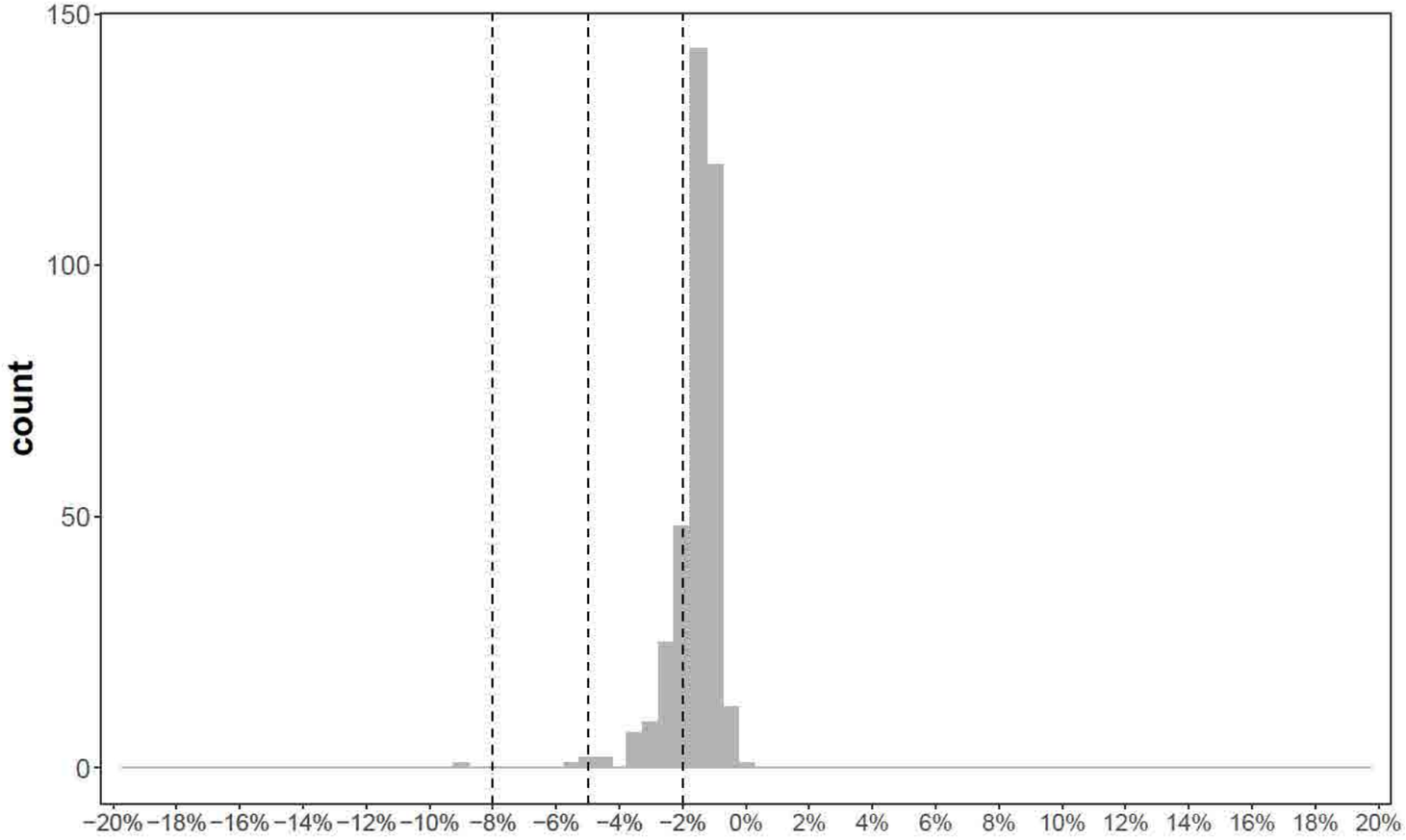
Distribution of decarbonization rates in IPCC baseline scenarios

Distribution of 10-year running average of global rates of change in GHG/GDP (change in global GHG/global GDP) from 2010 to 2100 in baseline scenarios (that is, scenarios with no new GHG mitigation policies) from the IPCC's SR1.5 report. Negative rates of change are referred to as "decarbonization rates".



Iyer & Ou et al. 2022, Nature Climate Change

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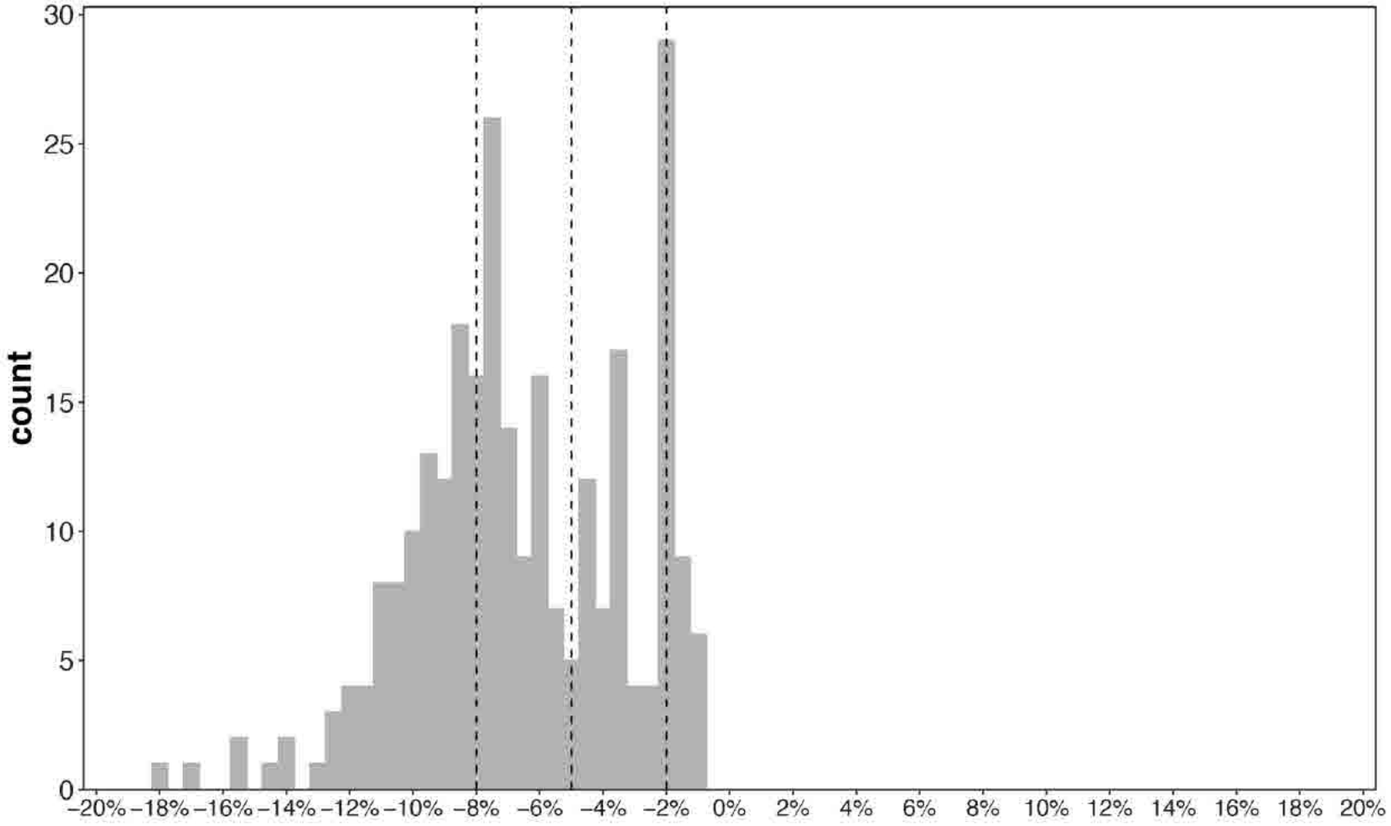
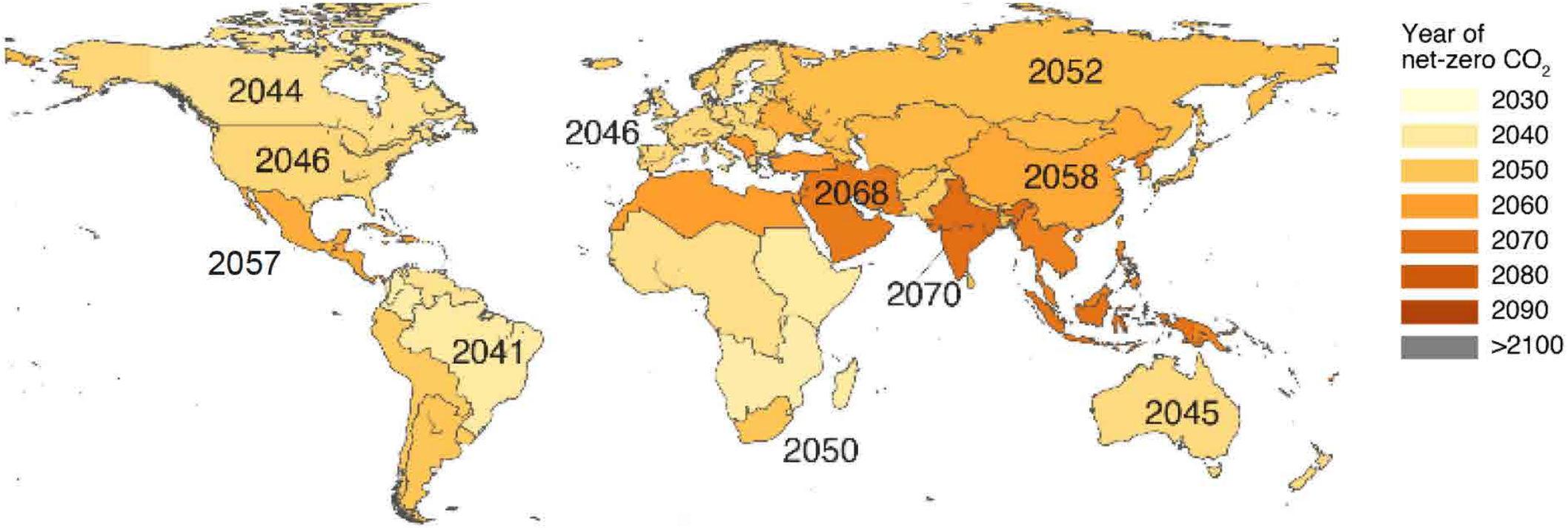
Distribution of decarbonization rate in IPCC 1.5°C scenarios

Distribution of 10-year running average of global rates of change in GHG/GDP (change in global GHG/global GDP) from 2010 until the year of net-zero CO2 emissions in 1.5°C-consistent scenarios (including pathways with no overshoot, with limited (low) overshoot, and with high overshoot) from the IPCC's SR1.5 report. Negative rates of change are referred to as "decarbonization rates".



Iyer & Ou et al. 2022, Nature Climate Change

Year of net-zero CO2 emissions in S6



*Year of net-zero emissions are based on linear interpolations between 5-year model timestep

** In the case of countries/regions with an explicit net-zero CO2 pledge (e.g. India), the figure shows an assumption; in the case of countries/ regions with net-zero GHG pledges (e.g. U.S.), the figure shows a model outcome

Source: Iyer & Ou et al. 2022, Ratcheting of climate pledges needed to limit peak global warming, Nature Climate Change

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Thank you

DRAFT/ PRE-DECISIONAL AND DELIBERATIVE

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Historical price calibration in GCAM

- In GCAM, historical gas producer prices are calibrated at the global scale, i.e. all GCAM regions are calibrated to a global average producer price

- In a future model period, as demand changes, the change in regional producer prices from the historical calibrated values are calculated off of regional supply curves

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International price update

- For the US, we used Henry Hub prices from EIA to calibrate the US producer price in 2015 (last historical period in GCAM)
  - In a future model period, the US supply curve will dictate changes to this price in response to demand changes.

- For non-US regions, we use CIF prices from S&P to calibrate the producer prices in 2015 (last historical period in GCAM)

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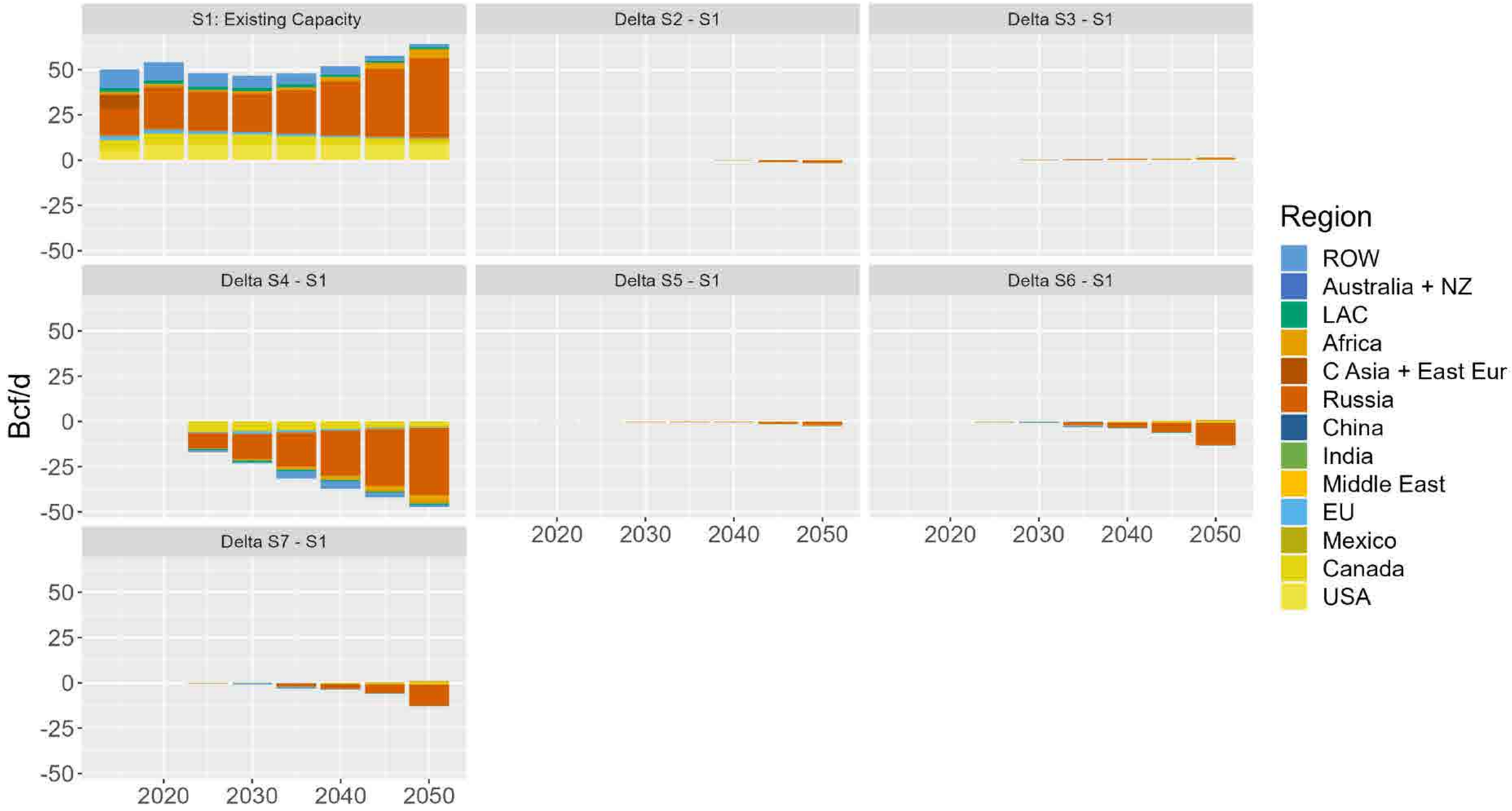
Pipeline exports: differences from S1



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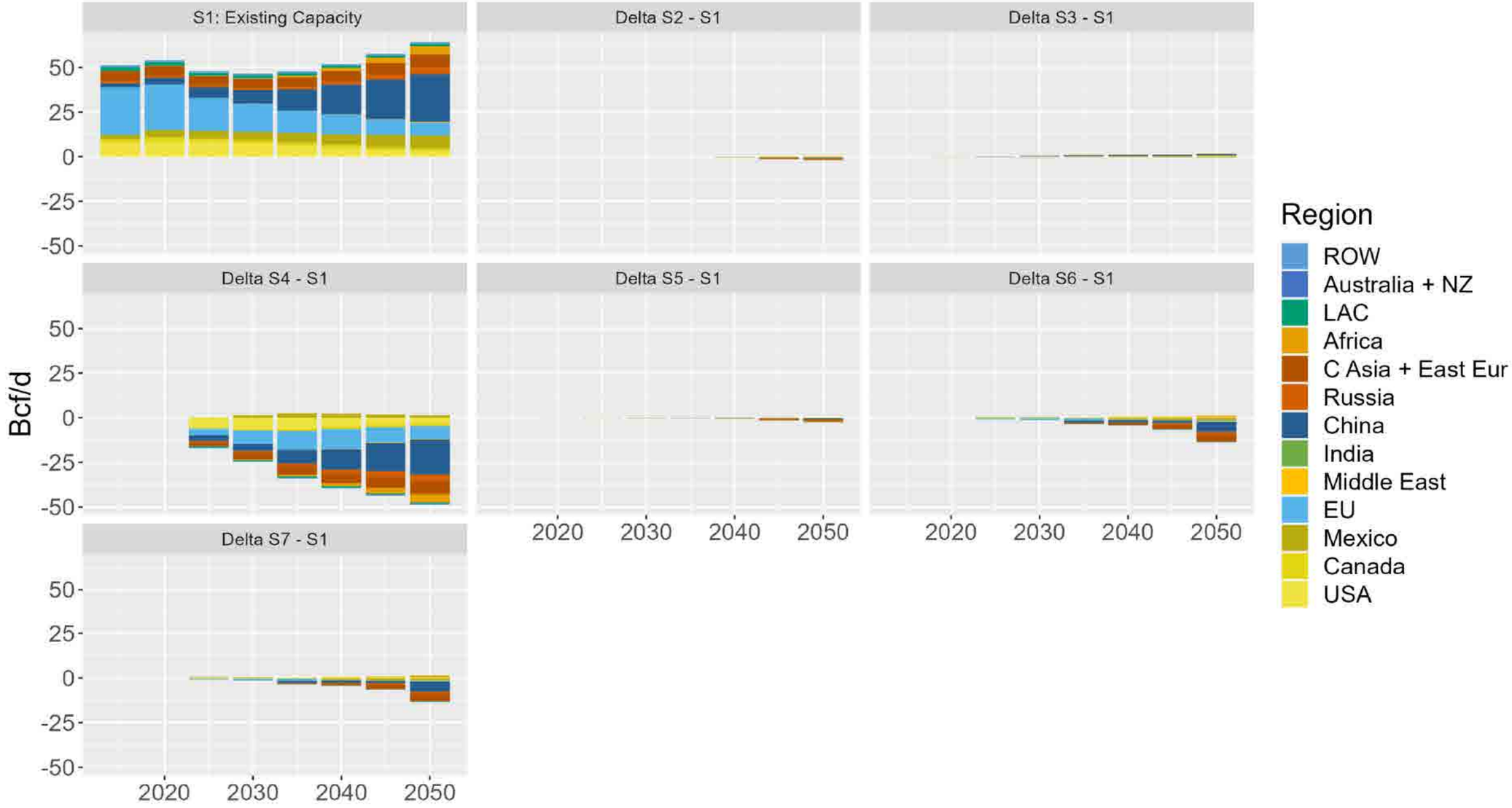
Pipeline imports: differences from S1



From: Curry, Thomas
Sent: Fri, 22 Sep 2023 15:30:48 +0000
To: Francisco De La Chesnaye; Iyer, Gokul; Edmonds, James A (Jae); Binsted, Matthew; Wolfram, Paul; Whitman, Peter C; Daniel Hatchell; Riera, Jefferson; Scott Matthews; Jamieson, Matthew B.
Cc: Skone, Timothy; Sweeney, Amy; Easton, James
Subject: RE: Modeling FECM LNG Export Project Coordination
Attachments: Consolidated GC Key comments.docx, FECM LNG Analysis paper 2023 - IA comments.docx

DRAFT – DELIBERATIVE – PRE-DECISIONAL

Hi All,

On today's call, we would like to review the attached consolidated key comments we received from IA and GC. We would like to have an initial discussion of the comments and prioritize responses, with a goal of having responses by next Friday. We also have line and editorial comments that we can share next week but we want to focus on these broader comments today.

Thanks.
Tom

-----Original Appointment-----
From: Francisco De La Chesnaye <francisco.delachesnaye@onlocationinc.com>
Sent: Friday, September 22, 2023 7:07 AM
To: Francisco De La Chesnaye; Iyer, Gokul; Edmonds, James A (Jae); Binsted, Matthew; Wolfram, Paul; Whitman, Peter C; Daniel Hatchell; Riera, Jefferson; Scott Matthews; Jamieson, Matthew B.
Cc: Skone, Timothy; Curry, Thomas; Sweeney, Amy
Subject: Modeling FECM LNG Export Project Coordination
When: Friday, September 22, 2023 12:00 PM-1:00 PM (UTC-05:00) Eastern Time (US & Canada).
Where: Microsoft Teams Meeting

Slight modification for today's meeting. It is still on with a focus on review of comments on modeling items.

Please add anyone I may have missed from the modeling teams at PNNL and NETL.

Microsoft Teams meeting

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DRAFT – DELIBERATIVE – PRE-DECISIONAL

Summary of Key GC Comments

Global

Global comment: this report consistently uses bar charts rather than actual figures. Can we include all these figures in appendices?

Page 3

There is a notable difference in the way we present the data from our conclusions. When we reference GDP, gas consumption, and prices, we scale the effect against the global or national total, resulting in small percentage changes. When we talk about GHGs we scale the effect to units of gas exported. But the table in the appendix shows that the reduction in emissions between S2 and S1 is 50 million tons - or roughly 0.01% of global emissions. I recommend that we take a more consistent approach to characterizing the model results.

Page 22

S1 shows global gas consumption increasing to 2050 (and maybe beyond?). Even S6 and S7 seem to show global gas consumption plateauing in 2045 (but not decreasing event then). Meanwhile, we understand that this month the IEA will release a global outlook document that will project gas consumption peaking this decade. This seems like a vast discrepancy and perhaps one that should be addressed. Is it feasible to run another scenario? If not, how would we defend the validity of our assumptions as compared to those of others?

Page 23

Looking at the bar chart in figure 5, it appears that global gas consumption increases by roughly 5 bcf/day between S2 and S1. In other words, for every 4 Bcf/d of incremental US exports, global consumption goes up by roughly 1 Bcf/d. This does not seem accurately characterized as going up by a very small amount.

Page 25

Figure 6 is almost impossible to read. It seems like there are differences between S1 and S2 but the reader can't judge the magnitude just by looking at the bar charts.

Page 39

A few points:

1. This data should be presented in numbers as well as visually.
2. We state that higher exports is positive on GDP until 2050, but S1 seems greater than S2 throughout the entire time series.

3. Does the last sentence mean we think that 0.3% of GDP is a small amount that doesn't warrant further discussion? 0.3% of 42 trillion is over 100 billion. Are we saying that incremental exports of 20 Bcf/d would reduce the size of the US economy by that amount? Over $5b per Bcf/d? If so that seems like a very consequential finding and one that should be explored in greater depth.

Page 45

If we used the GCAM estimate, how would that affect our GHG projections? Some will argue that we cherry picked a more favorable estimate, so it would be helpful to say that our conclusions are robust to that assumption.

Page 46

(b) (5)

(1) To what extent are these GHG reductions attributable to US exports displacing other sources of gas? From what countries do we see displacement , and on what sources are we basing our LCA estimates for those foreign sources of gas being displaced?
(2) To what extent are these GHG reductions attributable to reduced use of coal and in what countries?
(3) To what extent does the model find that increased US exports will lead to increased deployment of gas-fired DAC? If the answer to this question is that gas-fired DAC is a material driver for the GHG decrease, then there are a number of other questions we will need to answer: (A) what assumptions are we making about the price/ton of DAC? (B) Given that DAC has not been deployed at scale, shouldn't we run a sensitivity analysis? If it turns out that DAC can't be scaled at an acceptable price, would that change the sign on our GHG analysis? and (C) why would it make sense to use LNG exports for DAC? If DAC is the preferred solution wouldn't it make more sense to locate the DAC hub near the point of production and then rely on international transfers for GHG accounting?

Page 63

Would be very helpful to state our assumptions regarding the cost of DAC over the 2035 to 2050 period.

DRAFT – DELIBERATIVE – PRE-DECISIONAL
9/21/23

LNG Analysis paper comments from IA

The report shows that with increased US LNG exports global demand does not rise, but instead US LNG substitutes for higher cost LNG. From what I can see in the chart, the Middle East seems to be losing the most to the U.S. This is surprising given Qatar's extremely low cost of production. I would expect the Middle East to maintain or grow their share of the LNG market.

We would like to understand more about why the model shows a substitution of LNG supply instead of increasing demand?

In S1 and S2, U.S. LNG exports approach 40 and 50 bcf/d, up from 12.5 bcf/d today. Do you consider infrastructure, production constraints, and reserves in these scenarios? 50 bcf/d is equivalent to about 50% of total U.S. gas production today so theoretically this export level would require vast expansion of domestic gas production and infrastructure, which seems quite a stretch.

It doesn't seem like renewables are not competing with LNG in any of these scenarios, including the transition scenarios. Are the costs not competitive? What do you think explains the relatively low growth and ultimately minority share of renewable energy production? Is grid storage technology incorporated into this model and how does it or would it impact renewables?

I think it is telling that there are only significant emissions reductions in the energy transition scenarios S6 and S7. The heavy reliance on CO2 removal in these scenarios still does not sit well with me. I feel that these are used to remove emissions in the models so that the trajectory meets a predetermined target rather than being incorporated into the energy system at realistically economic and achievable levels.

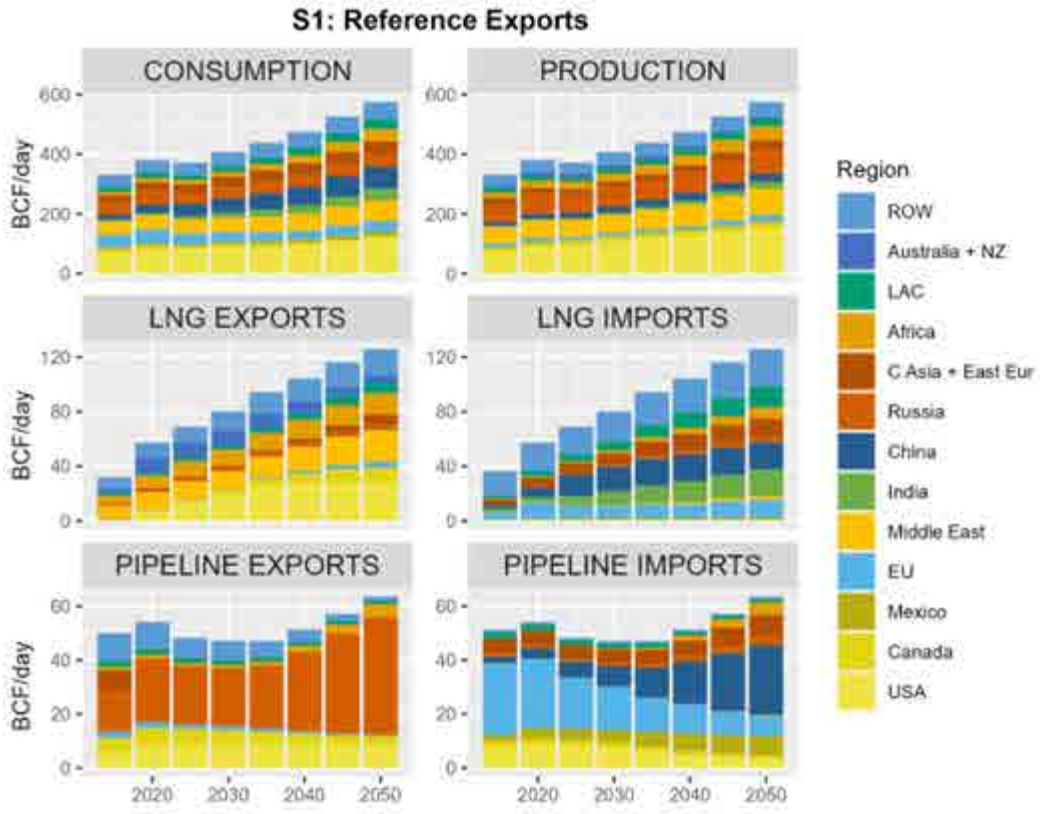
I don't know the costs and production capacity you have assumed for renewables, but even in S6 and S7 I feel that renewable energy production is much lower than other estimates, especially given the falling cost and increasing production of renewable energy. Essentially, there is not energy transition happening in S6 and S7. Instead, it remains business as usual for the most part with CO2 DAC, biomass and LUC offsetting increased emissions.

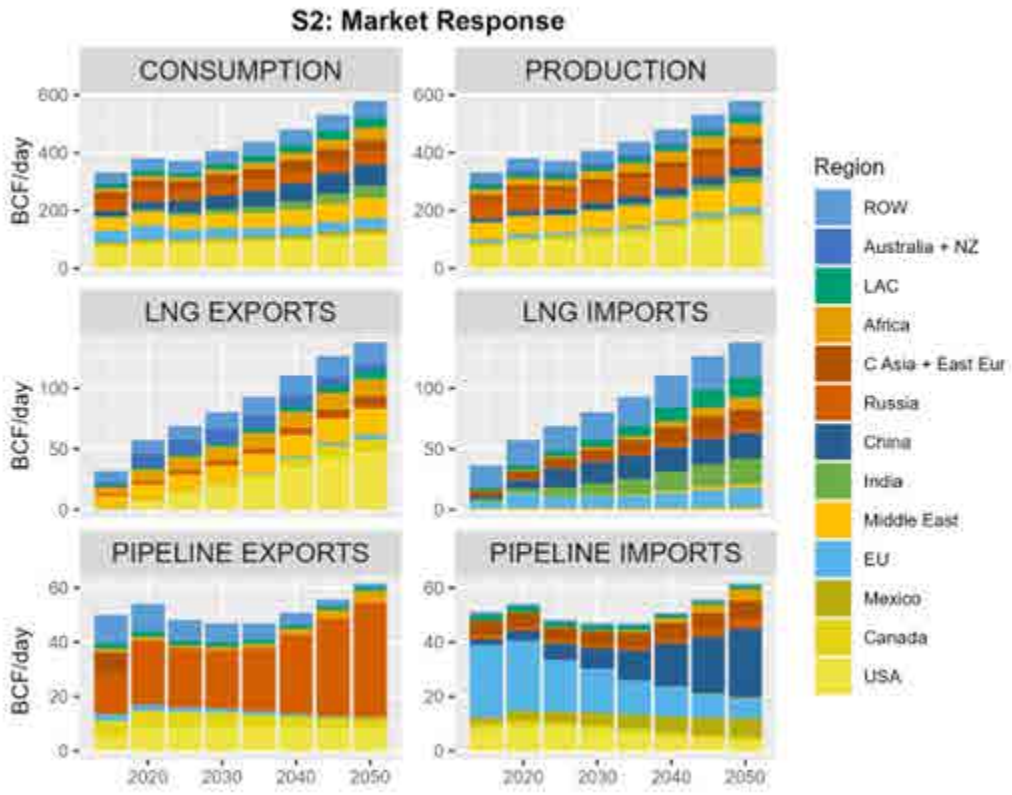
The carbon removal values and lack of renewables growth are the two main concerns of ours in this report.

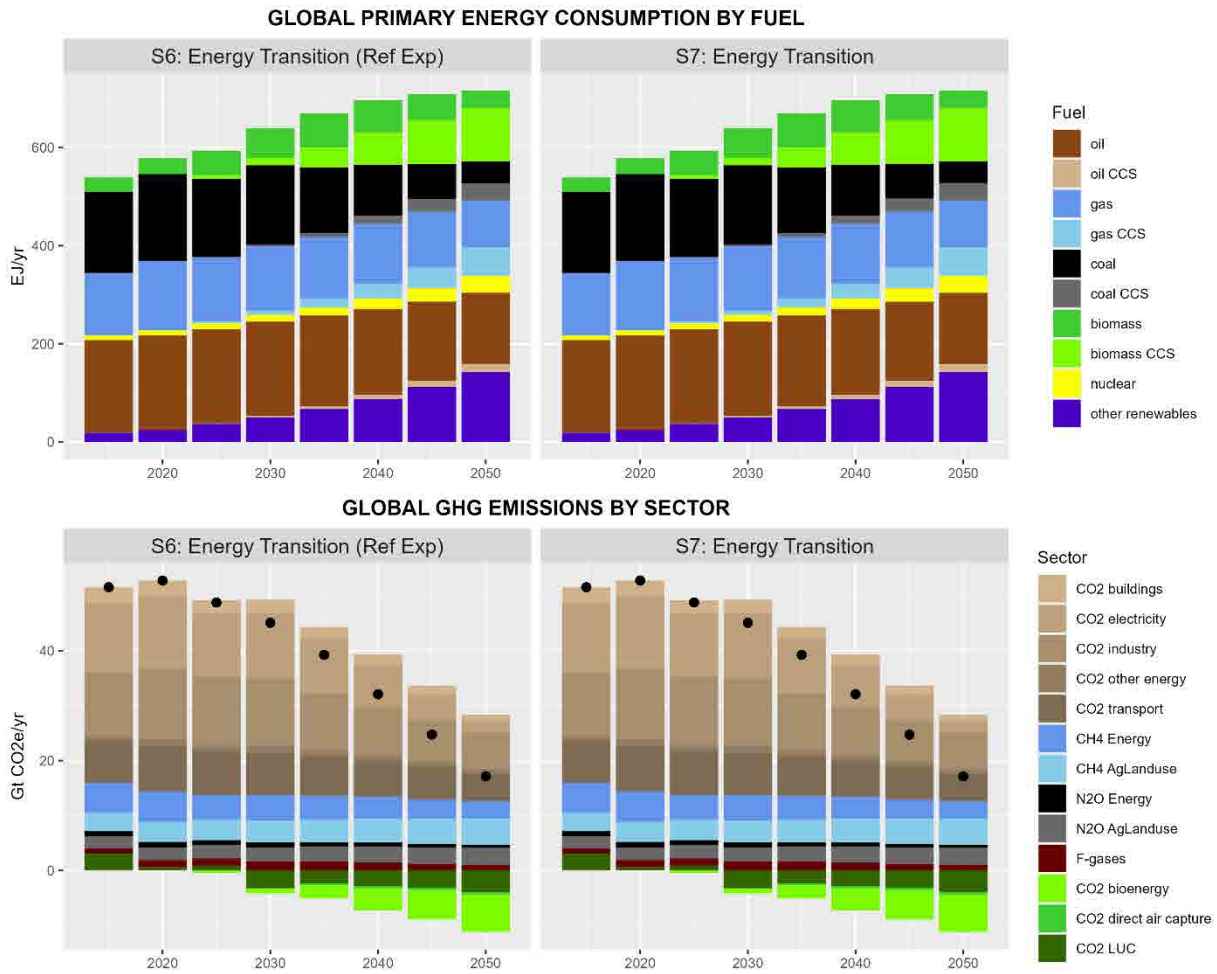
Can you explain to us why you examine GHG emissions as a whole on a 100-year basis, where the potency of certain GHGs vary significantly. Since methane has significantly more potency within 25 years than it does in 100 years, and therefore its impact on the atmosphere is a lot more in that shorter time frame we think we'd be remiss if we overlook those shorter term impacts, because solely looking at this long term frame is missing a lot of the importance nuance of how GHG emissions impacts the climate before 100 year basis. The20 year basis is in Appendix C, but there does seem to be a bigger difference. It could be valuable to highlight that finding, especially in light of some of the climate related LNG restrictions we are considering which would have an immediate, short-term impact on the market more than a longer term impact.

The model assumes flat demand for Russian LNG past 2025, while Russian pipeline exports to Europe remain low. What is the reasoning for the assumption that additional LNG demand would go to US LNG rather than lead Russia to increase its LNG exports globally? Is it because Russian LNG is at capacity?

Why are the US LNG exports under S5 not lower? It seems that if S5 is the same as S2, but effectively subsidizing a substitute for LNG (renewables), demand for LNG should be lower in S5 rather than essentially the same as in S2 (according to Figure ES-1).




S2: Market Response
CONSUMPTION
PRODUCTION
LNG EXPORTS
LNG IMPORTS
PIPELINE EXPORTS
PIPELINE IMPORTS
BCF/day
2020
2030
2040
2050
Region
ROW
Australia + NZ
LAC
Africa
C Asia + East Eur
Russia
China
India
Middle East
EU
Mexico
Canada
USA


GLOBAL PRIMARY ENERGY CONSUMPTION BY FUEL
S6: Energy Transition (Ref Exp)
S7: Energy Transition
EJ/yr
600
400
200
0
2020
2030
2040
2050
Fuel
oil
oil CCS
gas
gas CCS
coal
coal CCS
biomass
biomass CCS
nuclear
other renewables
GLOBAL GHG EMISSIONS BY SECTOR
S6: Energy Transition (Ref Exp)
S7: Energy Transition
Gt CO2e/yr
40
20
0
2020
2030
2040
2050
Sector
CO2 buildings
CO2 electricity
CO2 industry
CO2 other energy
CO2 transport
CH4 Energy
CH4 AgLanduse
N2O Energy
N2O AgLanduse
F-gases
CO2 bioenergy
CO2 direct air capture
CO2 LUC

From: Francisco De La Chesnaye
Sent: Fri, 26 May 2023 16:41:13 +0000
To: Iyer, Gokul; Binsted, Matthew; Wolfram, Paul; Whitman, Peter C; Daniel Hatchell; Riera, Jefferson; Curry, Thomas; Skone, Timothy
Cc: Wallace, Robert T. (CONTR); Yarlagadda, Brinda; Sweeney, Amy; Harker-Steele, Amanda J (NETL); Robert Wallace; Agboola, Ajoke; Jamieson, Matthew B.; Michael Blackhurst; Edmonds, James A (Jae)
Subject: [EXTERNAL] FECM LNG Export Project Coordination - Report Outlines
Attachments: DOE_FECM_LNG_2023_Analysis_Report_Outlines_GCAM _NEMS_V4.docx
Importance: High

*DISCUSION DRAFT*DELIBERATIVE*PRE-DECISIONAL*

All,

Please see updated Outlines for the GCAM and NEMS Analysis Reports as well as the Full Summary Report. There is also a proposed writing schedule for these at the end.

The PNNL and OnLocation teams have reviewed the Report Outlines. Need review of schedule and coordination with the NETL team on Task 3.

Best, Paco

Francisco De La Chesnaye | **Vice President**
m: (b) (6) | onlocationinc.com

ENERGY, ECONOMIC, AND ENVIRONMENTAL ASSESSMENT of U.S. LNG EXPORTS

Proposed Report Structure and Content (26 May 23)

Section	Pgs	Lead
I. EXECUTIVE SUMMARY (Identify and focus on Key Messages)	2	Paco, Gokul, Amanda + All Review
II. BACKGROUND ON LNG EXPORT STUDIES COMMISSIONED DEPARTMENT OF ENERG.Y	1	OL
(Lists of Tables, Figures, Acronyms and Abbreviations)		
III. INTRODUCTION		
A. Project Background	1	OL
B. Purpose of the Study	1	OL
C. Organization of the Report	0.5	OL
IV. STUDY METHODOLOGY, SCENARIO DESIGN, & KEY ASSUMPTIONS	0.5	OL
A. GCAM Model & Global Scenarios Design	2	PNNL
B. NEMS Models & U.S. Modeling Scenarios Design (including linkages between GCAM and NEMS)	3	OL
C. LCA Model & Scenarios Design	2	NETL
V. SUMMARY of ANALYSIS & ASSESSESMENT (organization desc)	0.5	OL
A. NATURAL GAS MARKET RESULTS	0.5	OL
1. Core Results for U.S. LNG Exports	3	
2. Natural Gas Henry Hub Prices	2	
3. U.S. LNG Export Revenues	2	
4. Role of U.S. in global market		
B. U.S. MACROECONOMIC OUTCOMES (only NEMS)	0.5	OL
1. Macroeconomic Effects - Total Economic Activity (GDP)	2	
2. Consumer Effects (Prices mainly)	2	
3. Aggregate Consumption and Investment Effects	1	
C. ENVIRONMENTAL OUTCOMES	1	Paco
1. Global Greenhouse Gas Results	3	PNNL
2. U.S. Greenhouse Gas Results	2	OL
3. LCA Results	3	NETL
4. Environmental Review	3	NETK
5. How to compare results across different modeling frameworks	2	Paco, Gokul, Amanda
Total	Min 40	
REFENCES	?	
(for sections below – each team is responsible for proposing own structure)		
APPENDIX A. Global Analysis and Description of GCAM	?	PNNL
APPENDIX B. U.S. Analysis and Description of NEMS-AOE23 and NEMS-FECM	?	OL
APPENDIX C. LCA Analysis and Description of Model	?	NETL

APPENDIX D. Environmental Issues Report	?	NETL

GCAM ASSESSMENT of U.S. LNG EXPORTS

Proposed Report Structure and Content (22 May 23)

Section	**Pgs**	**Lead**
I. EXECUTIVE SUMMARY (Identify and focus on Key Messages)		
(Lists of Tables, Figures, Acronyms and Abbreviations)		
II. INTRODUCTION (same as with NEMS and LCA Reports)		
A. Project Background		
B. Purpose of the Study		
C. Organization of the Report		
III. STUDY METHODOLOGY, SCENARIO DESIGN, & KEY ASSUMPTIONS		
A. GCAM Model & Global Scenarios Design		
B. NATURAL GAS MARKET RESULTS		
1. Role of U.S. in global market		
2. Global market for natural gas		
3. Core Results for U.S. LNG Exports		
4. Gas Prices ??		
C. Global Greenhouse Gas Results		
1. Carbon dioxide energy		
2. Methane from energy		
3. Other priority results		
REFENCES		
(for sections below – each team is responsible for proposing own structure)		
APPENDIX A. xxxx		

U.S. NEMS ENERGY & ECONOMIC ASSESSMENT of U.S. LNG EXPORTS
Proposed Report Structure and Content (22 May 23)

Section	**Pgs**	**Lead**
I. EXECUTIVE SUMMARY (Identify and focus on Key Messages)		
(Lists of Tables, Figures, Acronyms and Abbreviations)		
II. INTRODUCTION (same as with GCAM and LCA Reports)		
A. Project Background		
B. Purpose of the Study		
C. Organization of the Report		
III. STUDY METHODOLOGY, SCENARIO DESIGN, & KEY ASSUMPTIONS		
A. NEMS-AEO23 and FECM-NEMS Models		
B. Global and U.S. Modeling Scenarios Design (including linkages between GCAM and NEMS)		
A. NATURAL GAS MARKET RESULTS		
1. Core Results for U.S. LNG Exports		
2. Natural Gas Henry Hub Prices		
3. U.S. LNG Export Revenues		
4. Role of U.S. in global market		
B. U.S. MACROECONOMIC OUTCOMES (only NEMS)		
1. Macroeconomic Effects - Total Economic Activity (GDP)		
2. Consumer Effects (Prices mainly)		
3. Aggregate Consumption and Investment Effects		
C. ENVIRONMENTAL OUTCOMES		
1. U.S. Greenhouse Gas Results		
REFENCES		
(for sections below – each team is responsible for proposing own structure)		
APPENDIX X.		

*DISCUSION DRAFTS*DELIBERATIVE*PRE-DECISIONAL*

Proposed Working Schedule –

	PPNL and OL Teams	
Dates w/o	**MODELING AND ANALYSIS**	**Report Writing**
5/21/2023	GCAM and NEMS (AEO23 & FECM) LOCK down modeling inputs and assumptions. GCAM & NEMS Runs on Sce 1 to 5	Start on drafts Sections (OL) Background On LNG Export Studies Introduction & Scenario Design
5/28/2023	Final Runs Sce 1 to 6 & REVIEW	Start Working drafts of GCAM & NEMS Reports
6/4/2023	Finalize ALL MODEL Runs **To whom do we need to brief the results to finalize?** GCAM and NEMS Final Results	
6/18/2023		Shareable Drafts of GCAM & NEMS Reports
7/2/2023		Final Drafts of GCAM & NEMS Reports Initial Draft of Summary Report
7/9/2023		Final Version of GCAM & NEMS Reports
7/17/2023		Final Draft of Summary Report for FECM Review
Tuesday Aug 1		Final Version of Summary Report Appendices and Data Annexes Appendices: Model Descriptions
		Beyond FECM Review Steps?
9/30/2023		FINAL VERSION

Need to Coordinate with NETL on Task 3 Analysis & Report

From: Matthews, Howard Scott (CONTR)
Sent: Fri, 21 Jul 2023 20:52:30 +0000
To: Francisco De La Chesnaye; Iyer, Gokul; Edmonds, James A (Jae); Binsted, Matthew; Wolfram, Paul; Whitman, Peter C; Daniel Hatchell; Riera, Jefferson
Cc: Curry, Thomas; Yarlagadda, Brinda; Sweeney, Amy; Harker-Steele, Amanda J (NETL); Robert Wallace; Agboola, Ajoke; Wallace, Robert T. (CONTR); Scott Matthews; Skone, Timothy
Subject: RE: FECM LNG Export Project Coordination
Attachments: LNG Task 3 Progress Update.pptx

All: As promised, here are the Task 3 Progress Update slides for today.

-Scott

From: Francisco De La Chesnaye <francisco.delachesnaye@onlocationinc.com>
Sent: Friday, July 14, 2023 12:02 PM
To: Iyer, Gokul C <Gokul.Iyer@pnnl.gov>; Edmonds, James A (Jae) <jae@pnnl.gov>; Binsted, Matthew T <matthew.binsted@pnnl.gov>; Wolfram, Paul <paul.wolfram@pnnl.gov>; Peter Whitman <peter.whitman@onlocationinc.com>; Daniel Hatchell <daniel.hatchell@onlocationinc.com>; Jefferson Riera <jefferson.riera@onlocationinc.com>
Cc: Curry, Thomas <thomas.curry@hq.doe.gov>; Yarlagadda, Brinda N <brinda.yarlagadda@pnnl.gov>; Sweeney, Amy R <amy.sweeney@hq.doe.gov>; Harker Steele, Amanda J. <Amanda.HarkerSteele@netl.doe.gov>; Robert Wallace <robert.wallace@keylogic.com>; Agboola, Ajoke <ajoke.agboola@hq.doe.gov>; Wallace, Robert T. (CONTR) <Robert.Wallace@NETL.DOE.GOV>; Scott Matthews <scott.matthews@keylogic.com>; Matthews, Howard Scott (CONTR) <Scott.Matthews@netl.doe.gov>; Skone, Timothy J <timothy.skone@hq.doe.gov>
Subject: [EXTERNAL] FECM LNG Export Project Coordination

For today

LNG Analysis: Task 3 Progress Update

Scott Matthews, NETL

July 21, 2023

U.S. DEPARTMENT OF ENERGY

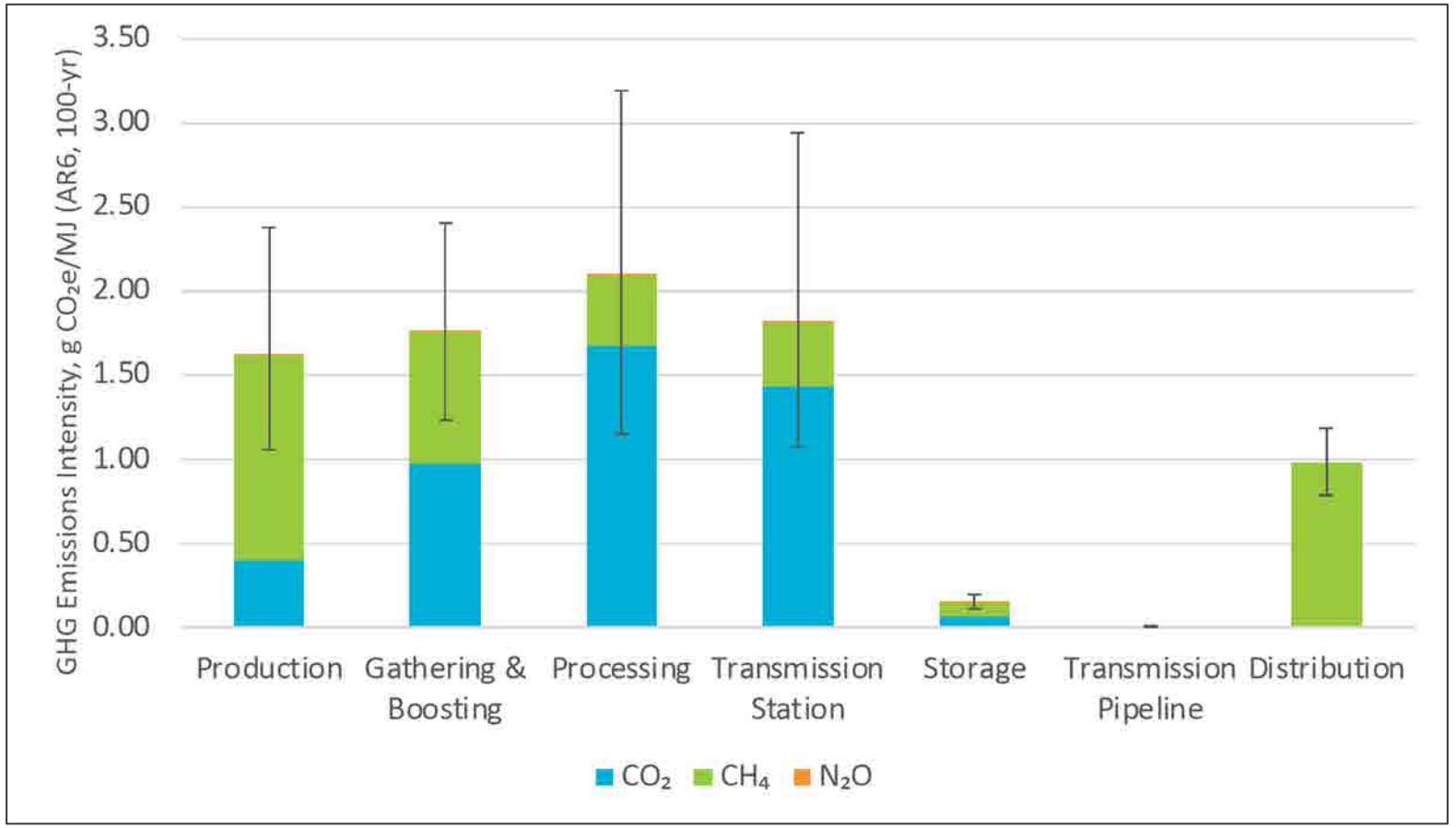
NATIONAL ENERGY TECHNOLOGY LABORATORY

Task 3 Update

- **Continue to explore all the places where GHG emissions are modeled in GCAM**
  - But our focus of course is on the NG sector
- **We had originally created "trace" code to follow inputs and outputs of GCAM sectors, which, aids with NETL/GCAM comparisons, specifically to the NG sector**
  - We know from NETL NG modeling work how stages are typically framed and bounded

Sample NETL NG Model Results by Stage

From upcoming 2020 version of report



Example NETL-GCAM mapping

And how at this point we would be doing it..

GCAM Sector	NETL LCA Stage	Comments/Potential mapping inaccuracy
delivered gas	NA	No emission values for delivered gas in the GCAM sector (possible market exchange sector), therefore the mapping of this sector with the NETL stage isn't feasible.
gas pipeline	Pipeline	
gas processing	Processing	Both GCAM and NETL stages report "processing" emission. However, the issue with this mapping is the allocation to the products being considered within "total gas processed", i.e., biomass gasification is also considered to be the input within GCAM sector processing, which is not the case for the NETL processing stage.
regional natural gas	Production + Gathering & Boosting + Processing + Transmission + Storage	"Region" in GCAM model stands for geopolitical region, which for the NETL stage was assumed as consisting of all the natural gas production through storage stages, since it considers the case of United States only.

Task 3 Update (cont.)

- **We had originally created "trace" code to follow inputs and outputs of GCAM sectors, which, aids with NETL/GCAM comparisons, specifically to the NG sector**
  - We know from NETL NG modeling work how stages are typically framed and bounded
  - Main underlying challenge is that there are 'pockets' of GHG emissions represented in lots of places that are not explicitly shown as connected to the NG sector
  - And we continue to find, through discussions with PNNL, that there are more
  - As a result, we are not actively using the trace code any more

- **Received info from Matt Binsted a week-ish ago about IEA *energy* data used in the "other industrial energy use" sector**
  - We hope to get the GHG associated data soon.
- **We are also doing a sensitivity analysis on the "adder" results, to ensure we see the relative contribution of NG sector emissions on the adders**
  - Preliminary results of this show that these emissions are small.

Things We Need

- **Remaining Model Runs (sounds like last ones being done now, for S1, to be delivered next week)**
  - This timeline is not hindering us at this point

- **IEA data with GHG emissions (to verify)**
  - This will help us finalize the NETL-GCAM modifications, if any, to be done

Timeline

- We expect to be done with our background analyses and GCAM sector mapping middle of next week
- We have begun writing up our work, as a memo, for eventual chapter. Will be updating it every week or so to keep up.
- Expect middle of August to have a credible draft of all LCA-related work

From: Skone, Timothy J.
Sent: Fri, 3 Feb 2023 19:16:41 +0000
To: Sweeney, Amy
Cc: Morreale, Bryan (NETL); Gerdes, Kirk (NETL); Gerdes, Kristin (NETL); Richardson, Steven (NETL); Whyte, Cliff (NETL); Balash, Peter (NETL); Cunha, Luciane B (NETL); Borek, Sandra L. (NETL); Waller, John W. (CONTR); Johnson, Sarah B (CONTR)
Subject: Revised Alaska LNG Analysis Support FWP - Ready for Signature
Attachments: NETL RIC FY21 Alaskan LNG Analysis Support FWP 1022483_20230203_Update_RIC.pdf

Amy,

Please find attached the updated Field Work Proposal for supporting the Alaska LNG SEIS project at NETL.

The revised FWP does two primary things:

1. Updates the costs incurred by each Task and Subtask to reflect the cost updates and allocations within the project.
    a. A summary of the cost changes from the original FWP to this revision is included on Page 2 of the embedded PDF file.
2. Provides the documentation for the NEPA Task 1.b support cost increase request of $59,100. This is the total amount being requested for transfer to NETL to complete the funding required to support this project.
    a. The requested increase is documented as “Phase 2, FY23 Funding” within the revised FWP to keep it separate from the original FWP funding elements.

This has been a great project and NETL has been honored to provide the analytical support for this effort as it comes to close in the near future.

If you have any questions please feel free to reach out directly.

At your earliest convenience please (1) sign and return the attached revised FWP and (2) transfer the remaining funding request of $59,100 to NETL.

FWP NO: 1022483
FWP Title: Alaskan LNG Analysis Support
Funding Amount: $59,100.

Respectfully,

Tim Skone

U.S. DEPARTMENT OF ENERGY

RIC Field Work Proposal

Document 79 - Attachment

1. FWP Number:	2. Revision Number:	3. Date Prepared:
1022483	0, Update 1	02/03/2023

4. Field Work Proposal Title:
Alaskan LNG Analysis Support

5. Program Funding:
1611460-Import Export Authorization

6. Field Work Proposal Term: 08/01/2021 through 03/31/2023

7. RIC Technical Portfolio Lead: Timothy Skone

8. FECM-HQ Program Manager and Phone Number:
Amy Sweeney, 202-586-2627

9. HQ Organization:
Fossil Energy and Carbon Management

10. S&T SPP Technology Manager:
None

11. Program Office:
Office of Resource Sustainability

12. Public Abstract:

The U.S. Department of Energy (DOE), Office of Fossil Energy and Carbon Management (FECM) announced its intent to prepare a supplemental environmental impact statement (SEIS) for the Alaskan liquified natural gas (LNG) Project (DOE/EIS-0512-21) on (1) the potential environmental impacts associated with natural gas production on the North Slope of Alaska and (2) a life cycle analysis (LCA) calculating the greenhouse gas (GHG) emissions for LNG exported from Alaska by vessel to import markets in Asia and potentially in other regions. A Notice of Intent was issued on the DOE website on June 30, 2021, with a formal notification in the Federal Register on July 2, 2021.

The objective of the Alaskan LNG Analysis Support Field Work Proposal (FWP) is to provide the analysis support to complete the following in support of the DOE/FECM development of the SEIS as proposed in the Notice of Intent. The following two efforts will be conducted:

1. Upstream Study
   a. Upstream Oil and Natural Gas Production Study
   b. Non-GHG Environmental Impact Assessment and SEIS Documentation and Process Workflow Management
2. LCA Study
   a. LNG Export LCA GHG Study

This project is anticipated to start in August 2021 and conclude in March 2023.

13. Approval Signatures:

Associate Laboratory Director for Research & Innovation

FECM-HQ Program Manager

14. Detailed Attachments:

FY21 Alaskan LNG Analysis Support FWP 1022483_20230203_Update

Alaskan LNG Analysis Support
FY21 Field Work Proposal (FWP)

Public Abstract

The U.S. Department of Energy (DOE), Office of Fossil Energy and Carbon Management (FECM) announced its intent to prepare a supplemental environmental impact statement (SEIS) for the Alaskan liquified natural gas (LNG) Project (DOE/EIS-0512-21) on (1) the potential environmental impacts associated with natural gas production on the North Slope of Alaska and (2) a life cycle analysis (LCA) calculating the greenhouse gas (GHG) emissions for LNG exported from Alaska by vessel to import markets in Asia and potentially in other regions. A Notice of Intent was issued on the DOE website on June 30, 2021, with a formal notification in the Federal Register on July 2, 2021.

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    a. Upstream Oil and Natural Gas Production Study
    b. Non-GHG Environmental Impact Assessment and SEIS Documentation and Process Workflow Management
2. LCA Study
    a. LNG Export LCA GHG Study

This project is anticipated to start in August 2021 and conclude in March 2023.

FWP Summary Budget Table

The following FWP Summary Budget Table includes the following adjustments to the project from the original FWP, signed July 2021, by the FECM-Headquarters (HQ) Program Manager.

- Task 1.a "Upstream Oil and Natural Gas Production Study" scope was expanded to include the assessment of viable carbon management strategies on the North Slope. This resulted in additional reports being produced to assess the geologic storage potential and the carbon dioxide enhanced oil recovery (CO_2-EOR). Two additional reports were produced and delivered, as well as subject matter expert support to respond to the public Draft SEIS comments related to the Upstream Oil and Natural Gas Production Study reports. This expansion of scope changes the estimate to complete for Task 1.a from $235,000 to $365,000—a $130,000 increase.
  - Production Report 2–Impacts of PBU Major Gas Sales on Oil Production and CO_2 Storage Potential, dated May 20, 2022.
  - Production Report 3–Storing Byproduct CO_2 from the Alaska LNG Gas Treatment Plant at the Prudhoe Bay Unit, dated April 5, 2022.
- Task 1.b "Non-GHG Environmental Impact Assessment and SEIS Documentation and Process Workflow Management" scope was increased to address the extended project timeline to allow the additional work on carbon management strategies to progress forward and additional scope to address substantial Draft SEIS comment responses and coordination with FECM-HQ. For example, the Draft Final SEIS was amended to include the social cost of the carbon impact assessment and expanded discussion of impacts to permafrost and impacts from black carbon. This resulted in two cost increases to the original site support estimate of $75,000 in September 2022 and $59,100 in January 2023. This resulted in a net increase in the Task 1.b value by $134,100. However, the Task 1.b original cost estimate was estimated by the government at the time of the FWP (July 2021). The original government estimate exceeded the site support fixed cost award by $249,000. These funds were re-allocated to Task 1.a (described above) and Task 1.c (described below). The net change to Task 1.b from the original FWP estimate is a reduction from $833,000 to $768,100—a net decrease of $64,900.
- Task 1.c "LNG Export Life Cycle Analysis (LCA) Greenhouse Gas (GHG) Study" scope was increased from the original estimate to include the assessment of carbon management strategies, an expanded discussion of qualitative global market drivers that may affect LNG market viability, expanded scenario matrix count, and responding to substantial external and internal Draft SEIS comments. The cost estimate for Task 1.c was increased from $100,000 to $175,000—a $75,000 increase.
- Other FWP cost plan adjustments include a reduction of $7,000 in project contingency to account for the difference in funding received and the original FWP cost estimate. The reduction was removed from Task 1.b. The second adjustment was another reduction in project contingency of $25,000 in project funding that was returned to FECM-HQ at the end of fiscal year 2022 (FY22).

The revised FWP Summary Budget Table, inclusive of the changes noted above, is provided below. The difference between the original July 2021 FWP estimate of $1,283,000 and the revised January 2023 FWP estimate of $1,402,000 is $119,000. All changes, except the January 2023 increase of $59,100, is applied to the Phase 2 FY22 Funding column in the table. The Task 1.a increase of $59,100 is included in the table as Phase 2 FY23 Funding. The Phase 2 FY23 Funding column also denotes the remaining funding to be provided to the National Energy Technology Laboratory (NETL) to complete the project.

Task	Task Title	NETL Program Number	Phase 1, FY21 Funding ($k)	Phase 2, FY22 Funding ($k)	Phase 2, FY23 Funding ($k)	Total to Complete
1	Alaskan LNG Analysis Support	1611460	$575	$674	$59.1	**$1,308**
1.a	*Upstream Oil and Natural Gas Production Study* *NETL RIC Funding (100%)*	1611460	*$235*	*$130*	*$0*	***$365***
1.b	*Non-GHG Environmental Impact Assessment and SEIS Documentation and Process Workflow Management* *NETL NEPA Funding (100%)*	1611460	*$280*	*$429*	*$59.1*	***$768***
1.c	*LNG Export Life Cycle Analysis (LCA) Greenhouse Gas (GHG) Study* *NETL RIC Funding (100%)*	1611460	*$60*	*$115*	*$0*	***$175***
Z	FWP Execution and Shared Research Costs *NETL RIC Funding (100%)*	1611460	$46	$38	$0	**$85**
	Subtotal(s)		**$621**	**$712**	**$59.1**	**$1,393**
	Laboratory-Directed Research & Development *NETL RIC Funding (100%)*		$4	$5	$0	**$9**
Plan Total Budget	**Grand Total**		**$626**	**$717**	**$59.1**	**$1,402**

NETL Funding Allocation FWP Summary	NETL Program Number	Phase 1, FY21 Funding ($k)	Phase 2, FY22 Funding ($k)	Phase 2, FY23 Funding ($k)	Total to Complete
Research & Innovation Center (RIC)	1611460	$346	$288	$0	$634
National Environmental Policy Act (NEPA)	1611460	$280	$429	$59.1	$768
Total		**$626**	**$717**	**$59.1**	**$1,402**

Background

The U.S. DOE-FE announced its intent to prepare a SEIS for the Alaskan LNG Project (DOE/EIS-0512-21) on (1) the potential environmental impacts associated with natural gas production on the North Slope of Alaska and (2) a LCA calculating the GHG emissions for LNG exported from Alaska by vessel to import markets in Asia and potentially in other regions. A Notice of Intent was issued on the DOE website on June 30, 2021, with a formal notification in the Federal Register on July 2, 2021.

Objective

The objective of this FWP is to provide the analysis support to complete the following in support of the DOE/FECM development of the SEIS as proposed in the Notice of Intent. The following two efforts will be conducted:

1. Upstream Study
    a. Upstream Oil and Natural Gas Production Study
    b. Non-GHG Environmental Impact Assessment and SEIS Documentation and Process Workflow Management
2. LCA Study
    a. LNG Export LCA GHG Study

Approach

Task 1.a Upstream Oil and Natural Gas Production Study

NETL will examine the potential upstream impacts of natural gas production on the North Slope of Alaska for purposes of exporting the natural gas in the form of LNG, including:

1. Determining technical performance changes in oil and natural gas production operations necessary to support Alaska LNG's exports. Specifically, the work will:
    a. Determine the extent of new production necessary to accommodate the Alaska LNG Project through the life of DOE's 30-year authorization (to include Alaska LNG's authorized 2.55 Bcf/d of exports, as well as additional volumes for off-take within Alaska, compression, and liquefaction), and the likely timing (and other relevant details) of that production.
        - The Federal Energy Regulatory Commission's (FERC's) environmental impact statement (EIS) includes the following information from the sponsor of the Alaska LNG Project:

            "[T]he Alaska LNG Project would not induce development of additional production fields, at least in the initial years of its operation." Specifically, "the Project would be fully utilized by natural gas produced from wells already drilled on the North Slope for about 20 years before there would be available pipeline capacity for new production."

        – The SEIS would need to make a finding on this statement and assure the National Environmental Policy Act (NEPA) review is inclusive of the impacts of production to support the Alaska LNG, both the production contemplated within the original EIS, as well as any additional production beyond what was contemplated in the EIS.

b. Determine the expected technical performance changes necessary to divert some portion of current North Slope natural gas production, currently used for enhanced oil recovery (EOR), to support Alaska LNG's exports, including:

- Changes in the production and handling of CO_2 produced with oil and natural gas, including the likely volume of CO_2 produced from processing natural gas for pipeline conditions (CO_2 and carbon intensity findings will also inform the LCA Study—see below).
- Actions that will be necessary for oil producers to maintain reservoir pressure and oil production with a reduced volume of natural gas available for reinjection.

NETL will use public data to construct three representative Sector Models for the Prudhoe Bay Oil Pool to address the three oil recovery practices being used in the three distinct portions of the Prudhoe Bay Oil Pool. The following three Sector Modeling approaches will be developed:

1. *Gravity Drainage*. An analytical gravity drainage model for Sector 1 will be based on the volume of remaining reserves in the central portion of the Prudhoe Bay Oil Pool still under primary production and relative rate of oil and natural gas production over time.
2. *Waterflood*. A finite difference streamtube model for waterflooding operations in Sector 2 will be developed using the CO_2 Prophet Model to evaluate the remaining oil and natural gas production potential from this portion of the Prudhoe Bay Oil Pool using waterflood operations.
3. *Miscible Gas Flood*. A finite difference streamtube model for miscible hydrocarbon injection in Sector 3 will be developed using the CO_2 Prophet Model to evaluate the remaining oil and natural gas production potential from the portion of the Prudhoe Bay Oil Pool using miscible gas injection.

The following three cases will be modeled with each of the Sector Models. The results from each Sector Model will be combined, based on the three cases, to generate three impact assessments. Each impact assessment will include an overall oil production potential and carbon intensity estimation for the Prudhoe Bay Oil Pool. Cases 2 and Case 3 (if determined to be applicable) will be represented within the Non-GHG Environmental Impact Assessment (Task 1.b) and the LCA Study (Task 1.c).

1. *Case 1 "Business as Usual."* This case will determine the expected volume and carbon intensity of the oil production by each Sector Model, where natural gas produced from the Prudhoe Bay Oil Pool is reinjected into portions of the reservoir, and reservoir pressure is maintained. Case 1 will assume current production practices are maintained, and no additional optimization of Prudhoe Bay Oil Pool production takes place.
2. *Case 2 "Pressure Depletion."* This case will determine the expected volume and carbon intensity of the oil production by each Sector Model, where a portion of the natural gas produced from the Prudhoe Bay Oil Pool is exported for the Alaska LNG Project. Case 2 will establish the level of pressure drop that would occur across the production sectors consistent with the volume of natural gas exported from the field over time, with no additional injection of fluids into the reservoir for pressure maintenance.
3. *Case 3 "Pressure Maintenance."* This case will determine the expected volume and carbon intensity of the oil production by each Sector Model, where a portion of the natural gas produced from the Prudhoe Bay Oil Pool is exported and a variety of actions are taken by the operator to help mitigate the expected decline in reservoir pressure over time. Case 3 will assume reservoir pressure is maintained, to the extent possible, through injection of a combination of water, CO_2, and/or miscible gas, as required.

The effort will determine the additional activity and notable additional water and miscible gas injection required to maintain pressure in the Prudhoe Bay Oil Pool, required for Case 3. This would include additional gas supplies from the Point Thomson and possibly other fields near the Prudhoe Bay Oil Pool included within Case 2. The effort will also provide an assessment of the additional volumes of CO_2 captured at the gas plant for each study case (as applicable) and the overall volumes of CO_2 stored as part of the EOR operations. And finally, the effort will estimate the scope of additional resource required to meet the expected natural gas export volume of 2.55 Bcf/d, if needed. This would include additional development of natural gas production from other nearby oil fields.

The primary outcome of this effort will be a report outlining the results of three production assessments with documentation defining the reservoir characteristics, model parameters, and assumptions used to develop the three Sector Models. The results of this effort will be transitioned to Tasks 1.b and 1.c to be used as the basis of the non-GHG and GHG environmental assessments.

This effort is estimated to take approximately 6 months to complete and will be quick started as soon as funding is available on the NETL cost plus award fee site support contract, herein referred to as the "Mission Execution and Strategic Analysis (MESA) site support contract."

Task 1.b Non-GHG Environmental Impact Assessment and SEIS Documentation and Process Workflow Management

NETL will determine the potential environmental impacts resulting from changes in upstream oil and gas operations identified in item (1.a) (to the extent not already analyzed in the EIS due to the scope limitations of that document) on the following resource areas, as required by NEPA:

a. Geology
b. Soils
c. Water quality and aquatic resources
d. Wetlands
e. Vegetation
f. Wildlife
g. Land use and visual resources
h. Socioeconomics and environmental justice
i. Transportation
j. Cultural resources
k. Subsistence
l. Air quality
m. Noise

This effort will also provide the necessary support for SEIS documentation and process workflow for the final SEIS documents, assessing and responding to public comments, and final SEIS documents. Tasks 1.a and 1.c will provide technical support for response to public comments in support of this effort.

This effort will be supported in the following two phases to align with programmatic funding resource allocations. Key activities to be conducted within each phase are outlined below.

Phase 1 Support (September 2021–November 2021)

1. Project Management and Meetings Attendance
2. Internal SEIS Scoping
    a. Review Alaska LNG Project EIS, supporting documentation, and supplementary data to evaluate available data and resources, and potential data needs required to prepare the SEIS.
    b. An internal scoping document will document the review findings.
3. Data Collection, Gap Analysis, and Approach
    a. Develop environmental impact assessment approach, collect data, and assess knowledge gaps.
    b. Review and assess findings from Task 1.a Upstream Oil and Natural Gas Production Study.

Phase 2 Support (November 2021–March 2023)

1. Preliminary Draft SEIS (version 1 and 2)
    a. Prepare Preliminary Draft SEIS (version 1) for DOE review and comment.
    b. Coordinate as necessary with DOE on comment resolution.
    c. Prepare Preliminary Draft SEIS (version 2) for DOE review and comment.
    d. Coordinate as necessary with DOE on comment resolution.
2. Concurrence Draft and Draft EIS
    a. Prepare Concurrence Draft for DOE approval.
    b. Resolve comments (if necessary).
    c. Prepare 508 compliant version of the Draft SEIS for posting to DOE website.
    d. Support DOE in preparation and publication of the Draft SEIS Notice of Availability (NOA).
3. Public Hearings and Comments
    a. Develop a brief public participation plan.
    b. Support virtual public hearing(s), including preparation of presentation materials, fact sheets, and other documents.
    c. Process and manage comments received on the Draft SEIS.
    d. Prepare comment management report.
    e. Support DOE in developing responses to comments received.
    f. Prepare comment response document for inclusion in Final SEIS.

4. Final SEIS
    a. Prepare Preliminary Final SEIS (version 1) for DOE review and comment.
    b. Coordinate as necessary with DOE on comment resolution.
    c. If necessary, prepare Preliminary Draft SEIS (version 2) for DOE review and comment.
    d. Coordinate as necessary with DOE on comment resolution.
    e. Prepare Concurrence Final for DOE approval.
    f. Resolve comments (if necessary).
    g. Prepare 508 compliant version of the Final SEIS for posting to DOE website.
    h. Support DOE in preparation and publication of the Final SEIS NOA.
5. Record of Decision and Administrative Record
    a. Support preparation of Administrative Record throughout the project.
    b. Support DOE in the development of a Record of Decision.
    c. Review and assist DOE in the Final Administrative Record.
    d. Review and coordinate any responses in the Final SEIS.

This effort is estimated to take approximately 12 months to complete and will start upon award of a competitive fixed price contract vehicle for NEPA contact vehicle accessible to NETL. An award is anticipated to be made by the end of September or early October 2021. The procurement will request work in two options to align the work with DOE funding resources. The first option will provide support for activities planned to be conducted within the first 60-days of the effort. The second option will be started upon receipt of FY22 funding.

Task 1.c LNG Export Life Cycle Analysis (LCA) Greenhouse Gas (GHG) Study

NETL will assess the life cycle GHG emissions of Alaskan North Slope extraction, intrastate pipeline transport, liquefaction, ocean transport, regasification in Asia, and natural gas combined cycle power production for electricity production. The report will be like the 2014 and updated 2019 studies that examined U.S. LNG exports from the lower-48 states, but it will consider the unique attributes of natural gas production in Alaska and Alaska LNG's proposed export project. The Alaskan LNG LCA Export Study will only include deliver to Asian markets, unlike the 2014 and 2019 reports that also included European delivered destinations. Specifically, the LCA will consider natural gas sourced on the North Slope, transported through Alaska on an approximately 800-mile long pipeline to Alaska LNG's proposed liquefaction facility, and exported by vessel from south central Alaska to markets in Asia (Japan, China, South Korea, and India)—as compared to LNG sourced from Australia and Qatar to markets in Asia.

The LCA will include scenarios consistent with the current EIS proposed plan and any additional production scenarios identified from Task 1.a Upstream Oil and Natural Gas Production Study.

The results of this effort will be an "Alaskan LNG LCA Export Study." The study will be included as a document within the SEIS.

This effort is estimated to take approximately 12 months to complete and will be quick started as soon as funding is available on the MESA site support contract. This effort will also provide project management coordination and meeting support as needed throughout the project.

Task Milestones Table

Identifier	Task	Expected Completion Date	Description (What, How, Who, Where)
1	1.a, 1.c	08/02/2021	Initiate work under MESA site support contract.
2	1.b	10/01/2021	Initiate work under competitive firm fixed price contract.
3	1.a	01/14/2022	Draft final production assessment for each case.
4	1.a	03/31/2022	Draft summary presentation to project team on key findings.
5	1.c	04/08/2022	Draft LCA results briefing to project team on key findings.
6	1.c	04/15/2022	Draft Final Alaskan LNG LCA Export Study to project team.
7	1.b	05/02/2022	Preliminary Draft SEIS ready for project team review.
8	1.b	08/07/2022	Comment response document for inclusion in Final SEIS ready for project team review.
9	1.b	08/26/2022	Final SEIS, ready for project team review.
10	1.b	01/2023	Record of Decision and administrative record completed.

Task Deliverable Table

Regular progress meetings/briefings will serve the role for task activity status and progress in lieu of written quarterly progress reports for this FWP.

Identifier	Task	Deliverable Title	Expected Completion Date	Description
1	1.a	Alaska North Slope Oil and Natural Gas Production Assessment	03/16/2022	NETL Report
2	1.b	SEIS Scoping Document	12/10/2021	Internal Project Report
	1.c	Alaskan LNG LCA Export Study	04/08/2022	NETL Report
3	1.b	Preliminary Draft SEIS	05/02/2022	Internal Project Report
4	1.b	Concurrence Draft SEIS	05/30/2022	SEIS Report, 508 Web-Compliant for Posting
5	1.b	Release Draft SEIS	07/01/2022	Out for Public Comment (30 days)
6	1.b	Comment/Response Report	08/26/2022	Internal Project Report
7	1.b	Comment Response Document for Inclusion in Final SEIS	09/12/2022	Project Report, For External Use
8	1.b	Preliminary Final SEIS	10/03/2022	SEIS Report
9	1.b	Concurrence of Final SEIS	10/19/2022	SEIS Report, 508 Web-Compliant for Posting
10	1.b	Record of Decision and Administrative Record	02/10/2023	Project Report and Posting to Federal Register

Task-Level Budget Detail

Phase 1 Budget (FY21 Funding)

Cost Category	Task 1.a		Task 1.b		Task 1.c		Total	
	~FTEs	$k	~FTEs	$k	~FTEs	$k	~FTEs	$k
Contract Labor	0.8	235	0.7	280	0.3	60	1.2	575
Travel	--	0	--	0	--	0	--	0
Training	--	0	--	0	--	0	--	0
Equipment	--	0	--	0	--	0	--	0
Supplies	--	0	--	0	--	0	--	0
Other	--	0	--	0	--	0	--	0
Federal FTEs	0.05	--	0.03	--	0.03	--	0.2	--
TOTAL:	**0.85**	**235**	**0.73**	**280**	**0.33**	**60**	**1.4**	**575**

Full Time Equivalent (FTE) = 2,080 hours per year.

Phase 2 Budget (FY22 Funding)

Cost Category	Task 1.a		Task 1.b		Task 1.c		Total	
	~FTEs	$k	~FTEs	$k	~FTEs	$k	~FTEs	$k
Contract Labor	0.4	130	1.0	429	0.6	115	2.0	674
Travel	--	0	--	0	--	0	--	0
Training	--	0	--	0	--	0	--	0
Equipment	--	0	--	0	--	0	--	0
Supplies	--	0	--	0	--	0	--	0
Other	--	0	--	0	--	0	--	0
Federal FTEs	0	--	0.07	--	0.03	--	0.1	--
TOTAL:	**0.4**	**130**	**1.07**	**429**	**0.63**	**115**	**2.1**	**674**

Full Time Equivalent (FTE) = 2,080 hours per year.

Phase 2 Budget (FY23 Funding)

Cost Category	Task 1.a		Task 1.b		Task 1.c		Total	
	~FTEs	$k	~FTEs	$k	~FTEs	$k	~FTEs	$k
Contract Labor	0.0	0	0.14	59.1	0.0	0	0.14	59.1
Travel	--	0	--		--	0	--	0
Training	--	0	--	0	--	0	--	0
Equipment	--	0	--	0	--	0	--	0
Supplies	--	0	--	0	--	0	--	0
Other	--	0	--	0	--	0	--	0
Federal FTEs	0	--	0.01	--	0	--	0.01	--
TOTAL:	**0**	**0**	**0.15**	**59.1**	**0.00**	**0**	**0.15**	**59.1**

Full Time Equivalent (FTE) = 2,080 hours per year.

Total Project Budget (Phase 1 Plus Phase 2 FY22 Plus Phase 2 FY23 Funding)

Cost Category	Task 1.a		Task 1.b		Task 1.c		Total	
	~FTEs	$k	~FTEs	$k	~FTEs	$k	~FTEs	$k
Contract Labor	1.2	365	1.8	768.1	0.9	175	3.9	1,308
Travel	--	0	--	0	--	0	--	0
Training	--	0	--	0	--	0	--	0
Equipment	--	0	--	0	--	0	--	0
Supplies	--	0	--	0	--	0	--	0
Other	--	0	--	0	--	0	--	0
Federal FTEs	0.05	--	0.1	--	0.1	--	0.2	--
TOTAL:	**1.25**	**365**	**1.9**	**768.1**	**1.0**	**175**	**4.2**	**1,308**

Full Time Equivalent (FTE) = 2,080 hours per year.

Task Z: FWP Execution and Shared Research Costs Summary

Task Z is comprised of scope in the following cost categories:

- FWP Execution Costs—Scope that extends across the tasks in the FWP and can be attributed and explicitly costed to a specific FWP and program.
- RIC Shared Research Costs—The FWP's contribution to scope that extends across multiple FWPs ("RIC Shared Research Costs").

Task Z is divided into five Subtasks as described below:

Subtask 1: Project Management (FWP Execution Costs)

Project management functions are led by Federal staff via the Project Manager (PM) and the Technical Portfolio Lead (TPL). Supplemental contractor staff is used as needed. The following scope is performed by a combination of Federal and contractor staff:

- Milestone tracking and reporting.
- Budget development and updates, funding requests and tracking, and cost reporting.

All contractor project management costs are in the "FWP Execution Costs" category.

Subtask 2: Research Equipment & Operations Support (FWP Execution Costs*)

Engineering; operations; quality assurance; and environmental, safety, and health (ES&H) support are required to maintain and update existing laboratory projects and design and permit new laboratory projects in direct support of the FWP. Continuing laboratory research requires a baseline level of on-going support including annual assessments, addition of approved chemicals, equipment calibration, modest changes requiring engineered design, trained technician installation, inspection, training, etc. New laboratory projects and major modifications require design, construction, and commissioning. If applicable, major modifications and new projects in FY21 or anticipated in FY22 or FY23 associated with this FWP are as listed below:

- None.

Funding for this support is included in all FWPs with a laboratory research component and excluded from any with exclusively computational tasks. The above scope is budgeted and costed as "FWP Execution Costs."

* *In addition, a small portion of this Subtask supports "Shared Research Costs" for equipment maintenance and calibration agreements for equipment that crosses multiple FWPs. The distribution of these shared research costs is based on FWP usage of the RIC directorate that has ownership of the agreements.*

Subtask 3: Research Computing (RIC Shared Research Costs)

Research and scientific computing support includes maintaining the Center for High Performance Computing, Joule 2.0 Supercomputer, Center for Data Analytics and Machine Learning, Energy Data eXchange (EDX®), and research computing communications. Also included is software that is used across multiple FWPs. The distribution of these "Shared Research Costs" is based on FWP usage of the RIC directorate that has ownership of the software/computational need, where applicable.

Subtask 4: Multi-Program Analyses, Data, and Information (RIC Shared Research Costs)

This includes subscriptions and data acquisition required to perform research and analysis across multiple FWPs and the Advanced Systems and Market Analysis (ASMA) FWP. This FWP is reviewed separately with HQ and includes the following: (1) conduct analyses that support and defend the broader FE Mission with respect to relevance and value (cumulative FE benefits across multiple programs), (2) develop tools and capabilities that serve multiple FE programs (difficult to align accountability to a single program), and (3) establish quality guidelines and baselines (for comparing NETL advanced technologies). The distribution of these "Shared Research Costs" is based on each FWP's usage of the RIC directorate that has ownership of the ASMA FWP and subscription/data agreements (primarily Strategic Systems Analysis & Engineering [SSAE]).

Subtask 5: Research Business Process Support (RIC Shared Research Costs)

Included here are costs associated with maintaining the business processes and tools to develop and maintain budgets, track deliverables and milestones, and ensure quality control on work products. These "Shared Research Costs" are distributed across all FWPs based on the size of the FWP.

Subtask Budget Detail Table

The budget detail for each Subtask is provided below:

Subtask	Task Title	NETL Program Number	FWP Execution Costs ($k)	FWP Contribution to RIC Shared Resource Costs ($k)	Total Task Z ($k)
1	Project Management	1611460	$8	$0	**$8**
2	Research Equipment & Operations Support	1611460	$0	$0	**$0**
3	Research Computing	1611460	$0	$33	**$33**
4	Multi-Program Analyses, Data, and Information	1611460	$0	$28	**$28**
5	Research Business Process Support	1611460	$0	$15	**$15**
	Subtotal(s)		**$8**	**$77**	**$85**
	Grand Total		**$8**	**$77**	**$85**

Note: The Total may not equal the sum of parts due to internal rounding.

From: Nunez-Lopez, Vanessa
Sent: Mon, 27 Mar 2023 16:04:14 +0000
To: Rogers, John D.
Cc: Provenzano, Anthony (NETL)
Subject: RE: Updated LNG Regulartory Analysis Support FWP - Ready for HQ Signature

John, I have good news regarding this tax. The HQ study on LNG regulatory analysis support should come out of the HQ 5% tax. There is a separate line for it in the "Other taxes" section of the spend plan, but there shouldn't be.

Vanessa.

From: Rogers, John D. <John.Rogers@netl.doe.gov>
Sent: Thursday, March 23, 2023 5:22 PM
To: Nunez-Lopez, Vanessa <vanessa.nunez-lopez@hq.doe.gov>
Cc: Provenzano, Anthony (NETL) <anthony.provenzano@netl.doe.gov>
Subject: FW: Updated LNG Regulartory Analysis Support FWP - Ready for HQ Signature

Venessa,

This is an FWP requesting continuation of the LNG Life Cycle analysis that was sent down a few months ago.

Do I need to somehow work it into the prior year funds of the EPD program? It appears that they want an additional $245K

Is the EPD program the right program to do this in?

We BD'd $146k 12/20/2022 of FY21 (prior year) funds as directed by Guidance letter but RIC also wanted $67.5K of FY23 funds but it was taken back since the B&R codes were changing but we never received it back on the new B&R codes. Is this supposed to come out of the HQ 5% for FY23.

Regards
John R

John D Rogers, PhD, PE
Technology Manager ART
S&T Strategic P&P USDOE/NETL
John.rogers@netl.doe.gov
(b) (6)
Briar Hills One, Ste. 309
1011 Highway 6 South, Houston, Tx 77077

From: Jamieson, Matthew B. <Matthew.Jamieson@NETL.DOE.GOV>
Sent: Thursday, March 23, 2023 2:59 PM
To: Curry, Thomas <thomas.curry@hq.doe.gov>
Cc: Sweeney, Amy R <amy.sweeney@hq.doe.gov>; Harker Steele, Amanda J. <Amanda.HarkerSteele@netl.doe.gov>; Morreale, Bryan D. <Bryan.Morreale@NETL.DOE.GOV>; Gerdes, Kirk R. <Kirk.Gerdes@NETL.DOE.GOV>; Gerdes, Kristin J. <Kristin.Gerdes@NETL.DOE.GOV>; Richardson, Steven W. <Steven.Richardson@NETL.DOE.GOV>; Whyte, Cliff D. <Cliff.Whyte@NETL.DOE.GOV>; Hakala, Jacqueline Alexandra <Alexandra.Hakala@NETL.DOE.GOV>; Balash, Peter C. <Peter.Balash@NETL.DOE.GOV>; Adder, Justin M. <Justin.Adder@NETL.DOE.GOV>; Dale, Evelyn H. <Evelyn.Dale@NETL.DOE.GOV>; Johnson, Sarah B (CONTR) <Sarah.Johnson@NETL.DOE.GOV>; Rogers, John D. <John.Rogers@netl.doe.gov>; Cunha, Luciane B. <Luciane.Cunha@netl.doe.gov>
Subject: Updated LNG Regulartory Analysis Support FWP - Ready for HQ Signature

Please find attached the revised NETL Research and Innovation Center Field Work Proposal for providing LNG Regulatory Support updated with Task 3, Life Cycle Analysis support.

Respectfully, please sign the cover page and email the signed FWP back to NETL (Amanda Harker-Steele and Matt Jamieson) at your earliest convenience.

Respectfully,
Matt Jamieson
Department of Energy National Energy Technology Laboratory
Strategic Systems Analysis & Engineering
Senior Life Cycle Analyst
412.386.7610 (direct) | (b) (6) (mobile)

U.S. DEPARTMENT OF ENERGY

RIC Field Work Proposal

1. FWP Number:	2. Revision Number:	3. Date Prepared:
1022483	0, Update 1	02/03/2023

4. Field Work Proposal Title:
Alaskan LNG Analysis Support

5. Program Funding:
1611460-Import Export Authorization

6. Field Work Proposal Term: 08/01/2021 through 03/31/2023

7. RIC Technical Portfolio Lead: Timothy Skone

8. FECM-HQ Program Manager and Phone Number:
Amy Sweeney, 202-586-2627

9. HQ Organization:
Fossil Energy and Carbon Management

10. S&T SPP Technology Manager:
None

11. Program Office:
Office of Resource Sustainability

12. Public Abstract:

The U.S. Department of Energy (DOE), Office of Fossil Energy and Carbon Management (FECM) announced its intent to prepare a supplemental environmental impact statement (SEIS) for the Alaskan liquified natural gas (LNG) Project (DOE/EIS-0512-21) on (1) the potential environmental impacts associated with natural gas production on the North Slope of Alaska and (2) a life cycle analysis (LCA) calculating the greenhouse gas (GHG) emissions for LNG exported from Alaska by vessel to import markets in Asia and potentially in other regions. A Notice of Intent was issued on the DOE website on June 30, 2021, with a formal notification in the Federal Register on July 2, 2021.

The objective of the Alaskan LNG Analysis Support Field Work Proposal (FWP) is to provide the analysis support to complete the following in support of the DOE/FECM development of the SEIS as proposed in the Notice of Intent. The following two efforts will be conducted:

1. Upstream Study
   a. Upstream Oil and Natural Gas Production Study
   b. Non-GHG Environmental Impact Assessment and SEIS Documentation and Process Workflow Management
2. LCA Study
   a. LNG Export LCA GHG Study

This project is anticipated to start in August 2021 and conclude in March 2023.

13. Approval Signatures:

Associate Laboratory Director for Research & Innovation

FECM-HQ Program Manager

14. Detailed Attachments:

FY21 Alaskan LNG Analysis Support FWP 1022483_20230203_Update

Liquefied Natural Gas (LNG) Regulatory Analysis Support EY22/23 Field Work Proposal (FWP)

FWP Summary Budget Table

Task	Task Title	Period of Performance	Draft Deliverable	Hours	Funding ($k)
1	Global Economic Analysis	n/a	n/a	n/a	n/a
2	Domestic Economic Analysis	n/a	n/a	n/a	n/a
3	Life Cycle Analysis	March 2023 to March 2024	n/a	2,765	$245
3.1	*LCA Modeling of Consequential Global Economic Scenarios & Task Level Collaboration Support*	*March 2023 to September 2023*	*June 2023*	*1,000*	*$85*
3.2	*Dynamic US LNG GHG LCA Tool*	*May 2023 to January 2024*	*November 2023*	*1,765*	*$160*
3.3	*Dynamic US LNG LCA GHG Tool Expansion for non-GHG Air Emissions and Water Consumption*	*May 2023 to November 2023*	*September 2023*	*0*	*$0*
4	Environmental Review	December 2022 to September 2023	May 2023	1,080	$206
Z	FWP Execution and Shared Research Costs	December 2022 to March 2024	n/a	n/a	$0
	Subtotal(s)			3,845	$451
	Laboratory-Directed Research and Development				$8
	Grand Total				$459

Please note, this update adds Task #3 to the Field Work Proposal (FWP). There is no change in the Laboratory-Directed Research and Development (LDRD) from the original FWP as LDRD was inadvertently not lowered to reflect only Task #4 and had already reflected the total for Task #3 and Task #4. The incremental funding request to support the addition of Task #3 is $245,000.

A. Public Abstract

The Office of Resource Sustainability (ORS), within the Department of Energy's (DOE's) Office of Fossil Energy and Carbon Management (FECM), manages the natural gas regulatory program. FECM's National Energy Technology Laboratory (NETL) will provide analysis support to ORS in support of LNG public interest determinations. The type of analytical services required will vary based on ORS's needs and timing. The analytical support includes but is not limited to market analysis, economic evaluation, and environmental life cycle analysis (LCA).

B. Program Goals and Benefits

Program Intent

The ORS within the DOE's FECM manages the natural gas regulatory program and commissions analysis to support public interest reviews for the export of LNG sourced from the lower 48 states to non-free trade agreement (non-FTA) countries.

Specific Goals

The goal of this FWP is to provide analytical support for the evaluation of LNG exports with respect to the U.S. and global economic and environmental benefits and impacts.

Benefits of Research

The analytical research to enhance the DOE's understanding of the direct and potential indirect effects of LNG exports will help inform better decisions while enhancing public confidence in those decisions.

C. Technical Challenges and Research Strategies

Fundamental Challenge

The ORS's analytical work on LNG exports was originally completed in the 2014 time period. The previous analysis work on market effects, qualitative understanding of potential environmental impacts from natural gas production and exports, and quantitative analysis of life cycle greenhouse gas (GHG) have limitations for use today in informing export decisions. Public feedback on LNG export authorizations have revealed the following challenges to be addressed:

- Global GHG Impacts: Need to consider if authorized LNG exports, permitted through 2050, would make it less likely that other countries will achieve the emissions reductions necessary to limit global warming.
- LNG End-Use: Need to consider if exporting LNG will displace other fossil fuels to avoid increasing emission over the status quo.
- Domestic GHG Impacts: Need to evaluate the impact of exporting LNG on the U.S. ability to meet domestic emission reduction targets.
- Reconciliation of Modeled versus Measured Upstream Emissions: Need to improve the upstream natural gas emissions estimates to align with field measurement data to improve the representativeness of U.S. natural gas methane emissions.

Research Strategy

In coordination with ORS, NETL will design and execute analytical research to support LNG regulatory decisions. Each task is described below. Additional tasks will be amended to the FWP based on ORS support needs.

D. Product/Task Overview

Note: The task numbers within this FWP have been maintained to align with the original request for proposal received from FECM/ORS. Tasks #1 and #2 are not used. Task #3: Life Cycle Analysis and Task #4: Environmental Review are the only tasks described below, and funding requirements are summarized within the FWP.

Task #3: Life Cycle Analysis

Program Funding: Office of Regulation, Analysis, and Engagement; Program Funding TBD	
Task PI: Matt Jamieson	**Research Theme:** LNG Regulatory Support
Other Key Personnel: Harshvardhan Khutal	**Timeline:** March 2023–March 2024
Est. EY Budget ($k): 245	**Est. Total Budget ($k):** 245

1. Product/Task Objective

Provide environmental LCA modeling support for assessing the domestic and global life cycle environmental performance of natural gas production, liquefaction, the ocean transport of LNG, regasification, and the end-use of LNG exports, domestic natural gas, and substitutes identified through market equilibrium modeling and discussions with the research team.

2. Problem Statement

The current LCA modeling of U.S. LNG exports does not account for the market consequences within the changes in energy production and consumption, globally, that result from changes in U.S. LNG export volumes. This project will use energy supply and consumption general market equilibrium model results provided by ORS to estimate the changes in macro-level GHG emissions by economic sector. This task will also develop a dynamic LCA model to estimate life cycle GHG performance under varying decarbonization scenarios, regional natural gas production routes, and LNG delivery destinations. The objective is to improve the understanding of GHG emissions associated with LNG exports today and to help guide the program in the future.

3. Justification and Benefits

New, current state of science information is needed to inform the current LNG export decisions with the DOE and to enhance public and other stakeholder understanding of potential LNG environmental benefits and impacts.

4. R&D Challenges

The public data availability to effectively capture the current state of knowledge within the wide range of various perspectives on environmental impacts from natural gas production and export is a challenge.

5. Past Work and Progress

Not applicable.

6. Approach

This task provides support for two primary efforts referred to as Subtask 3.1: LCA Modeling of Consequential Global Economic Scenarios and Subtask 3.2: Dynamic U.S. LNG GHG LCA Tool. Each subtask is described below.

Subtask 3.1: LCA Modeling of Consequential Global Economic Scenarios

NETL will coordinate with ORS to obtain model results for energy supply and consumption for global economic scenarios. NETL will use existing life cycle modeling resources for energy supply and consumption (use) emission factors to estimate GHG intensity changes across modeled scenarios. Specifically, NETL expects ORS to provide three LNG export scenarios that forecast global energy production and use through the year 2050. Data will be provided on global natural gas production by region; imports, exports, and re-exports of LNG by source country, route, and transportation mode; and consumption by fuel, country, and end-use sector.

NETL will use the data to identify the production-to-consumption LNG pathways predicted by the economic equilibrium model. These pathways and their respective flows of natural gas will be used as inputs to the LCA. NETL will develop production-weighted average life cycle greenhouse emission factors for each production region, transportation mode and route, end-use sector, and end-use region and then apply these average factors to estimate the total emissions associated with each economic equilibrium scenario.

Life cycle models will include all natural gas processes, starting with source extraction and extending to end-use combustion. NETL will provide emission comparisons for alternative primary energy source scenarios or energy sources estimated as displaced by natural gas as a result of the market equilibrium modeling using existing NETL lifecycle-based data and/or global modeling proxy data. The lifecycle-based models for alternative energy supplies and consumption, similar to natural gas and LNG pathways, data will not be representative of country specific performance parameters. NETL will use existing U.S. data and models as proxies where commensurate data and models for foreign operations are missing.

The scope of the life cycle GHG inventory includes carbon dioxide, methane, and nitrous oxide. Other GHGs provided by the Intergovernmental Panel on Climate Change with a global warming potential will be considered on a case-by-case basis if determined to be significant to the results interpretation. Black carbon, water vapor, and aerosol emissions that are known to contribute to climate change but lack scientific consensus on their quantitative contribution are excluded from the analysis but will be discussed qualitatively.

The outcome of the consequential informed life cycle GHG results will report the change in terms of Global Warming Potential (GWP) based on the most recent Intergovernmental Panel on Climate Change report (the Sixth Assessment Report) for 20 and 100 year time frames for each scenario. The results will also be reported in terms of social cost of carbon (SCC) based on the most current U.S. guidance provided by ORS to NETL. The SCC requires all emission to be reported on a time-step increment to account for the time value of money. Standard economic practices will be used to discount to a specified nominal dollar time period. Therefore, all modeled scenarios will be based on annual or 5 year time steps. The modeling time period is anticipated to cover 2020–2050.

NETL will require a minimum of 90 days from the receipt of data from ORS to model each scenario, perform internal quality assurance on the underlying model, and document project findings. This 90 day lead time will require that ORS provide preliminary Task #1 results to NETL by March 27, 2023, to meet the overall project schedule.

NETL will provide a written report documenting the comparative findings of the LCA results for ORS use in developing the broader project level report. LCA results for all scenarios will be provided in Microsoft Excel. NETL will use refences to existing NETL models to the greatest extent to reduce new methodology documentation. Methods/approach, data sources, and data limitations will be included in the written report along with a discussion of the study results.

NETL will use the following primary models:

- NETL Natural Gas Baseline Model (2020 update to be completed in winter 2022)
- 2019 LNG GHG Study
- Alaska LNG Draft Supplemental Environmental Impact Statement (SEIS)
- NETL U.S. Electricity Baseline Model (2020 update of thermal electric and renewable energy production pathways)
- NETL Biomass and Renewable Natural Gas (RNG) Production Models (updated in 2022, as needed)
- NETL Fossil Hydrogen Baseline Report
- NETL Hydrogen and Water Analysis
- NETL Unit Process Library and other LCA Resources, www.netl.doe.gov/LCA

NETL will use the above models to develop packaged cradle-to-gate, gate-to-gate, and gate-to-grave unit process models to create GHG emission profiles for the applicable material and energy reference flows (technosphere flows of interest). The aggregated emission scalers will then be combined with scenario output data provided by ORS to determine the annual or 5 year time period GHG inventory data. End-use emission factors will be applied to represent each economic sector's weighted average use of the delivered energy. The inventory data for each scenario will then be used to calculate the GWP and SCC results for each scenario.

NETL will estimate model sensitivity to expected future technological change in the natural gas system. Modeled technology changes will be applied at the macro-level to assess broad emissions reductions or efficiency improvements at the life cycle stage level (e.g., U.S. natural gas methane emissions are reduced by X%, ocean transport boil-off emission are reduced Y%, etc.). NETL will neither assess the uncertainty around the reductions themselves nor the uncertainty of the rest of the natural gas life cycle with the modeled reduction in this subtask.

The results of the consequential LCA will include: (1) estimated unit life cycle emissions factor associated with major supply-to-consumption pathways expected from LNG imports, exports, and re-exports; (2) average total life cycle emissions associated with the range of global economic, policy, and security postures represented by the equilibrium modeling, which includes estimating emissions associated with LNG substitutes; and (3) improved empirical basis for emissions driven by the inclusion of the modeling of upstream processes involved in supplying, transporting, and consuming LNG. These results will allow for summary information that compares the life cycle emissions associated with exported LNG to alternative scenarios where a substitute portfolio of energy sources satisfies the same or similar demand, allowing for an estimate of net emissions associated with alternatives.

Subtask 3.2: Dynamic U.S. LNG GHG LCA Tool

NETL will collaborate closely with ORS to develop a customization tool to estimate GHG performance of LNG sources from various U.S. basins and be delivered to existing global LNG regasification ports. This collaboration will include at least two virtual work sessions with ORS to align the development of this tool with LCA work under the Natural Gas Infrastructure FWP and LCA work with the European Union.

NETL will evaluate the customization with respect to supply and demand locations and quantities; end-use sector consumption; transportation demands by mode, route, and quantity; known or anticipated technological changes deemed influential of life cycle emissions; natural variation in supply sources; and variation in flaring efficiency and fugitive emissions. This tool will be informed by the development of the work under Subtask 3.1.

The tool will be constructed by leveraging the Decarbonization What-If-Tool being developed under the Natural Gas Infrastructure FWP in Subtask 6.2. This effort will expand the Decarbonization Tool scope to include (1) LNG operations, (2) LNG decarbonization options, and (3) global consequential adder developed under Subtask 3.1.

To the extent feasible, NETL will use open access tools and data to enhance transparency and facilitate updates.

Sources of technological change to be modeled include but are not limited to improvements to pneumatics, compressors, emergency shutdown equipment and operations, pipeline modifications, liquefaction, regassification, and flaring throughout the production, processing, distribution, end-use combustion, and transportation of natural gas. The model will also allow users to specify carbon capture or the use of electric motor drives during liquefaction and source supplies of renewable natural gas.

NETL will also develop a user guidance document and model documentation.

7. Task Milestones Table

Identifier	Type[1]	Expected Completion Date	Description (What, How, Who, Where)
EY23.3.A	Project	06/30/2023	Draft GHG intensity and social cost of carbon results for each general equilibrium model scenario provided by ORS to assess LNG exports. Delivered to ORS for comment and review as Excel tabulated results.
EY23.3.B	Major	09/29/2023	Final GHG intensity and social cost of carbon results for each general equilibrium model scenario provided by ORS to assess LNG exports. Delivered to ORS in Excel tabulated results with high-level modeling documentation.
EY23.3.C	Project	11/17/2023	Draft dynamic LCA tool with LNG operations and decarbonization strategies.
EY23.3.D	Major	01/31/2024	Final dynamic LCA tool with LNG operations and decarbonization strategies.

[1] *Valid milestone types: Project; Major; Go/No-Go.*
Major milestones and Go/No-Go decisions are tracked in the VUE. All milestones should follow the SMART model (Specific, Measurable, Achievable, Relevant, Timely).

8. Task Deliverables Table

Quarterly reports and annual reports will be delivered 30 days after the end of the relevant period. One report will be provided each period at the FWP level and will cover the progress of this and other tasks. Topical reports specific to this task are presented in the table below and will be used to report on a certain technical aspect/topic/finding.

Number	Deliverable Title	Expected Completion Date	Description
1	Consequential LCA Scenario Results: Draft	06/30/2023	Microsoft Excel Spreadsheet with GHG intensity and social cost of carbon results for each general equilibrium model scenario.
2	Consequential LCA Scenario Results: Final	09/29/2023	Microsoft Excel Spreadsheet with GHG intensity and social cost of carbon results for each general equilibrium model scenario and high-level modeling documentation.
3	Dynamic Life Cycle Assessment Tool: Draft	11/17/2023	Microsoft Excel-based tool and model documentation for estimating delivered LNG life cycle greenhouse gas emissions from natural gas production through delivery to a receiving regasification facility ready for ORS review.
4	Dynamic Life Cycle Assessment Tool: Final	01/31/2024	Microsoft Excel-based tool and model documentation for estimating delivered LNG life cycle greenhouse gas emissions from natural gas production through delivery to a receiving regasification facility with ORS comments incorporated.

9. Task-Level Budget Detail

NETL Program Number	1025016	
Category	**FTEs**	**EY22/23 ($k)**
Contract Labor	1.0	$245
Travel	0.0	$0
Training	0.0	$0
Equipment	0.0	$0
Supplies	0.0	$0
Other	0.0	$0
Federal FTEs	0.1	Not Applicable
Grand Total	**2.1**	**$245**

Contractor Travel Detail

No contractor travel is planned as part of this task—not applicable. Please note, Federal staff time and travel is not funded thorugh the FWP.

10. Unique NETL Competencies

- Nationally Recognized Leader in Characterizing Natural Gas Value Chain Performance: NETL is a national leader in modeling energy systems from extraction to the delivery of services to the end customer (public). Historical work has focused on characterizing the environmental performance of the natural gas system using life cycle-based thinking and modeling approaches. The same skills and foundational models will be leveraged to deliver operational efficiency/energy intensity analysis value.
- Owner and Developer of 400+ Life Cycle Inventory (LCI) Databases for Energy Systems: NETL developed and maintains a public database of over 400 unit processes (dynamic engineering-based modeling blocks) that can be tailored to model different energy systems. All unit processes are made publicly available on the NETL website to enable transparency in modeling results and promote the Federal goals of open data access for work conducted with public funding.

11. Complementary Efforts and Partnerships

- Advanced Systems and Markets Analysis FWP: This FWP provides the base support for maintaining and advancing the models, tools, and databases for non-program specific elements and non-fossil energy (FE) comparison technologies.
- Natural Gas Infrastructure FWP: This FWP provides the base support for developing tools and materials to quantify and mitigate emissions from natural gas infrastructure. The execution year 2023 (EY23) work under the Natural Gas Infrastructure FWP is required to develop the Dynamic U.S. LNG GHG LCA Tool within this FWP.

12. Technology to Market Plan

Not applicable.

13. Tables and Figures

Not applicable.

Task #4: Environmental Review

Program Funding: Environmentally Prudent Development	
Task PI: Amanda Harker Steele	**Research Theme:** LNG Regulatory Support
Other Key Personnel: Justin Adder	**Timeline:** December 2022–September 2023
Est. EY Budget ($k): 165	**Est. Total Budget ($k):** 206

1. Product/Task Objective

Review and update the 2014 Addendum to the Environmental Review to provide information on the resource areas potentially impacted by expanded unconventional gas production across the U.S. The update to the Addendum will provide a qualitative assessment of the environmental impacts, including the environmental justice implications from expanding natural gas production and transport based on a review of the most recent scientific peer-reviewed literature. Quantitative data resources will be leveraged where necessary.

2. Problem Statement

Existing research requires an update from the 2014 time period to the current state of knowledge. New considerations for environmental justice and social considerations were not previously considered.

3. Justification and Benefits

New, current state of science information is needed to inform the current LNG export decisions with the DOE and to enhance public and other stakeholder understanding of potential LNG environmental benefits and impacts.

4. R&D Challenges

The public data availability to effectively capture the current state of knowledge within the wide range of various perspectives on environmental impacts from natural gas production and export is a challenge.

5. Past Work and Progress

Not applicable.

6. Approach

NETL will support the DOE's ORS as the project lead to update the 2014 Addendum to Environmental Review Documents Concerning Exports of Natural Gas from the United States, hereafter, the 2014 Addendum or Addendum. As the purpose of the 2014 Addendum was to provide information to the public regarding the potential environmental impacts of natural gas production and exploration activities, updates to the Addendum will focus on updating the information to reflect advances in the understanding of the potential environmental impacts of these activities. Special consideration will be given to the environmental risks, mitigation strategies, and regulatory landscape associated with natural gas production, processing, transport, and end-use and the influence of and implications to domestic and global GHG emissions policies. Consideration will also be given to major differences in the potential environmental impacts if the expanded production of domestic natural gas from unconventional resources were to be transported out of the U.S. via pipeline and liquefied and exported from liquefaction plants in neighboring countries, including Canada and Mexico.

Updates to the 2014 Addendum will be focused on the following topic areas: water resources (quality and quantity), air quality, GHG emissions, induced seismicity, land use impacts, and environmental justice considerations. The information reported on each topic area will be informed by the results of an in-depth review of the most recent scientific literature. With the exception of GHG emissions, the environmental impacts from expanding unconventional natural gas production and transport in the U.S. will occur at the local level. Appropriately, NETL will update the 2014 Addendum with a discussion of the local (e.g., regional) consequences of expanding natural gas production from unconventional resources. The unique conditions, challenges, and environmental resources of each local area to be impacted will be considered.

The environmental justice discussion included in the update will focus on the potential impacts of expanding production and transport for disadvantaged communities. Disadvantaged communities will be identified using publicly available tools and datasets, including but not limited to the Environmental Protection Agency's (EPA's) EJScreen, the Council of Environmental Quality's Climate and Economic Justice Screening Tool (beta version), the DOE's Low-Income Energy Affordability Data (LEAD) Tool, and the mapping tool developed by the U.S. Department of Transportation, to identify historically disadvantaged communities. The environmental justice discussion will also provide insight into what the benefits and costs associated with expanding natural gas production and transport domestically are and how those benefits and costs might be distributed across communities. A review of the different tenants of environmental justice, including distributive justice, procedural justice, and recognition justice, will also be provided by the updates made to the Addendum.

NETL will also identify and provide examples of the steps industry can take to reduce GHG emissions and other environmental impacts (e.g., groundwater contamination) at each point along the natural gas supply chain from extraction to pipeline transport, LNG facility operation, and marine shipping. Suggested steps will be informed by the results of the literature review conducted by NETL, which will consider the results of the LCA being completed under Task #3. Specifically, strategies for mitigating GHG emissions will be consistent with and complement the assumptions of the LCA conducted for the cradle-to-gate GHG emissions of expanding production and transport activities. The review will be divided to discuss the impacts of upstream (construction and completion of gas wells and subsequent production and processing), midstream (further processing and transport), and downstream (end-use activities).

Final deliverables will include a report summarizing the current state of published descriptions of the potential environmental impacts of expanding natural gas production and transport. The primary objective of the report will be the provision of the predominant concerns about natural gas development and transport, as covered by the current literature. The sources to be reviewed will include scientific journal articles, reports, and other publicly available peer-reviewed publications. The report will be divided by chapter, and each chapter will contain its own reference section to permit further exploration by the reader. To complete the update to 2014 Addendum, NETL will explore the resources available from the following organizations:

- Bureau of Land Management (BLM)
- Department of Interior (DOI)
- Energy Information Administration (EIA)
- Congressional Research Service (CRS)
- EPA
- International Energy Agency (IEA)
- NETL
- Resources for the Future (RFF)
- U.S. Geological Survey (USGS)
- Peer-reviewed publications, reports, and other documents

Please note, the period of performance for this task is set as September 2023, to provide minor resources based on the remaining funding after the completion of the primary delivery in accordance with the milestone and deliverable schedules in the following sections. No work is planned or estimated in this FWP for the period after the acceptance of the Final Draft Environmental Review Addendum update and September 2023.

7. Task Milestones Table

Identifier	Type[1]	Expected Completion Date	Description (What, How, Who, Where)
EY23.4.A	Project	04/30/2023	Complete the review of the current state of science for incorporation into the updated Environmental Review Addendum reviewed by the NETL Technical Project Monitor.
EY23.4.B	Major	05/31/2023	Draft Environmental Review Addendum is updated and ready for submission to HQ.

[1] *Valid milestone types: Project; Major; Go/No-Go.*
Major milestones and Go/No-Go decisions are tracked in the VUE. All milestones should follow the SMART model (Specific, Measurable, Achievable, Relevant, Timely).

8. Task Deliverables Table

Quarterly reports and annual reports will be delivered 30 days after the end of the relevant period. One report will be provided each period at the FWP level and will cover the progress of this and other tasks. Topical reports specific to this task are presented in the table below and will be used to report on a certain technical aspect/topic/finding.

Number	Deliverable Title	Expected Completion Date	Description
1	2023 Environmental Review Addendum: Draft	05/31/2023	Update of the 2014 Environmental Review Addendum with the new addition of environmental justice considerations.
2	2023 Environmental Review Addendum: Final	06/30/2023	Update of the 2014 Environmental Review Addendum with the new addition of environmental justice considerations. Draft Final with HQ comments incorporated.

9. Task-Level Budget Detail

NETL Program Number	1025016	
Category	**FTEs**	**EY22/23 ($k)**
Contract Labor	0.9	$206
Travel	0.0	$0
Training	0.0	$0
Equipment	0.0	$0
Supplies	0.0	$0
Other	0.0	$0
Federal FTEs	0.1	Not Applicable
Grand Total	**1**	**$206**

Contractor Travel Detail

No contactor travel is planned as part of this task—not applicable. Please note, Federal staff time and tavel is not funded thorugh the FWP.

10. Unique NETL Competencies

- Hitachi Energy Velocity Database, which contains a suite of power-related and emissions datasets.
- Enverus (formerly Drillinginfo), which provides data on natural gas and liquids exploration and production, including completion data and permitting.
- NETL in-house developed models: NETL's Water Needs and Technology Benefits Model and Linear Optimization and Dispatch (LOAD) Tool.
- National Energy Modeling System (NEMS) Energy Water Model: NETL is the first to incorporate water availability and use into the EIA NEMS. NETL was the primary modeling institution for all previous revisions and has all the simulation models of all the technologies.
- NETL's support of on-going energy, environmental, and social justice efforts, including data collected to support the Justice40 Initiative, Communities LEAP Pilot, and Energy Communities.
- Directly impacted by coal closures and the Interagency Working Group (IWG) on Coal and Power Plant Communities and Economic Revitalization.
- Energy analyses include assessments of near- and long-term trends within the U.S. and world energy industries that may impact energy price, availability, and security.

11. Complementary Efforts and Partnerships

- Advanced Systems and Markets Analysis FWP: This FWP provides the base support for maintaining and advancing the models, tools, and databases for non-program specific elements and non-FE comparison technologies.
- Natural Gas Infrastructure FWP: This FWP provides the base support for developing tools and materials to quantify and mitigate emissions from natural gas infrastructure.
- Carbon Dioxide Removal FWP: This FWP investigates a combination of technologies, including point-source capture, hydrogen production with carbon management, carbon conversion to useful chemicals or products, reduction in methane emissions, increased and sustainable production of critical minerals, and carbon dioxide removal (CDR) designed to reduce the environmental impacts of fossil fuel-based energy production systems.
- U.S. Ethane: Market Issues and Opportunities Report to Congress (pending) in response to a request under the Consolidated Appropriations Act, 2021 (Public Law 116-260), specifically the Energy and Water Development and Related Agencies Appropriations Act, 2021–Division D. The report focuses on the projected long-term trends for the domestic production, consumption, and export of ethane and prospective opportunities and risks (environmental and local community impacts) associated with U.S. petrochemical manufacturing that uses ethane as a feedstock.
- Intermountain West Energy Sustainability & Transitions–Phase 1 Final Report: This report details findings to a broad range of stakeholders with shared interest in planning for the energy transition in the I-West region. NETL provided subject matter experts (SME) topic areas, including but not limited to the environmental justice impacts of the transition.
- NETL has engaged with several partners who are responding to the funding opportunity announcement (FOA) for Hydrogen Hubs. NETL is expected to be provided SME on energy and environmental justice, markets analysis, and LCA.

12. Technology to Market Plan

Not applicable.

13. Tables and Figures

Not applicable.

E. Major Project Milestones

Identifier	Type	Expected Completion Date	Description (What, How, Who, Where)
Task #3: Life Cycle Analysis			
EY23.3.B	Major	09/29/2023	Final GHG intensity and social cost of carbon results for each general equilibrium model scenario provided by ORS to assess LNG exports. Delivered to ORS in Excel tabulated results with high-level modeling documentation.
EY23.3.D	Major	01/31/2024	Final dynamic LCA tool with LNG operations and decarbonization strategies.
Task #4: Environmental Review			
EY23.4.B	Major	05/31/2023	Draft Environmental Review Addendum is updated and ready for submission to HQ.

From: Francisco De La Chesnaye
Sent: Tue, 25 Jul 2023 20:38:50 +0000
To: Curry, Thomas; Sweeney, Amy; Skone, Timothy; Jamieson, Matthew B.; Scott Matthews
Cc: Whitman, Peter C; Daniel Hatchell; Iyer, Gokul; Binsted, Matthew
Subject: [EXTERNAL] Options for LNG Export Analysis Report
Attachments: DOE_FECM_LNG_2023_Analysis_Report_Combined_V1_25JUL23.docx

DRAFT – DELIBERATIVE – PRE-DECISIONAL

FECM and NETL Teams,

Attached is the latest combined outline of the analysis report "ENERGY, ECONOMIC, AND ENVIRONMENTAL ASSESSMENT of U.S. LNG EXPORTS". We are proposing two options for organization and structure:

OPTION 1 by Geographic Scope, i.e., GCAM covers global, NEMS U.S., LCA; OR

OPTION 2 by Content Type (combined GCAM and NEMS results organized by Energy, Mkt, Economic, and GHG results)

The OnLocation and PNNL teams have a preference is for Opt 1 for ease of writing by team and for communication of results. We have been writing up the results in this structure so far.

Scott and Matt Jamieson, also please fill in the additional details on the LCA Analysis section.

Please review and let me know what you think. We can go in more detail on Friday's meeting.

Thanks, Paco

Francisco de la Chesnaye, PhD | **Vice President**
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DISCUSION DRAFTS*DELIBERATIVE*PRE-DECISIONAL

ENERGY, ECONOMIC, AND ENVIRONMENTAL ASSESSMENT of U.S. LNG EXPORTS

Proposed Report Structure and Content: OPTION 1 – By Geo Scope (25July23)

Section	Pgs	Lead
I. EXECUTIVE SUMMARY (Identify and focus on Key Messages)		
(Lists of Tables, Figures, Acronyms and Abbreviations)		
II. BACKGROUND ON LNG EXPORT STUDIES COMMISSIONED DEPARTMENT OF ENERGY		
III. INTRODUCTION		
A. Project Background		
B. Purpose of the Study		
C. Organization of the Report		
IV. SCENARIOS, METHODOLOGY, & KEY ASSUMPTIONS		
A. Scenarios Description		
B. GCAM Model (brief description) & Analysis Methodology		
C. NEMS Model (brief description) & Analysis Methodology		
D. LCA Model (brief description) & Analysis Methodology		
V. RESULTS		
A. GCAM Global Results		
1. Energy System (Global and Regional results) & Role of U.S. in global NG market		
2. Climate Mitigation Technology		
3. Global GHGs		
B. NEMS U.S. Results		
1. Energy System (Primary, Consumption)		
2. Natural Gas (Production, Consumption, Prices, Revenues)		
3. Economics (macro, Consumer prices, Consumption and Investment)		
4. CO_2 Emissions		
C. LCA Results		
1. Sub-section		
2. Sub-section		
3. Sub-section		
D. How to compare results across different modeling frameworks, How to compare to previous regulatory analyses, or both?		
Total		
REFENCES		
(additional model descriptions and data results if required; each team is responsible for proposing own structure)		
APPENDIX A. Global Analysis and Description of GCAM		PNNL
APPENDIX B. U.S. Analysis and Description of NEMS-AOE23 and NEMS-FECM		OL
APPENDIX C. LCA Analysis and Description of Model		NETL

ENERGY, ECONOMIC, AND ENVIRONMENTAL ASSESSMENT of U.S. LNG EXPORTS

Proposed Report Structure and Content: OPTION 2 – Content Type (25July23)

Section	Pgs	Lead
I. EXECUTIVE SUMMARY (Identify and focus on Key Messages)		
(Lists of Tables, Figures, Acronyms and Abbreviations)		
II. BACKGROUND ON LNG EXPORT STUDIES COMMISSIONED DEPARTMENT OF ENERG.Y		
III. INTRODUCTION		
A. Project Background		
B. Purpose of the Study		
C. Organization of the Report		
IV. SCENARIOS, METHODOLOGY, & KEY ASSUMPTIONS		
A. Scenarios Description		
B. GCAM Model (brief description) & Analysis Methodology		
C. NEMS Model (brief description) & Analysis Methodology		
D. LCA Model (brief description) & Analysis Methodology		
V. SUMMARY of ANALYSIS & ASSESSESMENT (organization desc)		
A. ENERGY AND CLIMATE MITIGATION TECHNOLOGY RESULTS		
1. Primary and Final Energy Results (How much regional detail)		
2. Energy and Climate Technology Deployment Results (any cost info?)		
B. NATURAL GAS MARKET RESULTS		
1. Core Results for U.S. LNG Exports		
2. Natural Gas Henry Hub Prices		
3. U.S. LNG Export Revenues		
4. Role of U.S. in global market		
C. U.S. MACROECONOMIC OUTCOMES (only NEMS)		
1. Macroeconomic Effects - Total Economic Activity (GDP)		
2. Consumer Effects (Prices mainly)		
3. Aggregate Consumption and Investment Effects		
D GHG OUTCOMES		
1. Global Greenhouse Gas Results		
2. U.S. Greenhouse Gas Results		
3. LCA Results (scope of coverage?)		
4. How to compare results across different modeling frameworks OR How to compare to previous regulatory analyses?		
REFENCES & APPENDICES same as Opt 1		
Total		

From: Francisco De La Chesnaye
Sent: Wed, 16 Aug 2023 16:22:14 +0000
To: Iyer, Gokul; Binsted, Matthew; Skone, Timothy; Curry, Thomas; Sweeney, Amy; Harker-Steele, Amanda J (NETL); Scott Matthews
Cc: Robert Wallace; Jamieson, Matthew B.; Edmonds, James A (Jae); Whitman, Peter C; Daniel Hatchell; Riera, Jefferson
Subject: [EXTERNAL] FECM LNG Export Project Briefing Presentation
Attachments: FECM_LNG_Analysis_Briefing_18Aug.pptx
Importance: High

DRAFT – DELIBERATIVE – PRE-DECISIONAL

Team,

Please see the attached draft presentation for Friday's Leadership briefing on the "Natural Gas Regulatory Analyses". Thanks to Gokul, Matt B, Pete and Daniel for putting this together quickly. Amy and Tom, see yellow heighted text for decisions/directions.

Believe the goal is to finish this by tomorrow morning and send out 24 hours before briefings (12 pm ET). My suggestion is for Gokul/Matt B, Scott, and Amanda do a quick review and then pass on to FECM for a final review.

Deck follows the plan and agenda we discussed:

Brief review of past approach and summary of new analyses (Amy)
Define scenarios (Tom)
Modeling approach
- Responding to past comments
- Using state-of-art modeling
- GCAM to NEMS linkage

Preliminary key findings (Amy/Tom intro then Gokul and Paco)
Key LNG export graphic
S1/S2 discussion
GCAM & NEMS results
Transition
S6/S7 discussion
GCAM & NEMS results

Next steps and timeline

Extra slides
Model Description Charts

Thanks all, Paco

Francisco De La Chesnaye | **Vice President**
m: (b) (6) | onlocationinc.com

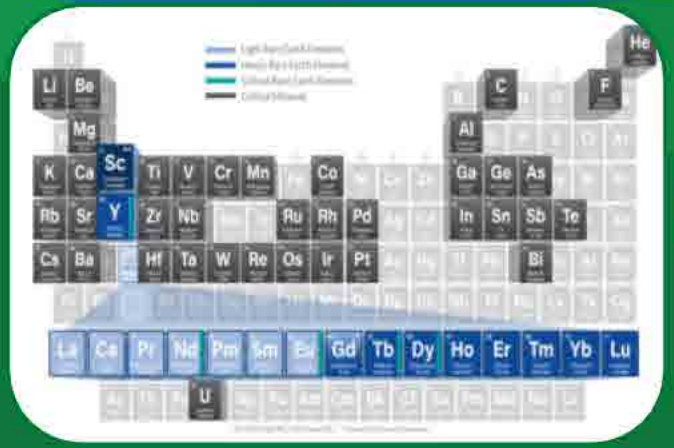
U.S. DEPARTMENT OF ENERGY
Fossil Energy and Carbon Management

Document 90- Attachment

Updated Natural Gas Regulatory Analyses

DRAFT – DELIBERATIVE – PRE-DECISIONAL

August 18, 2023



Agenda

Introductions

Summary Review of Past and New Analyses (Amy)

Define Scenarios & Analyses Approach (Tom)

Key Findings (Gokul & Paco)

Next steps and timeline (Tom/Amy)

Current Basis for Regulatory Decisions

The Office of Resource Sustainability (ORS) within DOE's Office of Fossil Energy and Carbon Management (FECM) is updating analytical work in support of the natural gas regulatory program, specifically to support public interest reviews for exports of liquefied natural gas (LNG) sourced from the lower-48 states to non-free trade agreement (non-FTA) countries, where a public interest determination must be made.

Current studies in support of the natural gas regulatory program include:

- 2018 Economic Analysis prepared by NERA Economic Consulting
- 2019 GHG Life Cycle Analysis and 2014 GHG Life Cycle Analysis by NETL
- 2014 Addendum to Environmental Review Documents by NETL

Additionally, FECM published an Alaska-specific Supplemental Environmental Impact Statement examining the potential upstream environmental effects associated with incremental natural gas production on the North Slope of Alaska to support Alaska LNG's authorized exports of LNG:

- 2023 Alaska LNG SEIS

Updated Analyses

Focus of this briefing

Task	Description	Status
1. **Global Market Analysis**	Pacific Northwest National Laboratory (PNNL) used the Global Change Analysis Model (GCAM) to analyze several global energy use and emissions scenarios.	Analysis Completed; working on final draft report.
2. **Domestic Economic Analysis**	OnLocation modeled domestic impacts with customized versions of the National Energy Modeling System (NEMS).	Analysis Completed; working on final draft report.
3. **Life Cycle Analysis**	NETL developed a consequential life cycle analysis (LCA) of the GHG emissions associated with the change in LNG exports across scenarios.	Analysis in final review; working on draft report.
4. **Environmental Review**	NETL updating the 2014 review of environmental issues associated with natural gas development.	Completed final draft report, currently being reviewed by FECM.

Target date:

- **End of September:** Publish summary report and supporting documentation for public comment.

Scenarios (larger or smaller font)

Scenario	Description	U.S. LNG Export Volumes
S1: Reference Capacity	Reference scenario that follows EIA's 2023 Annual Energy Outlook (AEO) including U.S. policy assumptions (including the 2022 Inflation Reduction Act). Assumes existing policies and measures, globally.	Grows to 27.34 Bcf/d by 2050
S2: Market Response	Assumes policies consistent with S1 and an economic solution for LNG exports.	GCAM Market Response
S3: High Global Demand	Same assumptions as S2, economic solution for LNG exports, but higher assumed population growth outside of the U.S.	
S4: Regional Import Limits	Same assumptions as S2, economic solution for LNG exports, but constraints on importing and exporting natural gas with a global focus to maximize use of domestic gas.	
S5: Low-cost Renewables	Same assumptions as S2, economic solution for LNG exports, but lower capital costs for renewable energy technologies.	

Scenarios – cont.

Scenario	Description	U.S. LNG Export Volumes
S6: Energy Transition (Ref Cap)	Assumes an emissions pathway consistent with a global temperature change of 1.5°C by end of century. Countries' emissions are constrained to announced GHG pledges, including the U.S. following a path to net-zero GHG emissions by 2050. NEMS follows CO_2 emissions constraint from GCAM. U.S. LNG exports are limited to the values from the AEO 2023 Reference scenario.	Grows to 27.34 Bcf/d by 2050
S7: Energy Transition (Mark Resp)	Same emissions pathway assumptions as S6 but economic solution for U.S. LNG exports.	GCAM Market Response

*S6 and S7 are not possible to model using EIA's version of NEMS, we are using a version of NEMS developed by FECM for S6 and S7.

Scenarios

Scenario	Description	U.S. LNG Export Volumes
S1: Reference Capacity	Reference scenario that follows EIA's 2023 Annual Energy Outlook (AEO) including U.S. policy assumptions (including the 2022 Inflation Reduction Act). Assumes existing policies and measures, globally.	Grows to 27.34 Bcf/d by 2050
S2: Market Response	Assumes policies consistent with S1 and an economic solution for LNG exports.	GCAM Market Response
S3: High Global Demand	Same assumptions as S2 but higher assumed population growth outside of the U.S.	
S4: Regional Import Limits	Same assumptions as S2, but constraints on importing and exporting natural gas with a global focus to maximize use of domestic gas.	
S5: Low-cost Renewables	Same assumptions as S2, economic solution for LNG exports, but lower capital costs for renewable energy technologies.	
S6: Energy Transition (Ref Cap)	Assumes an emissions pathway consistent with a global temperature change of 1.5°C by end of century. Countries' emissions are constrained to announced GHG pledges, including the U.S. following a path to net-zero GHG emissions by 2050. NEMS follows CO_2 emissions constraint from GCAM. U.S. LNG exports are limited to the values from the AEO 2023 Reference scenario.	Grows to 27.34 Bcf/d by 2050
S7: Energy Transition (Mark Resp)	Same emissions pathway assumptions as S6 but economic solution for U.S. LNG exports.	GCAM Market Response

*S6 and S7 are not possible to model using EIA's version of NEMS, we are using a version of NEMS developed by FECM for S6 and S7.

Key Takeaways (Insights?)

- U.S. LNG exports continue to grow beyond existing and planned capacity in all modeled scenarios through 2050.
- U.S. CO_2 emissions do not change significantly across scenarios (except S6 and S7 that assume a global 1.5°C consistent pathway).
- When compared to a scenario in which U.S. LNG exports follow AEO-2023 (S1), a scenario that assumes economically-driven LNG export outcomes (S2) results in:
  - Significant growth in U.S. LNG exports
  - Little change in global GHG emissions and global gas consumption
  - Moderate increases in U.S. natural gas prices (2050 prices projected to increase from $3.74/MMBtu to $4.95/MMBtu. Previous study, at lower export levels, projected 2050 prices above $6.00/MMBtu.)
- Under a global energy transition consistent with meeting a 1.5°C target and economically-driven LNG export outcomes, U.S. LNG exports continue to grow through 2050 – albeit at a slower rate compared to the scenario without the 1.5 °C target – driven by increased demand for gas in combination with CCUS in the power and industrial sectors and to support direct air capture operations for atmospheric CO_2 removal.

Global (GCAM) & Domestic (NEMS) Results

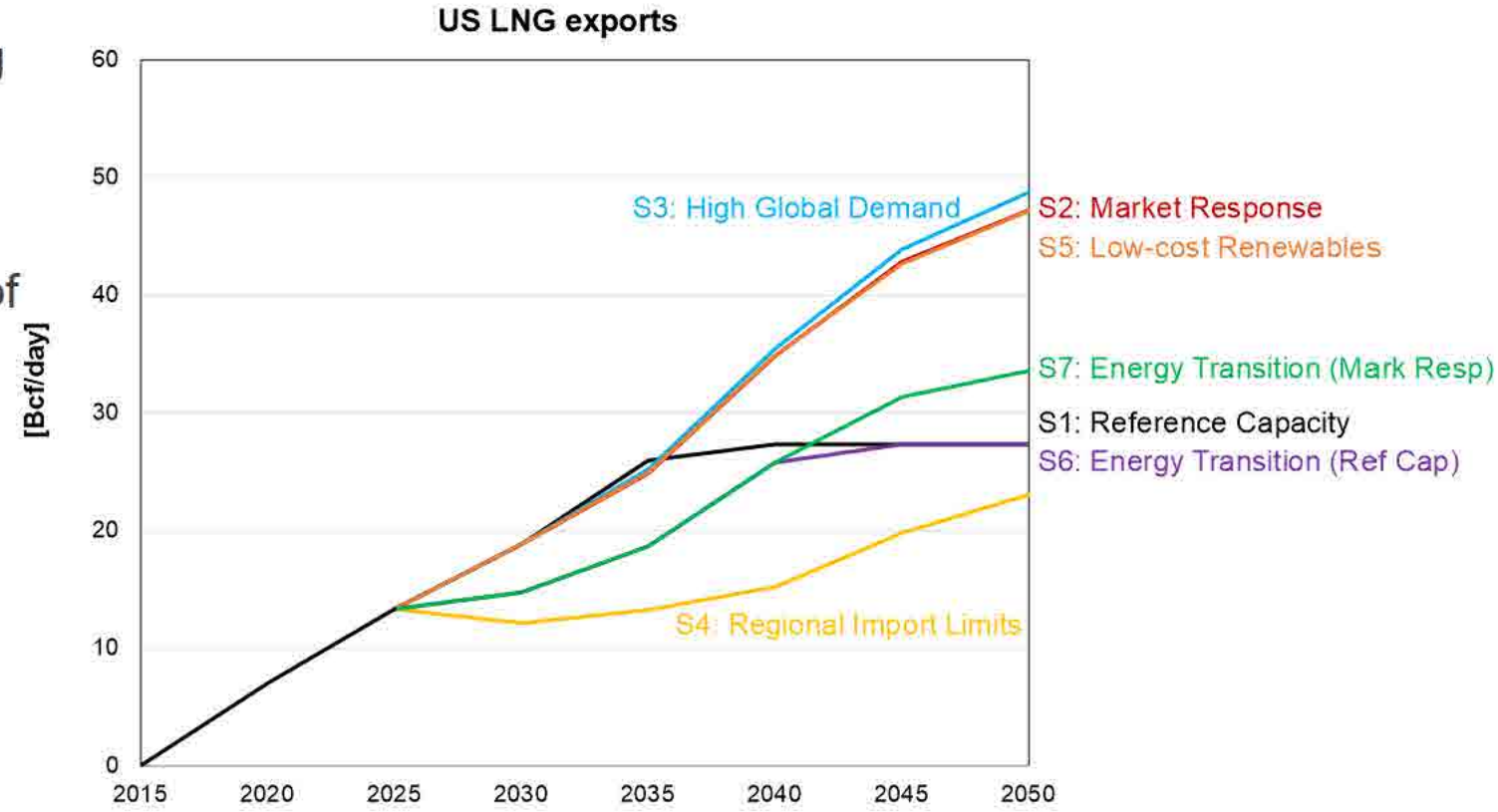
U.S. LNG Exports outcomes from GCAM global scenarios

U.S. LNG exports increase beyond existing and planned capacity in all scenarios by 2050 (except S1 and S6 which follow the AEO 2023's Reference case)

In all scenarios, the U.S. is a net exporter of natural gas

Under a scenario that assumes economically-driven outcomes, U.S. LNG exports increase to ~47 Bcf/day in 2050

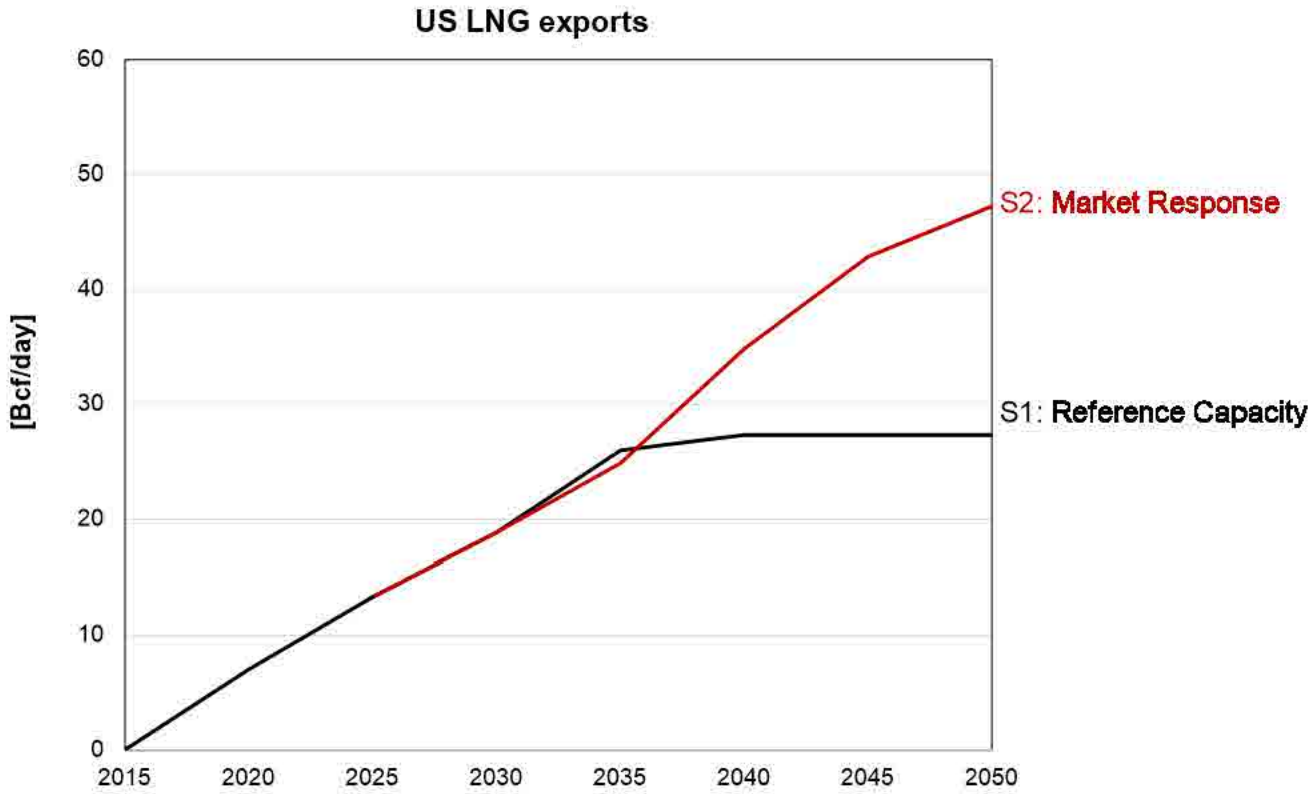
Under the *Energy Transition* scenario with economically-driven outcomes (S7), U.S. LNG exports increase to ~34 Bcf/day in 2050



Note: All scenarios include a constraint on Russian exports

U.S. LNG Exports outcomes from GCAM global scenarios

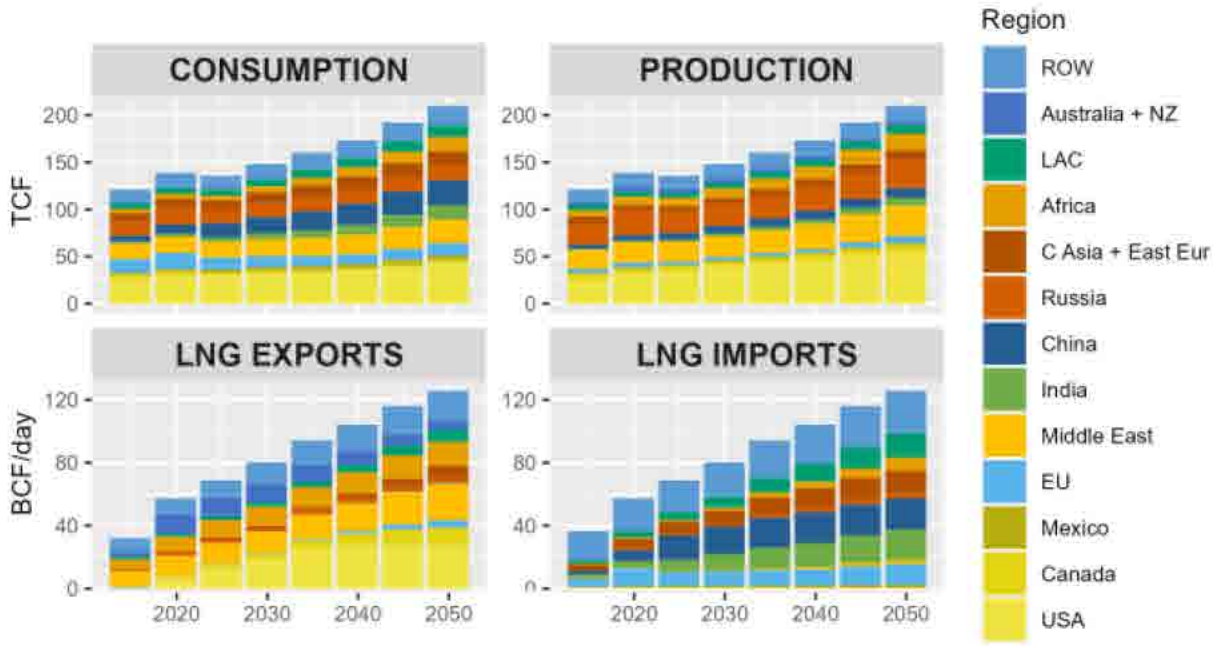
- The next few slides will focus on *S1: Reference Capacity* and *S2: Market Response*



Note: All scenarios include a constraint on Russian exports

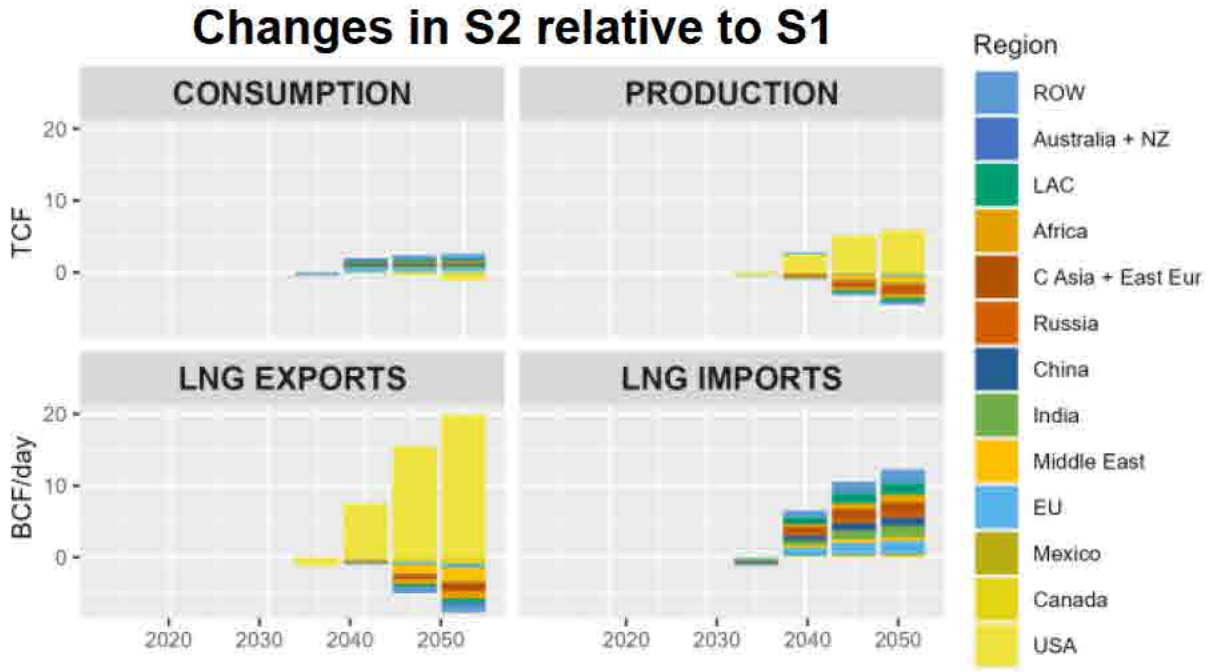
Global natural gas consumption, production, & trade under the S1: Reference Capacity scenario

- Under the *S1: Reference Capacity* scenario, production, consumption, and trade of gas increase in all regions across the globe driven by growing demands in the electricity, industrial, and buildings sectors



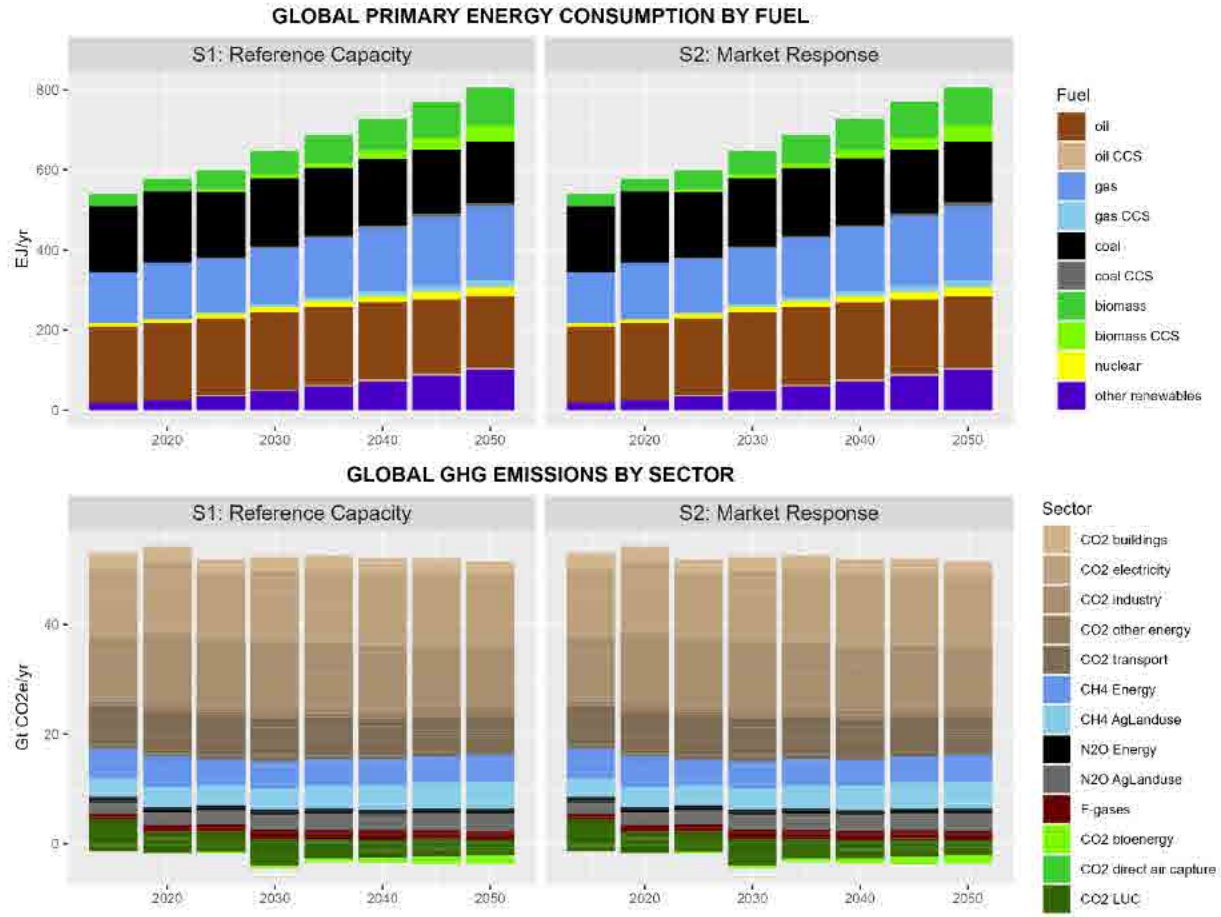
Global natural gas consumption, production, & trade (changes) under S2: Market Response

- Under *S2: Market Response*, the availability of additional U.S. gas in the global gas market at competitive prices results in:
  - A reduction in production outside the U.S.
  - A reduction in LNG exports outside the U.S.
  - An increase in LNG imports outside the U.S.
  - A small increase (<5%) in global gas consumption by 2050

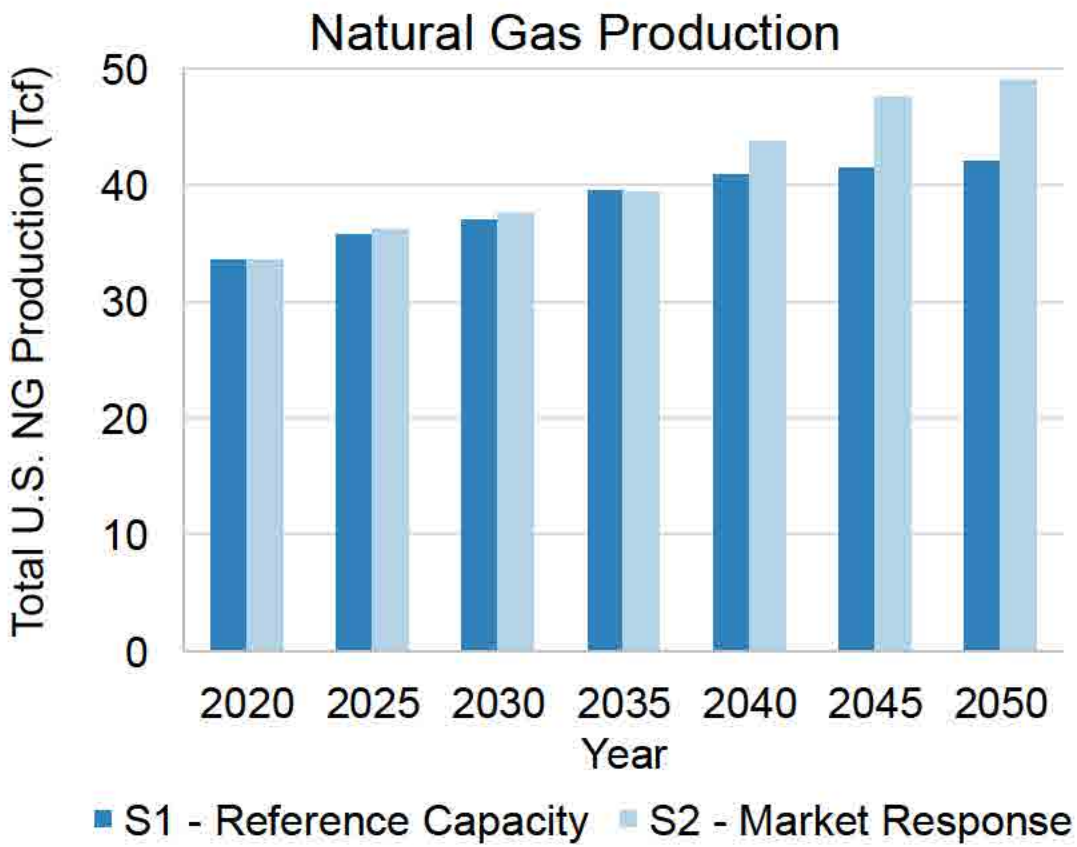


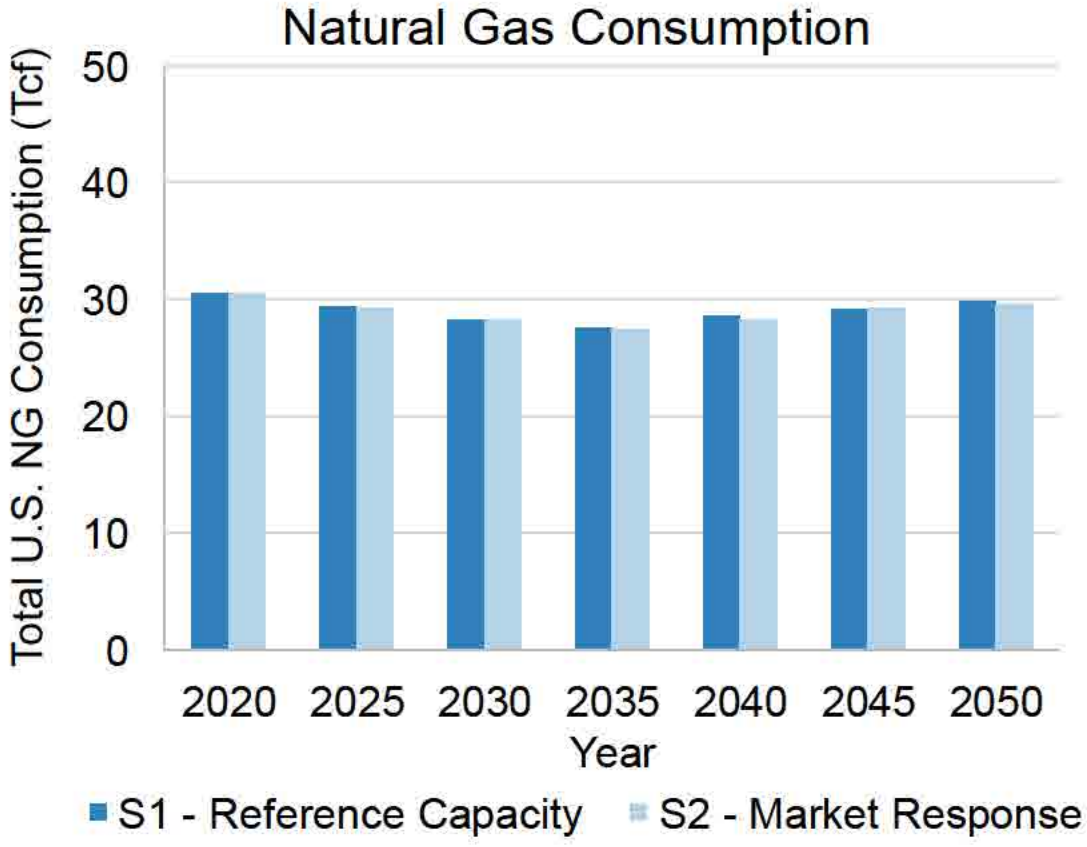
Global primary energy and GHG emissions under S1 & S2

- Our scenarios include updated representation of global gas prices
- Under *S2: Market Response*, the availability of additional U.S. gas in the global gas market results only in a small increase (<5%) in global gas consumption by 2050
  - This is because, the principal effect of the availability of additional U.S. gas is to displace production from rest of the world (as discussed in the previous slide)
  - Hence, the competitiveness of natural gas relative to other fuels remains materially unaffected
- Hence, the fuel composition of primary energy consumption and greenhouse gas emissions do not change much in S2 compared to S1

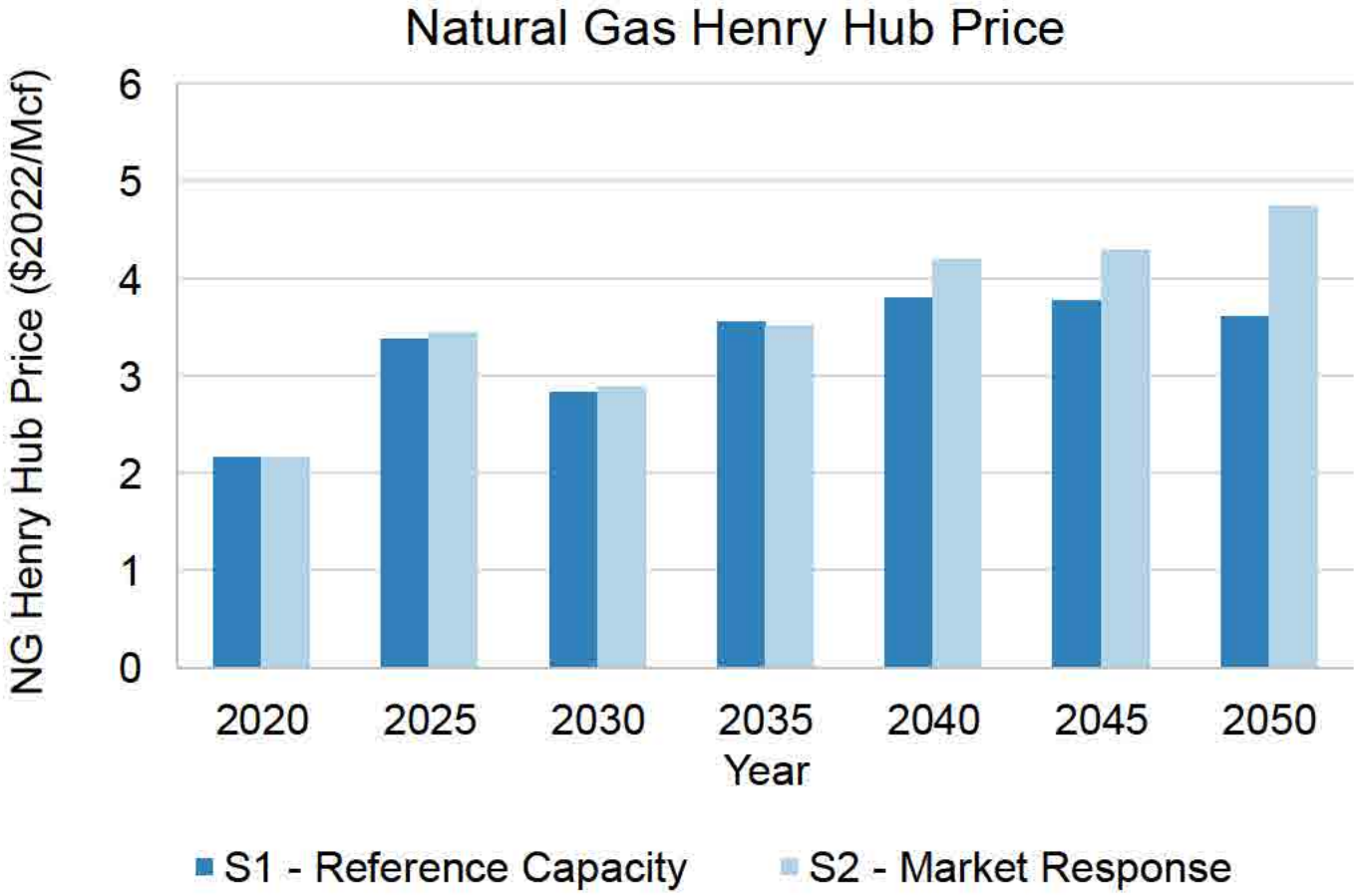


U.S. Natural Gas Balance S1 & S2 from NEMS

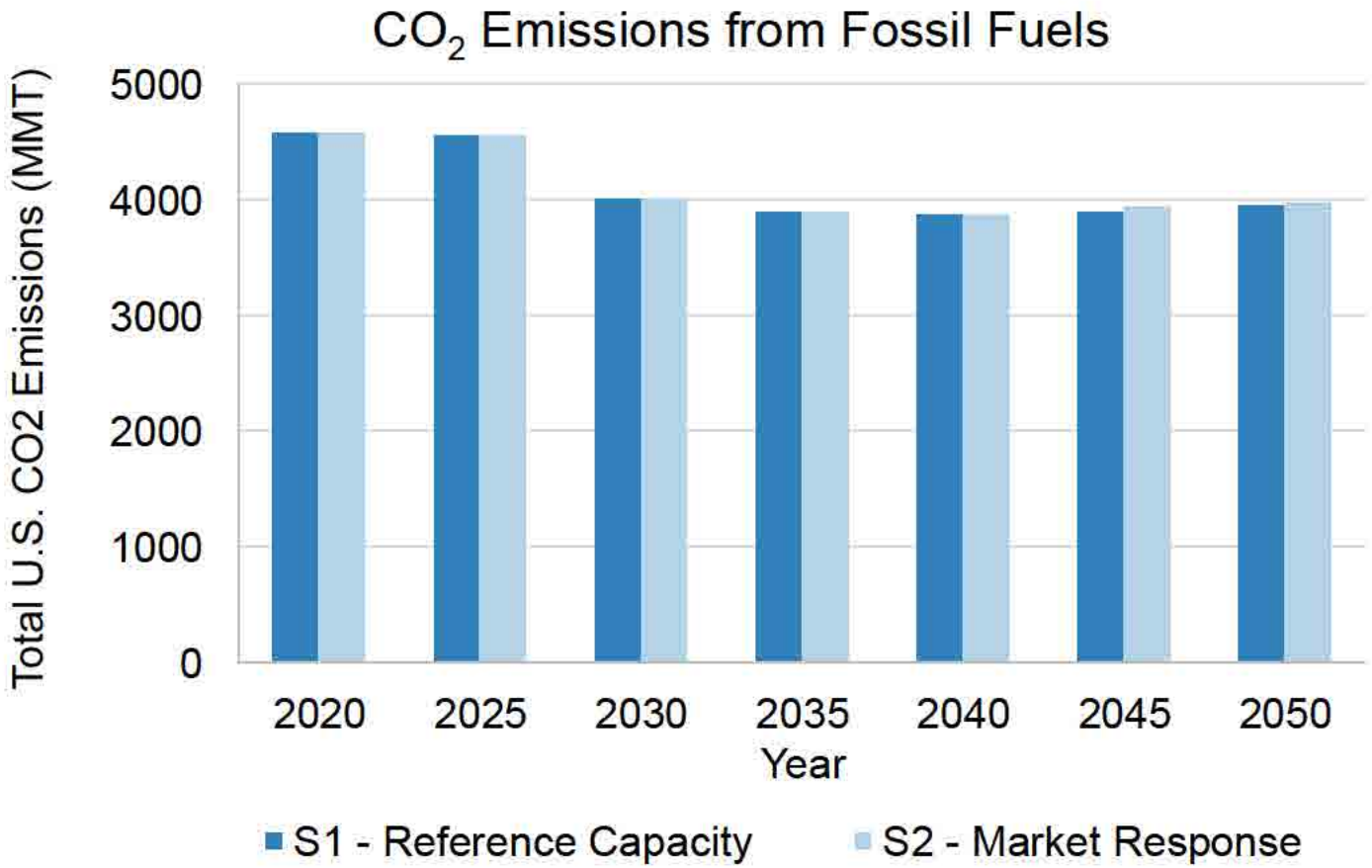




U.S. Gas Price Impacts Under S1 & S2 from NEMS



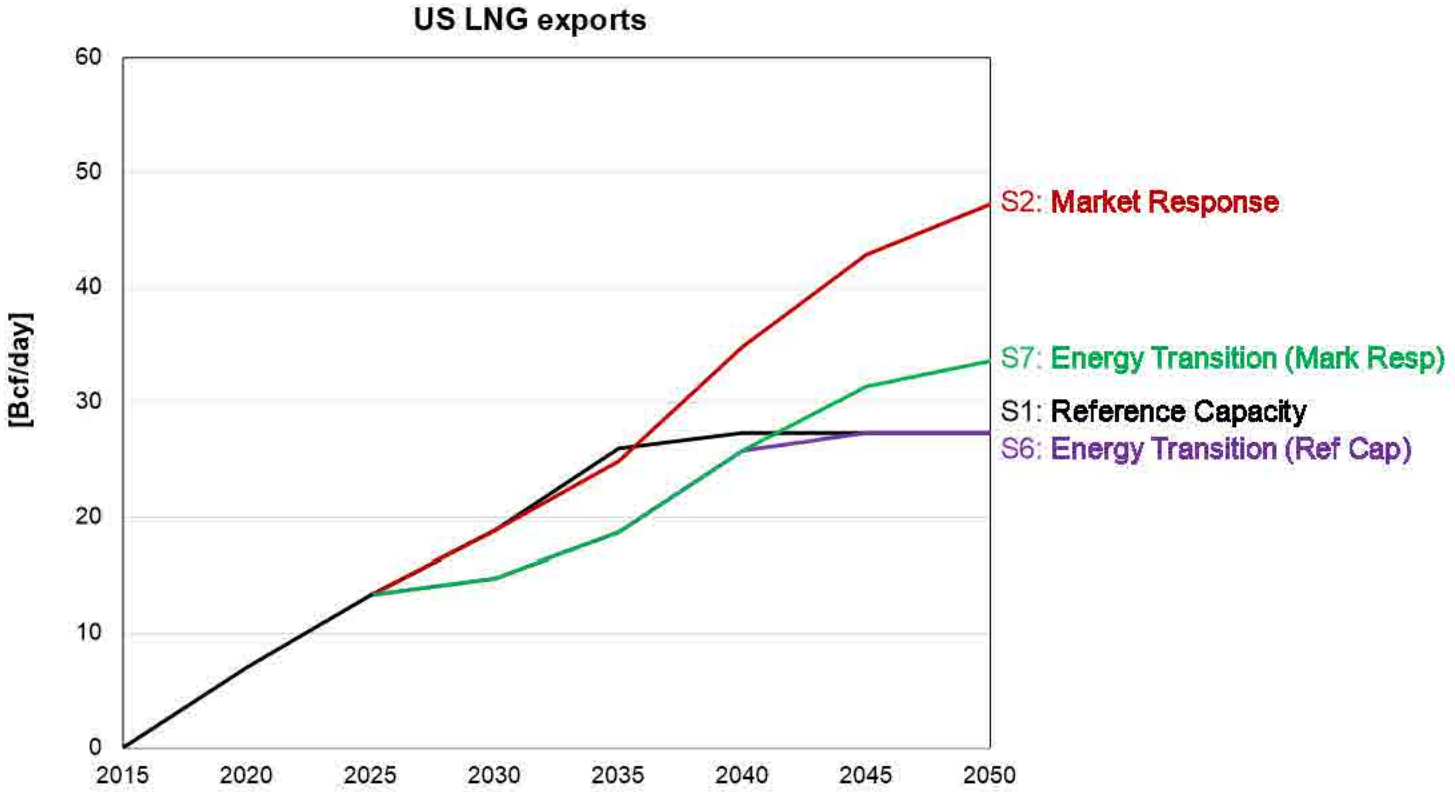
U.S. CO_2 Emission S1 & S2 from NEMS



The next few slides focus on *S6: Energy Transition (Ref Cap)* & *S7: Energy Transition (Mark Resp)*

- S6 assumes U.S. LNG exports from the AEO2023 Reference case as an upper bound and can be compared with S1 which is assumed to follow the AEO2023 Reference case trajectory

- S7 assumes economically-driven outcomes and can be compared with S2



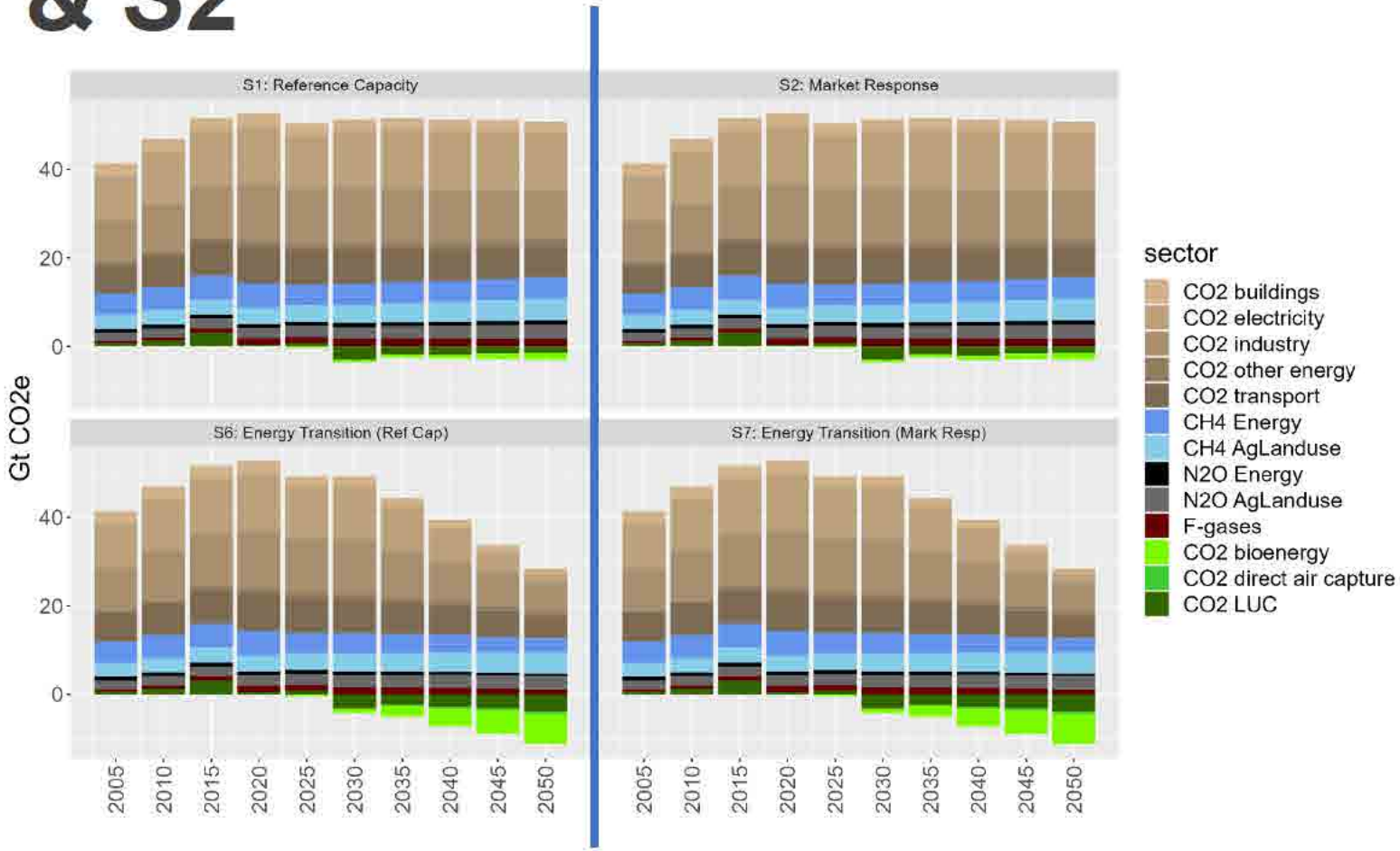
Note: All scenarios include a constraint on Russian exports

Scenarios S6 & S7: Detailed assumptions

- Through 2030, countries are assumed to achieve their nationally determined contributions (NDCs)
- Beyond 2030, countries without official UNFCCC net-zero pledges or long-term strategies (LTSs) are assumed to achieve the same level of decarbonization rate as the rate between 2015 and 2030 or a minimum rate if their decarbonization rate is below this minimum rate
- Countries with official net-zero pledges (e.g. U.S.) and LTSs are assumed to follow their net-zero pledges and LTSs till the target year, followed by the path defined by the minimum decarbonization rate

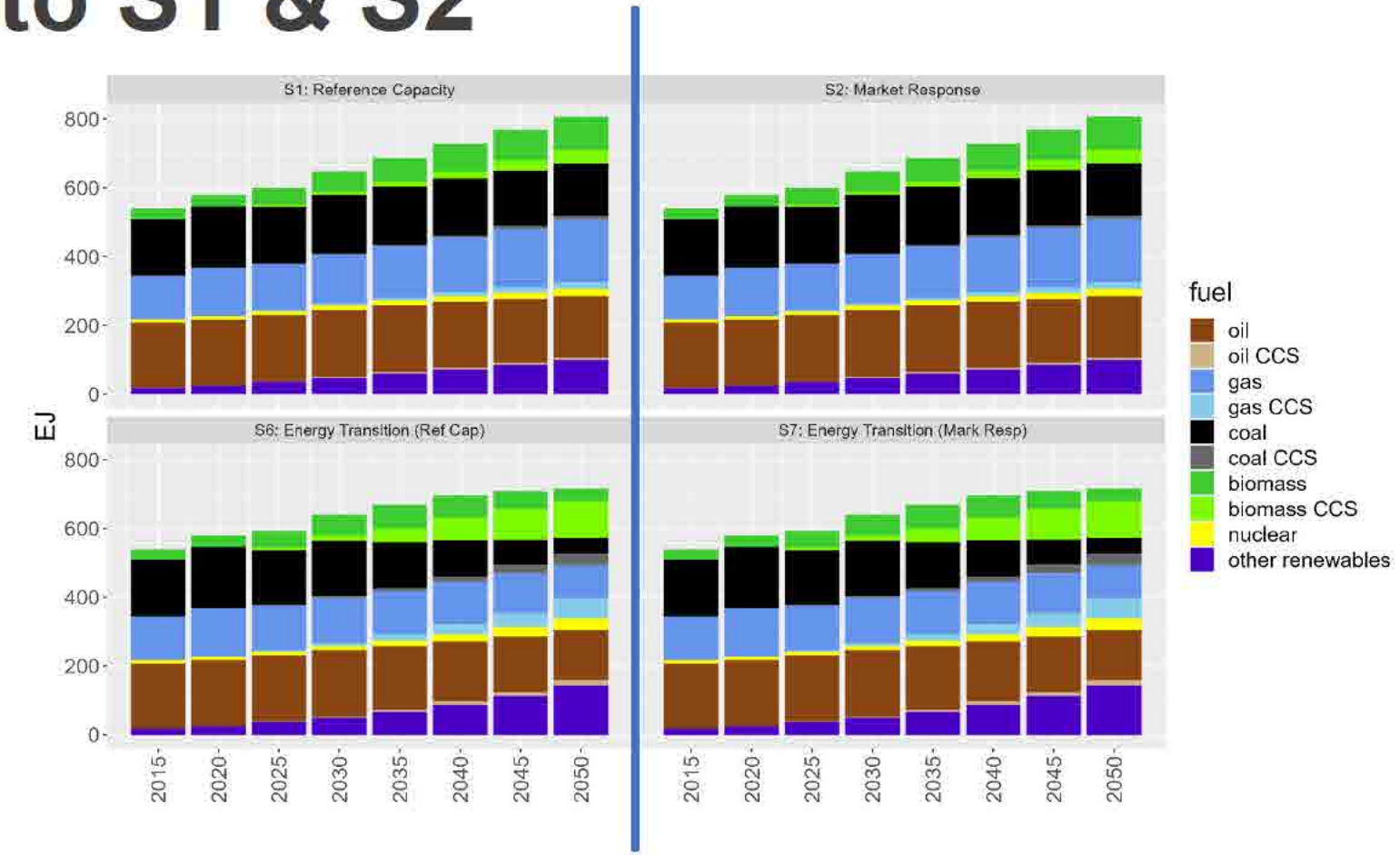
Global GHG emissions under S6 & S7 compared to S1 & S2

- Under S6 and S7, emissions from all sectors of the economy reduce significantly compared to S1 and S2
- These scenarios are also characterized by increased deployment of carbon dioxide removal strategies
- Under S6 and S7, global GHG emissions are net-positive (~20 GtCO2e), global CO_2 emissions are ~0 in 2050
  - Individual countries/regions that have explicit net-zero pledges (e.g. U.S.) are assumed to achieve those pledges in the stated target years
  - Countries are assumed to achieve their pledges through a combination of decarbonization strategies (subsequent slides) within their geographical boundaries without emission trading



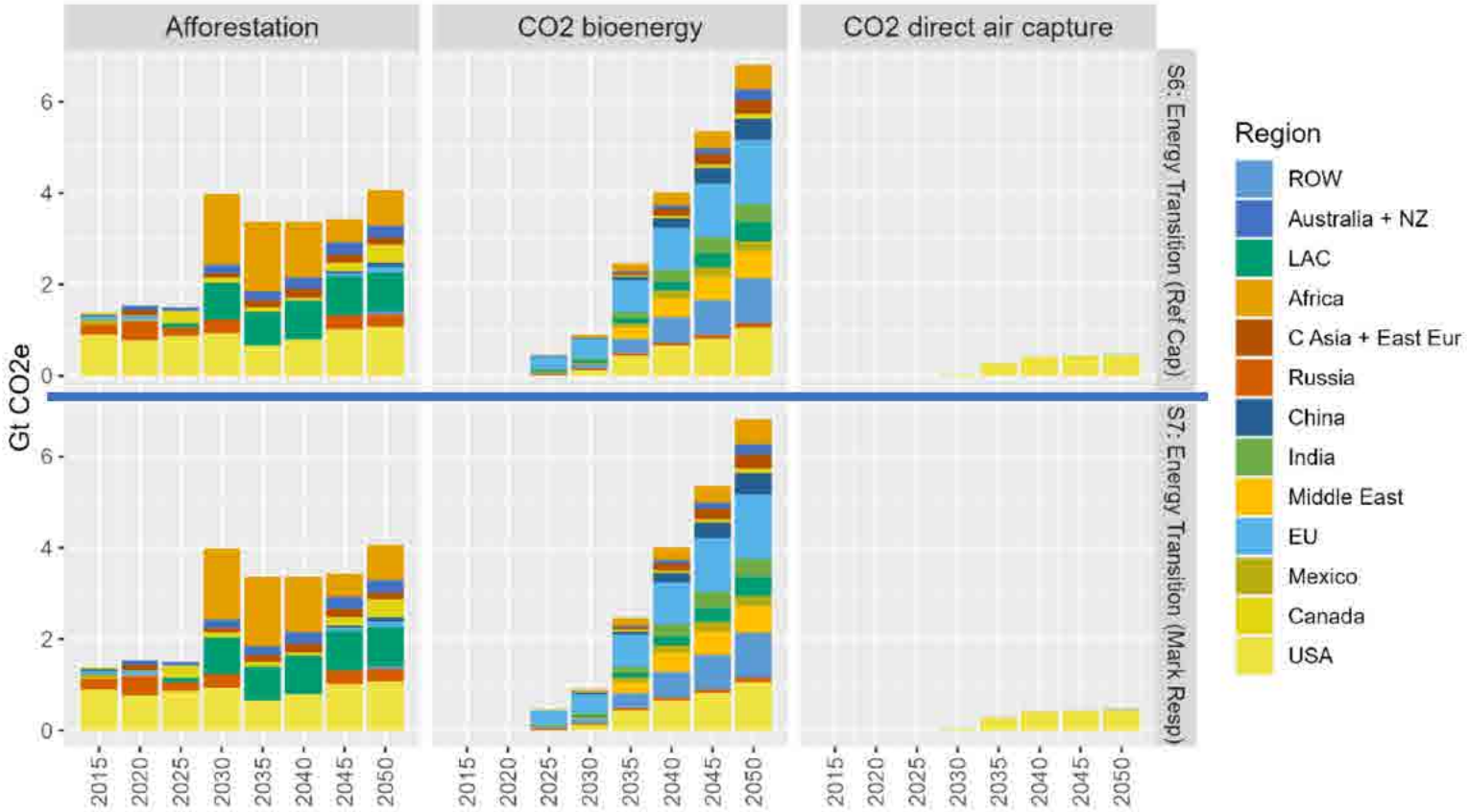
Global primary energy consumption under S6 & S7 compared to S1 & S2

- Compared to S1 and S2, the transition toward 1.5°C in S6 and S7 results in:
  - A reduction in gas, coal, and oil consumption w/o CCUS;
  - Increased deployment of gas, coal, and biomass w/ CCUS;
  - Increased deployment of renewables;
  - A net reduction in energy consumption



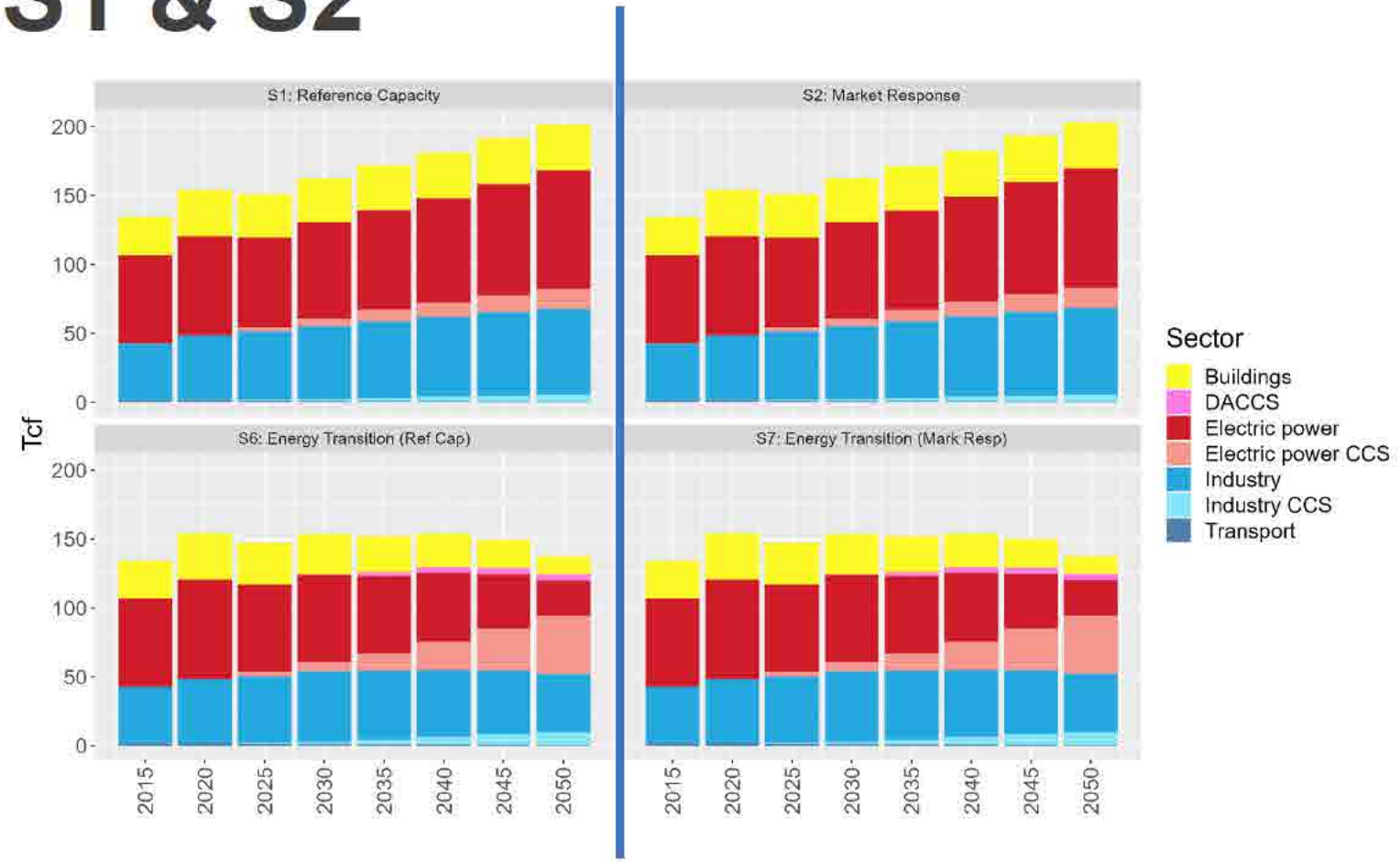
Global CO_2 removal by region under S6 & S7

- Our scenarios include representation of three types of carbon dioxide removal strategies, namely, afforestation, bioenergy in combination with CCUS (BECCS), and direct air capture (DAC) under S6 and S7
- While BECCS and afforestation are distributed more evenly across regions, most of the DAC is deployed in the U.S. primarily due to the availability of carbon storage
- DAC assumptions are consistent with NEMS and developed by FECM



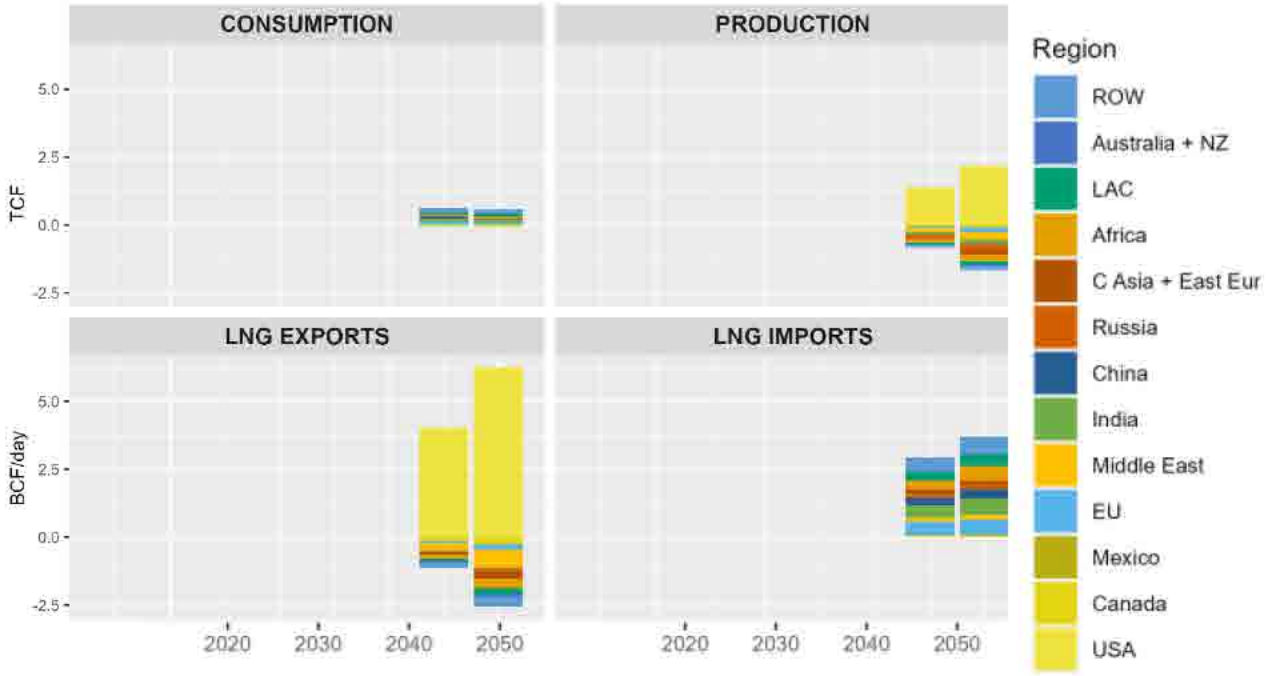
Global natural gas consumption under S6 & S7 compared to S1 & S2

- Compared to S1 and S2, the transition toward 1.5°C in S6 and S7 results in a net reduction in gas consumption by globally
- Most of the gas under S6 and S7 is consumed in the electric power and industrial sectors for CCUS applications

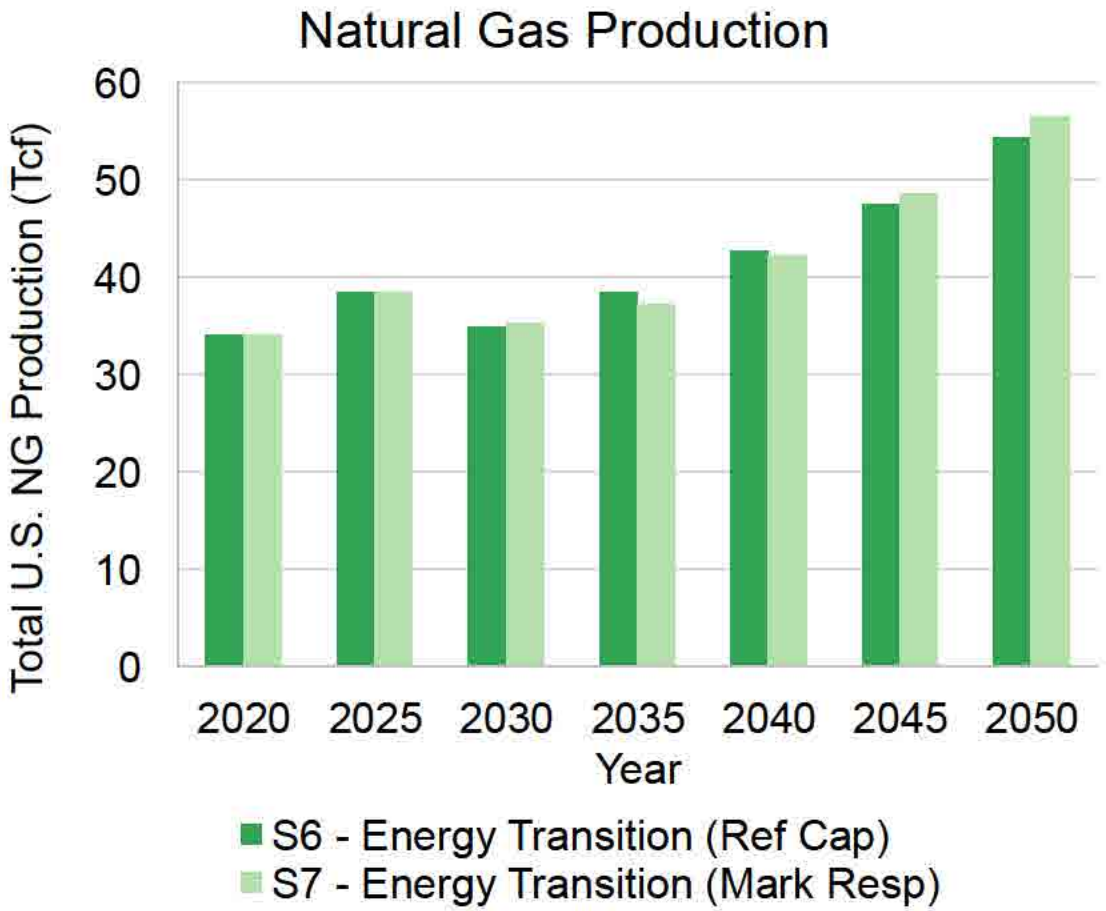


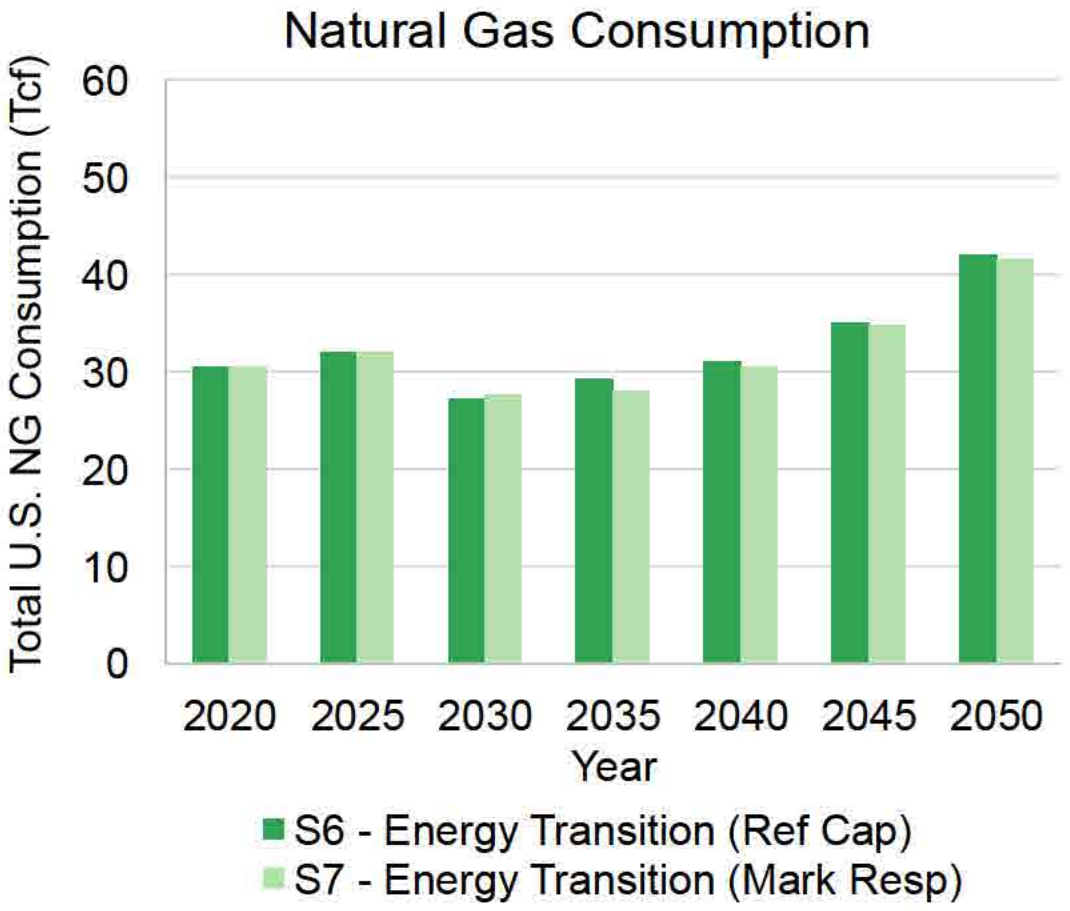
Global natural gas consumption, production, & trade (changes) under S7 relative to S6

- Similar to the comparison between S1 and S2, the availability of additional U.S. in S7 compared to S6 results in:
  - A reduction in production outside the U.S.
  - A reduction in LNG exports outside the U.S.
  - An increase in LNG imports outside the U.S.
  - A small increase (<5%) in global gas consumption by 2050

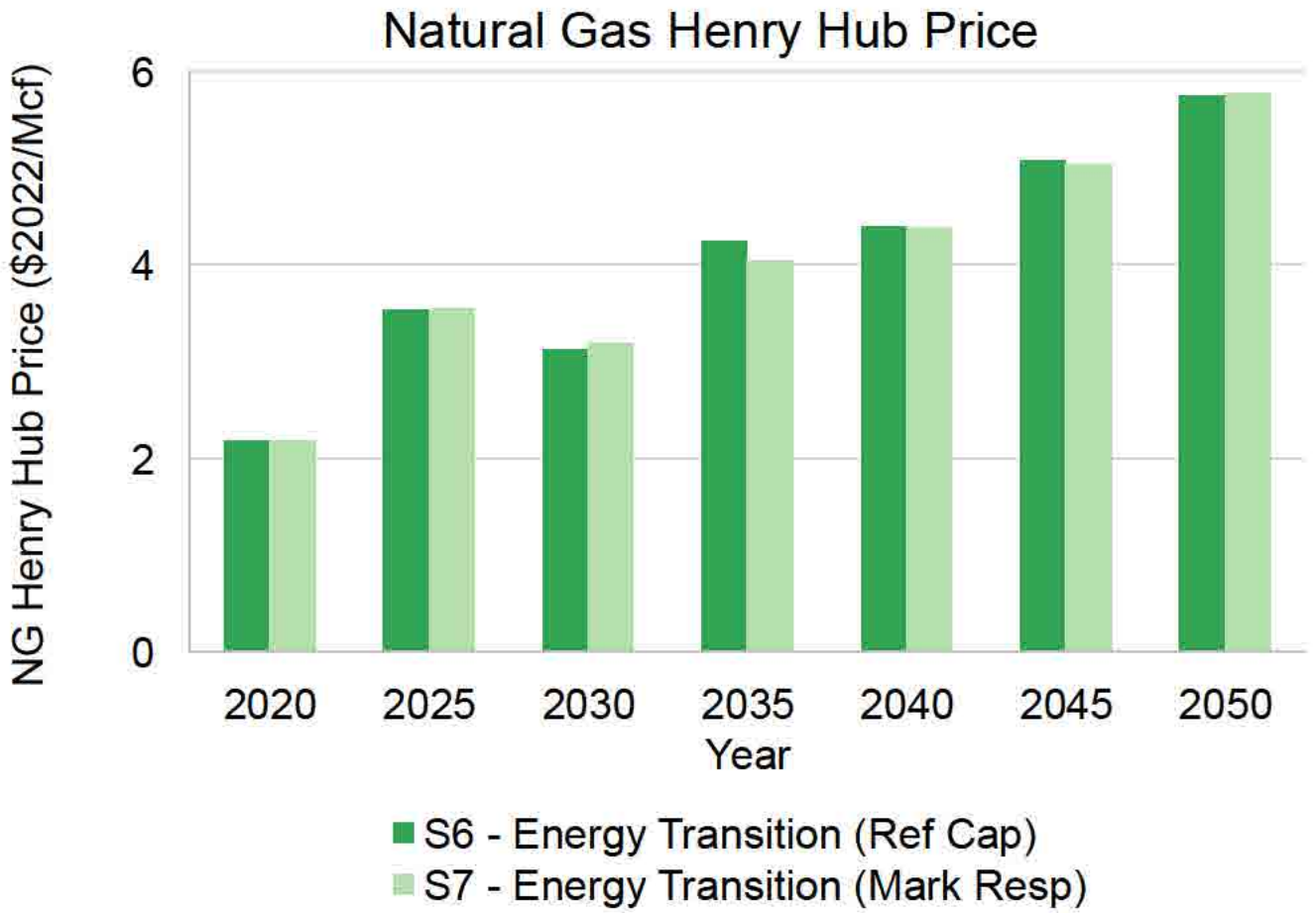


U.S. Natural Gas Balance S6 & S7 from NEMS

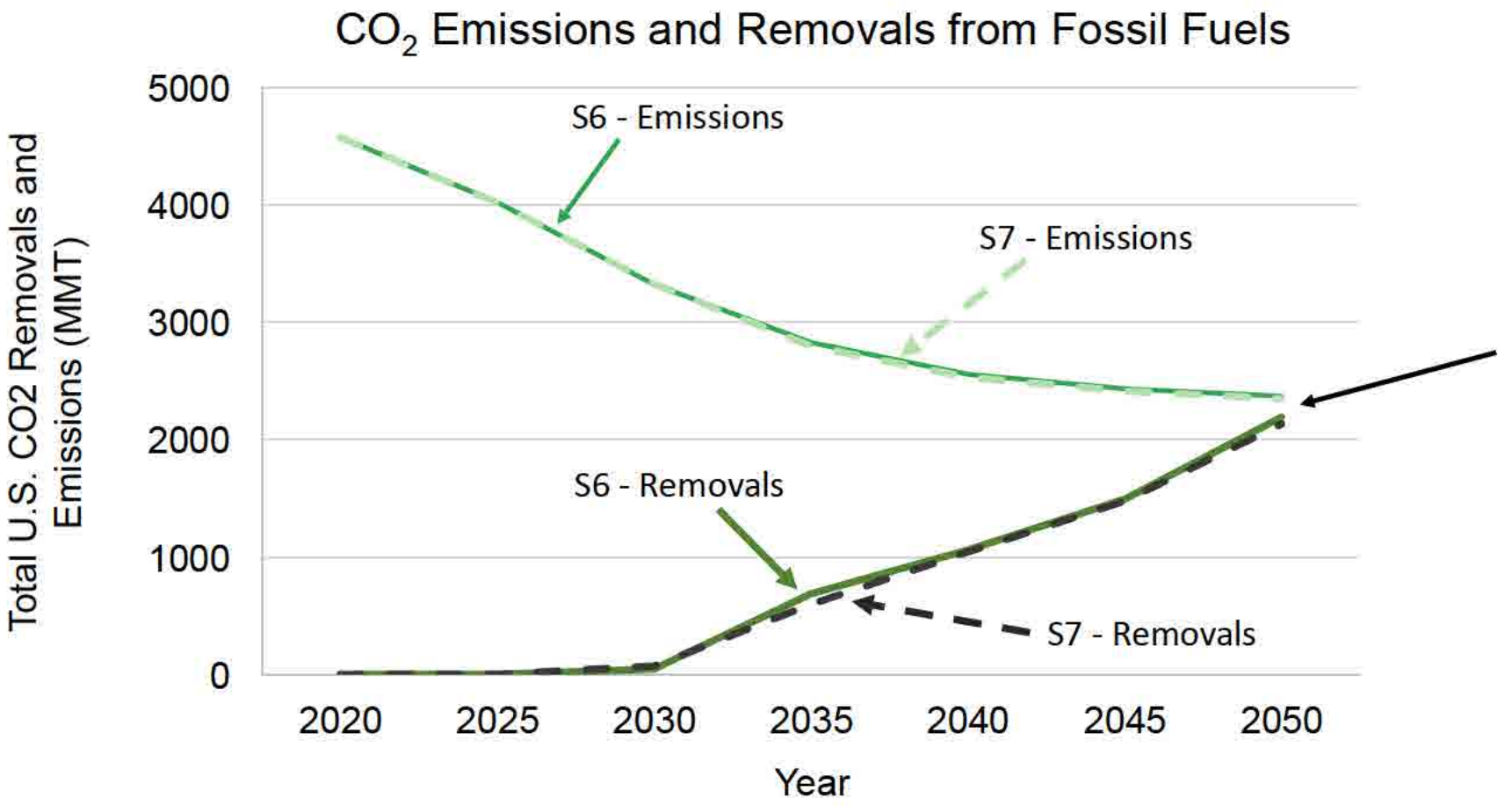




US Gas Price Impacts Under S6 & S7 from NEMS



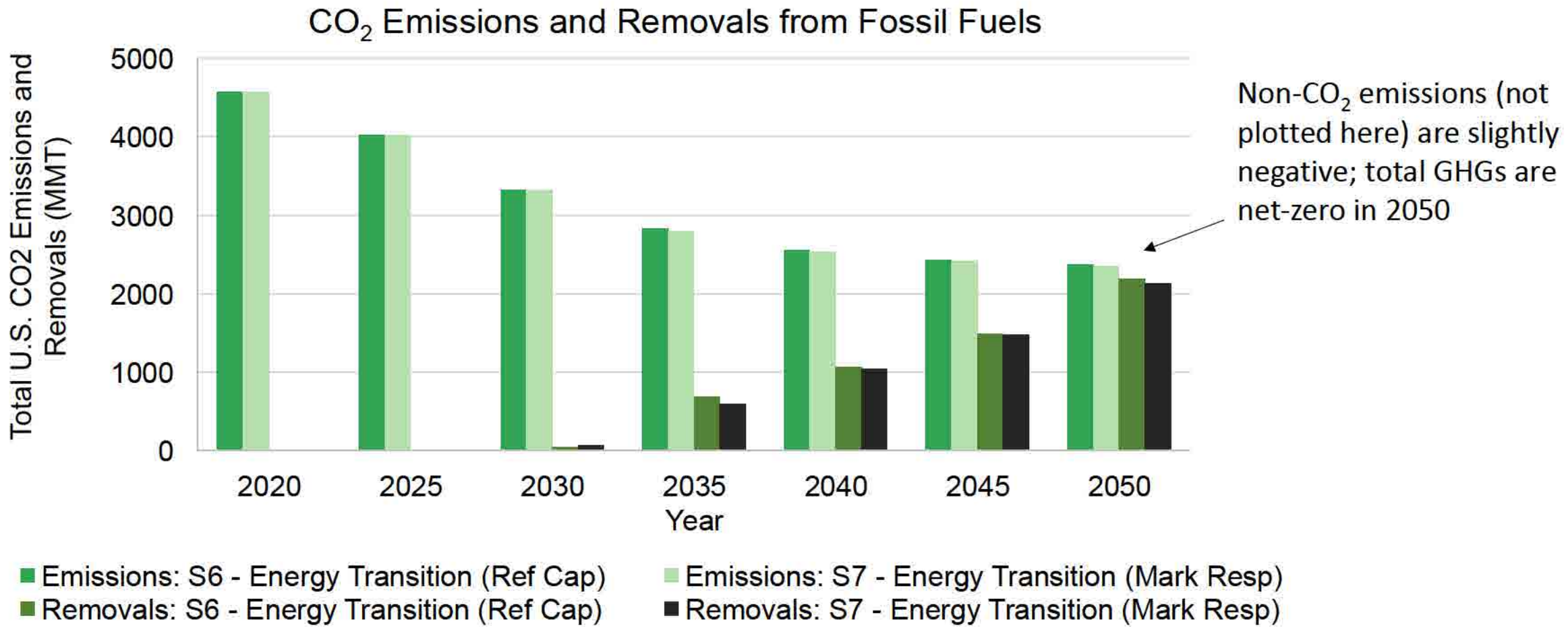
U.S. CO_2 Emission and Mitigation S6 & S7 from NEMS (this over next slide?)



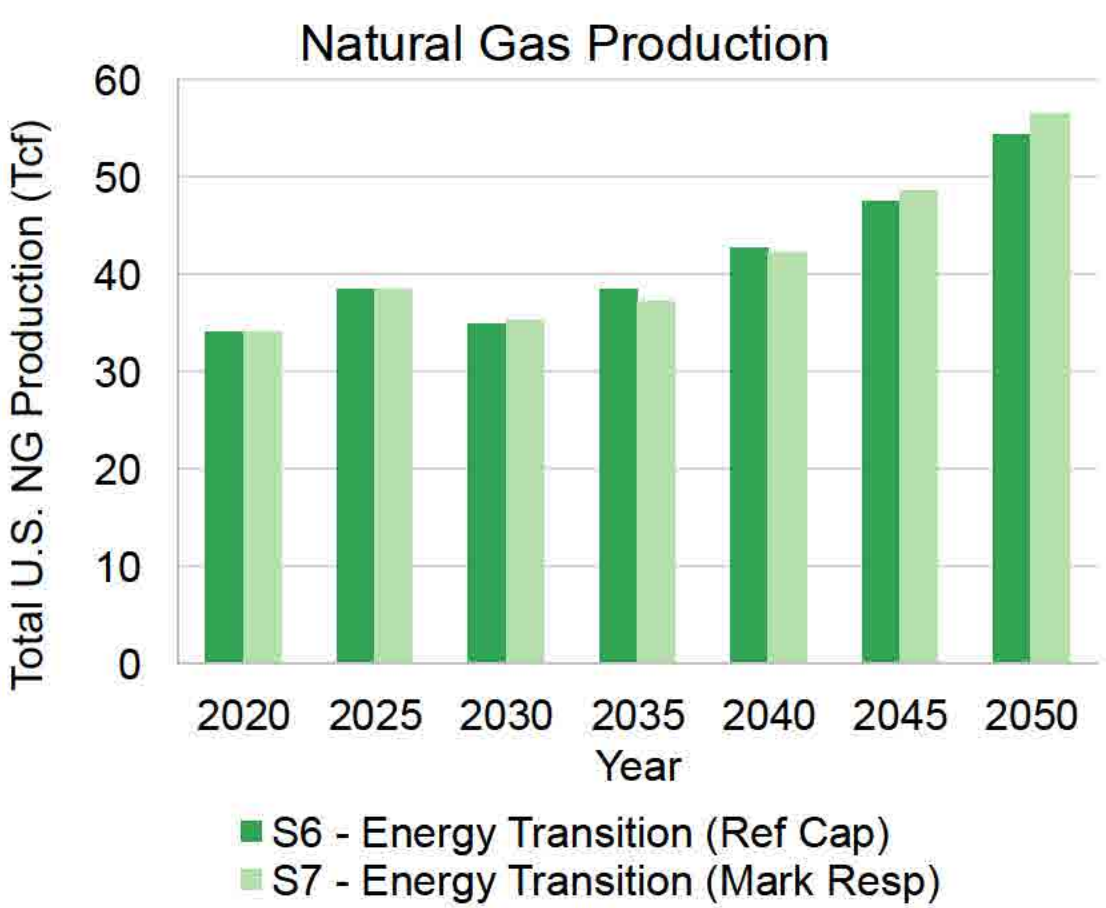
Non-CO_2 emissions (not plotted here) are slightly negative; total GHGs are net-zero in 2050

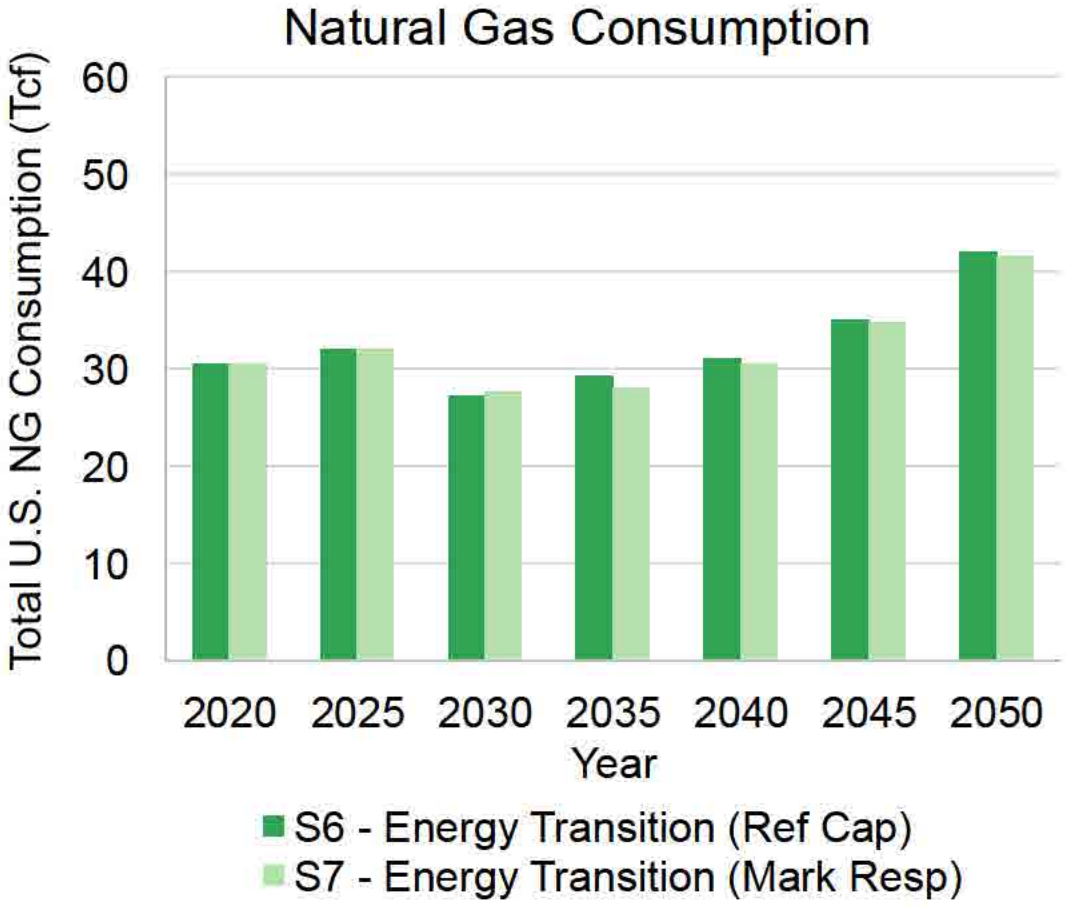
S6 - Energy Transition (Ref Cap)
S7 - Energy Transition (Mark Resp)

U.S. CO_2 Emission Mitigation S6 & S7 from NEMS



U.S. Gas Consumption by sector under S6 and S7





Key Takeaways

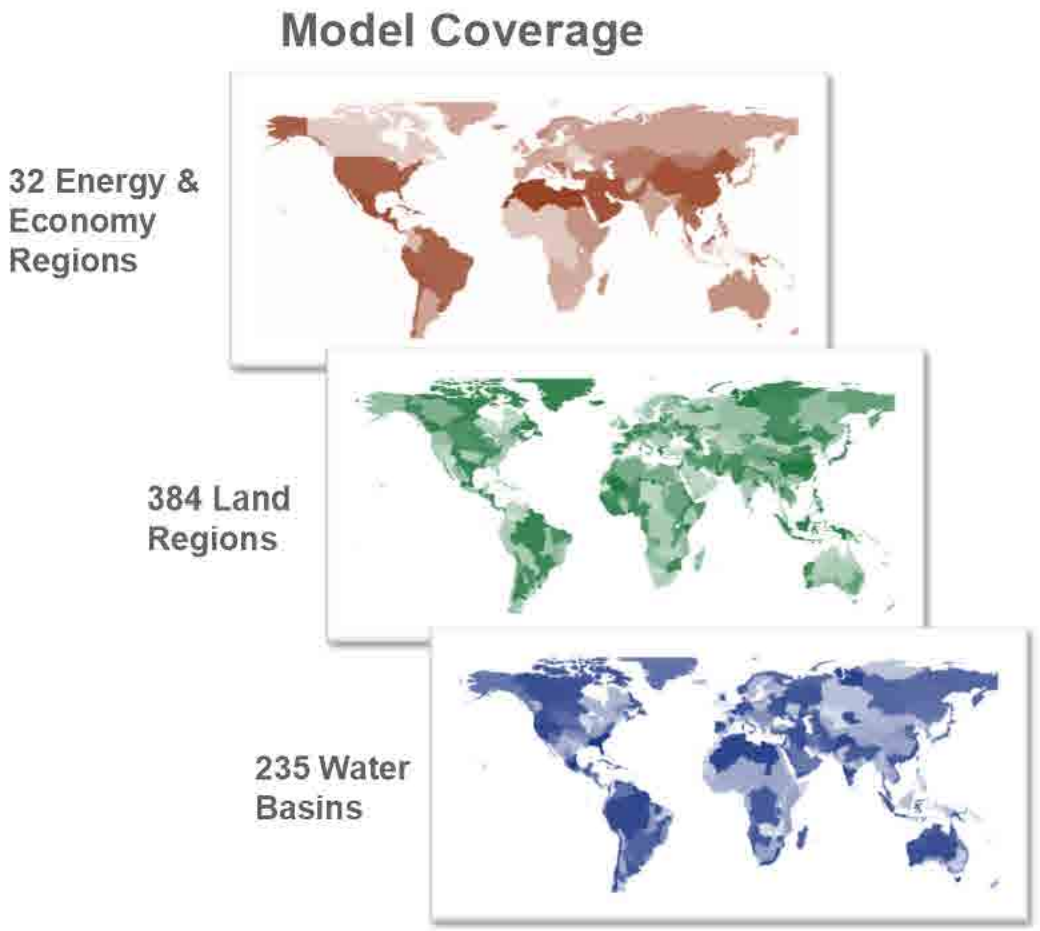
- U.S. LNG exports continue to grow beyond existing and planned capacity in all modeled scenarios through 2050.
- U.S. CO_2 emissions do not change significantly across scenarios (except the scenario that assumes a global 1.5°C consistent pathway, S6).
- When compared to a scenario in which U.S. LNG exports are constrained (S1), an unconstrained scenario that assumes economically driven LNG export levels (S2) leads to:
  - Significant growth in U.S. LNG exports
  - Little change in global GHG emissions and global gas consumption
  - Moderate increases in U.S. natural gas prices (2050 prices projected to increase from $3.74/MMBtu to $4.95/MMBtu. Previous study, at lower export levels, projected 2050 prices above $6.00/MMBtu.)
- Under a global energy transition consistent with meeting a 1.5°C target (S6), U.S. LNG exports continue to grow through 2050 – albeit at a slower rate compared to the unconstrained scenario – driven by increased demand for gas in combination with CCUS in the power and industrial sectors and to support direct air capture operations for atmospheric CO_2 removal.

Next Steps

- Finalize GCAM and NEMS analyses based on Leadership Briefing and complete report
- Conduct Final Review NETL LCA Analysis and Environmental Review
- Complete ALL Reviews and Briefings to Publish summary report and supporting documentation for public comment by End of September Target date

Appendix:
GCAM Extra Material

The Global Change Analysis Model (GCAM)



- GCAM links **Economic**, **Energy**, **Land-use**, **Water**, and **Climate** systems in a technology-rich model
- Runs from 2015 (calibration year) to 2100 in 5-year time-steps
- Emissions of 16 greenhouse gases (GHG) and air pollutants are tracked
- GCAM is a community model: http://jgcri.github.io/gcam-doc/toc.html
- GCAM includes representation of LNG and pipeline gas trade
- Our representation creates price-based competition between domestic gas and imported LNG/pipeline gas
  - Introduces realistic inertia in the evolution of trade from current patterns
- Traded LNG is represented as a single global market
- Traded pipeline gas is represented in six regional markets

Examples of GCAM's technological detail

Electricity generation

- Coal w/ and w/o CCUS
- Gas w/ and w/o CCUS
- Oil w/ and w/o CCUS
- Bio w/ and w/o CCUS
- Nuclear
- PV w/ and w/o storage
- CSP w/ and w/o storage
- Onshore and Offshore wind
- Geothermal

Buildings

- Residential cooling
- Residential Heating
- Residential other
- Commercial Cooling
- Commercial Heating
- Commercial Other

** Each of the above services includes representation of fuel competition. For e.g., residential heating service includes competition between electricity, gas, H2, biomass, and liquids.*

Transport

- Passenger
- Freight
- International freight shipping
- Long-distance passenger air travel

** Each of the above sectors includes representation of fuel competition. For e.g., the passenger sector includes different modes (e.g., road, rail), sub-modes (e.g., bus, light duty vehicle), size classes, and drivetrain technologies (e.g. electric, hybrid, combustion engine).*

Industry

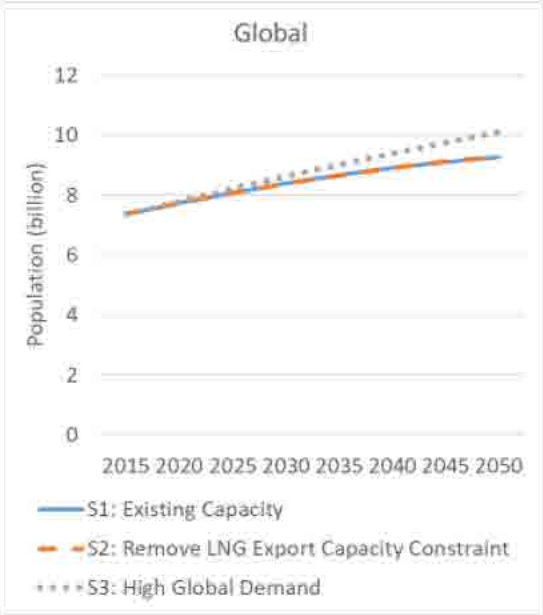
- Cement
- Fertilizers
- Iron & Steel
- Pulp & Paper
- Chemicals
- Aluminum
- Construction
- Mining
- Agriculture
- Other

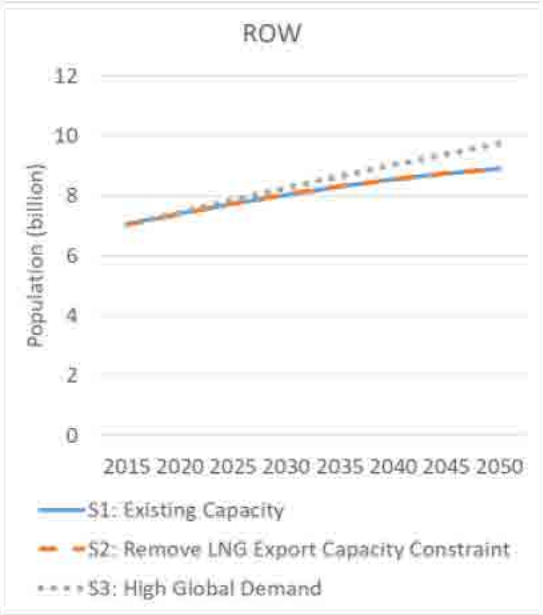
** Each of the above industries include more representation of processes and fuel competition. For e.g., the Iron & steel sector consists of three processes: Basic Oxygen Furnace, Electric Arc Furnace with scrap, and EAF with Direct Reduced Iron. Each process includes competing technologies, such as fossil fuels w/ & w/o CCS, electricity, hydrogen, and biomass.*

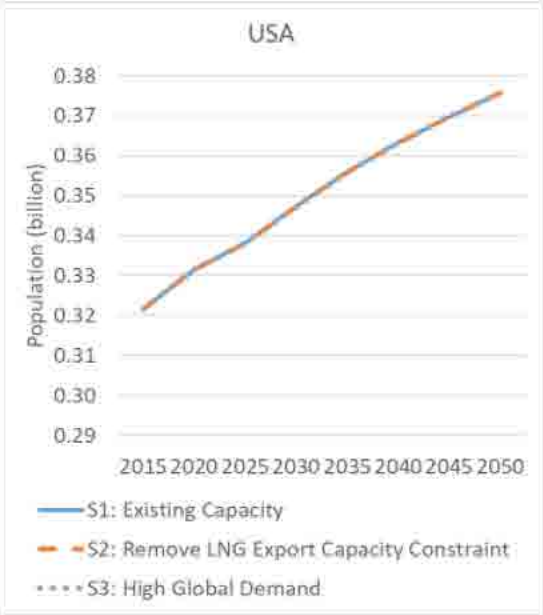
Common assumptions across all scenarios

- IRA in the US, and current emission policies in the rest of the world
- Constraint on Russian exports
  - Flat to declining Russian exports to EU
  - Flat LNG exports from Russia
  - Increasing Russian pipeline exports to the east
- Planned and existing LNG capacity additions in Middle East, Australia, Canada, Southeast Asia, and Africa
- U.S. population and economic growth harmonized to AEO-2023 Reference case

Scenario 3 (High Global Demand): Detailed assumptions







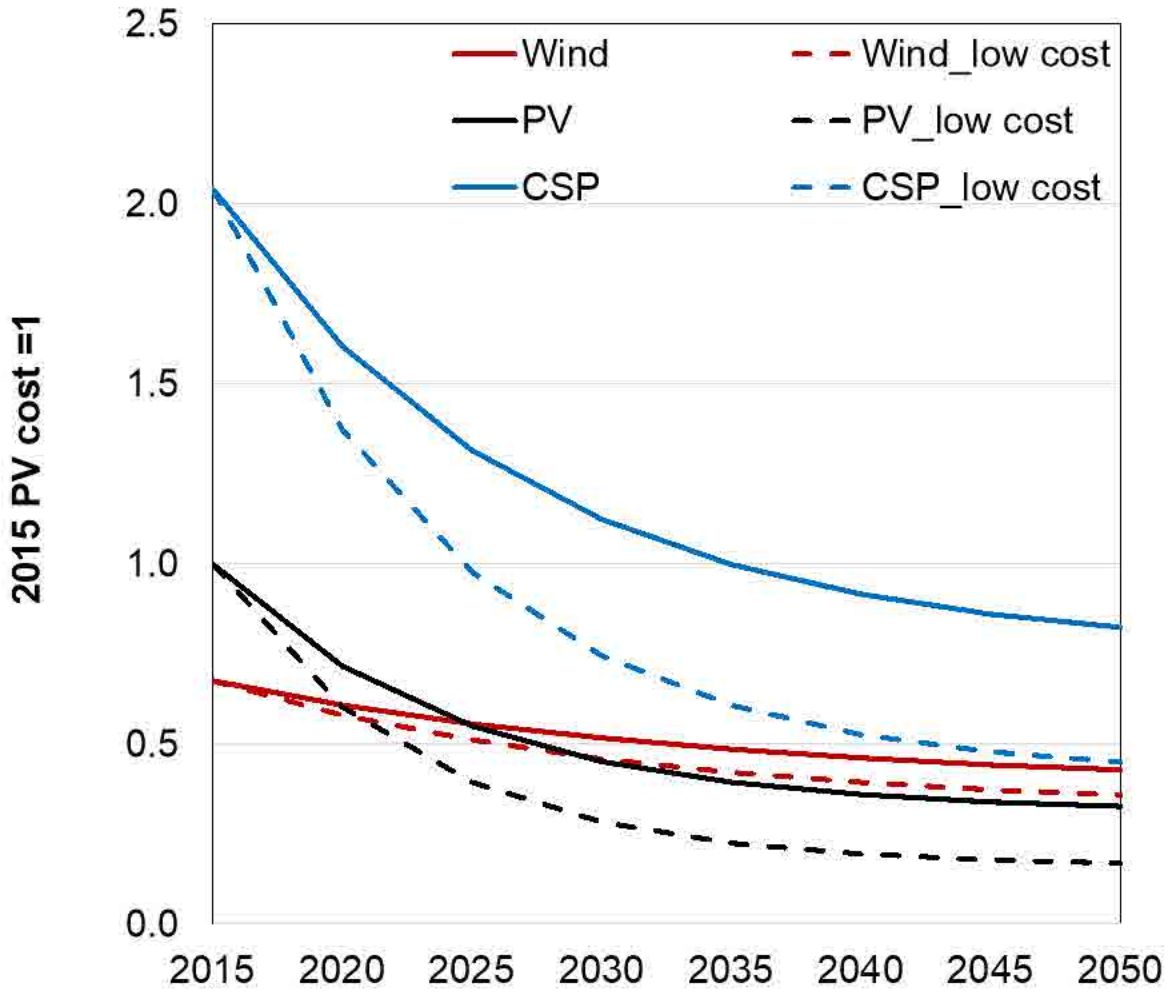
- To construct the High Global Demand Scenario, we assume the non-US regions to have higher population growth consistent with the Shared Socioeconomic Pathways – 3
- This results in ~1 billion more people globally in S3 by 2050 compared to S1/S2
- US population is assumed to remain unchanged relative to S1/S2
- US Population assumptions in Scenarios S1 and S2 are harmonized with AEO-2022

Scenario 4 (Regional Import Limits): Detailed assumptions

Region Type	GCAM Regions	High-level target / sanction
Developed countries, natural gas importers with sufficient resources	EU-12, EU-15, Europe_Eastern, Europe_Non_EU	Reduce gross imports to 90% by 2030 and zero by 2035
Developed countries, natural gas importers, low natural gas resources	Japan, South Korea, Taiwan	Maintain current import dependence through 2050
Developing countries, natural gas importers	Brazil, China, India, Pakistan, Southeast Asia, Mexico, South Africa	Maintain current import dependence through 2050
Natural gas exporters	USA, Africa_Eastern, Africa_Northern, Africa_Southern, Africa_Western, Australia_NZ, Canada, Central America and Caribbean, Central Asia, European Free Trade Association, Indonesia, Middle East, South America_Southern, South America_Northern, South Asia, Colombia, Argentina	Zero out any imports by 2035
Russia	Russia	• Flat to declining Russian exports to EU • Flat LNG exports from Russia • Increasing Russian pipeline exports to the east

Scenario 5 (Low Cost Renewables): Detailed assumptions

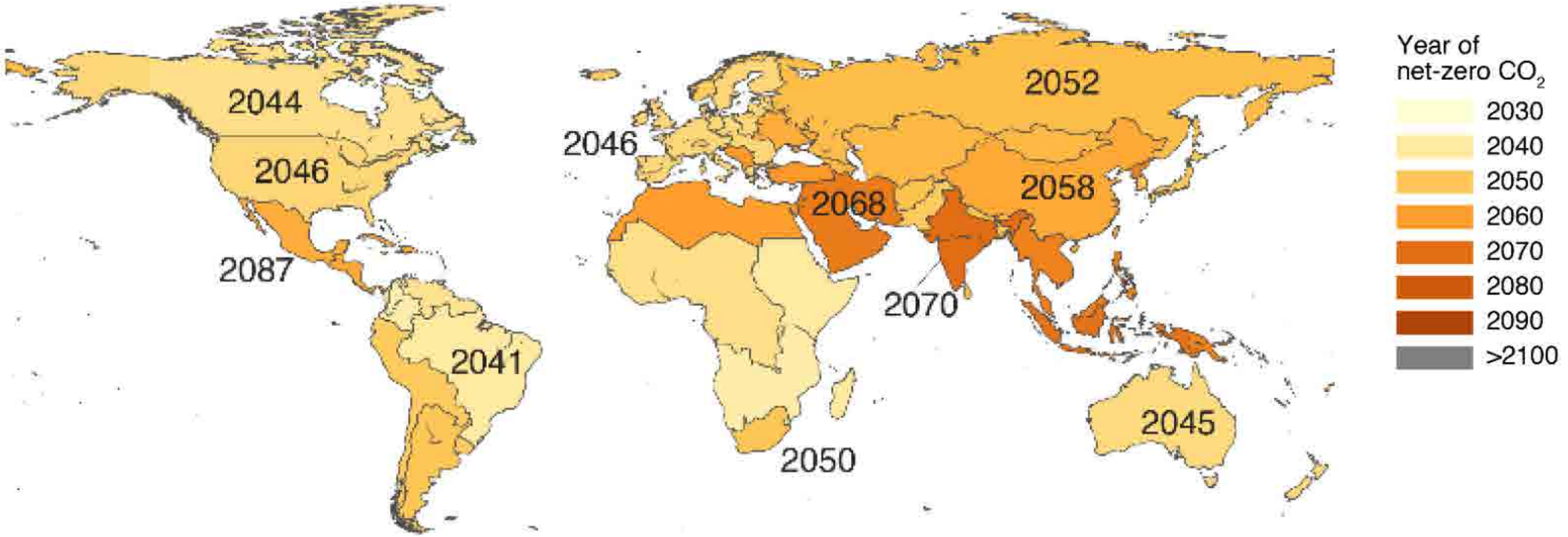
- To construct this scenario, we use capital cost assumptions for renewable technologies from the NREL's Annual Technology Baseline (ATB) "Low" assumptions



Scenario 6 (Energy Transition): Detailed assumptions

- To construct the Energy Transition scenario, we begin with countries' most recent commitments and pledges
- Countries are assumed to achieve their nationally determined contributions through 2030
- Countries with net-zero pledges (including the US), and long-term strategies are assumed to achieve those pledges
- For countries without net-zero or long-term pledges, the scenario assumes a minimum threshold for the post-2030 decarbonization rate such that globally emissions follow a path consistent with limiting global warming to less than 1.5°C
- These assumptions are consistent with published literature: Fawcett et al., 2015, *Science*; Ou & Iyer et al. 2021, *Science*; Iyer & Ou et al. 2022, *Nature Climate Change*

Year of net-zero CO2 emissions in S6



Source: Iyer & Ou et al. 2022, Ratcheting of climate pledges needed to limit peak global warming, *Nature Climate Change*

IRA assumptions in GCAM

- Power:
  - PTC extension (13101)
  - ITC extension (13102)
  - Production tax credit for existing nuclear (13015): We assume that the nuclear PTC prevents retirements of existing nuclear power plants through 2032
- 45Q: Extension of credits for captured CO2 (13104)
  - We take a middle of the road approach assuming that 50% of projects pay prevailing wages and 50% don't
  - To be conservative, the first model period the credit is available is 2030. Introducing the credit in 2025 may induce more CCS / DAC in GCAM than can be realistically built in the next 2 years
- 45V: Production credits for clean hydrogen (13204)
  - We assumed hydrogen with CCS receives a greater subsidy from 45Q than 45V (Clean Hydrogen Subsidy) and claims 45Q in lieu of 45V.
  - For grid electrolysis, we take 2020 (national average) grid CO2 intensity and assume a linear future emissions reduction to 90% below 2020 levels in 2035.

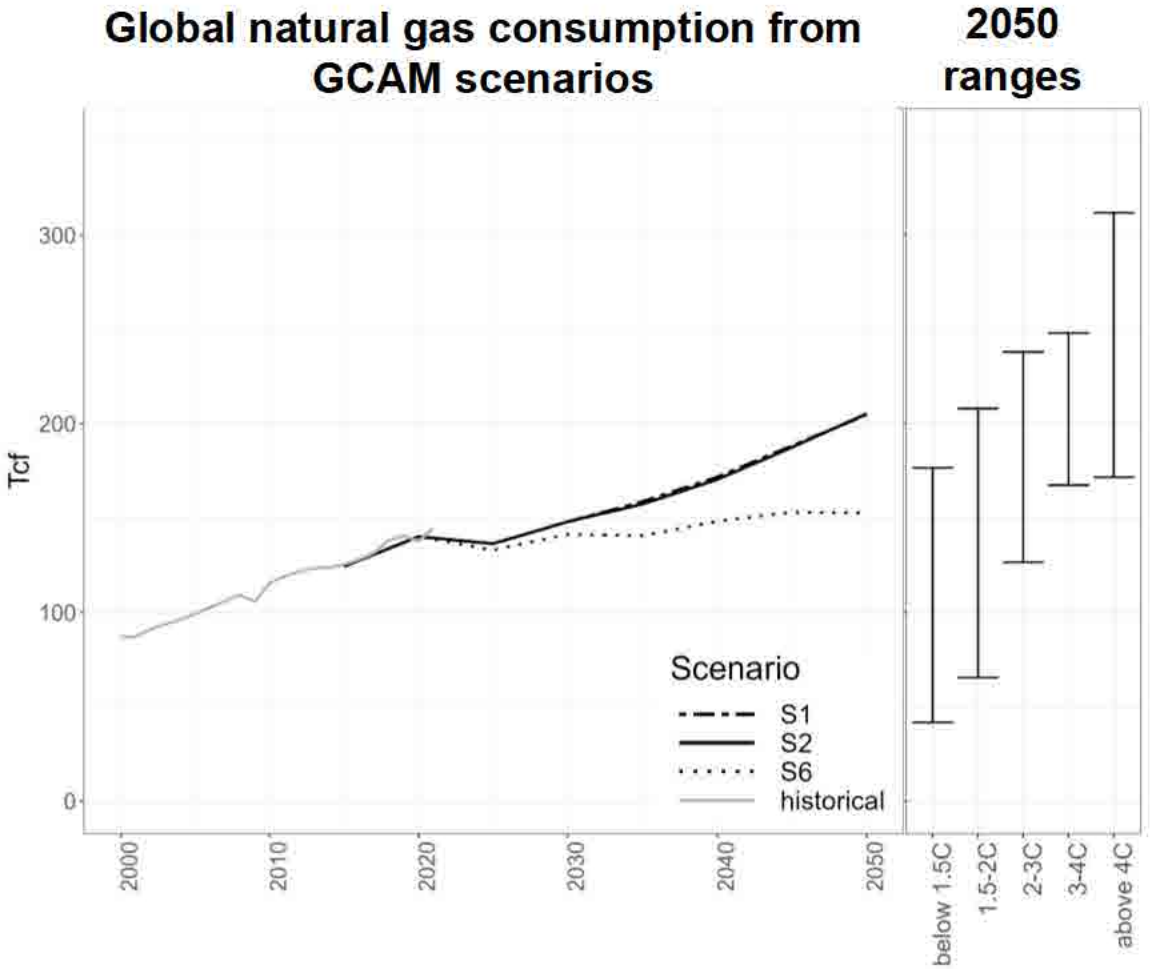
IRA assumptions in GCAM

- Transport:
  - Clean vehicle credit (13401):
  - We assume that the US auto manufacturing market will adjust their battery production to meet the domestic material requirements, allowing all new EVs produced in 2030 to qualify for the tax-credit.
  - We estimate that 89% of American taxpayers qualify for this tax-credit based on income eligibility requirements.
  - Commercial clean vehicle credit (13403)
  - Alternative refueling property credit (13404): Based on census data, 17.4% of Americans live counties that are either rural or low-income, so the $1,000 property credit is modeled as a weighted average national subsidy of $174 for capital infrastructure cost for LDV EVs.
  - Extension of incentives for biofuels (13201/13202)
  - Sustainable aviation credit (13203): subsidy for FT biofuels technologies (assumption is that jet fuel is first market for FT biofuels)
- Buildings:
  - Residential clean energy credit (13302): credit for rooftop PV
  - Energy Efficient Home Credit (13304): shell efficiency improvement
- Agriculture methane (21001): We assumed the 8.5 billion for EQIP contributed to ag CH4 reductions

Comparison with scenarios in the literature

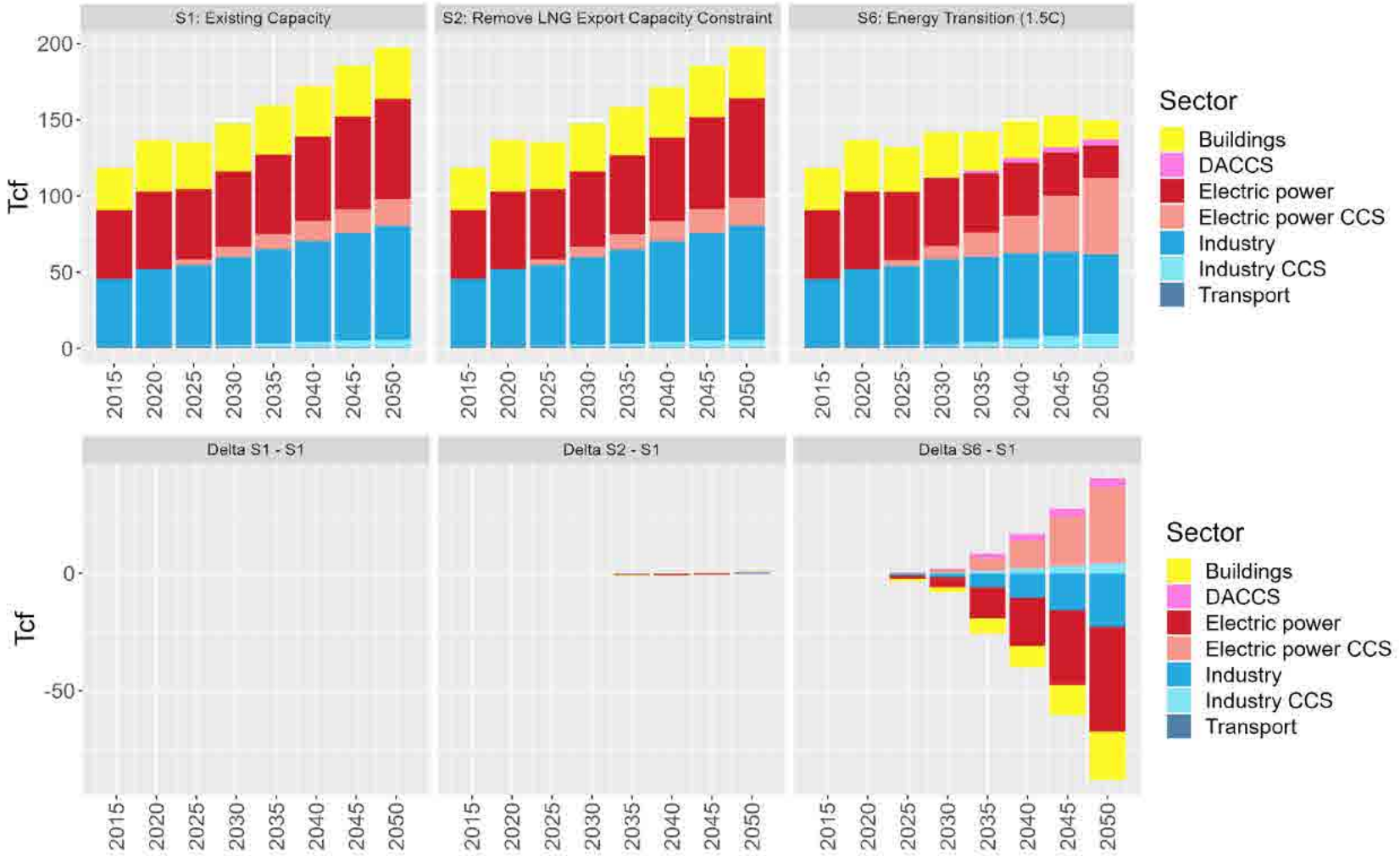
- The panel on the right shows 10-90th percentile ranges for global natural gas consumption in 2050 across scenarios in the sixth assessment report of the IPCC

- Our *Energy Transition* scenario lies within the range of scenarios assessed by the IPCC
  - It is on the higher end which is consistent with scenarios w/ CCUS



Global gas consumption by sector (key)

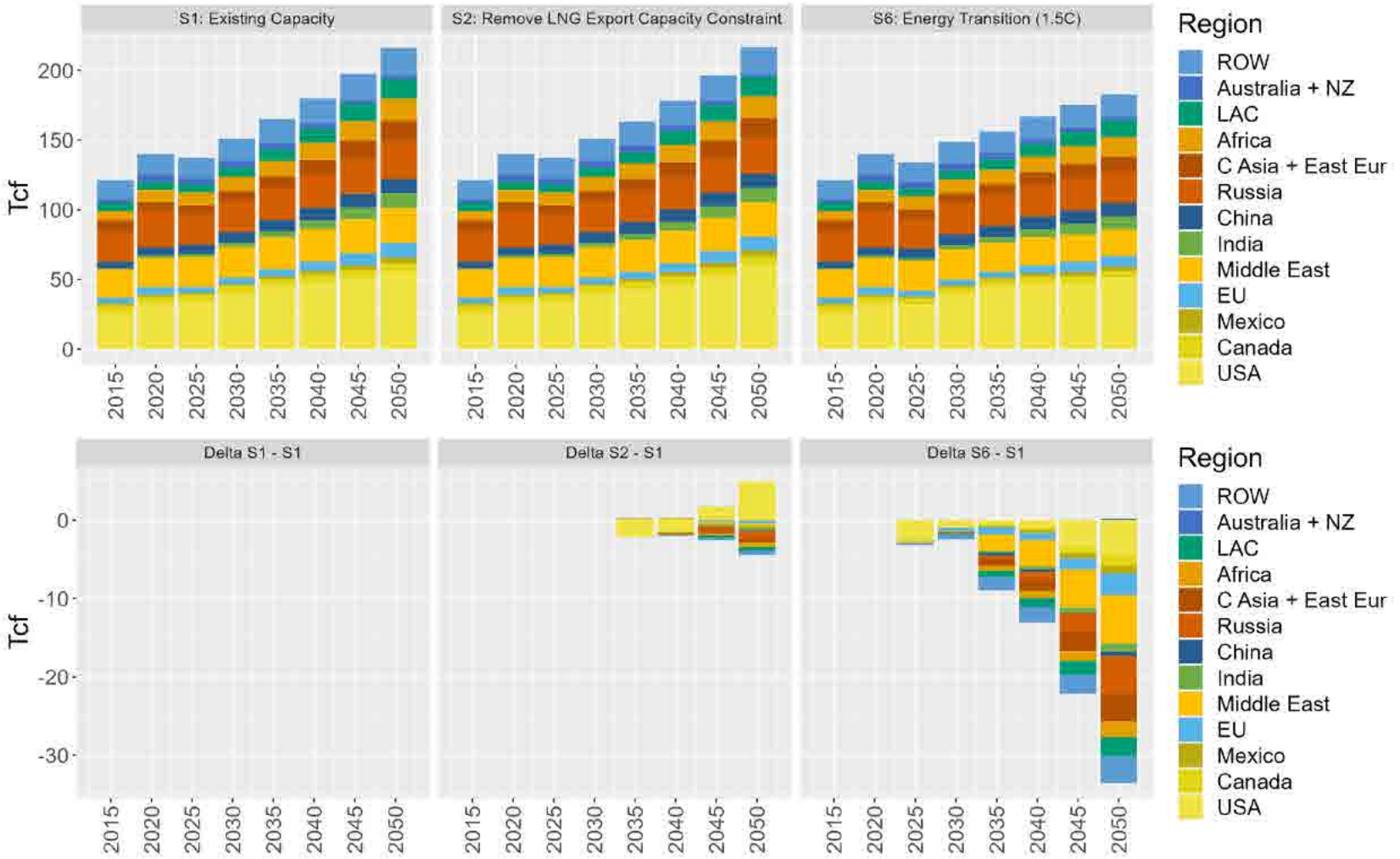
- Across all scenarios, the power and industrial sectors account for the major share of gas consumption by 2050
- Removing the US LNG export constraint (S2) results in slightly higher gas consumption globally (<5% by 2050)
- Under the Energy Transition scenario (S6), gas consumption is lower compared to S1 and S2; but continues to grow due to the deployment of gas w/CCUS in power and industrial sectors, and direct air capture



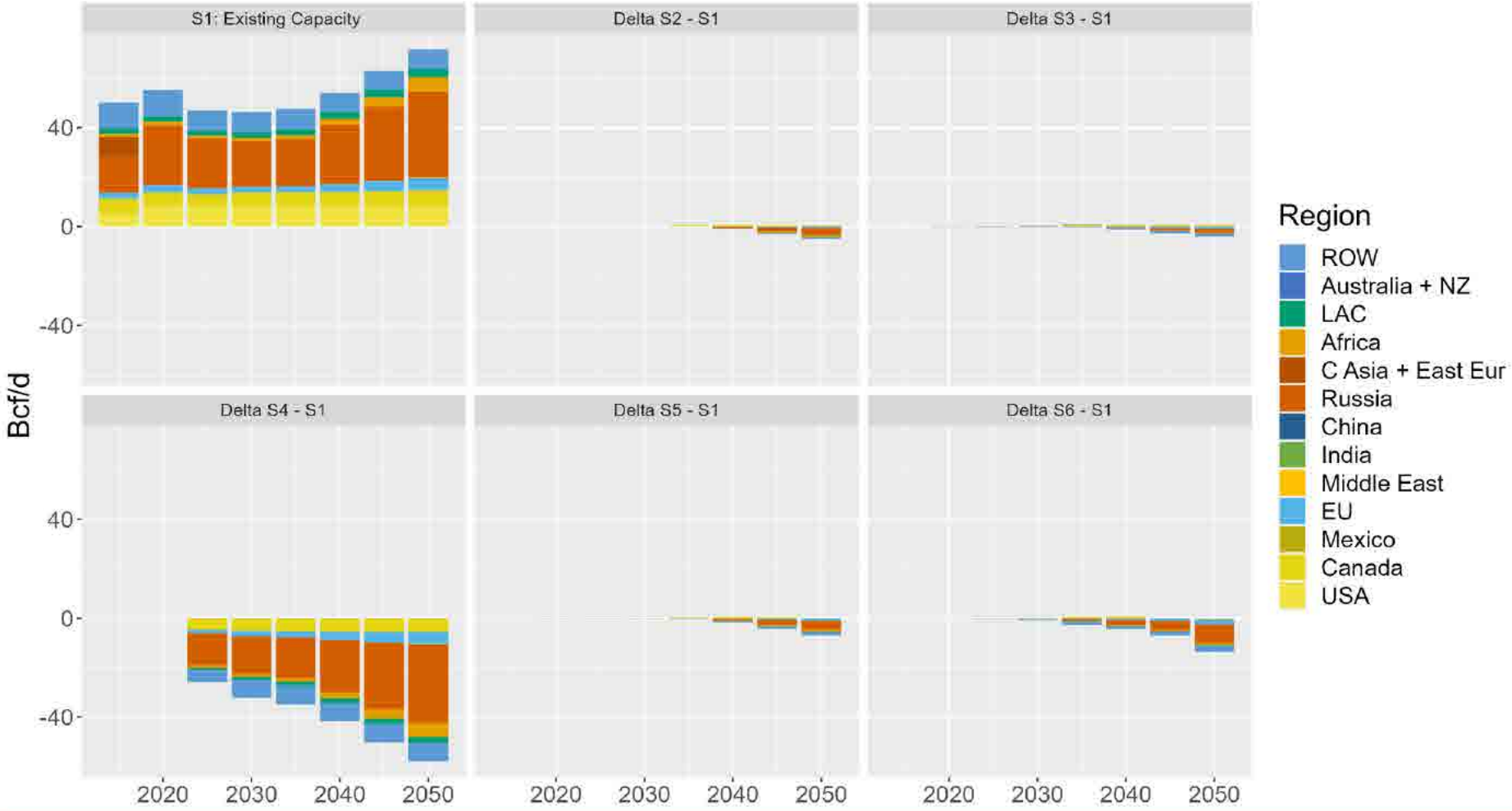
Global gas production by region

- Removing the U.S. LNG export constraint (S2) results in higher production in the US but lower production in other parts of the world as additional US LNG becomes available to meet gas demands

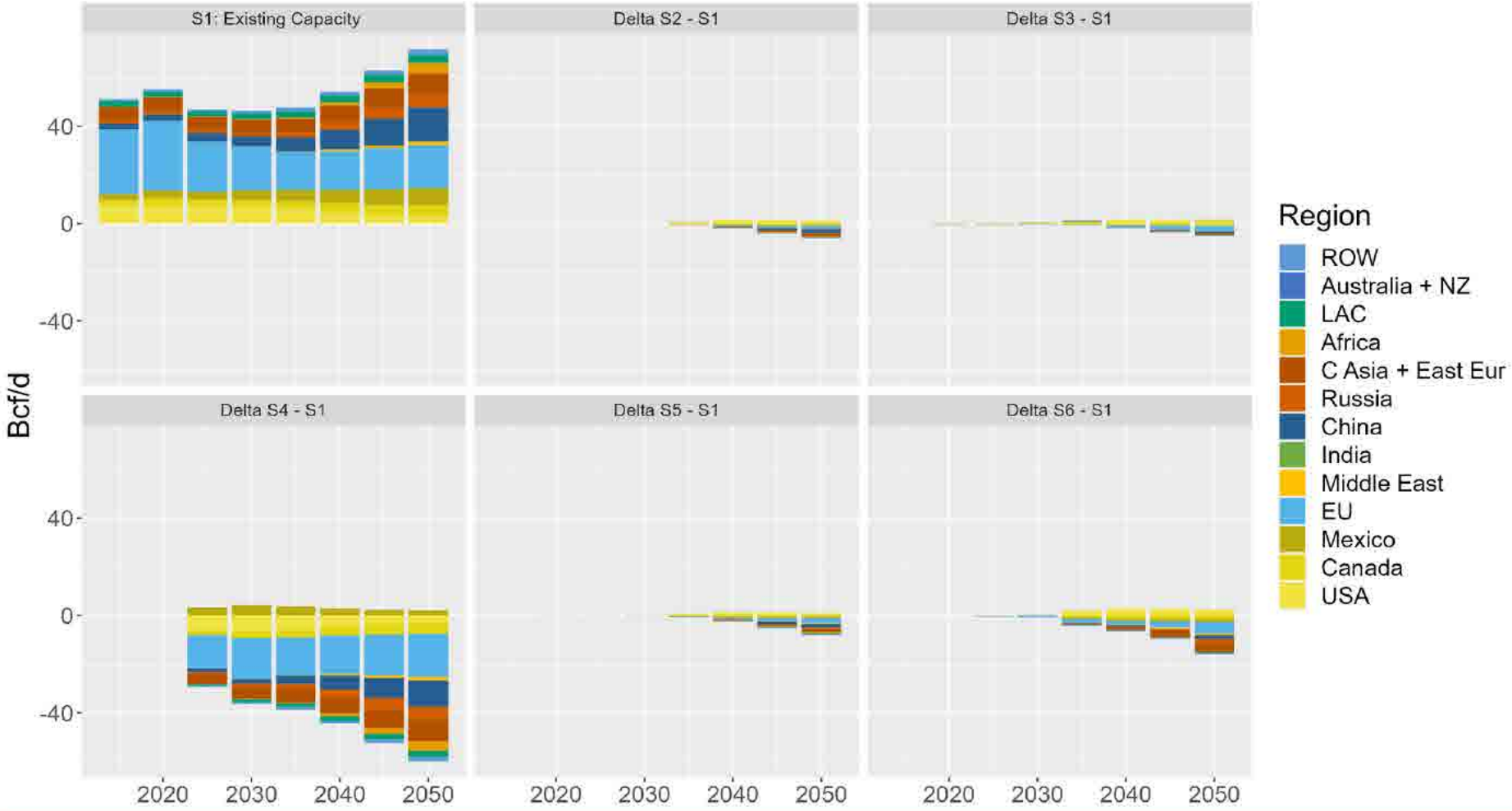
- Under the *Energy Transition* scenario (S6), gas production is lower in most regions due to the reduction in demand driven by the transition toward low-carbon fuels



Global pipeline exports



Global pipeline imports



Appendix:
NEMS Extra Material

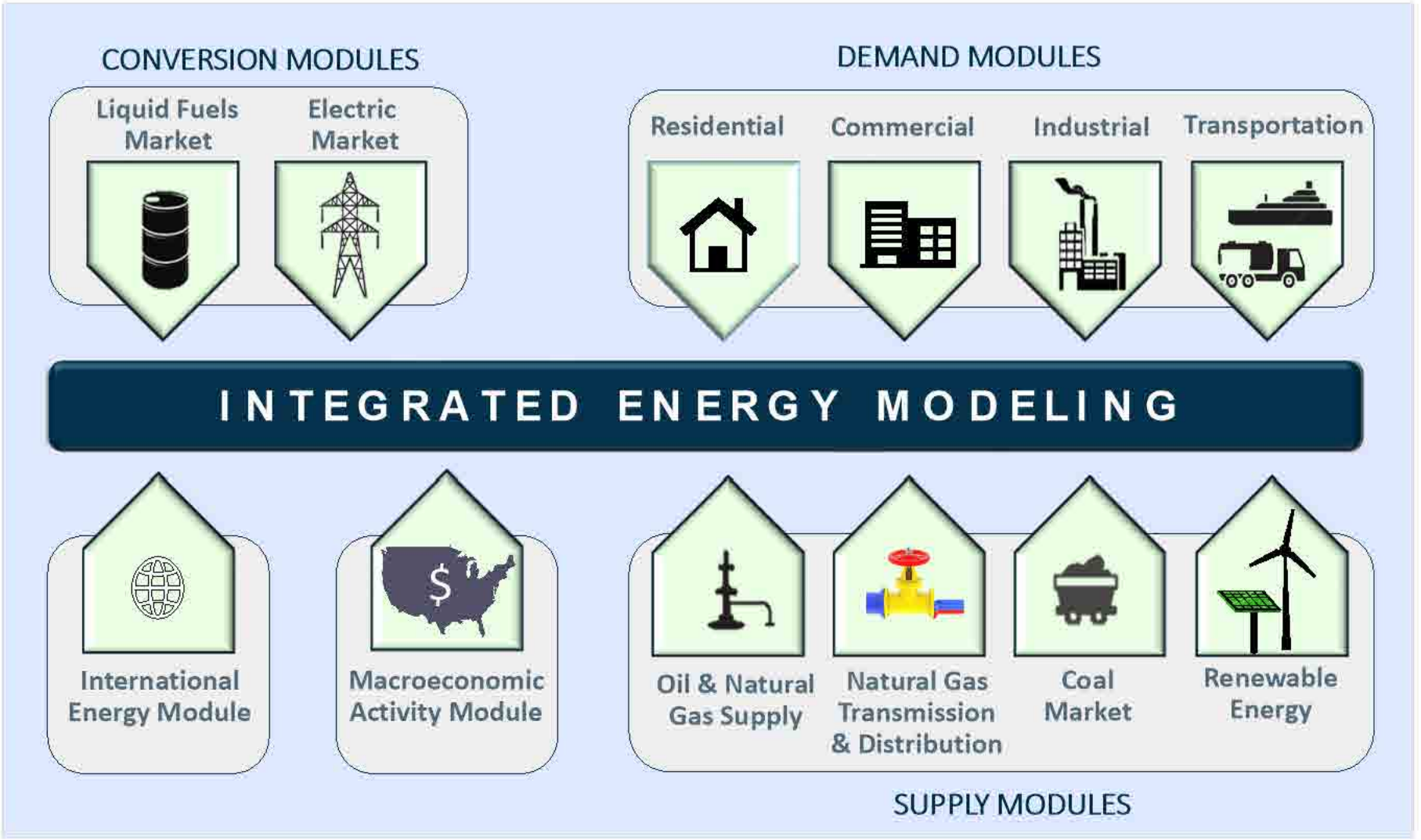
National Energy Modeling System

Development & Application of Energy System Models:

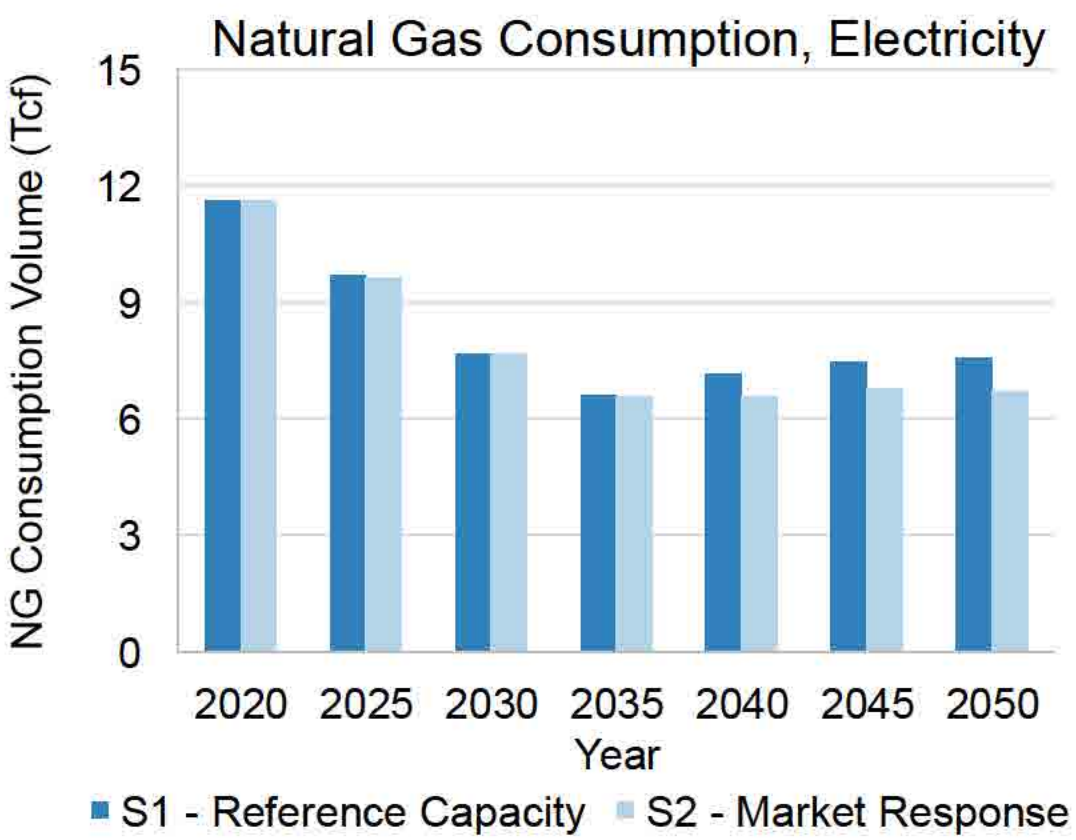
- Analyzing Energy and Climate Policy Impacts
- Assessing New Energy Technologies
- Informing Cost-effective Approaches and Policies (Government, industry, and NGOs)

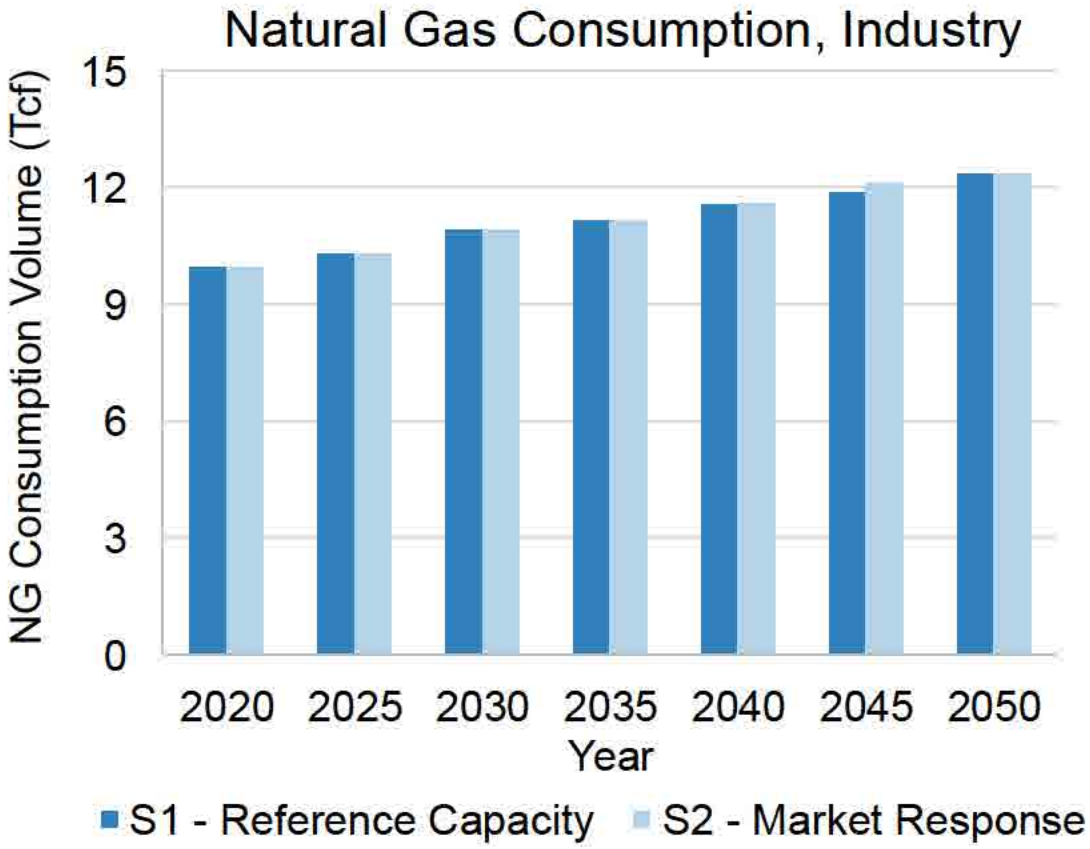
Customization & Analyses:

- Inflation Reduction Act
- Direct Air Capture
- Carbon Capture technologies
- Hydrogen Economy

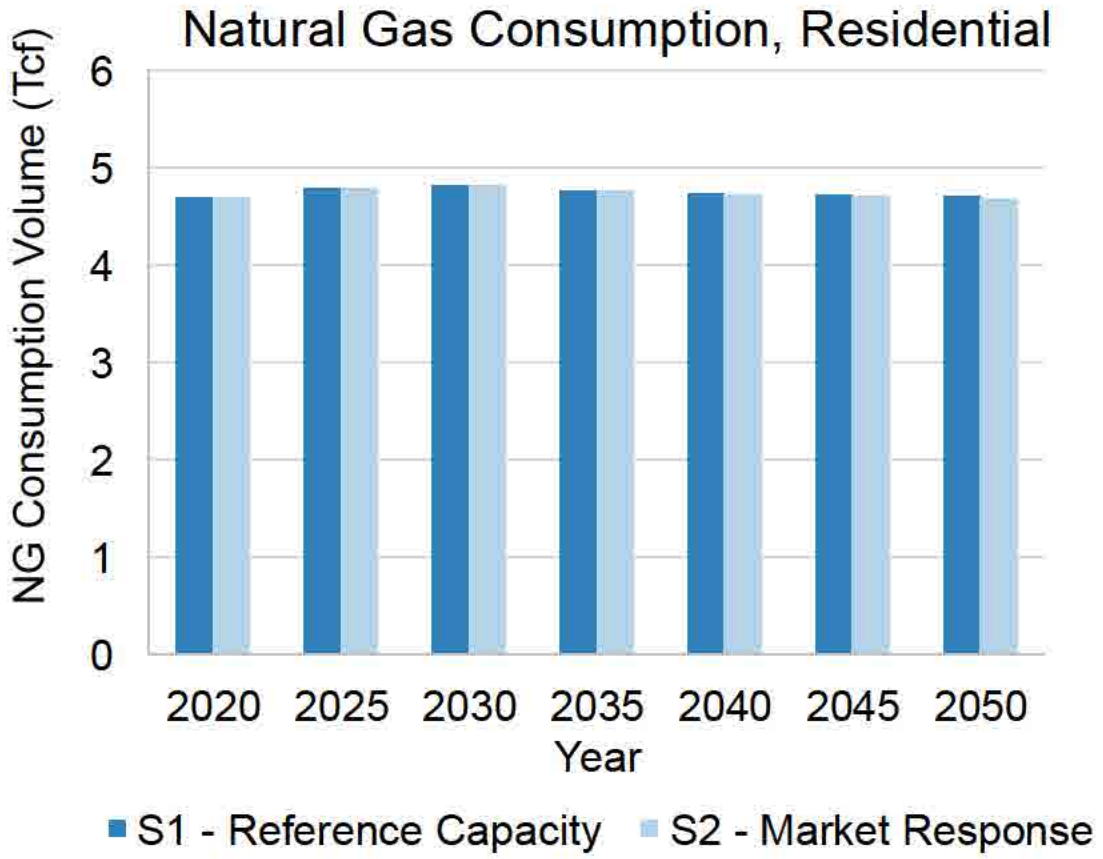


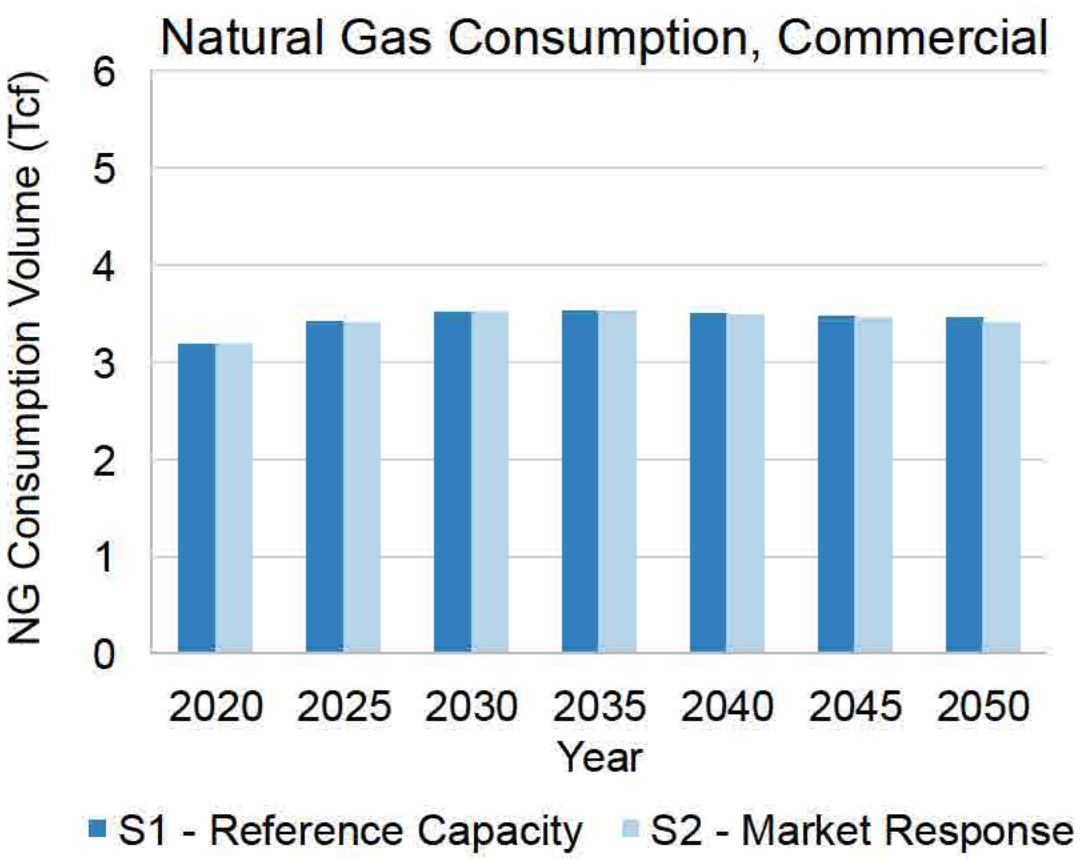
U.S. NG Consumption by Sector, S1 and S2



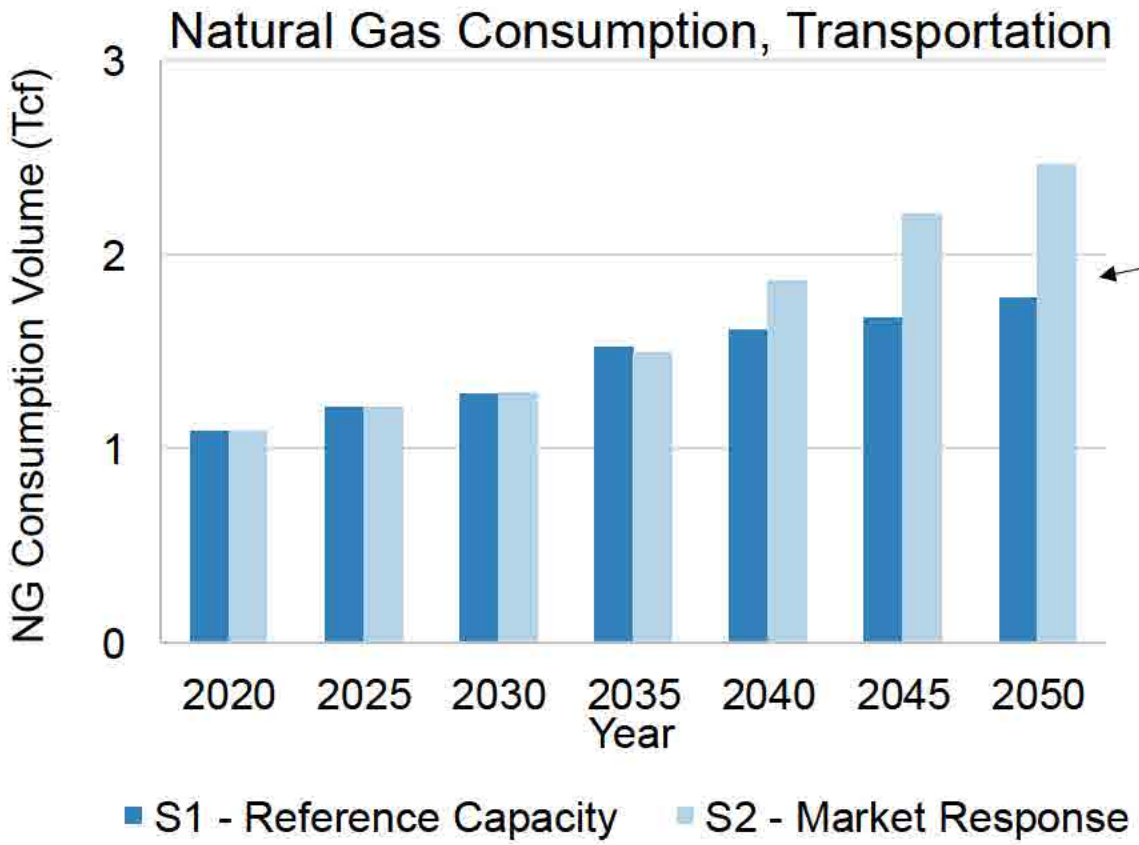


U.S. NG Consumption by Sector, S1 and S2



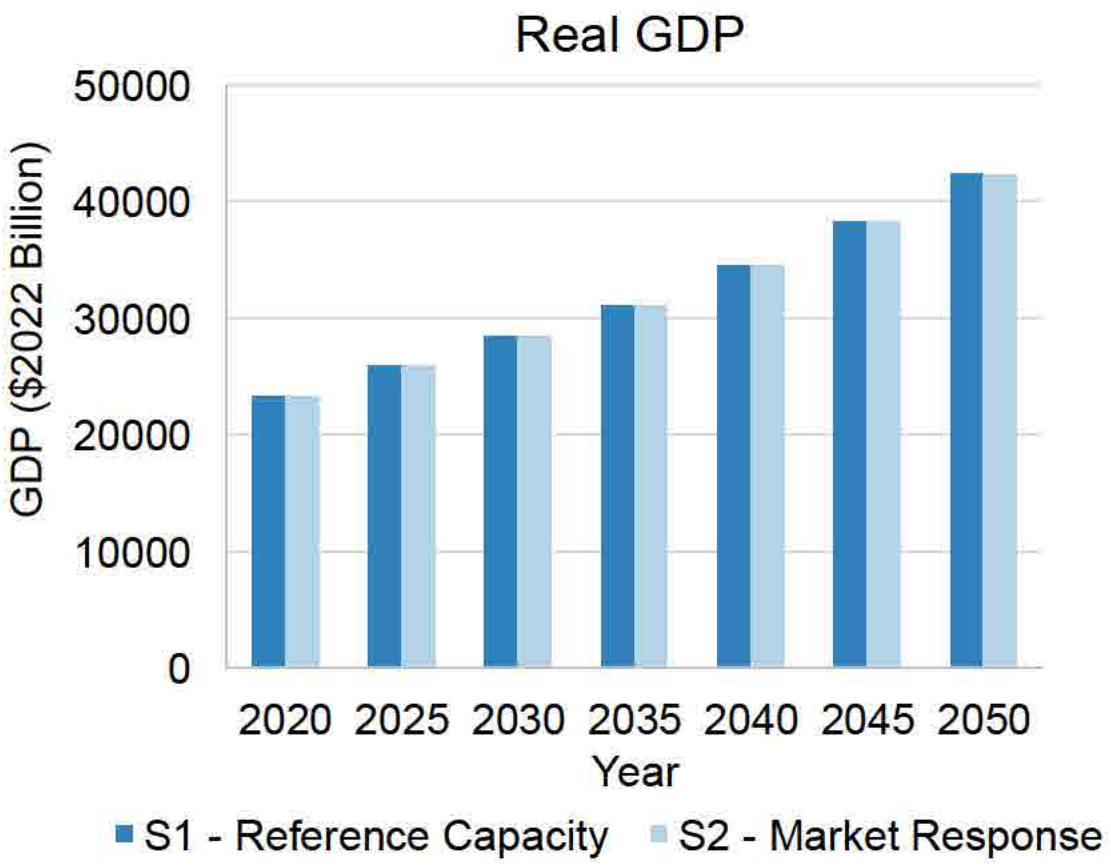


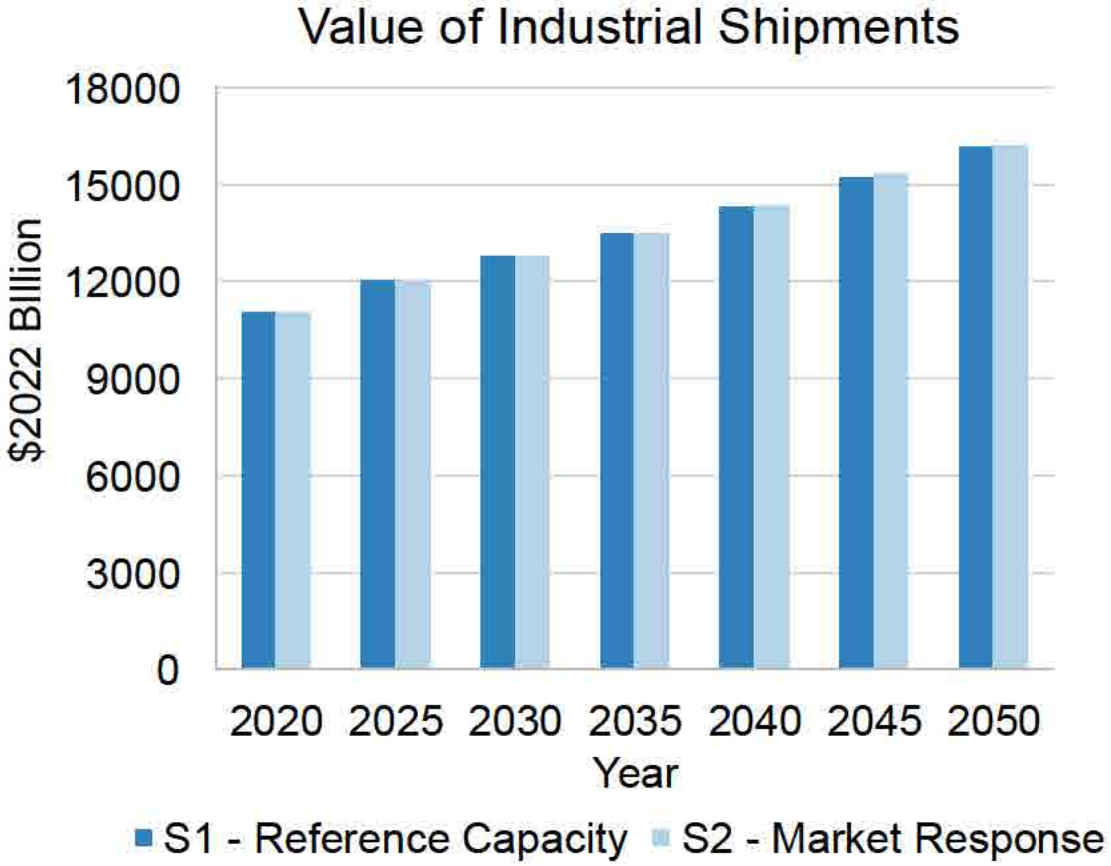
U.S. NG Consumption by Sector, S1 and S2



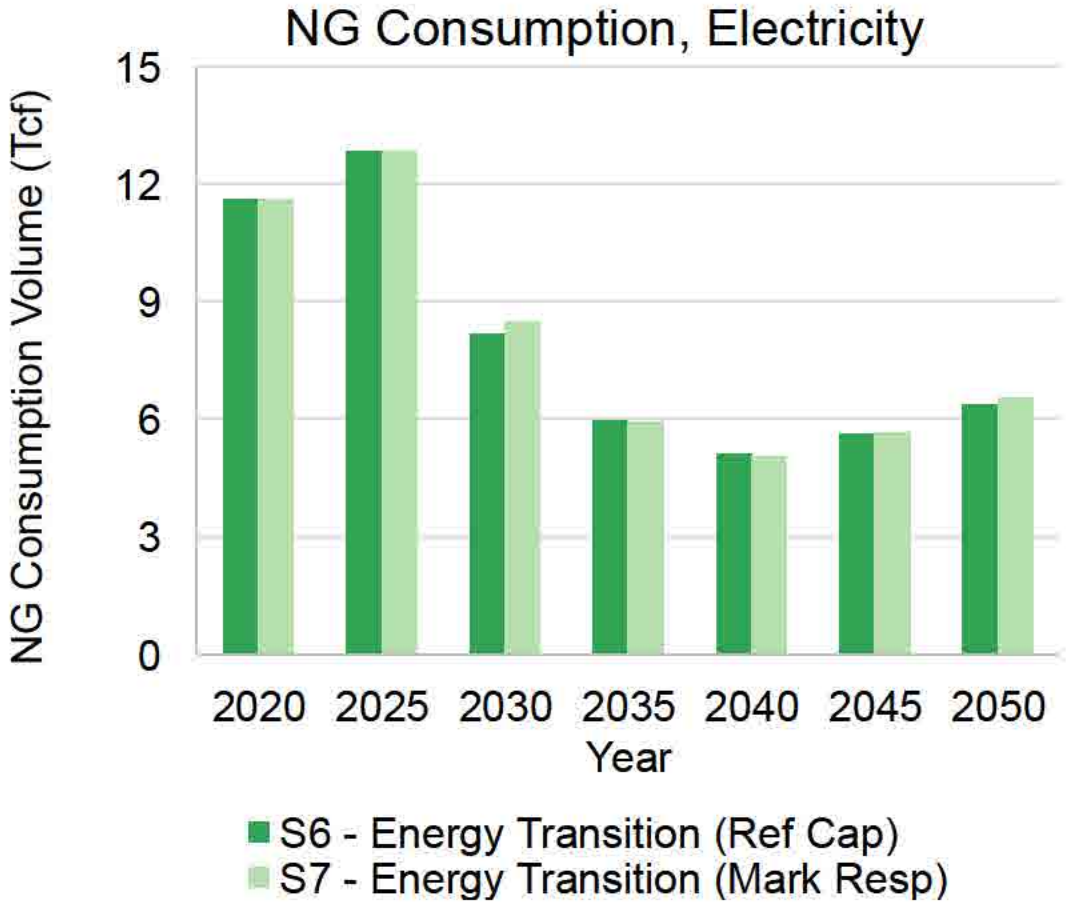
Difference comes from pipeline fuel for LNG infrastructure

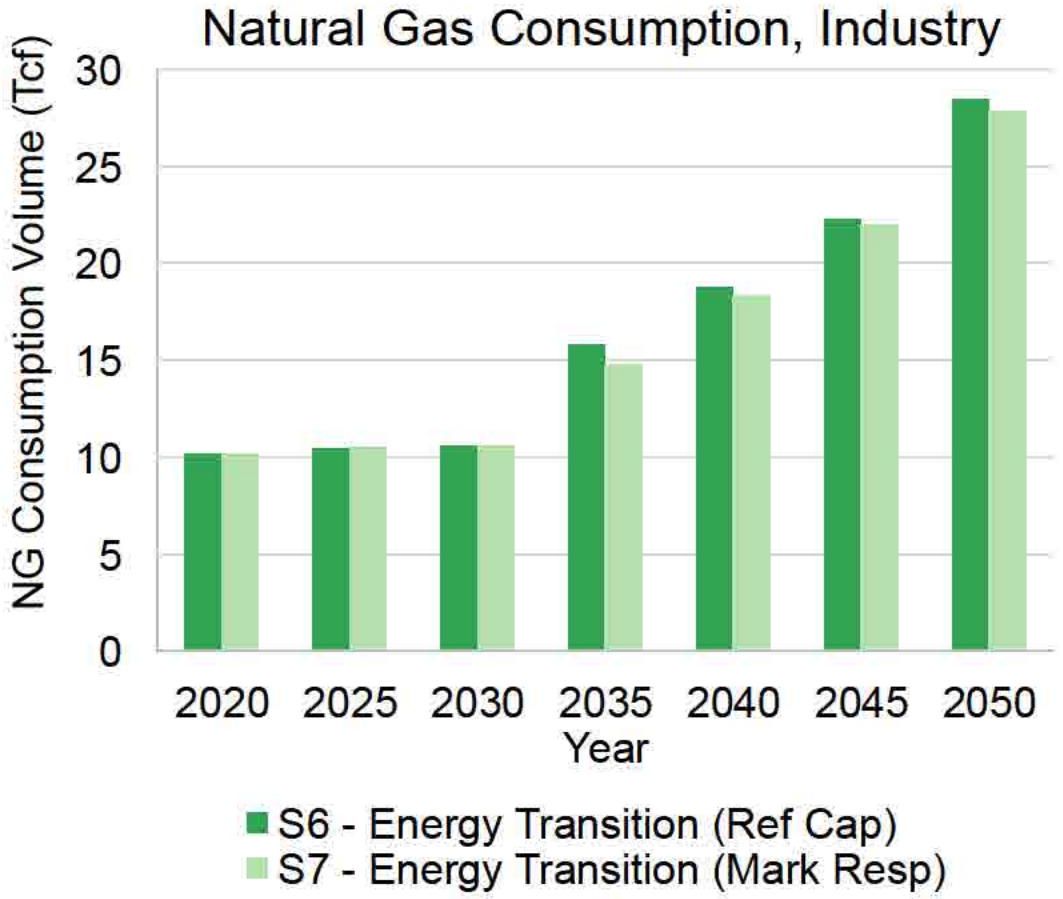
U.S. Economic Results



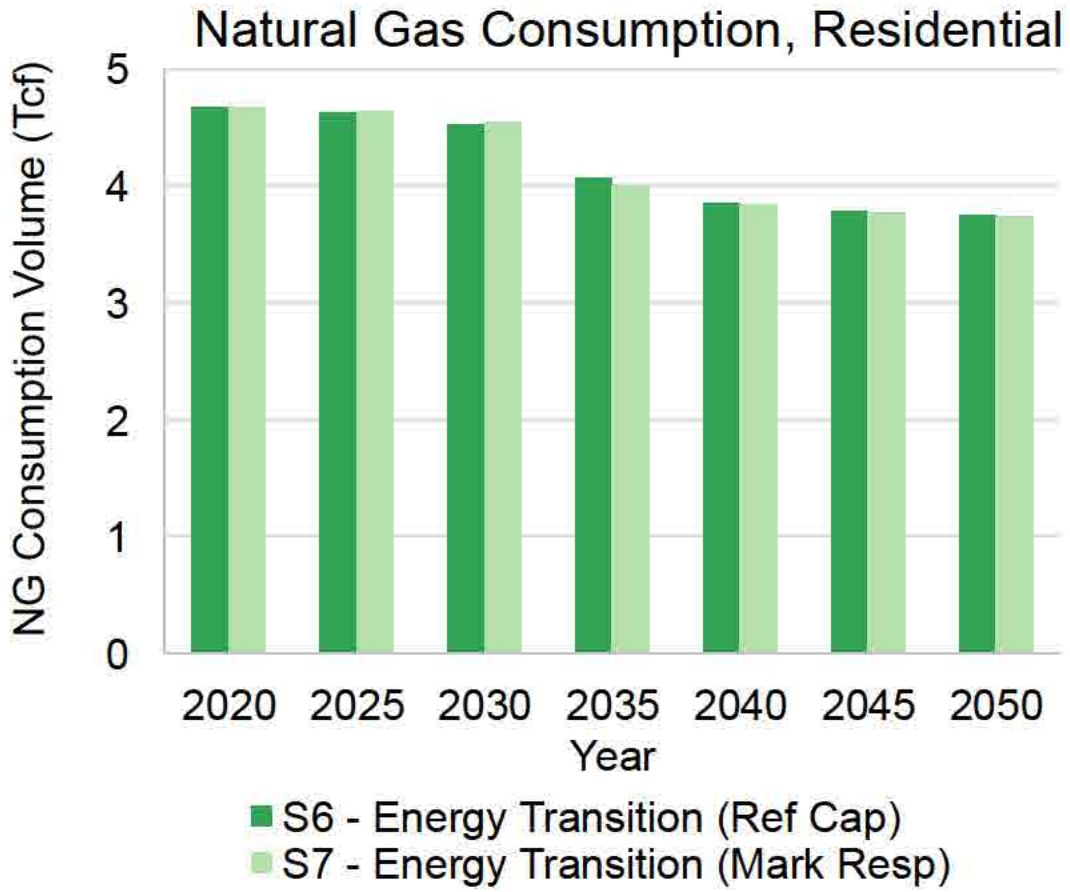


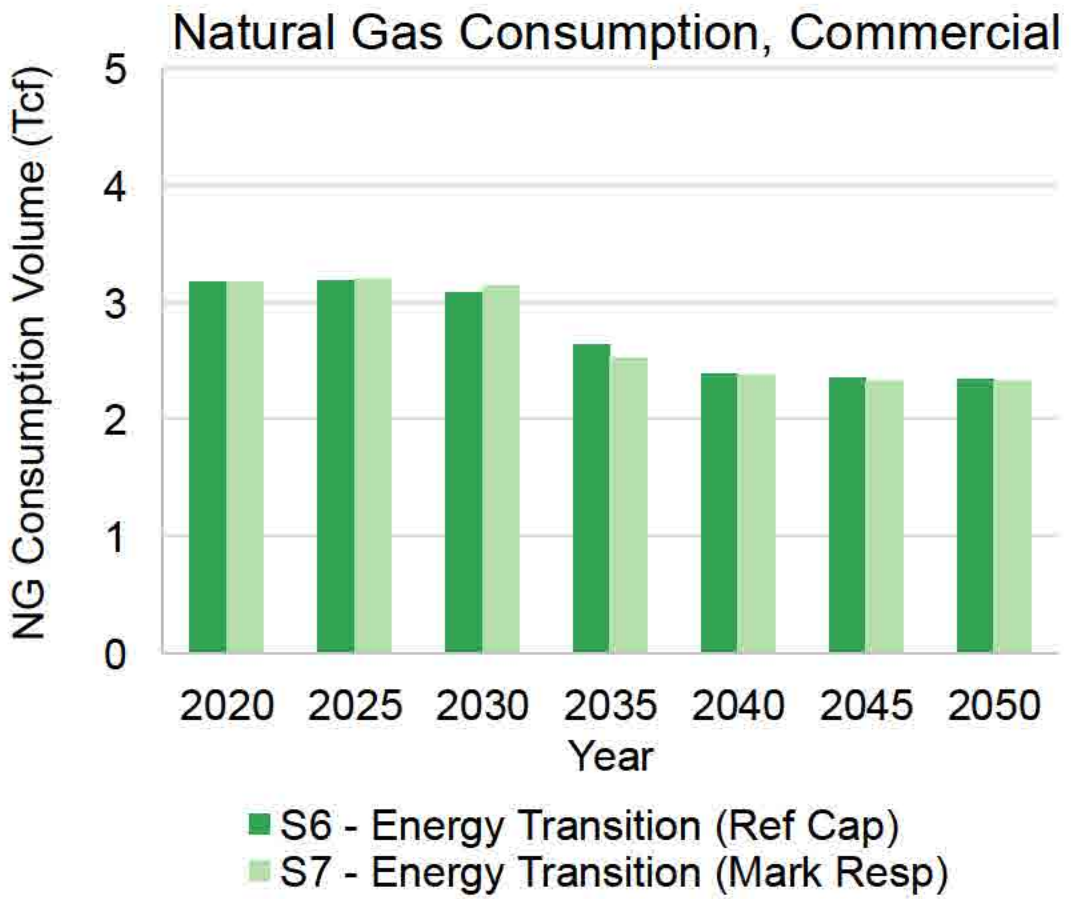
U.S. NG Consumption by Sector, S6 and S7



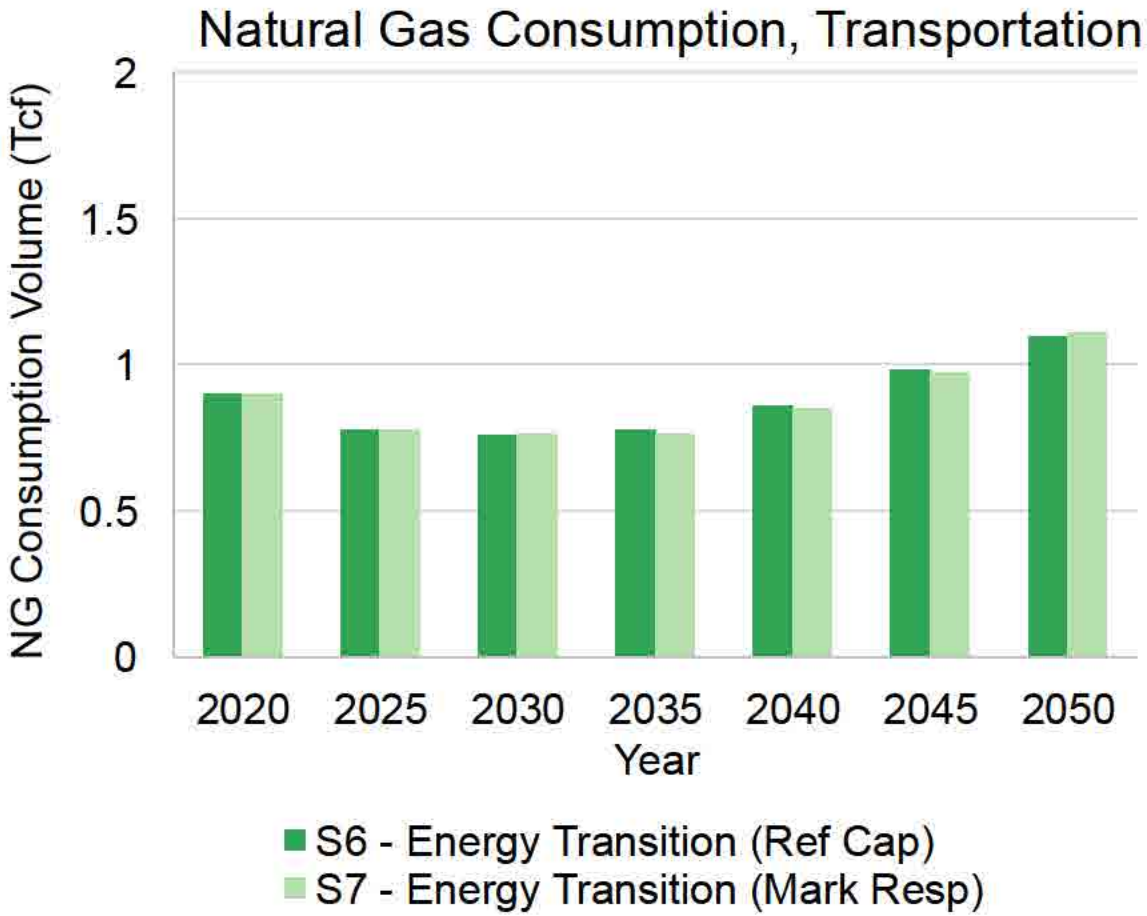


U.S. NG Consumption by Sector, S6 and S7





U.S. NG Consumption by Sector, S6 and S7



From: Francisco De La Chesnaye
Sent: Fri, 14 Jul 2023 16:01:39 +0000
To: Iyer, Gokul; Edmonds, James A (Jae); Binsted, Matthew; Wolfram, Paul; Whitman, Peter C; Daniel Hatchell; Riera, Jefferson
Cc: Curry, Thomas; Yarlagadda, Brinda; Sweeney, Amy; Harker-Steele, Amanda J (NETL); Robert Wallace; Agboola, Ajoke; Wallace, Robert T. (CONTR); Scott Matthews; Matthews, Howard Scott (CONTR); Skone, Timothy
Subject: [EXTERNAL] FECM LNG Export Project Coordination
Attachments: DOE_FECM_LNG_2023_Analysis_Report_Outlines_GCAM_NEMS_V8_14Jul23.docx

For today

DISCUSION DRAFTS*DELIBERATIVE*PRE-DECISIONAL

ENERGY, ECONOMIC, AND ENVIRONMENTAL ASSESSMENT of U.S. LNG EXPORTS

Proposed Report Structure and Content (14July23)

Section	Pgs	Lead
I. EXECUTIVE SUMMARY (Identify and focus on Key Messages)	2	Paco, Gokul, Scott + All Review
II. BACKGROUND ON LNG EXPORT STUDIES COMMISSIONED DEPARTMENT OF ENERG.Y	1	OL
(Lists of Tables, Figures, Acronyms and Abbreviations)		
III. INTRODUCTION		
A. Project Background	1	OL
B. Purpose of the Study	1	OL
C. Organization of the Report	0.5	OL
IV. STUDY METHODOLOGY, SCENARIO DESIGN, & KEY ASSUMPTIONS	0.5	OL
A. GCAM Model & Global Scenarios Design	2	PNNL
B. NEMS Models & U.S. Modeling Scenarios Design (including linkages between GCAM and NEMS)	3	OL
C. LCA Model & Scenarios Design	2	NETL
V. SUMMARY of ANALYSIS & ASSESSESMENT (organization desc)	0.5	OL
A. ENERGY AND CLIMATE MITIGATION TECHNOLOGY RESULTS		
1. Primary and Final Energy Results (How much regional detail)		
2. Energy and Climate Technology Deployment Results (any cost info?)		
B. NATURAL GAS MARKET RESULTS	0.5	OL
1. Core Results for U.S. LNG Exports	3	
2. Natural Gas Henry Hub Prices	2	
3. U.S. LNG Export Revenues	2	
4. Role of U.S. in global market		
C. U.S. MACROECONOMIC OUTCOMES (only NEMS)	0.5	OL
1. Macroeconomic Effects - Total Economic Activity (GDP)	2	
2. Consumer Effects (Prices mainly)	2	
3. Aggregate Consumption and Investment Effects	1	
D GHG OUTCOMES	1	Paco
1. Global Greenhouse Gas Results	3	PNNL
2. U.S. Greenhouse Gas Results	2	OL
3. LCA Results (scope of coverage?)	3	NETL
4. How to compare results across different modeling frameworks OR How to compare to previous regulatory analyses?	2	Paco, Gokul, Michael
Total	Min 40	
REFENCES	?	
(for sections below – each team is responsible for proposing own structure)		

APPENDIX A. Global Analysis and Description of GCAM	?	PNNL
APPENDIX B. U.S. Analysis and Description of NEMS-AOE23 and NEMS-FECM	?	OL
APPENDIX C. LCA Analysis and Description of Model	?	NETL

GCAM ASSESSMENT of U.S. LNG EXPORTS

Proposed Report Structure and Content (14July23)

Section	Pgs	Lead
I. EXECUTIVE SUMMARY (Identify and focus on Key Messages)		
(Lists of Tables, Figures, Acronyms and Abbreviations)		
II. INTRODUCTION (same as with NEMS and LCA Reports)		
A. Project Background		
B. Purpose of the Study		
C. Organization of the Report		
III. STUDY METHODOLOGY, SCENARIO DESIGN, & KEY ASSUMPTIONS		
A. GCAM Model & Global Scenarios Design		
B. ENERGY AND CLIMATE MITIGATION TECHNOLOGY RESULTS		
1. Primary and Final Energy Results (How much regional detail)		
2. Energy and Climate Technology Deployment Results (any cost info?)		
C. NATURAL GAS MARKET RESULTS		
1. Role of U.S. in global market		
2. Global market for natural gas		
3. Core Results for U.S. LNG Exports		
4. Gas Prices ??		
D. Global GHGs Results (Consistent GWPs – current EPA Inv @ 100 yr)		
1. Carbon dioxide energy		
2. Other GHGs - all together vs separate section for energy CO_2		
3. Other priority results		
REFENCES		
(for sections below – each team is responsible for proposing own structure)		
APPENDIX A. xxxx		

U.S. NEMS ENERGY & ECONOMIC ASSESSMENT of U.S. LNG EXPORTS

Proposed Report Structure and Content (14July23)

Section	Pgs	Lead
I. EXECUTIVE SUMMARY (Identify and focus on Key Messages)		
(Lists of Tables, Figures, Acronyms and Abbreviations)		
II. INTRODUCTION (same as with GCAM and LCA Reports)	PW/PD	
A. Project Background		
B. Purpose of the Study		
C. Organization of the Report	JG	
III. STUDY METHODOLOGY, SCENARIO DESIGN, & KEY ASSUMPTIONS		
A. NEMS-AEO23 and FECM-NEMS Models	DH	
B. Global and U.S. Modeling Scenarios Design (description of sce and including linkages between GCAM and NEMS)	JR	
B. ENERGY AND CLIMATE MITIGATION TECHNOLOGY RESULTS		
1. Primary and Final Energy Results (How much U.S. Regional Detail?)		
2. Energy and Climate Technology Deployment Results		
C. NATURAL GAS MARKET RESULTS	JR/MS	
1. Core Results for U.S. LNG Exports	DH	
2. Natural Gas Henry Hub Prices	DH	
3. U.S. LNG Export Revenues		
4. Role of U.S. in global market	JR	
D. U.S. MACROECONOMIC OUTCOMES (only NEMS)	PW/MS	
1. Consumer Effects (Prices mainly)		
2. Aggregate Consumption and Investment Effects		
E. GHG OUTCOMES	DH	
1. CO2 from Fossil Fuels (Methane?)		
REFENCES		
(for sections below – each team is responsible for proposing own structure)		
APPENDIX X.		

*DISCUSION DRAFTS*DELIBERATIVE*PRE-DECISIONAL*

Proposed Working Schedule –

	PPNL and OL Teams	
Dates w/o	**MODELING AND ANALYSIS**	**Report Writing**
7/05/2023	GCAM and NEMS (AEO23 & FECM) LOCK down modeling inputs and assumptions.	Start on drafts Sections (OL) Background On LNG Export Studies Introduction & Scenario Design
7/14/2023	Finalize ALL MODEL Runs Sce 1 to 7	Start Working drafts of GCAM & NEMS Reports
7/31/2023		Drafts of GCAM & NEMS Reports Draft of Summary Report
8/14/2023		Final Drafts of GCAM, NEMS, and Summary Reports
8/25/2023	Briefing with Senior Leadership DOE, Outside??	Final Draft out for Review
Tuesday Aug 1		Beyond FECM & DOE Review Steps?
9/29/2023		FINAL VERSION

Need to Coordinate with NETL on Task 3 Analysis & Report