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Major New US Industry at a Crossroads

A US LNG Impact Study – Phase 2

Report by Commodity Insights and Market Intelligence

March 2025

Study Preface

In the S&P Global December 2024 Phase 1 report, we examined the remarkable rise of the US liquefied natural gas (LNG) industry. In less than a decade, this sector has become a major export industry, contributing more than $400 billion to U.S. GDP and supporting hundreds of thousands of American jobs. This development has not only contributed positively to the US economy and export earnings but has also strengthened the international position of the United States and deepened relations with many other countries.

This Phase 2 companion study expands and complements key aspects of our first phase study:

1. The environmental impact of further development of US LNG -- in particular, the potential net impact on global GHG emissions of 40 million tons of incremental LNG export capacity tied to projects that are on hold or in the pre-FID (Final Investment Decision) stage from the Phase 1 Base Case
2. A State and Congressional-district level economic impact assessment, analyzing the l impact of US LNG across the national economy.
3. The potential benefits of infrastructure debottlenecking across the value chain, focusing primarily on the Northeast gas market

On the emissions front, Phase 2's central finding is that increasing US LNG exports leads to 780 million tonnes of CO_2e (GWP20) lower GHG emissions globally between 2028 and 2040 than would be the case if demand were met by the likely alternative sources. The study demonstrates why the bulk of demand – absent US LNG – would largely be met with other hydrocarbons, not renewables. This future saving equates to total road transport emissions in the UK over the same period. The reason for this savings is driven by the lower GHG intensity of US LNG compared to the average intensity of the combined energy sources that would replace that LNG in global markets.

This analysis shows that end-use combustion accounts for a significant 57 to 87% of the lifecycle intensity of coal, oil, gas and LNG. Varying levels of methane emissions in the supply chain prior to end-use lead to significant differences between the sources and pathways of each fuel. This highlights the need for frequent and reliable monitoring of methane emissions and the benefits of transparency in GHG intensity.

From a macroeconomic perspective, the Phase 1 Base Case outlook demonstrated that US LNG exports can contribute an additional $1.3 trillion to US GDP through 2040. This Phase 2 report illustrates that the economic impact extends beyond the seven core producing states, with 37% of jobs and 30% of GDP contributions occurring in non-producing areas.

The third part of the report examines the economic benefits of ending one major and costly distortion in the US energy system. This would be achieved by removing bottlenecks in infrastructure especially across the Northeast region. While the Northeast region has sufficient proved reserves to meet all U.S. demand for 17 years, existing pipeline constraints hinder optimal production. These result in gas prices in New York and Boston that are 15–40% higher than the national annual average, and 145% and 160% higher in the key winter heating month of January – imposing a heavy and unnecessary cost burden on consumers. Expanding egress capacity from the giant Marcellus supply by about 6 billion cubic feet per day could reduce January prices by 20% and 30%, respectively, from 2028 to 2040 (17-27% annualized), resulting in cumulative savings of $76 billion for consumers by 2040.

S&P Global Study Acknowledgements

S&P Global (NYSE: SPGI) provides essential intelligence. We enable governments, businesses and individuals with the right data, expertise and connected technology so that they can make decisions with conviction. From helping our customers assess new investments to guiding them through ESG and energy transition across supply chains, we unlock new opportunities, solve challenges and accelerate progress for the world. We are widely sought after by many of the world's leading organizations to provide credit ratings, benchmarks, analytics and workflow solutions in the global capital, commodity and automotive markets. With every one of our offerings, we help the world's leading organizations plan for tomorrow, today. For more information visit www.spglobal.com

This study offers an independent and objective assessment of the economic, market and global impact of the US LNG Industry built from a detailed bottom-up approach, at the asset and market level, technology by technology. It represents the collaboration of S&P Global Commodity Insights and the Global Intelligence and Analytics unit within S&P Global Market Intelligence supported by the world's largest expert team of over 1,400 energy and economic research analysts and consultants continuously monitoring, modelling and evaluating markets and assets. Explanation of the detailed study methodology is included in the Appendix. The analysis and metrics developed during the course of this research represent the independent analysis and views of S&P Global. The study makes no policy recommendations.

The study was supported by the US Chamber of Commerce. S&P Global is exclusively responsible for all of the analysis, content and conclusions of the study.

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As the LNG 'pause' is lifted, the Phase 2 US LNG Study highlights emissions benefits, economic impact beyond producing states and New England infrastructure constraints

- Continued development of US LNG (40 Mtpa of pre-FID or 'halted projects') results in **global GHG emissions being 324/780 M tCO2e (GWP100/GWP20) lower by 2040** than they would be if demand were met by the likely energy alternatives. This is equivalent to **the UK's road transport emissions** over the same period.
- End-use combustion generates 57 to 87 percent of analyzed fossil fuel emissions. The rest arise from each fuel's supply chain, **with methane being the primary cause of differences in their GHG intensity**
- **Coal emits roughly 70% more greenhouse gases than the US LNG it would replace** across all the alternatives analyzed

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- US LNG's unprecedented growth is enabled by an extended cross-state value chain, that reaches beyond the core-producing states – about **90% of every dollar spent remains within United States** supply chains
- Of the annual average of 495,000 US jobs supported through 2040, **37% will be in non-producing states.** As many jobs will be supported in on-producing states as in Texas
- Over the same period, LNG Exports will contribute $1.3 trillion in GDP, with **$383 billion or 30% in non-producing states.** On a per capita basis, producing states benefit from a cumulative **$13.2K GDP per capita**

- The US Northeast (NE) has vast amounts of low-cost gas reserves in the Marcellus and Utica formations (New York, Pennsylvania, West Virginia, Ohio), **sufficient to meet nationwide demand for ~17 years**
- Due to **pipeline constraints** these reserves are being developed at a suboptimal rate, pushing **gas prices at Boston, Chicago and New York City Gates up 160% higher** than the national gas market in peak months
- **Expanding NE pipeline capacity** by 6.1 Bcf/d could reduce HH gas prices by $0.20/MMBtu and significantly lower prices across the region. **Cumulative nationwide consumer savings could reach $76 billion** through` 2040

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Incremental US LNG is less GHG-intensive than modelled alternative energy sources, based on the best available data and analysis to date (including coal under any scenario)

- This analysis considers the **GHG emissions impact of 40 Mtpa incremental US LNG capacity** (pre-FID or 'halted' projects in our Phase 1 Base Case) relative to the alternative energy sources it would displace
- We use **S&P Global's detailed life cycle emissions assessment approach** for US LNG and energy alternatives, combining **the latest public, proprietary and third-party satellite and flyover data**

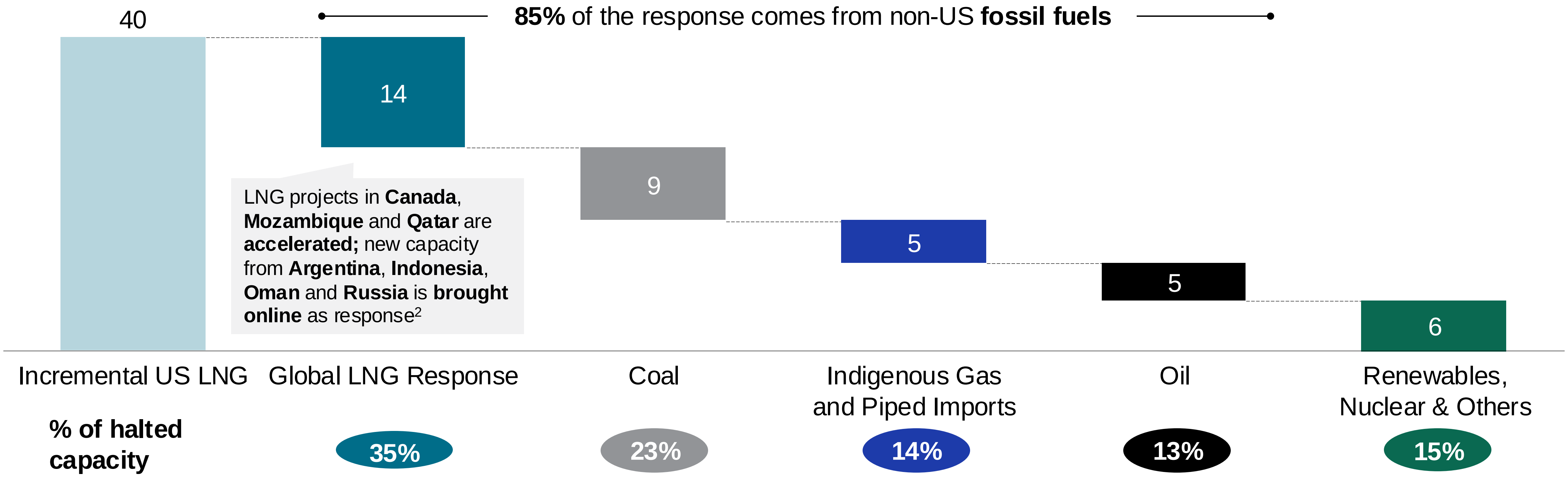
- **End use combustion** is responsible for **57 - 87% of GHG intensity** for coal, oil, gas and LNG
- **Supply chain methane emissions are currently the key driver of variation** between fuel pathways
- With the **global focus on US methane** emissions, US LNG producers stand to benefit from the **increased availability and granularity of measurement data** as importing regions demand stricter quantification

- Incremental US LNG exports from the projects in our Base Case would result in **324 / 780 M tCO_2e (GWP100/GWP20) lower emissions over 2028-2040** compared to emissions of the modelled alternatives
- This is equivalent to the emissions of the **UK road transport sector between 2028 and 2040**
- Coal's lifecycle **GHG emissions are on average 65% - 70% higher than the sources of LNG analyzed** across the selection of US or alternative global LNG projects

In Phase 1 we modeled the global energy response to the US LNG 'Extended Halt' Scenario with fossil fuels and renewable generation replacing impacted US LNG exports

LNG Change in S&P 'Extended Halt' vs. Incremental US LNG[1] Scenarios – Yearly Average 2028[2] – 2040

Mt LNG equivalent, yearly average 2028-2040



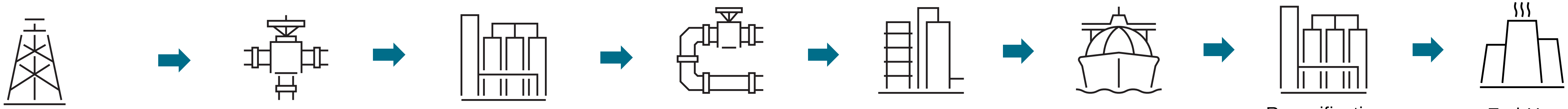
A comprehensive analysis of the global energy mix – integrating market and economic drivers, policy frameworks, and country-specific energy system factors – shows the LNG gap would be 85% backfilled by fossil fuels from global sources

1. Considers 2028 as it is the first year in which there are relevant changes in global markets vs. base case; 2. This is not an exhaustive list of projects included in S&P's Base Case, which includes projects in Australia, Malaysia, Papua New Guinea and United Arab Emirates.
Source: S&P Global

Phase 2 evaluates the GHG emissions impact of incremental US LNG (pre-FID or 'halted' projects) in our Base Case, relative to the alternative energy response modelled in Phase 1

Critical Definitions of the Lifecycle GHG Intensity Estimate from Production to End Use Combustion

Example supply chain for LNG



Functional unit:
1 MJ (LHV) delivered to end use

Emissions allocation:
Total GHG emissions **allocated to all co-products on an energy basis,** in line with industry best practices

Gas pathing: based on current and expected physical flows, calibrated using expert opinion of S&P Global gas analysts

End use: combustion by fuel type not adjusted for efficiency, as Phase 1 modeling already factors these into fuel volume responses

Gas feedstock supply:
Reflects a weighted **average of the mix of upstream plays** supplying each LNG facility

- **10** US plays feeding 6 LNG terminals
- **12** International plays feeding 7 LNG terminals and 5 gas export pipelines

Shipping routes: Destinations based on contracts and forecasts. Each LNG plant considers the mix of **distances, fleet composition, and vessel features**

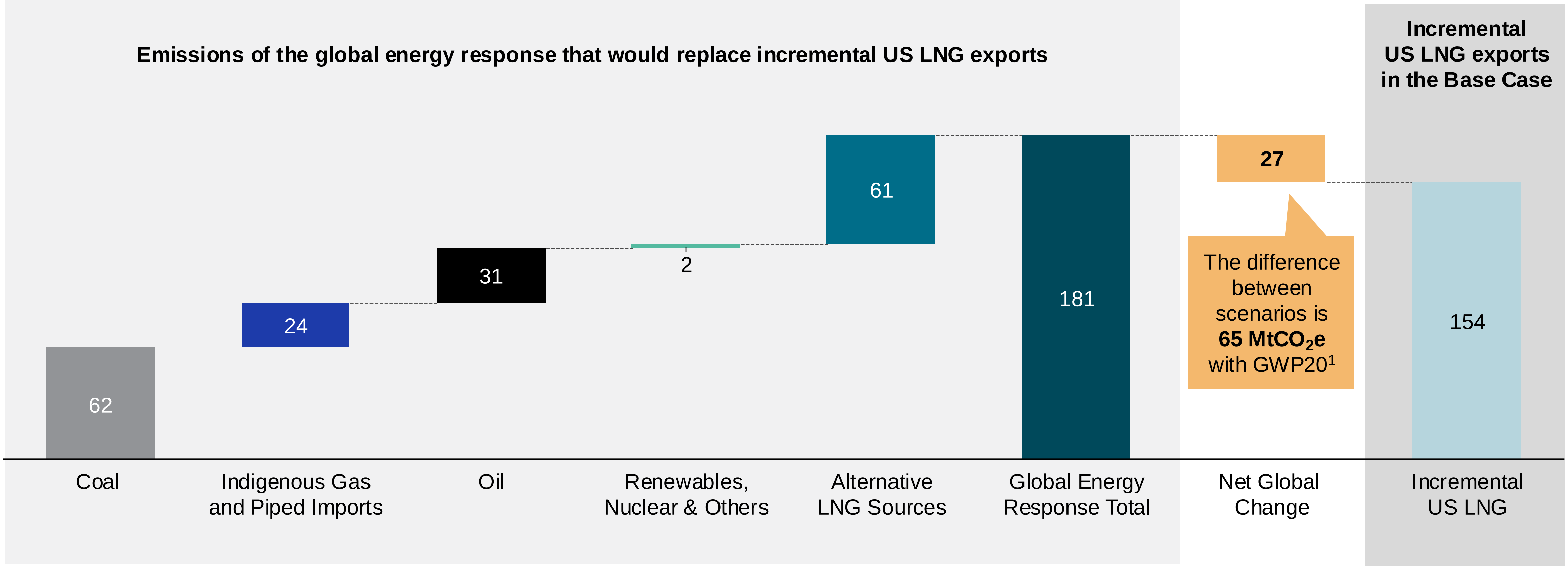
- **9** LNG carrier types
- **91** Shipping route combinations (13 terminals to 7 destination markets)

1. Both the natural gas and LNG value chain would typically include a local distribution segment after long-distance transmission or regasification and before delivery to the final point of consumption. This study assumes delivery of natural gas, LNG, and alternative fuels to a point adjacent to the regasification terminal or transmission line to simplify comparisons across fuels.
Source: S&P Global

Emissions from incremental US LNG exports in the Base Case are 27 / 65 $MtCO_2e$ (GWP100 / GWP20[1]) lower per year than the alternative energy sources modelled

GHG Emissions Corresponding to 'Extended Halt' vs. Incremental US LNG Scenarios[2]

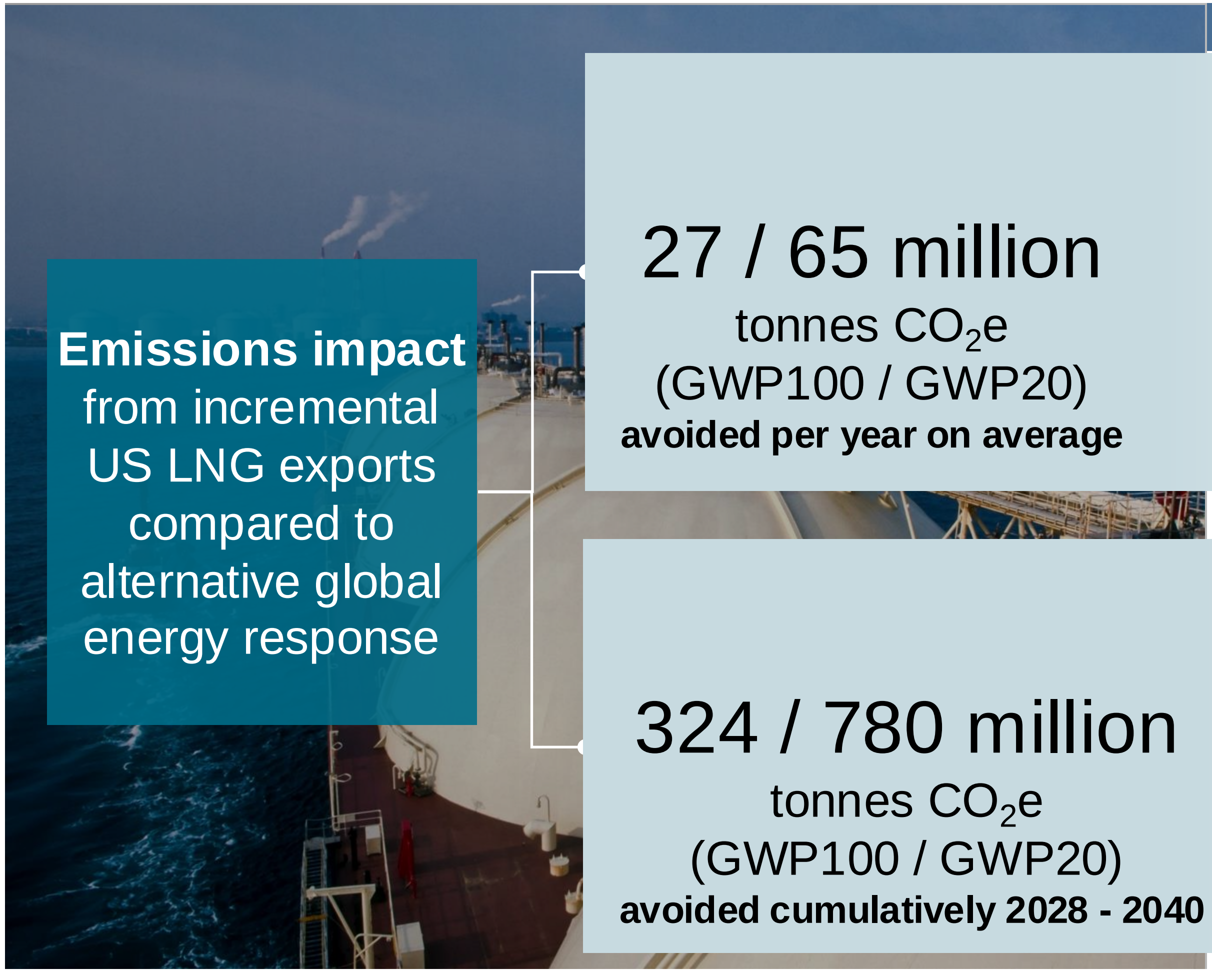
M tCO_2e, 100-yr GWP, yearly average 2028–2040, midpoint methane intensity[3]



1. Global Warming Potential (GWP) is a measure used to compare the impact of different greenhouse gases on global warming. It quantifies the heat a greenhouse gas traps in the atmosphere over a specific time period, relative to carbon dioxide (CO_2), which has a GWP of 1. See the appendix for full results in 20-yr GWP; 2. The volume of impacted LNG exports at risk and the response of the global energy system are based on the results of Phase 1; 3. Midpoint methane intensity represents the middle of the modeled methane uncertainty range. For results on the full range of methane uncertainty, see appendix.

Source: S&P Global

Increased exports of US LNG would lead to 780 MtCO_2e less emissions (GWP20) 2028-2040, equivalent to the emissions of the UK's road transport sector over the same period



Emissions impact from incremental US LNG exports compared to alternative global energy response

27 / 65 million
tonnes CO_2e
(GWP100 / GWP20)
avoided per year on average

324 / 780 million
tonnes CO_2e
(GWP100 / GWP20)
avoided cumulatively 2028 - 2040

Equivalent to the emissions of:

More than twice the cars in Los Angeles county each year (14 million gasoline-powered passenger vehicles) (GWP20)

7 average sized **coal-fired power plants** over a year

3.6 million homes' worth of energy use for one year

The **UK road transport sector** between 2028 and 2040 (GWP20)

A third of the reduction in EU27 energy-related emissions (GWP 20) over the past decade

The CO_2 absorbed by **5.4 billion trees** over 10 years

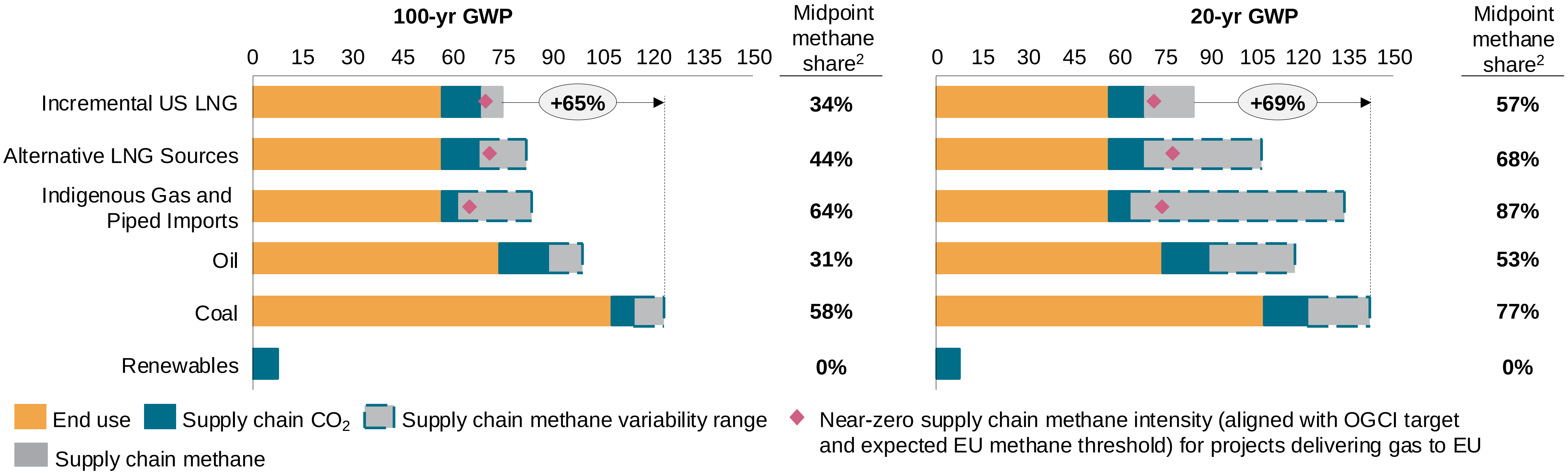
Note: The warming potential of each GHG differs depending on the time horizon considered, as each gas has a different lifespan in the atmosphere and a different ability to absorb energy. The UNFCCC publishes two time horizons to show the short- and long-term effects of GHGs on global warming: 20 years and 100 years. Both the 100-year and 20-year GWPs sourced from the IPCC AR6 were used to convert emissions into CO_2 equivalents. The equivalence conversions are done with average weights or volumes of the selected gases. Equivalences are intended for illustrative purposes only and should not be used to inform or guide decision making.

Source: S&P Global, US EPA, IEA, Our World In Data/Global Change Data Lab

GHG intensity is driven by end-use combustion: Coal replacing US LNG is 65% more intensive in GWP100 terms than US LNG across the impacted destination markets

Weighted Average Full Lifecycle GHG Intensity[1] (Production to End Use)

gCO_2e/MJ | % share of methane emissions in the supply chain (excluding end use)



Methane intensity in the supply chain is **much more uncertain on the fuels of the global alternative energy response** than the US LNG value chain because of the emphasis on quantification and mitigation in most US plays in recent years

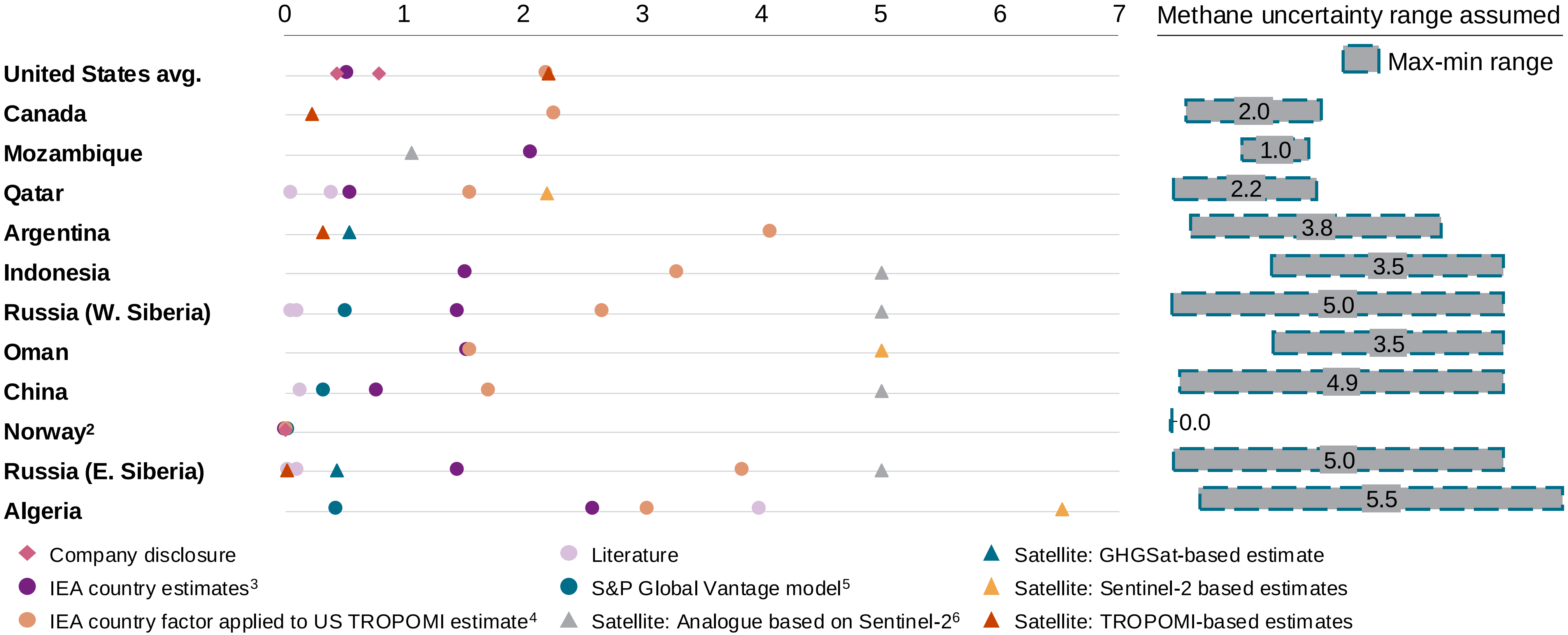
1. Averages shown include the weighted averages of all feedstock gas and shipping distances to destination markets for each fuel; 2. The share of methane emissions in the supply chain up to regasification, excluding end use, based on the midpoint range of methane variability; Key parameters from Phase 1 informing this GHG lifecycle intensity analysis include: a) LNG projects impacted, including the US LNG projects impacted under the US LNG 'Extended Halt' Scenario and the international LNG response (accelerated startup dates or incremental); b) upstream supply pathways and balance to each LNG facility at the play or basin level, for both US and international projects; c) shipping destinations and volumes from US and international LNG facilities, oil producers, and coal mines to respective end markets; d) global energy response, considering the efficiency of generation (heat rate) in the replacement of gas by other fuels in each destination market. Therefore, the end use of this LCA only reflects the combustion factor of each fuel

Source: S&P Global

Given commercially or publicly available data access by S&P Global, 20 – 300 times more observed methane data was accessed for US relative to alternative sources

Global O&G Methane Emissions Intensity Estimates (Production to Gas Processing) Sourced and Uncertainty Range Defined

Intensity for relevant basin in each country, $\%CH_4$ released / $\%CH_4$ in gas stream[1]



Flyover data accessed by S&P Global covered >280 bn pixels in the Permian basin while the satellite data sample analyzed averaged just 0.9-13 bn pixels across Middle East, Central Asia and N Africa

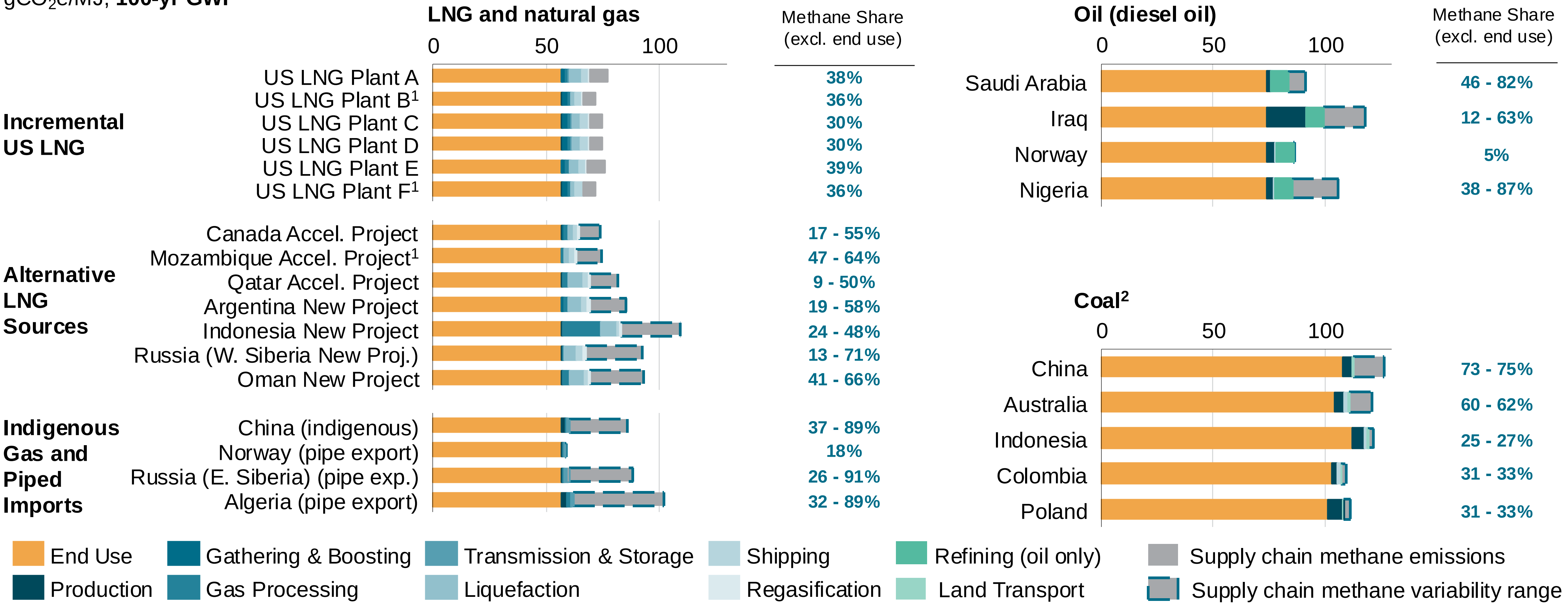
1. Expressed as methane emissions (on an energy basis) divided by methane content of the throughput, with marketable gas being the common denominator across the supply chain; 2. Although no satellite measurement was available for Norway in our study, the range is based on company disclosure with limited variability given the strong regulatory pressure and record of methane measurement and control by operators in the country; 3. IEA methane Tracker 2024 normalized with S&P Global O&G production data per country; 4. Average of US TROPOMI measurements with a methane scaling factor from IEA; 5. Average estimates at the country level; 6. For countries where no measurement data is available, we include the average intensity for upstream derived from Sentinel-2 observations to determine the uncertainty range. Refer to the appendix for additional information on satellite coverage across regions

Source: S&P Global leveraging TROPOMI, GHGSat, and Sentinel-2 observations; academic research (papers listed in appendix); and IEA's Global Methane Tracker

The resulting GHG intensity of alternative sources of LNG and other fuels varies widely, mainly due to methane, but flaring, reservoir properties, and operations also contribute

Lifecycle GHG Intensity of LNG, Oil, and Coal Delivered to the Destination Markets Assumed

gCO_2e/MJ, **100-yr GWP**

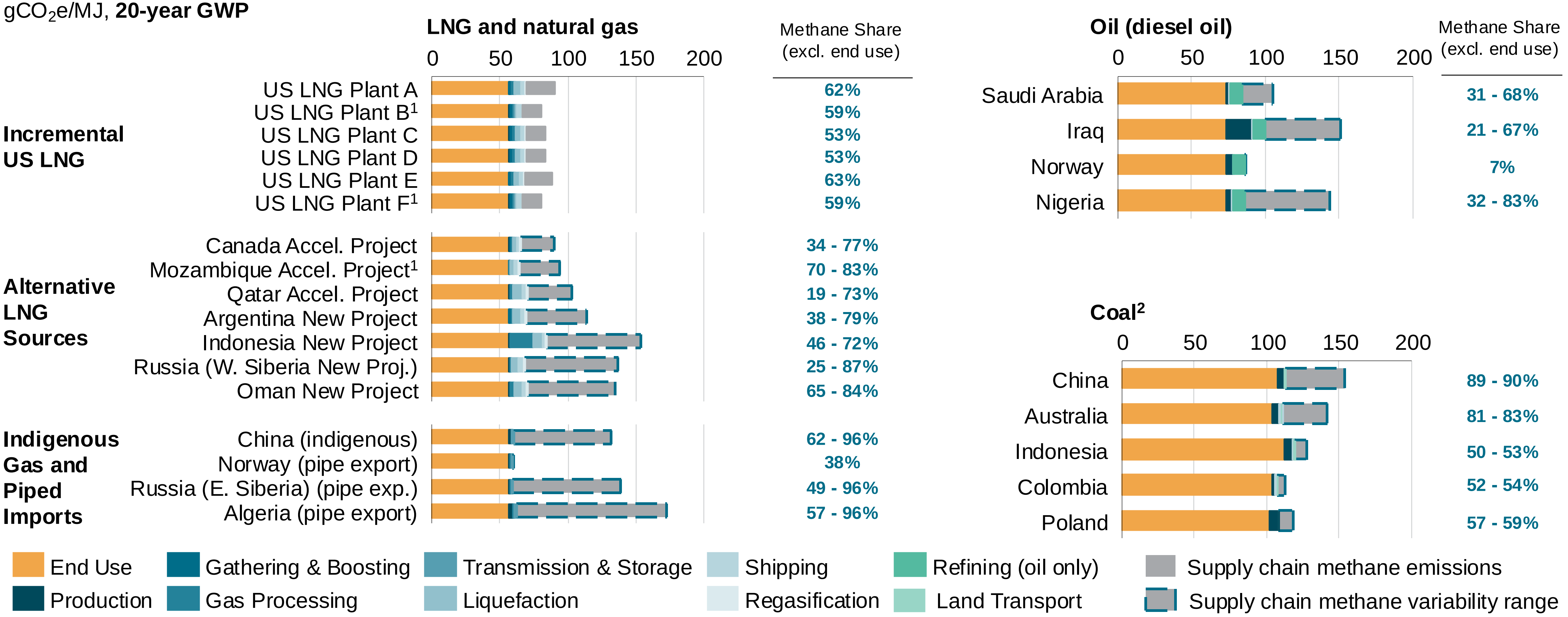


1. Electric-driven liquefaction plant assumed; 2. For the lifecycle analysis of coal, methane observation data are not available. Therefore, the methane range has been assumed as a sensitivity of the IPCC factors, aligned with the range obtained for gas analysis.
Source: S&P Global

Considering a 20-year GWP emphasizes the relative impact of methane emissions on lifecycle intensity differentials across the various fuels

Lifecycle GHG Intensity of LNG, Oil, and Coal Delivered to the Destination Markets Assumed

gCO_2e/MJ, **20-year GWP**

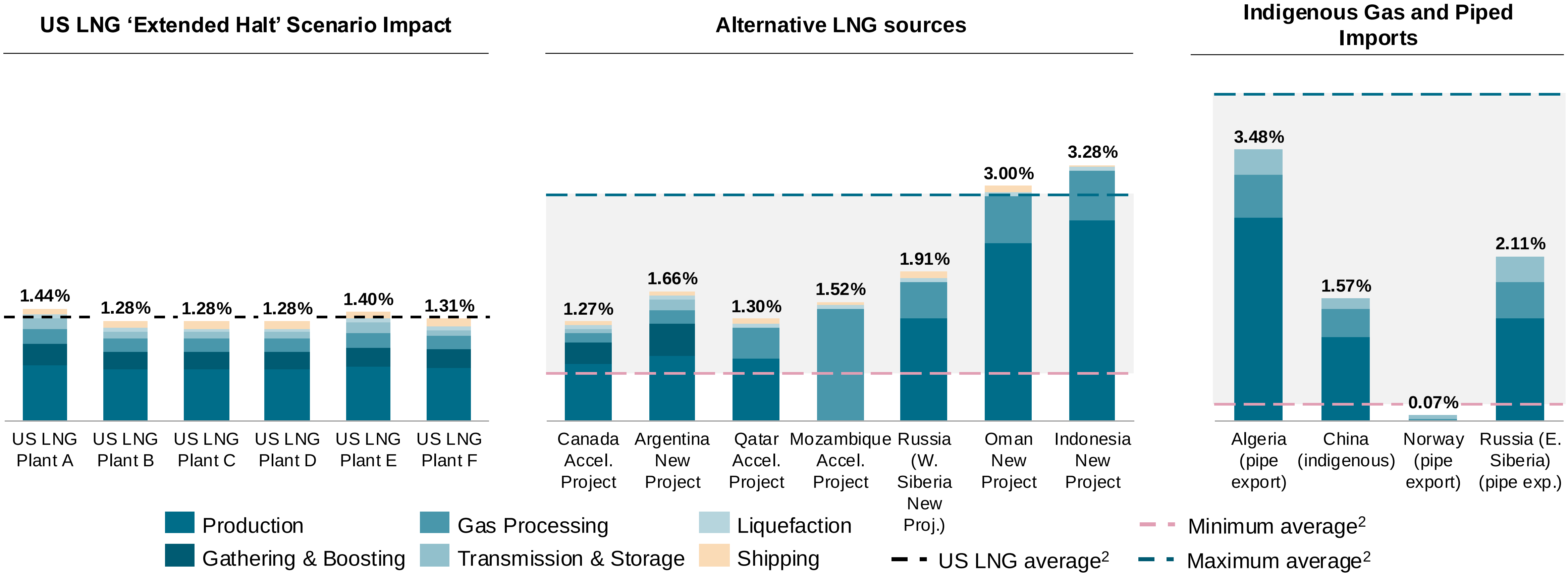


1. Electric-driven liquefaction plant assumed; 2. For the lifecycle analysis of coal, methane observation data are not available. Therefore, the methane range has been assumed as a sensitivity of the IPCC factors, aligned with the range obtained for gas analysis.
Source: S&P Global

Variations in methane intensities among gas sources are driven by country-specific emissions rate obtained from satellite observations and literature

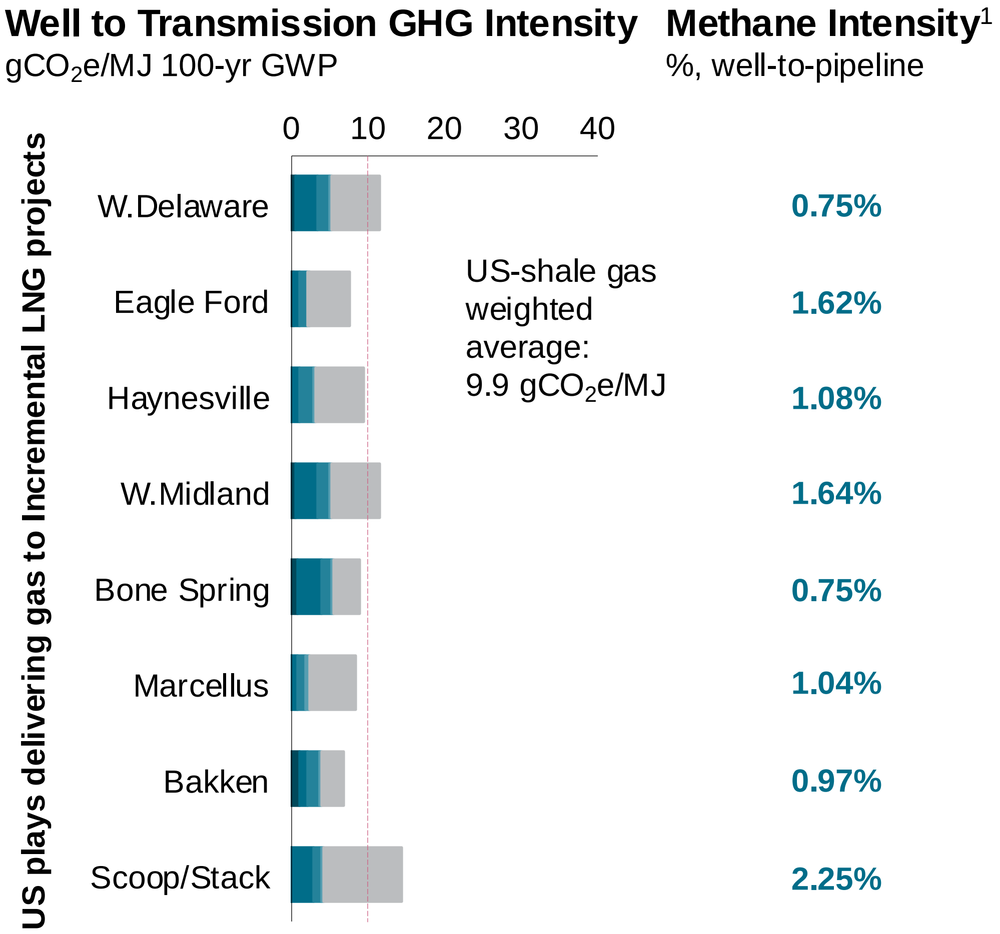
Midpoint Methane Intensity by Value Chain

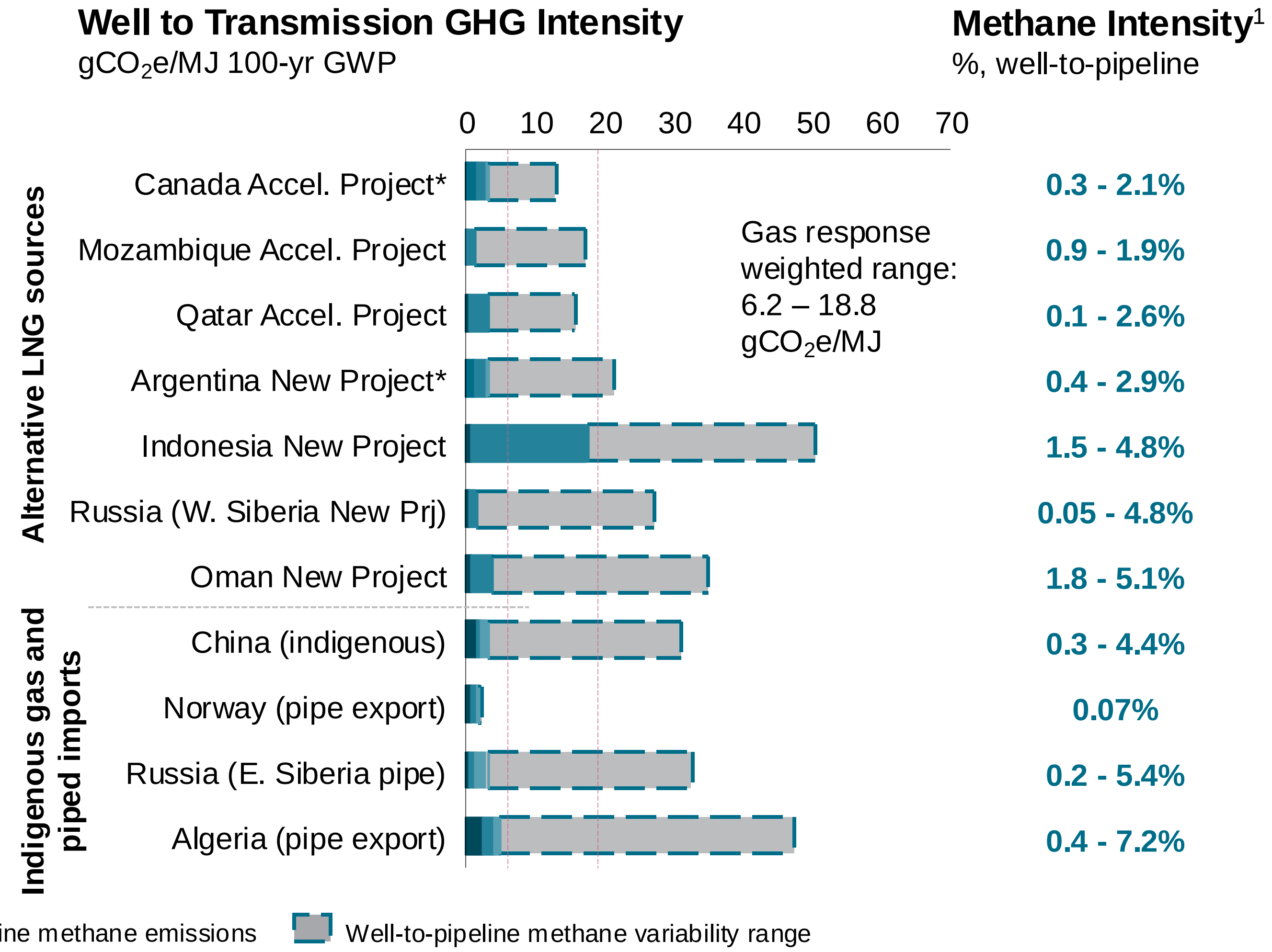
Intensity, $\%CH_4$ released / $\%CH_4$ in gas stream[1]



1. Methane emissions intensity expressed as methane emissions (on an energy basis) divided by methane content of the throughput, with marketable gas being the common denominator across the supply chain.
2. Weighted minimum and maximum methane across groups
Source: S&P Global

Non-US feedstock gas is mostly sourced from large conventional reservoirs with lower fuel use requirements in production but often with higher methane uncertainty





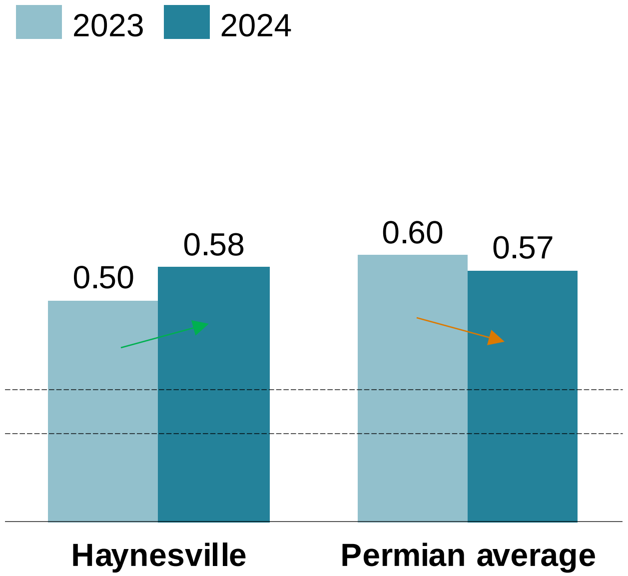
Note: Only plays contributing >100 mmcf/d of production are shown. All US plays studied are unconventional gas sources. * Denotes international unconventional gas sources.
1. Methane emissions intensity expressed as methane emissions (on an energy basis) divided by methane content of the throughput, with marketable gas being the common denominator across the supply chain.
Source: S&P Global data and measurements from TROPOMI

High-frequency, high-resolution methane flyover data available in the US indicates that upstream efforts to reduce methane emissions are gaining traction

Oil and Gas Production Segment Current Methane Intensity Levels

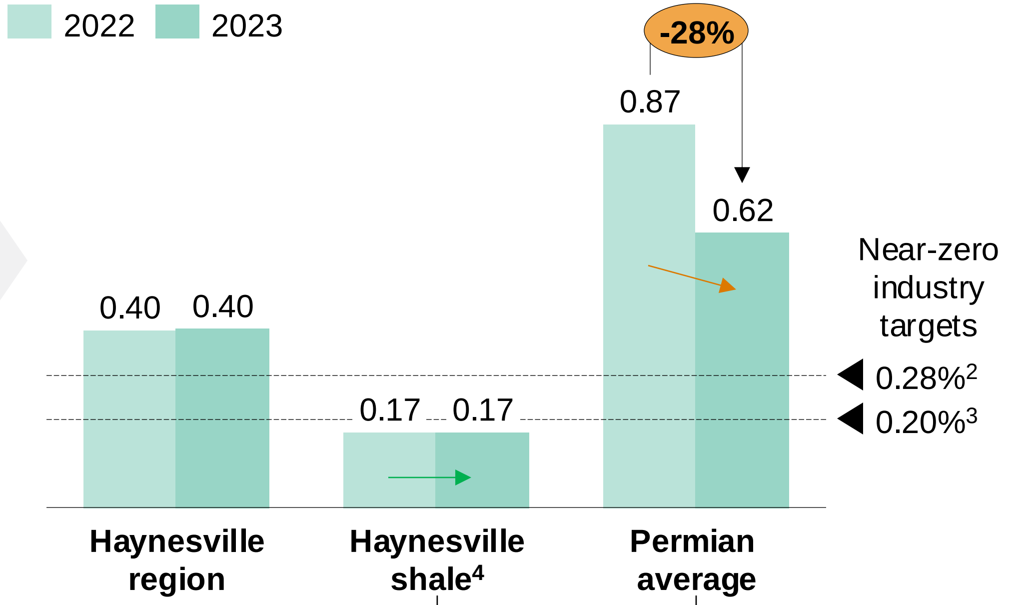
$\%CH_4$ released / $\%CH_4$ in gas stream[1]

Satellite-based (TROPOMI) Estimates



High-frequency and high-resolution flyover observation data from Insight M can help attribute **emissions to individual facilities**, allowing a more granular **understanding of trends** within each play

Flyover-based (Insight M) Measurements



Flyover data show Haynesville shale wells are already at or below industry near-zero methane targets.

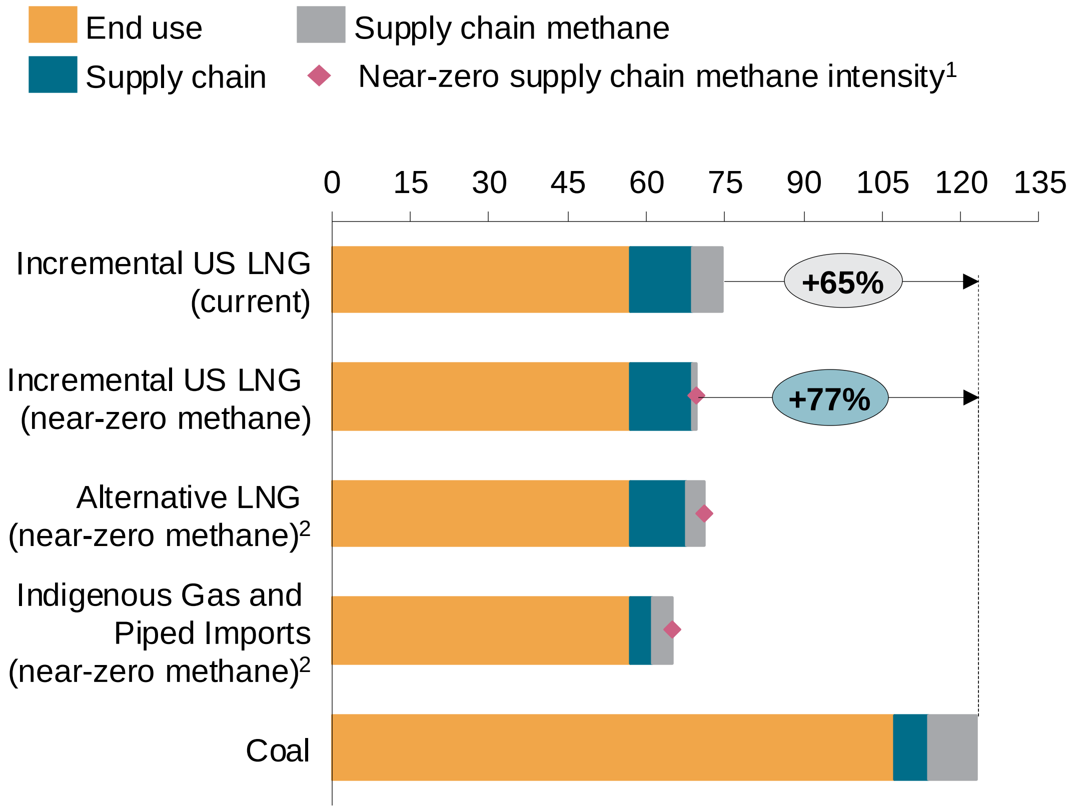
Satellite and flyover data show a significant improvement in the Permian basin—a key source of feedstock for LNG exports

1. Methane emissions intensity expressed as methane emissions (on an energy basis) divided by methane content of the throughput, with marketable gas being the common denominator across the supply chain; 2. ONE Future Coalition target (production); 3. Near-zero energy allocated methane intensity, aligned with OGCI 0.20% target for gassy plays. 4. The Haynesville region has ~5,000 wells producing from the Haynesville Shale versus ~28,000 vertical wells producing from other formations
Source: S&P Global data leveraging measurements from TROPOMI, Insight M

Achieving near-zero methane emissions in the gas and LNG value chains would make coal replacing US LNG 77% more intensive in GWP100 terms

Average Lifecycle GHG Intensity (Production to End Use)

gCO_2e/MJ, 100-yr GWP



Achieving near-zero methane intensity would mean:

18% - 31% Reduction in GHG intensity of Alternative LNG and indigenous gas and piped imports that start from a higher intensity today

7% Reduction in GHG intensity of Incremental US LNG

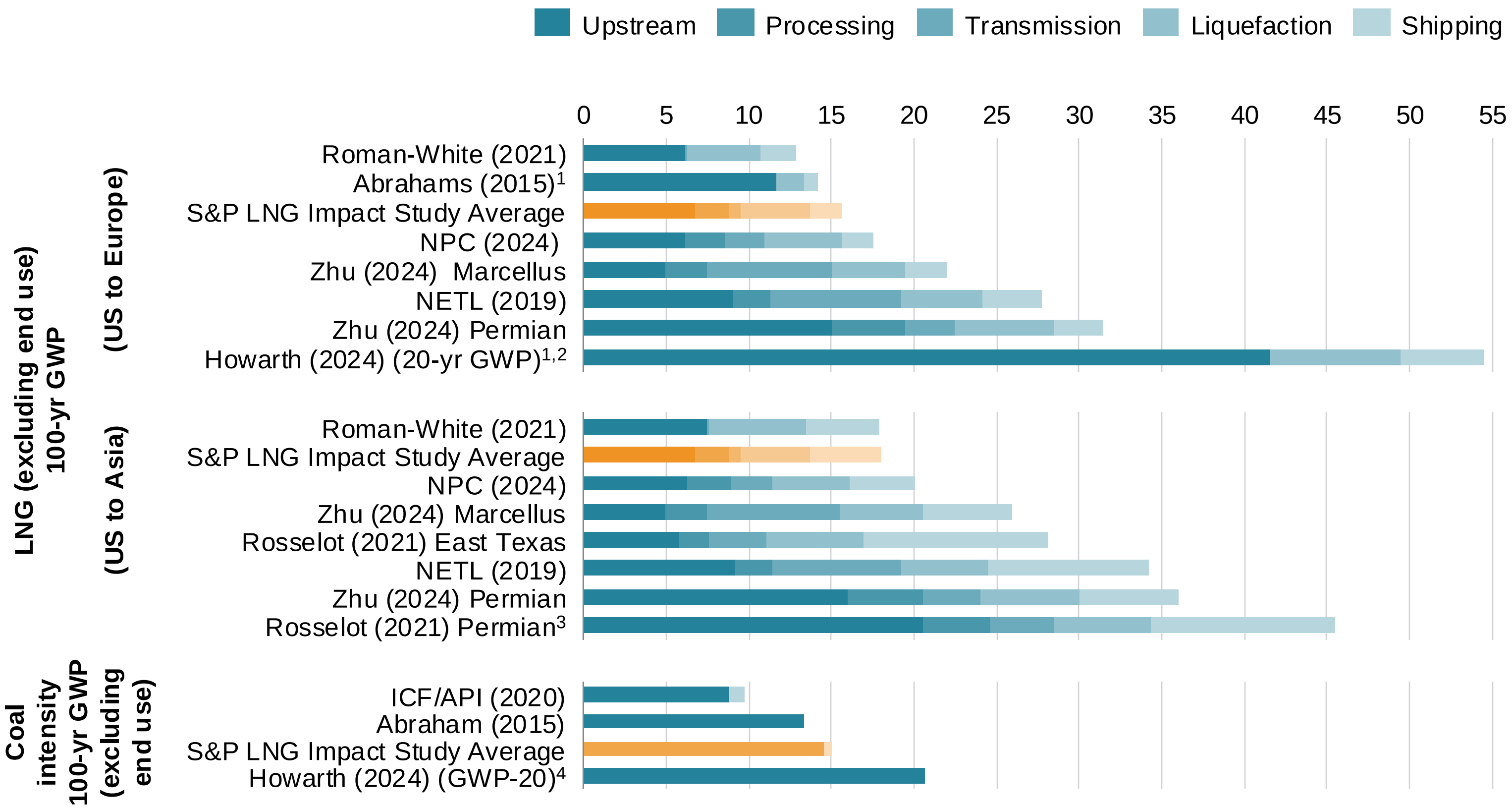
77% Difference in GHG intensity between coal and US LNG (up from 65% under current methane intensity)

1. Near-zero energy allocated methane intensity, aligned with OGCI 0.20% target for gassy plays. 2. Near-zero only for projects delivering to Europe
Source: S&P Global

Differences in results of S&P's analysis and other studies are driven by emissions allocations to co-products, 20- vs. 100-year GWP, and methane intensity assumptions

Supply Chain GHG Intensity Estimates Benchmarking (Excluding End Use)

gCO_2e/MJ 100-yr GWP (except where noted)



- S&P Global analysis reflects **the mix of intensities between all sources** of gas for each LNG facility and **of destination markets.** In contrast, other studies shown consider **single-play sourcing** and single destination markets
- The **2024 Howarth study is an outlier**, mainly because it fully attributes methane emissions from the upstream and midstream sectors to the natural gas stream and thus **overstates their impact on greenhouse gas intensity**
- This is a **crucial difference with all other studies that allocate emissions of each value chain segment to all co-products** of that stage (oil, condensate, gas, NGLs)

1. The Abrahams (2015) and Howarth studies group upstream, processing, and transmission emissions into a single category, consolidated into 'Upstream' for this chart; 2. The Howarth study allocates all emissions to the gas stream instead of to all co-products on an energy basis. This study is also not explicit on a single destination market, but the results shown correspond to a 38-day trip; 3.The Rosselot study's results with allocation of all emissions to gas are 80 gCO_2e/MJ for East Texas and 177 gCO_2e/MJ for the Permian; 4. The Howarth study assumes coal is used domestically and excludes coal shipping; Note: Most of these studies use a functional unit of MWh of electricity generated or delivered. To enable comparisons with our study, all intensity results were re-expressed in MJ of fuel delivered to the plant, using the power plant efficiency factor quoted in the study. Where not disclosed, we considered a 55% efficiency for gas-fired combined cycle power plants and 40% for coal-fired plants.
Source: S&P Global and published studies

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The regional impact of US LNG export value chain reaches all US states — supply chain integration is extensive, broad and homegrown

- The regional impact analysis builds on our Phase 1 study, which demonstrated that the **Base Case** outlook will support an annual average of **495K jobs** and generate **$1.3 trillion in US GDP** from 2025 through 2040

- Phase 2 analysis focused on providing a view at the state and congressional district level
- The sourcing of inputs for the US LNG export value chain will impact states beyond the seven core producing states: Texas, Louisiana, New Mexico, Oklahoma, Pennsylvania, Ohio and West Virginia
- **37% of jobs and 30% of GDP contributions will occur in non-producing states in our Base Case**

- At the US congressional district level, the economic contributions will concentrate in districts with either **(1) investment in natural gas exploration and production or (2) investment in liquefaction activities or (3) businesses within the extended supply chains serving the LNG export industry**

Growth in the US LNG export industry will utilize extended supply chains that involve both producing and non-producing states

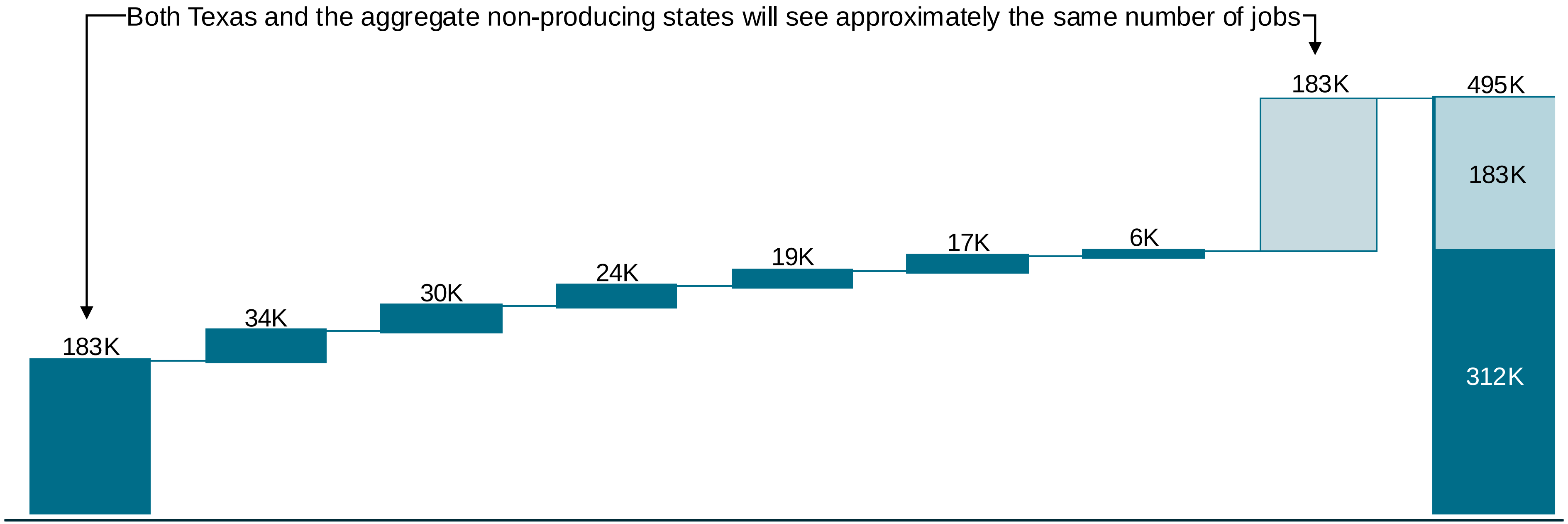
	Industrial equipment & machinery	Construction & well services	Information technology	Logistics	Materials	Professional & other services
Representative spending categories	• Construction equipment • Upstream field equipment • Machines and cutting tools • Medium / heavy-duty trucks and equipment • Compressors, generators and cryogenic heat exchangers	• Drilling wells support • Operations support • Upstream construction • Pipeline construction • Liquefaction facilities construction	• Hardware • Software • IT services	• Freight transportation • Pipeline transportation • Warehousing	• Frac sand • Chemicals • Cement and concrete • Steel and non-ferrous metal • Pipes and pipefittings	• Professional services • Engineering services • Equipment rental • Financial services
Representative supplying states	• Michigan • Ohio • Minnesota • Illinois	• Texas • Louisiana • Oklahoma • Arkansas	• California • Washington • Texas	• Texas • Louisiana • Illinois	• Pennsylvania • Ohio • Wisconsin	• New York • California • Texas • Florida

In the Base Case, 37% of the jobs supported by LNG exports to 2040 will be in non-producing states[1]

Average annual jobs supported in the Base Case

Annual average direct, indirect and induced jobs, 2025–2040

While the $938 billion of cumulative direct capital and operating spending will be focused on projects within the seven producing states, the follow-on indirect and induced effects will result in 37% of the jobs going to non-producing states



	Texas	Oklahoma	Louisiana	New Mexico	Pennsylvania	Ohio	West Virginia	Non-producing states	Total
Distribution of jobs, Base Case	37%	7%	6%	5%	4%	3%	1%	37%	
Jobs at risk, Extended Halt Scenario	41.5K	5.2K	5.0K	4.6K	4.2K	3.7K	1.9K	35.5K	101.4K

1. Other key economic metrics such show similar distributions to non-producing states: 31% of sales activity and 30% of contribution to GDP accrue to non-producing states in the Base Case Scenario.

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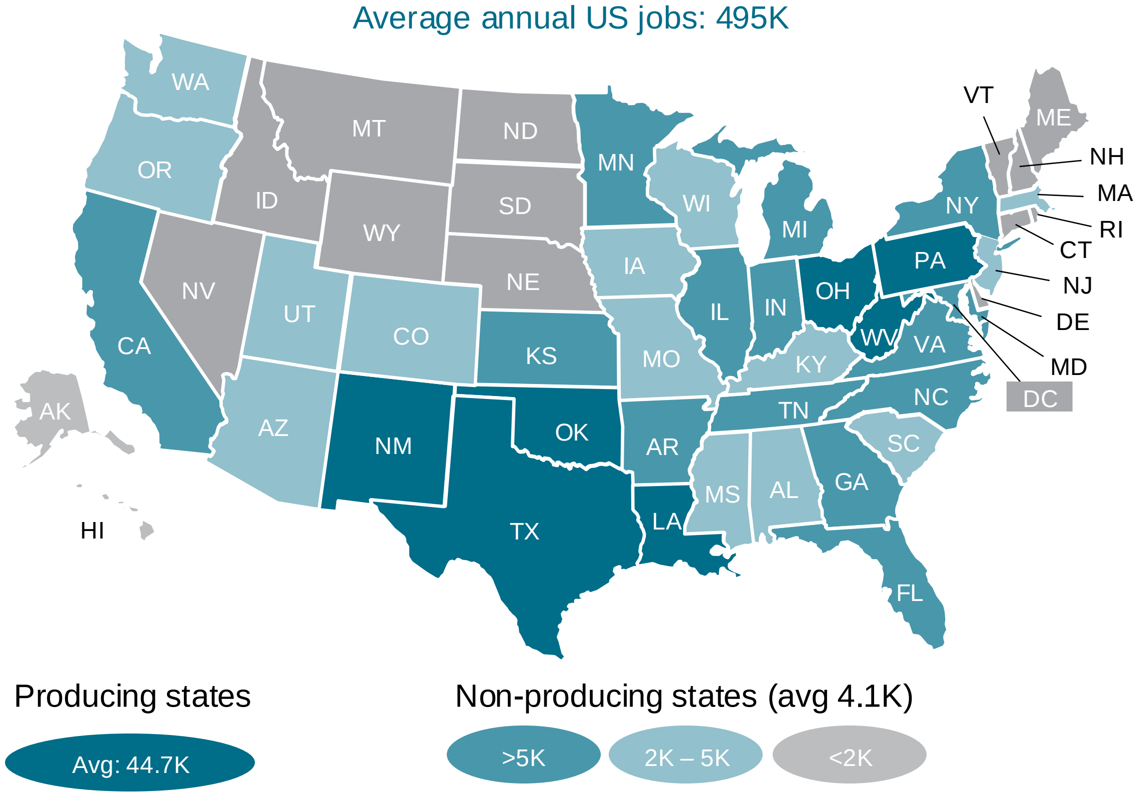
Economic impact from US LNG exports will span the US, focused on the producing states and the industrial mix of the Midwest, East and West Coasts

State-level distribution of jobs, Base Case Scenario

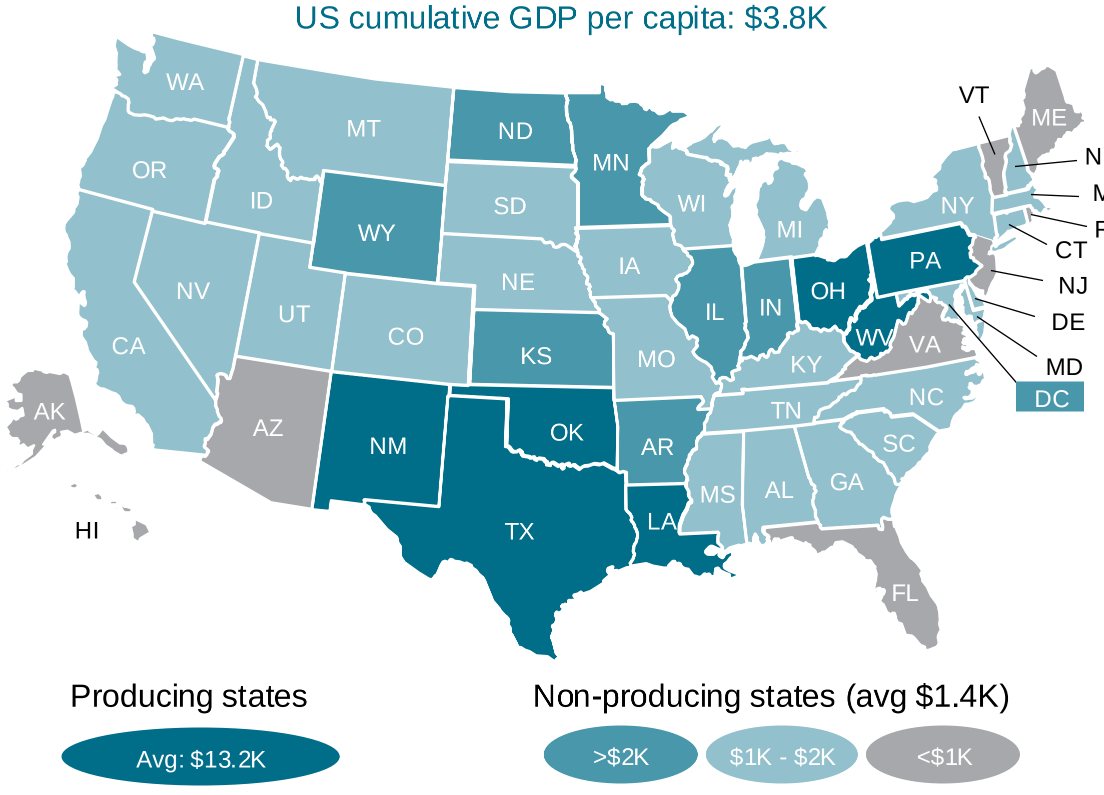
Average annual jobs, 2025 - 2040



On an absolute level, the distribution of jobs in non-producing states will show a "halo effect" around producing states

State-level distribution of GDP per capita, Base Case Scenario

Cumulative dollars of GDP per capita, 2025 - 2040

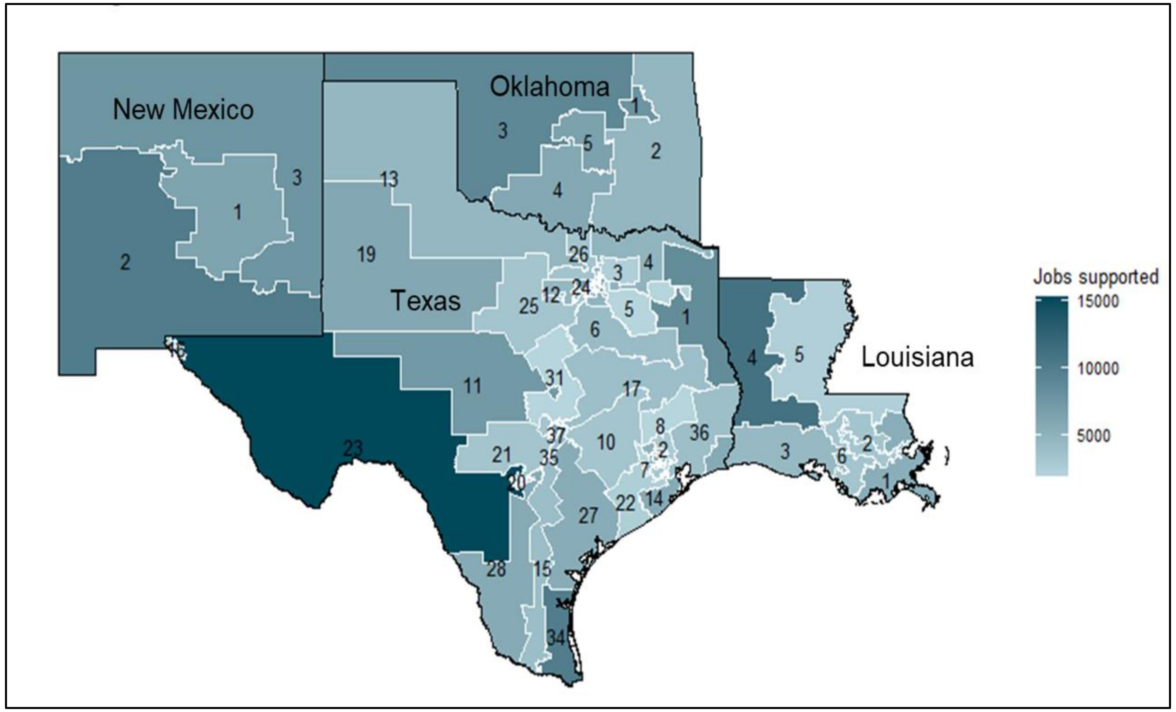


When results are normalized — such as GDP per capita — the proportional economic impacts are more widespread

Congressional districts with major US LNG value chain activity have higher concentrations of jobs supported

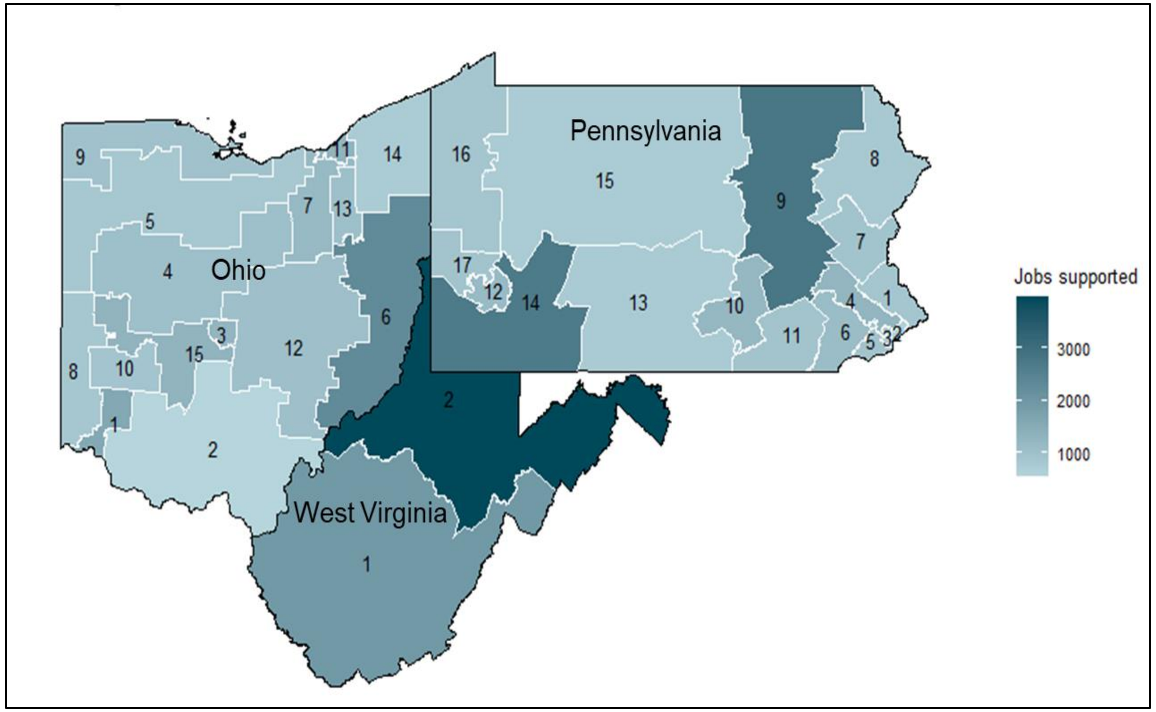
Jobs Supported by Congressional District: Southwestern Cluster

Average, 2025 - 2040



Jobs Supported by Congressional District: Midwest/Mid-Atlantic Cluster

Average, 2025 - 2040

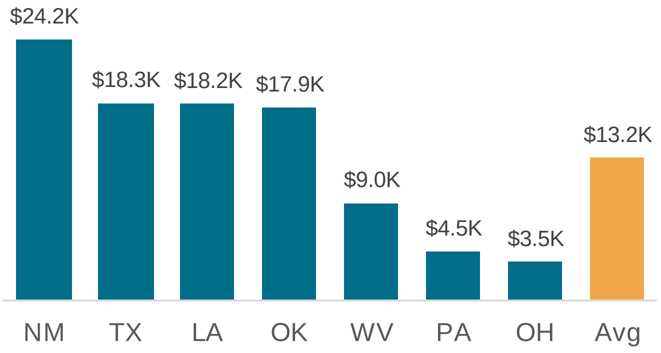


Source: S&P Global Market Intelligence

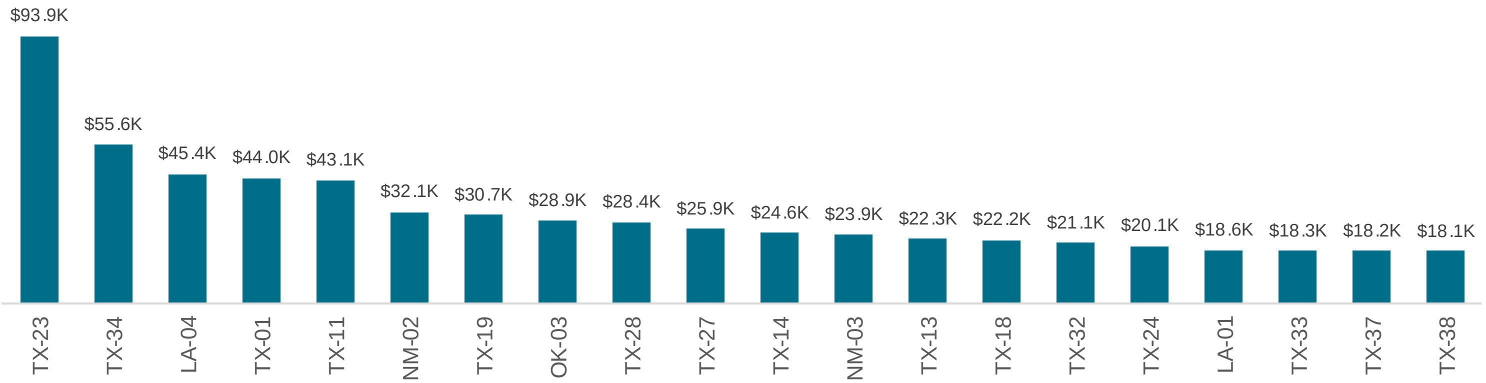
Congressional districts with major upstream plays – Permian, Eagle Ford, Haynesville, Utica, and Marcellus – will have major economic implications.

Congressional districts most benefited are in areas with the highest direct US LNG value chain activity, but gains are distributed throughout the US

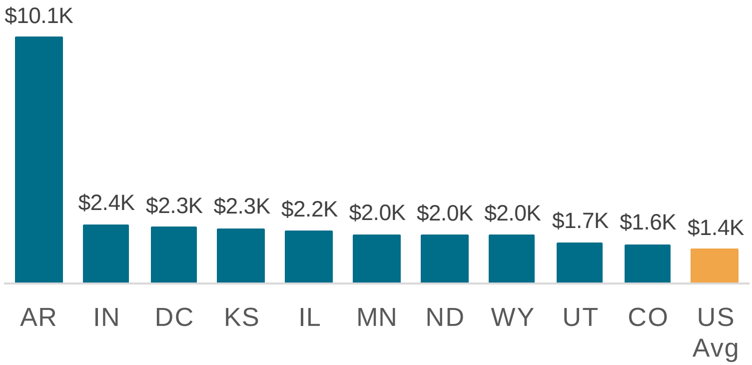
Cumulative GDP per capita in producing states



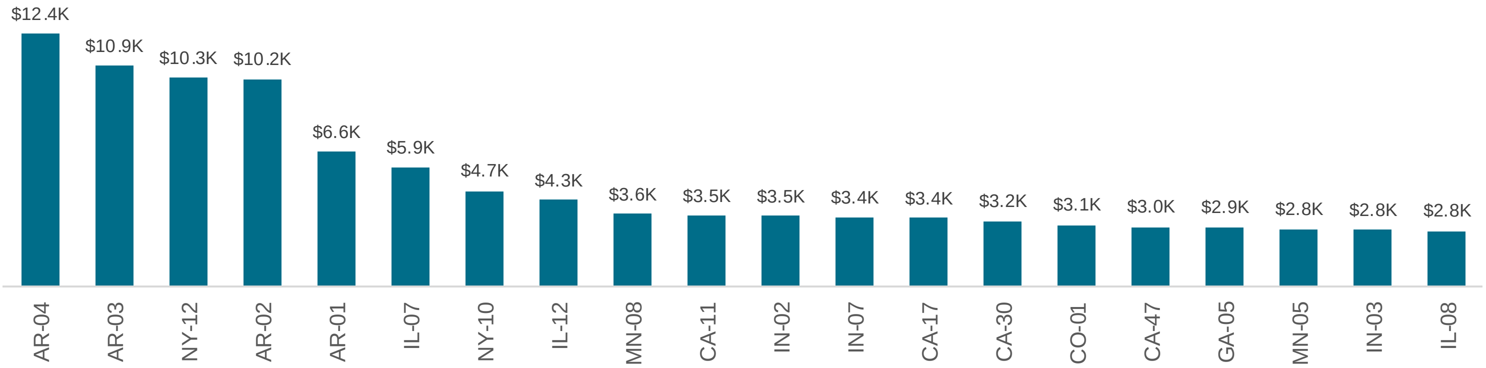
Cumulative GDP per capita, top 20 congressional districts in producing states



Cumulative GDP per capita, top 10 non-producing states[1]



Cumulative GDP per capita, top 20 congressional districts in non-producing states



Units: cumulative GDP per capita, 2025 — 2040, in thousands of real 2024 dollars

1. The strong economic response of Arkansas on the state and congressional district levels is due to the role it will play as a key provider of upstream support services. The response of the New York congressional districts is due to the role they will play in providing financial and businesses services.

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Unlocking the full potential of Marcellus and Utica shale gas through additional pipeline capacity would lead to lower prices and consumer savings, particularly in the Northeast

- The **Northeast has vast amounts of low-cost resources** with the Marcellus and Utica shales a cornerstone of natural gas supply in the United States, representing **1/3 of the US Lower 48's total production in 2025**, up from less than ¼ ten years ago
- The region has more than **620 Tcf of commercial gas resources**, or enough to supply the entire US market for 17 years and the Northeast region for 77 years at current demand levels

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- Due to pipeline constraints, **the Marcellus is being developed at a suboptimal rate** (2% of resource per year being produced)
- Lack of access to this low-cost gas has **pushed gas prices at Boston, Chicago and New York up to 160% higher** than the national gas marker, Henry Hub, (and elsewhere in the US) in peak months feeding into higher electricity prices to consumers

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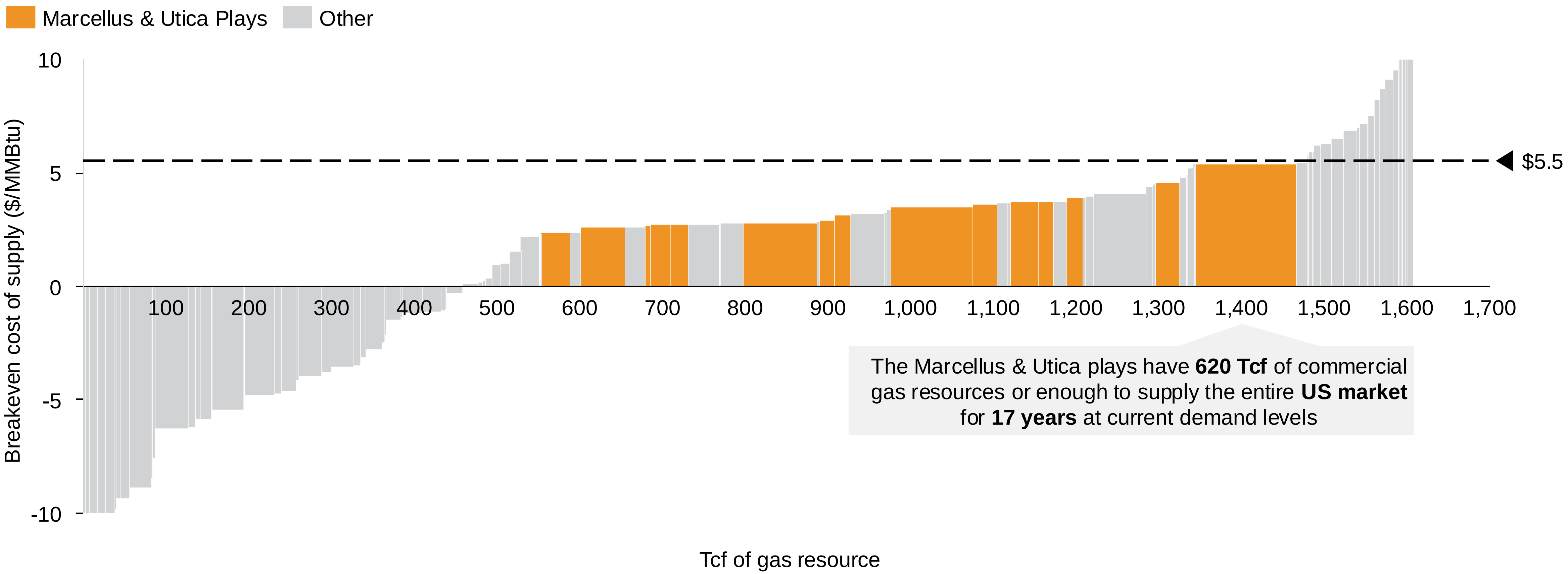
- Expanding Northeast exit capacity by 6.1 Bcf/d could **reduce Henry Hub gas prices by ~$0.20/MMBtu**, 1/3 more than the impact of a US LNG 'Extended Halt' Scenario at similar volumes
- Northeast markets see 20% to 30% gas price declines – **$2.25/MMBtu in Boston and $1.23/MMBtu in New York** in peak months
- **Cumulative savings** to 2040 reach **$76 billion**, far exceeding the estimated $14 billion in capital costs necessary for the pipeline expansions

The Northeast has vast amounts of low-cost gas resources, much of which is at risk of underdevelopment due to natural gas pipeline bottlenecks

Lower 48 US Onshore Commercial Gas Resources by Play[1]

$/MMBtu, Tcf of gas resource

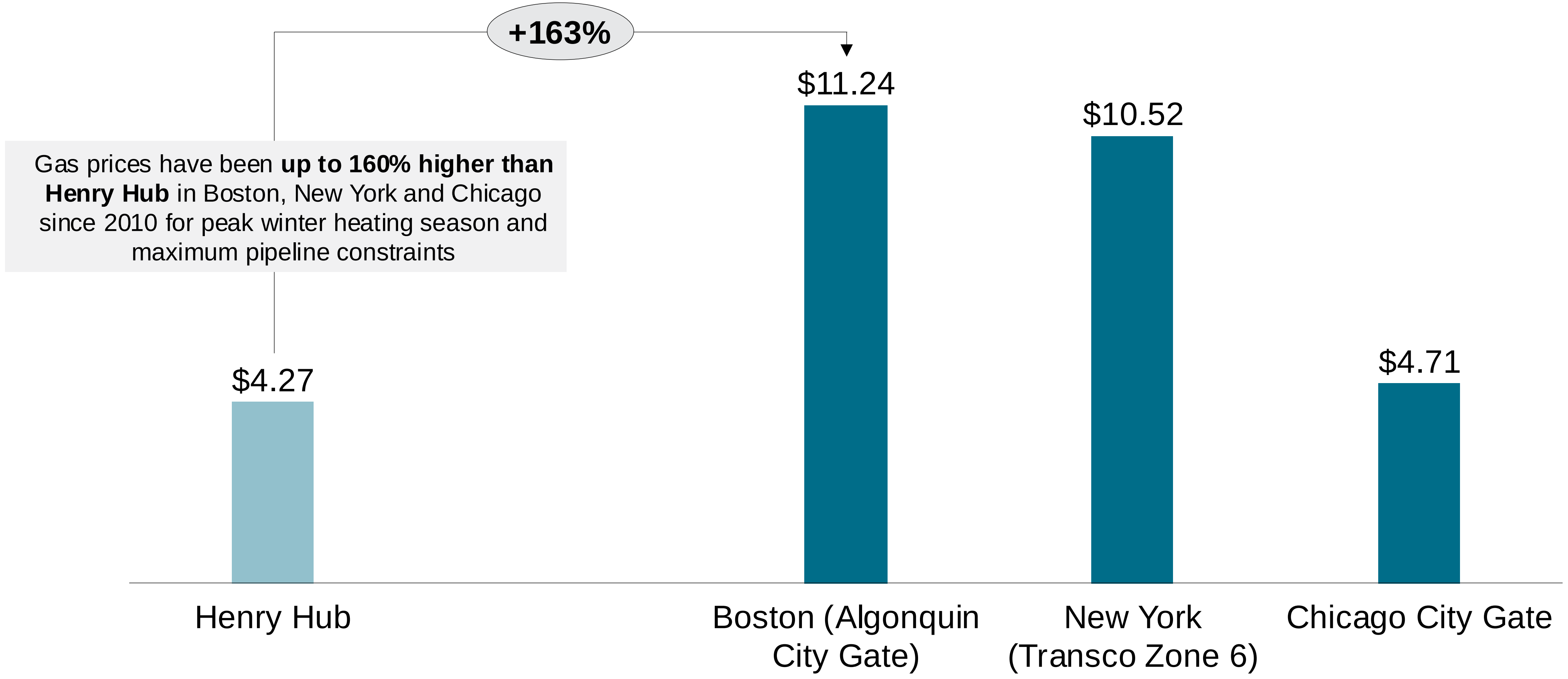


1 Commercial gas resources are remaining recoverable volumes, economical at referred prices, that broadly align with 1P and 2P reserves but reflect a longer-term development outlook.
Source: S&P Global Commodity Insights.

Despite having 620 Tcf of low-cost gas resources, pipeline constraints have caused Northeast and Midwest gas prices to be higher than Henry Hub over the last 15 years

Historical Natural Gas Prices – Northeast and Midwest Winter Peak Month Analogue (January) for the 2010 – 2024 Period

$/MMBtu, Real 2024



Source: S&P Global Commodity Insights.

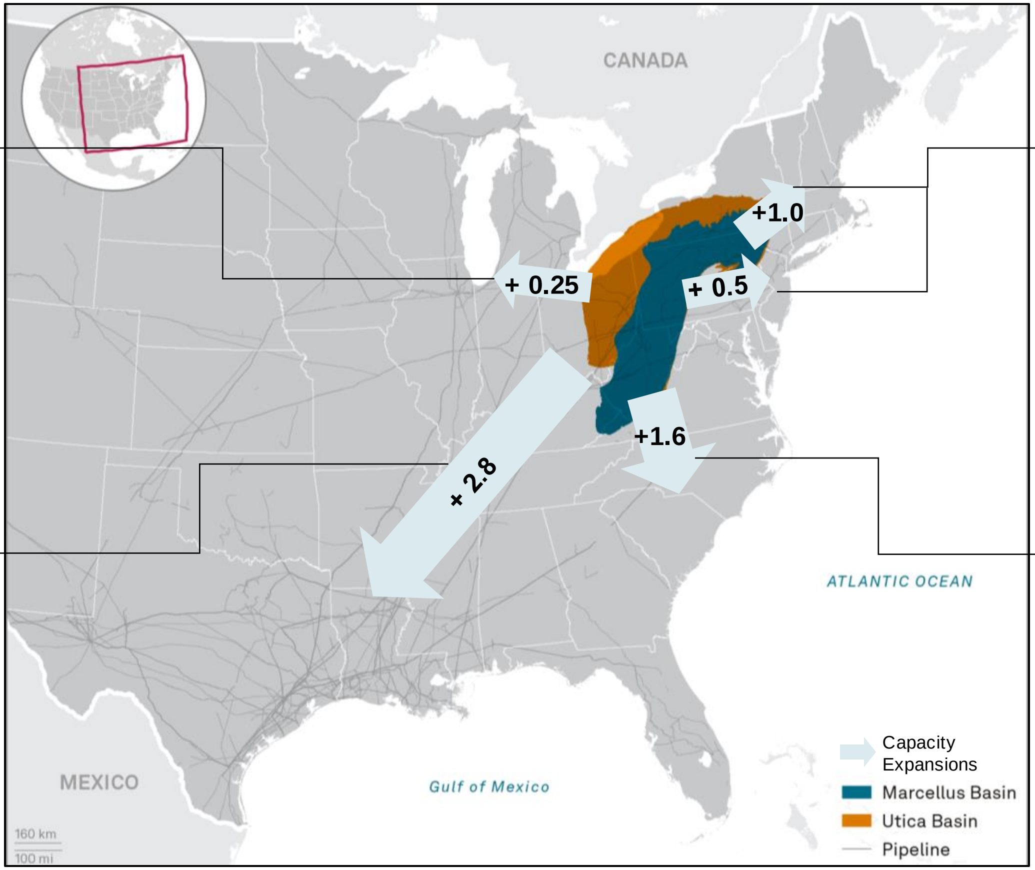
The addition of several pipeline expansion corridors would bring more low-cost resources to consumers throughout the eastern US

Northeast Egress Capacity Expansions Proposed in "NE Pipeline Expansion" Scenario – Total 6.1 Bcf/d expansions

Capacity additions in Bcf/d and assumed in-service year

0.3 Bcf/d expansion to **Mid-West** markets and into Chicago City Gate coming online in 2030

2.8 Bcf/d additional capacity to the **Gulf Coast** via smaller expansions in four major systems coming online in the 2028 – 2031 period



0.5 Bcf/d additional capacity into **New York** and **1.0 Bcf/d** expansion to **New England** going into Boston City Gate. In-service 2029 and 2030 respectively

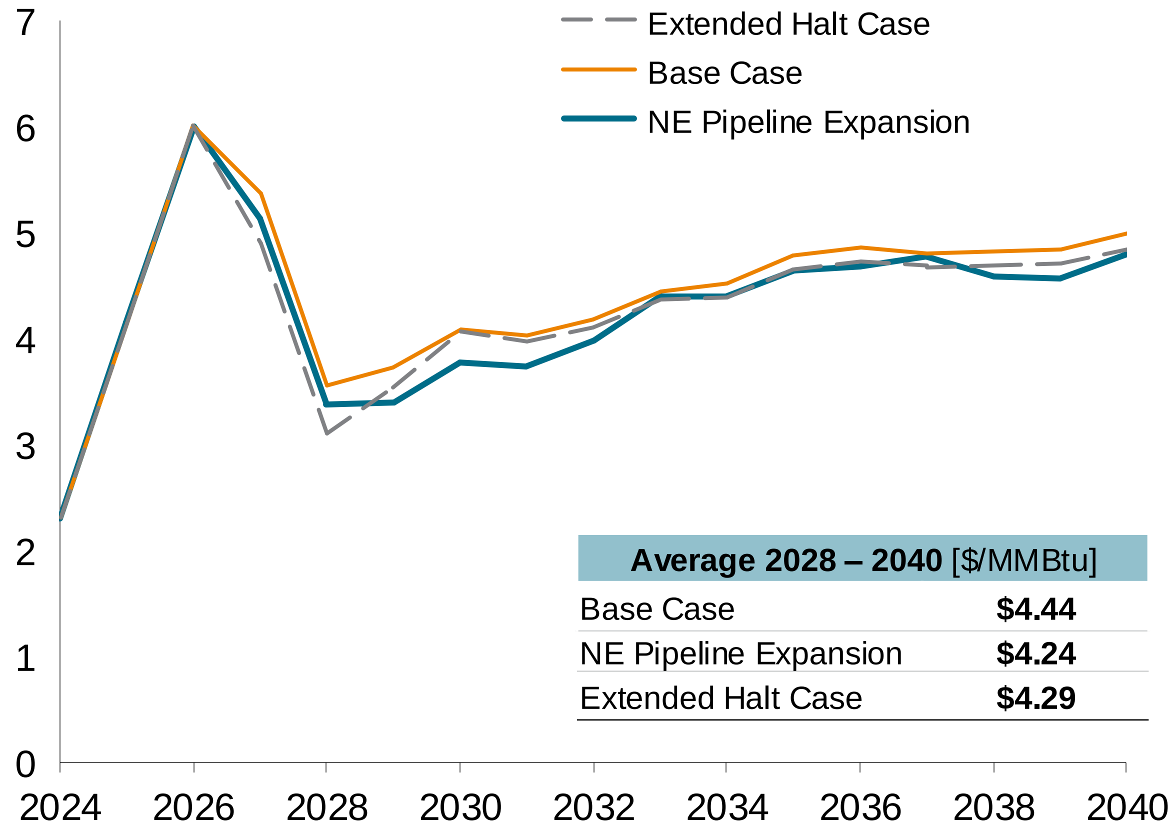
1.6 Bcf/d expansion to **Southeastern markets** via Mountain Valley and the Southgate expansion coming online in 2028 and 2029 respectively

Source: S&P Global Commodity Insights.

Northeast pipeline expansions would reduce gas prices across the entire US Lower 48, leading to a Henry Hub price reduction of 4% ($0.20/MMBtu) in the 2028 – 2040 period

Henry Hub Annual[1] Real 2024 Price

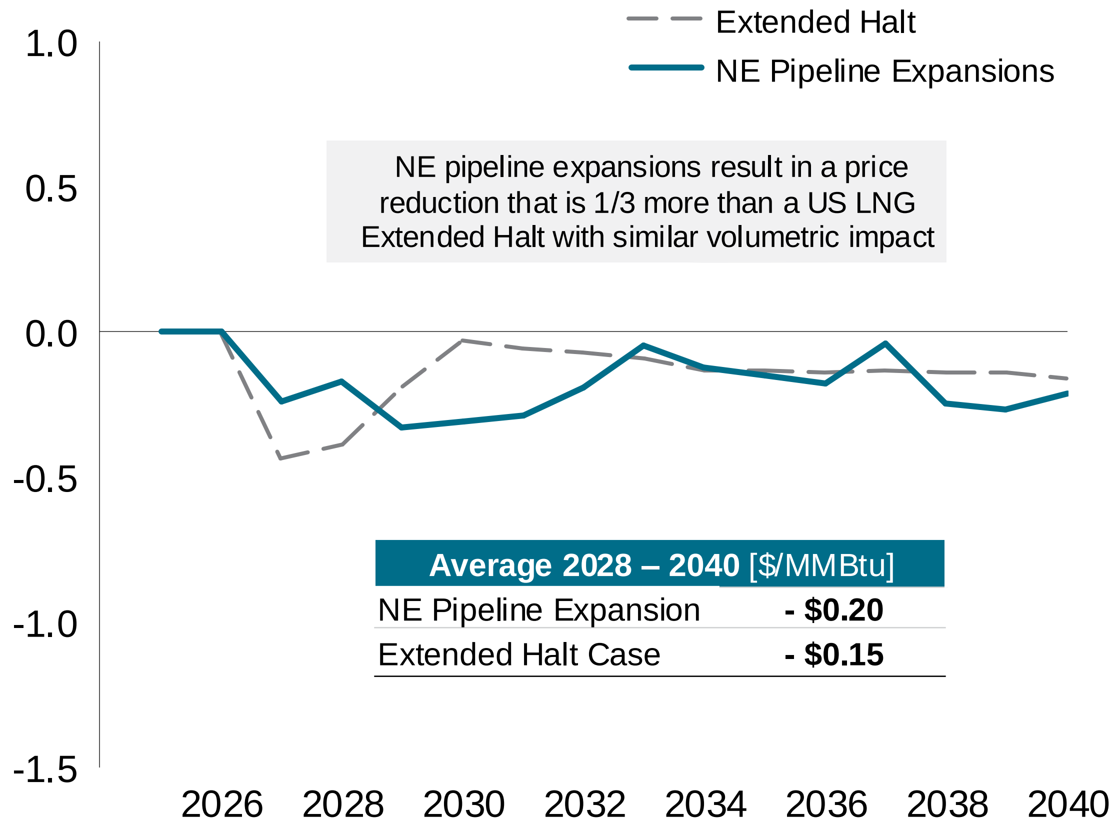
Real 2024 $/MMBtu



Average 2028 – 2040 [$/MMBtu]	
Base Case	**$4.44**
NE Pipeline Expansion	**$4.24**
Extended Halt Case	**$4.29**

Henry Hub Annual[1] Price Differential

Real 2024 $/MMBtu

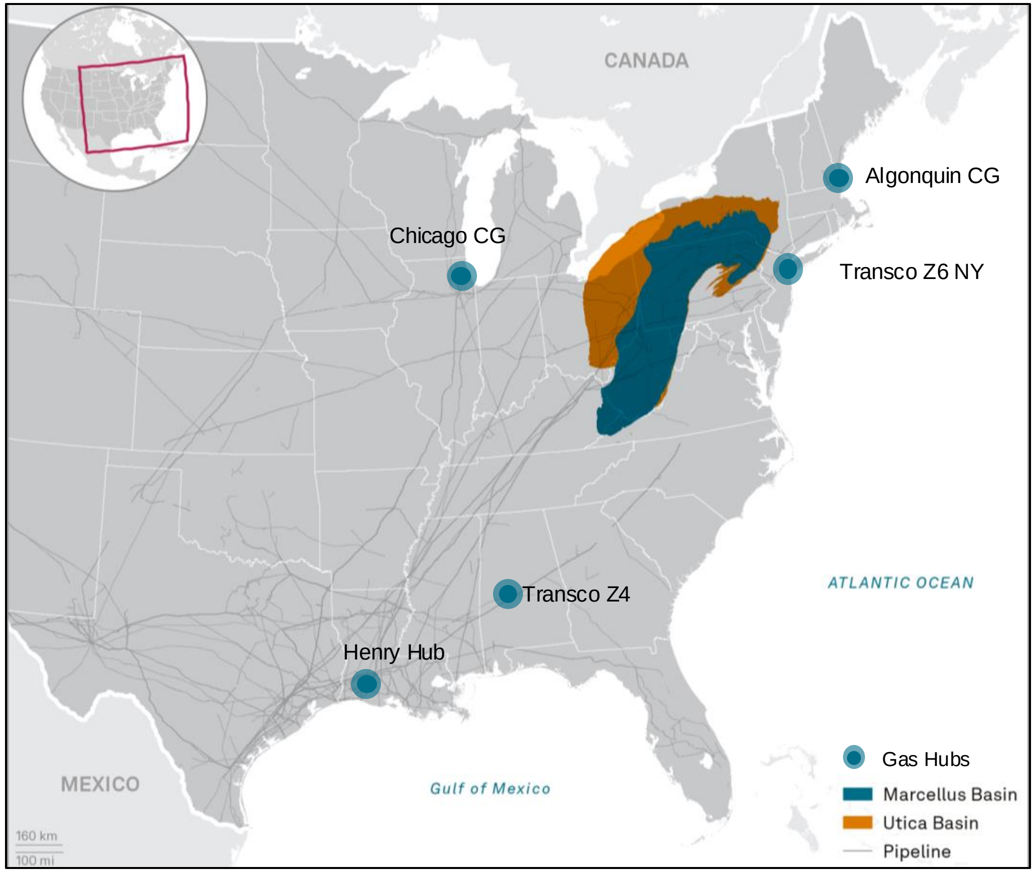


Average 2028 – 2040 [$/MMBtu]	
NE Pipeline Expansion	**- $0.20**
Extended Halt Case	**- $0.15**

Note: 1. Annual average of monthly modeled prices for each scenario
Source: S&P Global Commodity Insights

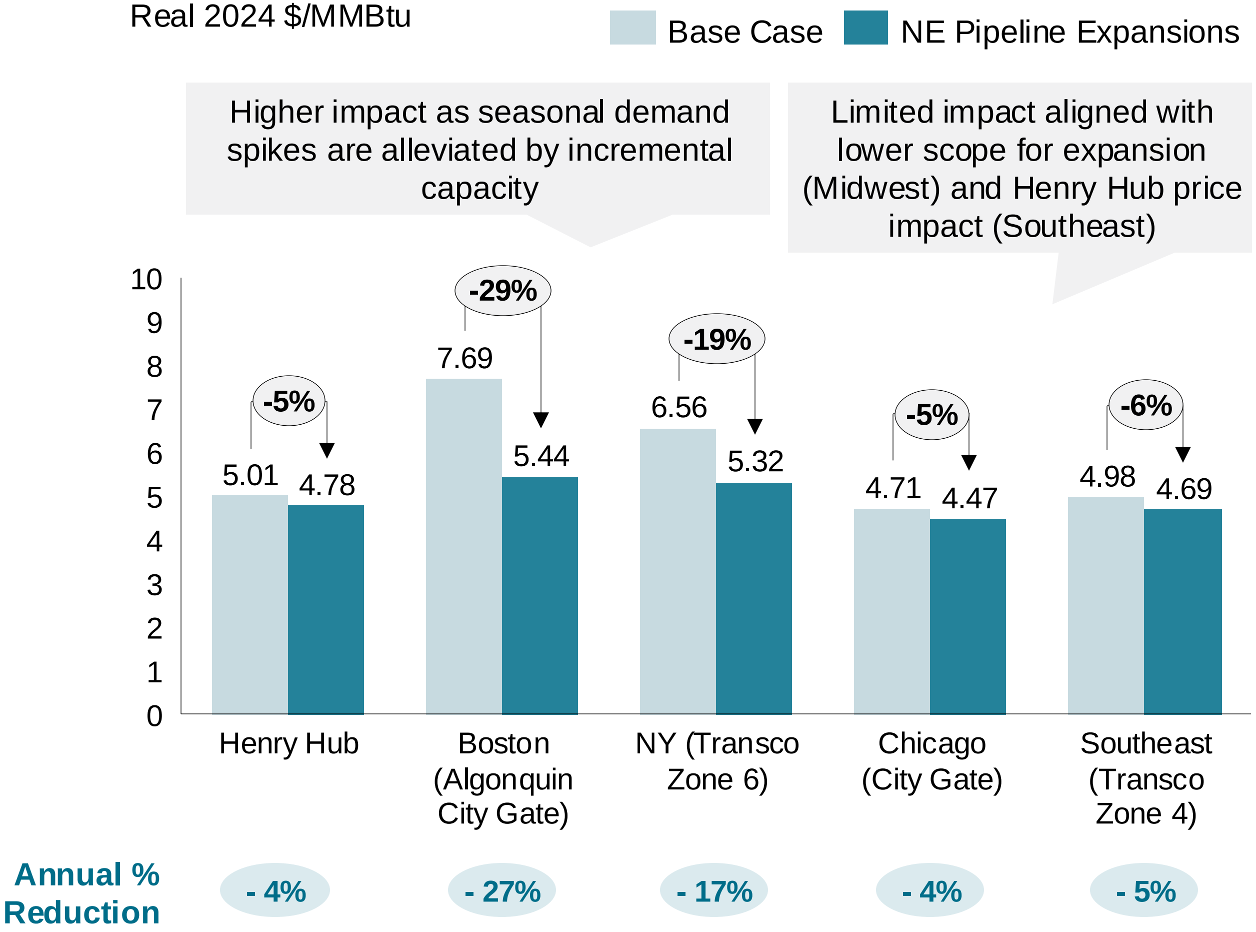
These pipeline expansions would particularly benefit more constrained and higher priced NE markets, reducing prices up to 30% in peak months and 17-27% on average to 2040

Relevant Gas Hubs



Change in Natural Gas Prices January Average – 2028 to 2040

Real 2024 $/MMBtu



Source: S&P Global Commodity Insights

Northeast gas pipeline debottlenecking would result in cumulative savings of $76 billion to 2040 to gas consumers relative to $14 billion of capital required for pipeline expansion

Northeast US Pipeline Expansion Summarized Results – 2028 to 2040 period
Real 2024 $

Most regions have **higher annual household savings** than the estimated $11 from a US LNG Extended Halt.

	Capex[1] Estimated	% Decrease in wholesale prices	Total Annual Savings less Opex[2]	Household Gas Savings[3] $/year	Household Gas Savings[3] Cumulative
New England	$4.3 B	27%	$1.02 B	$110	$1,435
NY / New Jersey	$0.5 B	17%	$1.41 B	$63	$813
Midwest	$0.6 B	4%	$0.93 B	$17	$220
Southeast	$2.5 B	5%	$1.14 B	$13	$170
Gulf Coast	$6.4 B	4%	$1.36 B	$9	$118
	Total: $14.3 B		**Total: $5.86 B**		

2028 – 2040 savings: ~$76 B

In addition to **residential savings** of **$15B**, gas consumers in the **power, industrial** and **commercial** sectors realize **$27B**, **$22B** and **$12B** savings respectively during the period

On top of the direct gas related savings, Households would also benefit from **lower electricity prices**

1.Capex estimation based on analogues of historical expansions in the specific regions and/or public fillings; 2. Annual savings refer to savings for all gas consumers, including residential, commercial, industrial, power and others. These are net of incremental operating costs for expanded capacity; 3. Considers residential demand and gas consuming households per region, calculated as discount in gas price ($/MMBtu) multiplied by average consumption per gas-consuming residence for the 2028 – 2040 period.
Source: S&P Global Commodity Insights, EIA

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The study evaluates emissions intensity across energy sources by analyzing supply chain segments and considering direct emissions

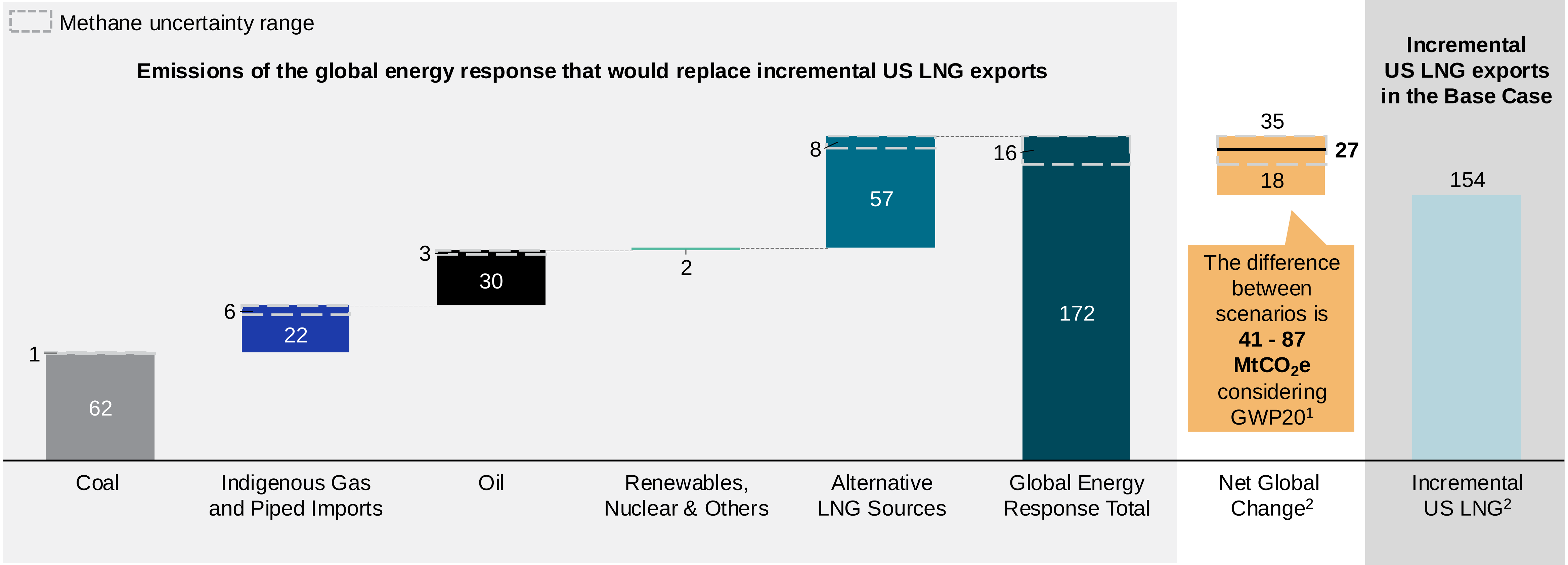
Goal and Functional Units	▪ **Goal:** To estimate the impact on life-cycle GHG emissions of the US LNG 'Extended Halt' Scenario and the global energy response described in Phase 1, where US LNG exports are replaced by various other fuels and renewable electricity in selected target markets. ▪ **Functional unit:** **1 MJ (lower heating value)** of each fuel/energy source **delivered to an end use point** near an LNG regasification terminal in the destination country. The results are expressed in terms of **gCO_2e/MJ**. ▪ **End Use:** The energy efficiency of the end use (e.g. gas vs. coal power plant efficiency) was considered in the global energy balance model used in Phase 1. In Phase 2, the quantity of each fuel is taken as given, and therefore GHG impacts are compared on a delivered basis, not accounting for differences in the efficiency of end use (e.g., power plant heat rates).
Scope	▪ **Boundary:** This study estimates the GHG intensity of each segment of the value chain for each fuel from **production to end use combustion**, accounting for volume/energy losses in each segment and producing an aggregated lifecycle intensity that is then multiplied by the variation in volume of each fuel identified in Phase 1. ▪ **Emission sources:** CO_2 and CH_4 direct emissions[1] from **combustion**, **flaring**, **venting** and **fugitives** are presented using their 100-year global warming potentials (AR6 GWP100) used for UNFCCC reporting. GWP20 results are also shown in this appendix.
Critical Supply Chain Segments	▪ **US upstream:** The volume and GHG intensity of natural gas supplied from each US play flowing to each US LNG facility impacted is used to determine the weighted average upstream and midstream emissions. The gas pathing analysis is based on current and expected physical flows and has been calibrated using the expert opinion of S&P Global gas analysts. ▪ **Shipping routes:** Shipping emissions for each fuel are based on a weighted average of the distance from the supply source (LNG facility, oil terminal, coal mine) to all the consumption markets impacted. For LNG exports, the destination markets are derived from both existing contractual agreements and forecast flows. Shipping emissions account for the total distance between ports, the fleet makeup, and typical vessel characteristics. ▪ **Methane:** Across each segment of the supply chain for each fuel, methane emissions were analyzed based on the data available during the time of this analysis, starting with remote observational data (i.e. historic data from previous observation campaigns captured via satellite and flyover), followed by reported, literature-based, and modeled emissions using standard factors.

1.This analysis excludes other greenhouse gases, such as nitrous oxide, that are relatively minor contributors to GHG intensity for the fuels under analysis.

Emissions from incremental US LNG exports in the Base Case are 18 to 35 $MtCO_2e$ (GWP100[1]) lower per year than the alternative energy sources modelled

GHG Emissions Corresponding to the Impacted US LNG Exports and the Potential Global Energy Response[1]

Million tCO_2e, 100-yr GWP, yearly average 2028–2040 for the range of methane intensities



1. Global Warming Potential (GWP) is a measure used to compare the impact of different greenhouse gases on global warming. It quantifies the heat a greenhouse gas traps in the atmosphere over a specific time period, relative to carbon dioxide (CO_2), which has a GWP of 1. See the appendix for full results in 20-yr GWP; 2. The volume of impacted LNG exports at risk and the response of the global energy system are based on the results of Phase 1; 3. Midpoint methane intensity represents the middle of the modeled methane uncertainty range. For results on the full range of methane uncertainty, see appendix

Source: S&P Global

We evaluated the typical segments of the LNG supply chain, which includes additional segments with significant energy requirements beyond the natural gas supply chain

Natural gas value chain

Liquefied natural gas (LNG) value chain

Production
- Exploration
- Development
- Production
- Gathering
- Processing

Pipelines
- Long- Distance
- Transmission

Liquefaction
- Treating / Stripping
- Liquefaction
- Storage
- Loading

Shipping
- Shipping
- Trucking

Regasification
- Receiving
- Storage
- Vaporizing
- Transport to market

End Use[1]
- Combustion for heat or electricity
- (Petrochemical use)

— Energy intensive segment —

Main sources of GHG emissions[2]

- Fuel use (mostly CO_2 from combustion)
- Methane vents and leaks (higher uncertainty)
- Methane vents and leaks
- Flaring
- CO_2 vented
- CO_2 vented

Lifecycle GHG emissions CO_2e

~ 20-25%

~ 75 - 80%

1. Both the natural gas and LNG value chain typically include a local distribution segment after long-distance transmission or regasification and before delivery to the final point of consumption. This study assumes delivery of natural gas, LNG, and alternative fuels to a point adjacent to the regasification terminal or transmission line to simplify comparisons across fuels. Petrochemical use is not included in the illustration of lifecycle GHG intensity. 2. Key typical sources of emissions shown, but individual plays can vary significantly from the average.

Source: S&P Global

In the oil value chain, methane emissions in the production segment dominate, while refining remain the most energy-intensive segments

Production

Exploration

Development

Production

Transport

Shipping

Shipping

Processing

Receiving

Storage

Refining

Transport to market

End Use[1]

Combustion for heat or electricity (Petrochemical uses)

Energy intensive segments

Main sources of GHG emissions

- Fuel use (mostly CO_2 from combustion)
- Methane vents and leaks (high uncertainty)
- Flaring
- CO_2 vented

Lifecycle GHG emissions CO_2e

~ 14-33%

~ 67 - 86%

1.This study assumes delivery of oil and alternative fuels to a point adjacent to the oil refinery or transmission line to simplify comparisons across fuels. Petrochemical use is not included in the illustration of lifecycle GHG intensity.
Source: S&P Global

For coal most of the supply chain GHG emissions are due to logistics and operations, except for subsurface mines where methane plays a larger role

Production

Mining

Extraction

Post-mining

Processing

Storing

Moving

Transportation[1]

Land transportation via truck or rail

Shipping

Receiving

Storage

Transport to market

End Use

Combustion for

heat or electricity

Energy intensive segment

Main sources of GHG emissions

Fuel use (mostly CO_2 from combustion)

Methane vents (higher in underground mines)

Lifecycle GHG emissions CO_2e

~ 5 - 14%

~ 86 - 95%

1. The model considers land transportation from mine to port (for exports) or mine to plant (for internal supply) and from port to plant for receiving countries, which occurs after shipping.
Source: S&P Global

Data sources for LNG GHG emission intensity estimates by country (1 of 2)

Unconventional Gas

Combustion emissions Flaring emissions Methane emissions

<table>
<tr><th></th><th>Drilling & Completion</th><th>Production</th><th>Gathering & Boosting</th><th>Gas Processing</th><th>Transmission & Storage</th><th>Liquefaction</th><th>Shipping & Regasification</th><th>End Use Transportation & Combustion</th></tr>
<tr><td rowspan="3">United States</td><td colspan="2">S&P Global IMPACT: enhanced emissions model calibrated against EPA</td><td colspan="4">S&P Global Center of Emissions Excellence (CofEE): Emission factor based on EPA and other reported data</td><td>CofEE’s EF & literature</td><td>OPGEE emission factors</td></tr>
<tr><td colspan="2">S&P Global IMPACT: enhanced emissions model calibrated against EPA</td><td colspan="4">CofEE: Emission factor developed based on EPA reported data</td><td>N/A</td><td>N/A</td></tr>
<tr><td colspan="6">Measurement-informed estimates[1] based on TROPOMI and Insight M data assigned to value chain segments using EPA reported data</td><td>Emission factors</td><td>N/A</td></tr>
<tr><td rowspan="3">Canada</td><td colspan="2">S&P Global IMPACT: enhanced emissions model calibrated against EPA</td><td colspan="3">Reported data based on similar Alberta operations</td><td>CofEE’s EF with reported data[3]</td><td>CofEE’s EF & literature</td><td>OPGEE emission factors</td></tr>
<tr><td colspan="2">S&P Global IMPACT: enhanced emissions model calibrated against EPA</td><td colspan="4">Based on VIIRS observation and EF derived from high-reliability reported data in US and Canada</td><td>N/A</td><td>N/A</td></tr>
<tr><td colspan="6">Measurement-informed estimates[1] based on TROPOMI data assigned to value chain segments using EPA and other reported data</td><td>Emission factors</td><td>N/A</td></tr>
<tr><td rowspan="3">Argentina</td><td colspan="2">Based on analogue US plays taken from S&P Global IMPACT</td><td colspan="3">Analogue from US emission factors</td><td>CofEE’s EF with reported data[3]</td><td>CofEE’s EF & literature</td><td>OPGEE emission factors</td></tr>
<tr><td colspan="6">Based on VIIRS observation and EF derived from high-reliability reported data in US and Canada</td><td>N/A</td><td>N/A</td></tr>
<tr><td colspan="6">Measurement-informed estimates based on GHGSat and TROPOMI data assigned to value chain segments using EPA and other reported data</td><td>Emission factors</td><td>N/A</td></tr>
</table>

1. TROPOMI estimates developed by S&P Global Center of Emissions Excellence and S&P Global Data Science team; 2. Liquefaction methane emission factor based on GHGSat and literature; 3. Leveraging average energy factors when no specific project data is available

Data sources for LNG (2 of 2)

Conventional Gas

Combustion emissions Flaring emissions Methane emissions

	Drilling & Completion	Production	Gathering & Boosting	Gas Processing	Transmission & Storage	Liquefaction	Shipping & Regasification	End Use Transportation & Combustion
Russia, Oman, Qatar, Indonesia, and other int. gas	Modeled in S&P Global QUE$TOR		N/A	Modeled in S&P Global QUE$TOR	N/A	EF developed with reported data (CofEE)[2]	CofEE's EF & literature	OPGEE emission factors
	N/A	Based on VIIRS observation	N/A	Based on VIIRS observation	N/A	CofEE emission factors	N/A	N/A
	Satellite measurements, reported data, and EF		N/A	Satellite, reported, & EF	N/A	Measurement informed[1] & emission factors	Emission factors	N/A
Mozambique	Modeled in S&P Global QUE$TOR		N/A	Modeled in S&P Global QUE$TOR	N/A	EF developed with reported data (CofEE)[2]	CofEE's EF & literature	OPGEE emission factors
	N/A (subsea completions)		N/A	Based on VIIRS observation	N/A	CofEE emission factors	N/A	N/A
	N/A (subsea completions)		N/A	Satellite, reported, and EF	N/A	Measurement informed[1] & emission factors	Emission factors	N/A

1. Liquefaction methane emission factor based on GHGSat and literature; 2. Leveraging average energy factors when no specific project data is available

Data sources for other fuels

Oil and Coal

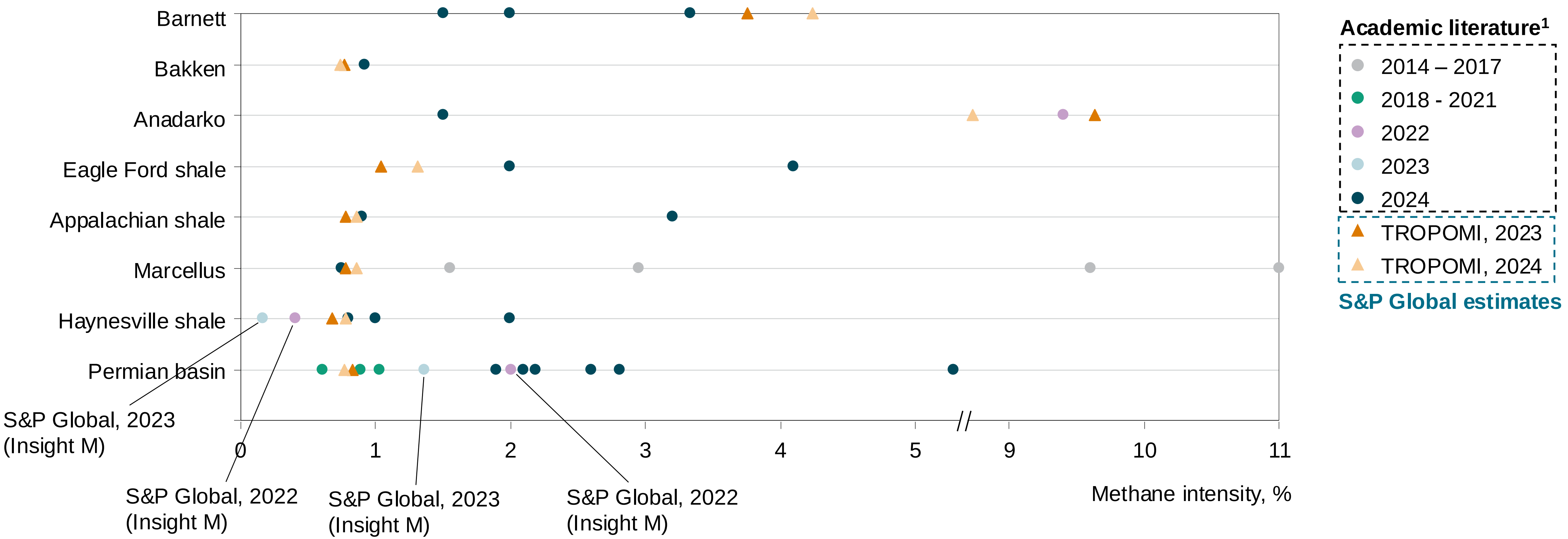
Combustion emissions   Flaring emissions   Methane emissions

		Upstream	Midstream	Downstream	End Use	Volume Allocations
Oil (all countries)	Combustion emissions	S&P Global Center of Emissions Excellence estimated modeled factors by crude grades	Emissions modeled	CofEE modeled factors	OPGEE & EPA emission factors	▪ Total shipped oil exports from source countries via Commodities at Sea ▪ Total destination import shares via Envisage/Global Gas analysis
	Flaring emissions		N/A	N/A	N/A	
	Methane emissions	Satellite measurements and emission factor	N/A	Emission factors	N/A	
Coal (all countries)	Combustion emissions	Emissions modeled	Emissions modeled	N/A	OPGEE & EPA emission factors	▪ Total destination import shares via Envisage/Global Gas analysis
	Flaring emissions	N/A	N/A	N/A	N/A	
	Methane emissions	UNFCCC emission factors	N/A	UNFCCC emission factors include stockpile emissions	N/A	

In the US, S&P Global leveraged TROPOMI satellite observation-based estimates of methane intensity

US Upstream Methane Intensity Benchmarking

% of gas produced



1. See next slide for details of academic studies considered

Source: S&P Global and published studies

Overview of global methane emission studies considered

Location	Study	Year published	Basins considered (US only)		Countries covered	
United States	Sherwin et al.	2024/2025	Barnett Denver Julesburg	Marcellus Permian		
	MethaneAIR	2024	Anadarko	Denver Julesburg		
			Appalachian	Eagle Ford		
			Bakken	Fayetteville		
			Barnett	Haynesville		
	Chen et al.	2022	Permian			
	Omara et al.	2016	Anadarko	Eagle Ford		
			Appalachian	Haynesville		
			Barnett	Marcellus		
	Peischl et al.	2015	Fayetteville	Marcellus		
			Haynesville			
	Caulton et al.	2014	Marcellus			
International	Chen et al.	2023			Argelia Iraq	Oman Saudi Arabia
					Qatar	
	Zichong et al.	2024			China	
	Lechtenböhmer et al.	2007			Russia	
	Kleinberg, R. L.	2022			Russia	

Source: Published studies

For international plays, GHGSat and Sentinel-2 plumes were used to estimate average emission rates and leak duration for certain value chain segments and asset types

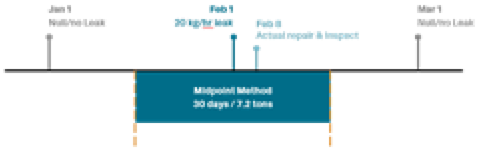
Methane Intensity Methodology for GHGSat and Sentinel-2 Data Analysis

1 Analysis and attribution of CH_4 plumes to facilities

- All plumes were attributed to the closest O&G asset/infrastructure
- Assets were categorized into LNG plants, gas plants, pipelines and upstream[1]

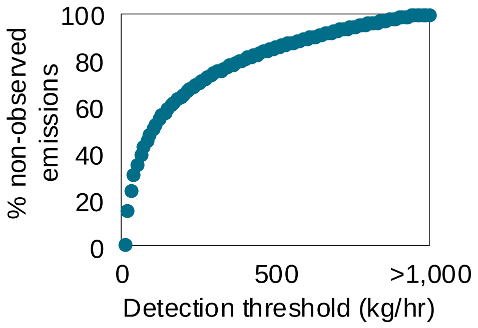
2 Estimation of leak duration

- For each asset with adequate plume and null observations, the duration of the plume was estimated using the **midpoint method**
- For non-observed plumes under the threshold duration was estimated based on typical leak durations for similar assets and similar size plumes



3 Define % of non-observed plumes

- Assumed GHGSat and Sentinel-2 detection threshold is approximately 100 $kgCH_4/hr$ and 1,000 $kgCH_4/hr$, respectively
- A statistical distribution of O&G plumes was defined using the distribution of O&G plumes in the **Permian basin** from similar assets obtained from Insight M and select academic papers[2]
- Calculated the % of non-observed plumes for each asset type and detection threshold



4 Calculate adjusted CH_4 volumes

- CH_4 volume is calculated using the plume rate and estimated leak duration
- The % of unobserved plumes is applied to the total CH_4 volume, not the plume rate
- Calculated the adjusted **CH_4 volumes by asset and country**, using the following formula:

$$\frac{Volume\ of\ detected\ plumes}{1 - \%\ undetected\ plumes}$$

5 Estimate intensity

- Assumed Sentinel-2 coverage includes all O&G assets in each country analyzed (total of 15 in Middle East, North Africa and Central Asia)
- GHGSat coverage includes O&G assets in Argentina, West Siberia, Oman, Indonesia, as well as global LNG facilities onstream
- Calculated **CH_4 intensity by energy content** by normalizing the methane volume with the production or throughput[3] for the corresponding assets included in the area of interest for detection
- Estimated **% of CH_4 released divided by CH_4 in the gas stream**

1. The Upstream segment includes storage infrastructure, wells, and fields; 2. Distribution of observed 2022 and 2023 Permian basin methane emissions; 3. Production used to normalize Sentinel-2 plumes corresponds to the total production of the observed country, while production used to normalize GHGSat plumes corresponds only to the production or throughput of the specific assets in the area of interest. The throughput used to normalize pipelines was estimated using the capacity of compressor stations, gas processing plants, electric plants, or industrial plants in the corresponding pipeline system

Source: S&P Global

70% of total CH_4 upstream and midstream emissions come from facilities emitting at rates >100 kg/h, hence the importance of adjusting emissions from satellite observations

Methane Intensity Results for GHGSat and Sentinel-2 Data Analysis

2 Average leak duration by plume size[1]

Plume size (kg/hr):	< 10	10 – 100	100 – 1,000	> 1,000
LNG plants	90 days	22 days	17 days	6 days
Gas plants	90 days	65 days	50 days	6 days
Upstream	90 days	71 days	54 days	6 days
Pipelines	90 days	70 days	53 days	6 days

3 % Unobserved plumes assumed

Detection threshold (kg/hr):	< 10	10 – 100	100 – 1,000	> 1,000
LNG plants	0%	N/A[2]	10%	50%
Gas plants	0%	N/A[2]	10%	50%
Upstream	0%	23%	37%	77%
Pipelines	0%	N/A[2]	37%	N/A[2]

;1. For detection threshold of < 10 kg/h and >1,000 kg/h it is assumed that all value chain segments will have similar durations as the upstream segment; 2. Not available information. Data not calculated
Source: S&P Global

Methane intensity estimates informed by Sentinel-2 plume detection (adjusted for its high sub-threshold detection using Permian basin distribution) are aligned with expectations

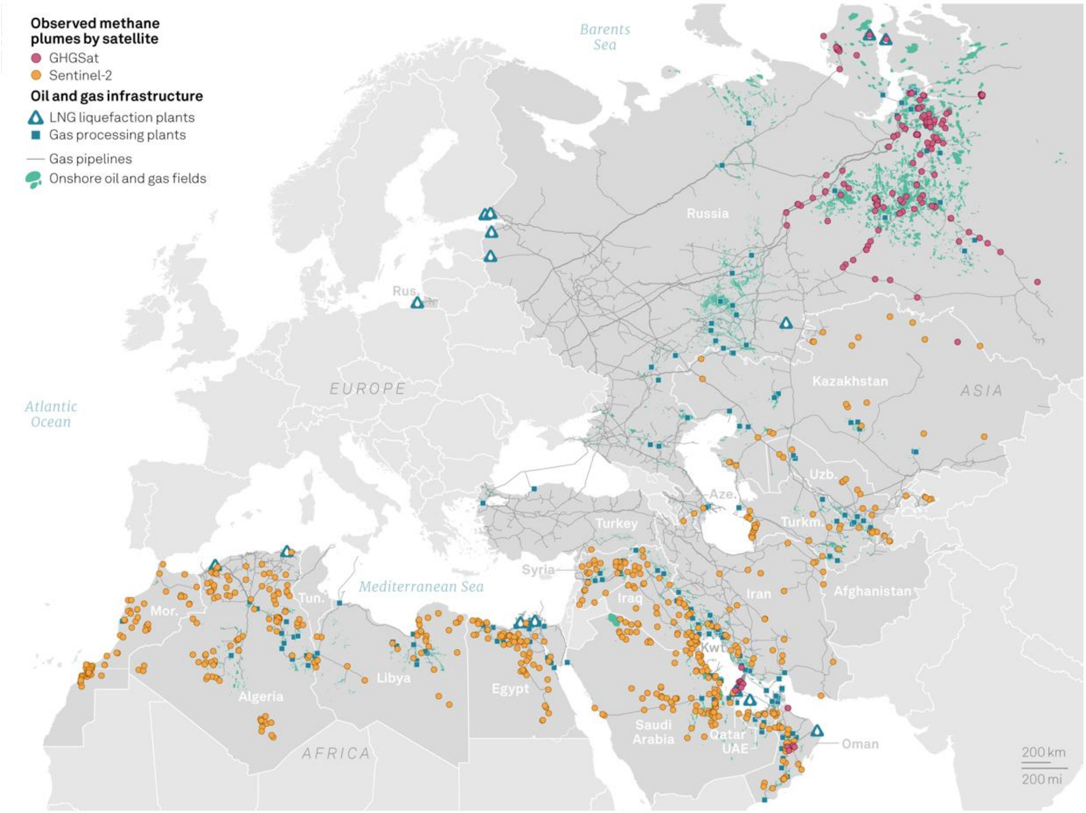
Sentinel-2 Estimated Upstream Methane Intensities for Selected Regions

Country	May-Nov 2024 O&G Production[1] Million boe	May-Nov 2024 CH_4 Plume Emissions $ktCH_4/yr$	Methane Emission Intensity $\%CH_4$ released / $\%CH_4$ in gas stream
Algeria	258	3,860	5.46%
Iran	710	1,555	2.30%
Libya	230	1,836	8.06%
Oman	351	1,307	3.95%
Qatar	153	162	1.14%
Saudi Arabia	1,919	2,823	1.50%
UAE	637	434	0.71%

1. Production adjusted based on Sentinel-2 analysis timeframe between May 2024 to November 2024
Source: S&P Global

Methane intensity of the international energy response is more uncertain given the limited availability to frequent and reliable measurement data

Select Sentinel-2 and GHGSat Observed Methane Plumes with Underlying Oil and Gas Assets from S&P Global Upstream Database



Source: Sentinel-2; GHGSat; S&P Global Commodity Insights, Upstream Content. Data compiled Feb. 27, 2025.

Region	Methane Detection Source	Estimated Coverage (Billion Pixels)
Haynesville (2022)	Insight M	14.3
Haynesville (2023)	Insight M	36.1
Permian (2023)	Insight M	318.9
Permian (2024)	Insight M	281.9
Middle East	Sentinel – 2	13.1
Other Asia	Sentinel – 2	9.3
North Africa	Sentinel – 2	7.5
Yamal Peninsula (West Siberia, Russia)	GHGSat	0.2
Vaca Muerta (Argentina)	GHGSat	0.04

Sentinel-2 data coverage for: Afghanistan, Algeria, Azerbaijan, Egypt, Iran, Iraq, Kazakhstan, Kuwait, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, Turkey, Turkmenistan, United Arab Emirates, and Uzbekistan. between June and November 2024; GHGSat data obtained for Western Siberia, Oman, Qatar, global active LNG plants and select coal mines in Indonesia and Australia for January to December 2023 (not all areas shown on the map). Pixel count based on a spatial resolution of 20 m for Sentinel-2's B12 band that is sensitive to methane; 25 m for GHGSat, and approximately 1 m for InsightM's Leak Surveyor instrument

Source: S&P Global with publicly available methane plumes data obtained from the European Space Agency's Sentinel-2 satellites and methane plume data acquired from GHGSat. O&G infrastructure data from S&P Global's international E&P database.

Failure to follow standard LCA approach of allocating emissions between co-products based on energy content leads to a significant overestimation of gas GHG intensity

Academic Studies Surveyed and their Main Parameters

Study	Author(s)	Date Published	Geography Covered	GHG Emissions Allocation Approach
The greenhouse gas footprint of liquefied natural gas (LNG) exported from the United States	Howarth, Robert W.	October 2024	US exports using a world-average voyage time (38-day roundtrip)	Emissions fully allocated to the gas production stream
Reducing GHG Emissions from the U.S. Natural Gas Supply Chain	National Petroleum Council (NPC)	April 2024	US exports to Europe and Asia	Allocation on energy basis between the key co-products
LNG Supply Chains: A Supplier-Specific Life-Cycle Assessment for Improved Emission Accounting	Roman-White et al.	August 2021	US exports to China and Europe	Allocation on energy basis between the key co-products and fully to gas separately
Geospatial Life Cycle Analysis of Greenhouse Gas Emissions from US Liquefied Natural Gas Supply Chains	Zhu et. al	2024	US exports to China and Europe	Allocation on energy basis between the key co-products
Comparing greenhouse gas impacts from domestic coal and imported natural gas electricity generation in China	Rosselot at. al	2021	US exports to China	Allocation on energy basis between the key co-products and fully to gas separately
Life Cycle Greenhouse Gas Emissions From U.S. Liquefied Natural Gas Exports: Implications for End Uses	Abrahams et. al	2015	US and Russia exports to Europe	Not explicit

Source: Published studies

Our estimate of coal GHG intensity reflects the type of mine and coal produced in the largest suppliers to the destination markets impacted under the LNG Halt scenario

Main Drivers of Coal GHG Emissions Intensity

Type of mine	Underground	Methane IPCC factor	25 m³/ton ~0.75 g/MJ
	Surface		0.3 m³/ton ~0.009 g/MJ
Type of coal	Bituminous	Heat content (MJ/kg)	27.8
	Sub-bituminous		19.9
	Lignite		14.9
Shipping distance	Asia → Asia	Emission factor (gCO_2e/MJ)	1.03
	Asia → Europe		3.18
	America → Europe		1.54

Legend:

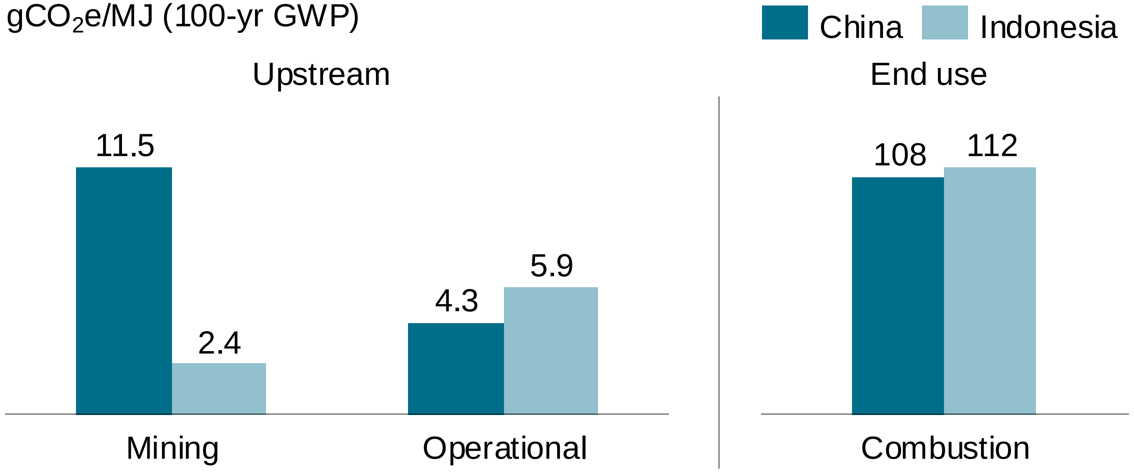
Low impact on emissions … High impact on emissions

Case Comparison: China vs. Indonesia

	Typical type of mine	Typical types of coal	Moisture percentage
China	Underground (high depth)	Lignite and bituminous	10%
Indonesia	Surface	Sub-bituminous and bituminous	20% and 10%

GHG emissions intensities

gCO_2e/MJ (100-yr GWP)

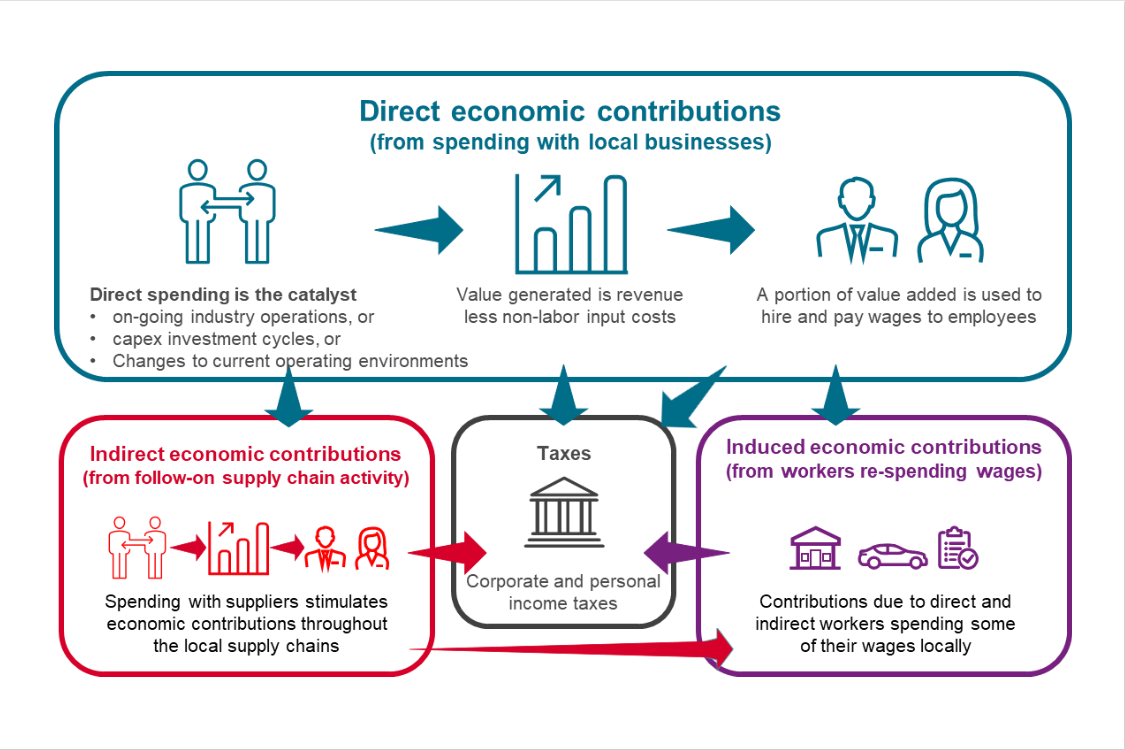


Note: Coal source countries and mine types were selected based on current trade flows to the selected destination markets impacted by the LNG Halt in Phase 1.
Source: S&P Global internal modelling assumptions and IPCC emissions factors

Contents

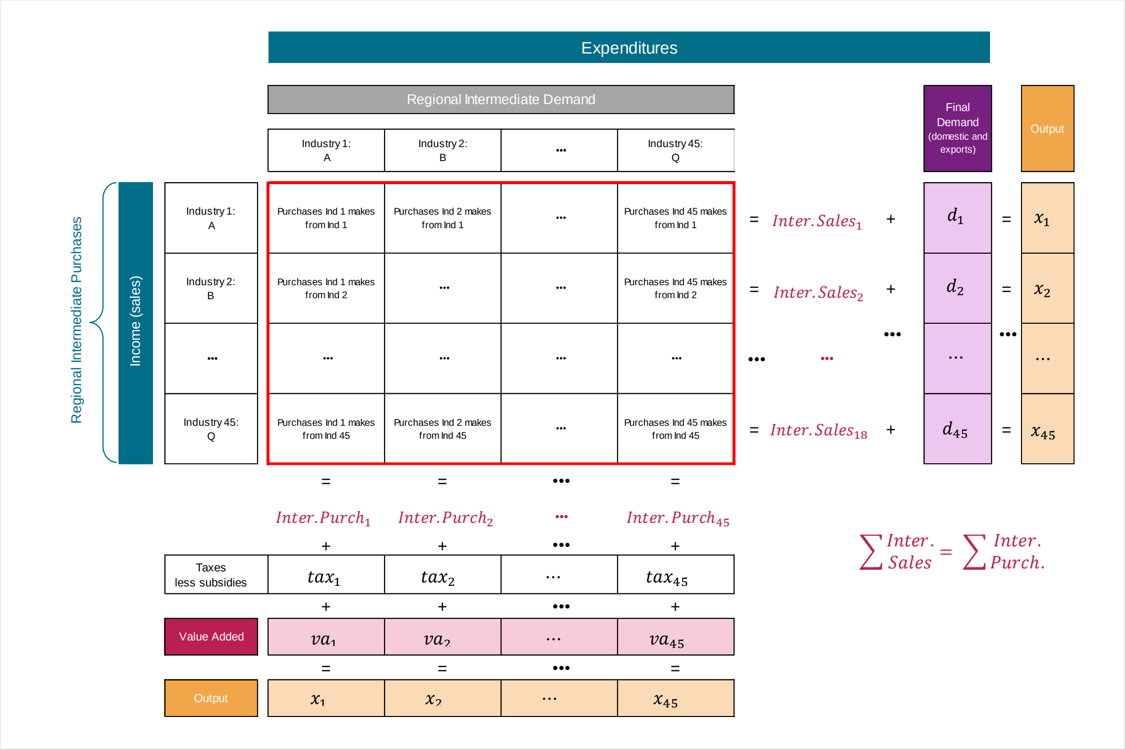
Economic impact methodology: overview

- Economic impact estimates – including the direct, indirect, and induced effects of US LNG activity – were generated for the US and 50 states and Washington DC.
- Direct spending, initiated when firms engage local suppliers with operational and capital expenditures, initiates the economic impact sequence.
- Direct suppliers engage with their suppliers, which begins the indirect contribution cycle.
- Direct and indirect output contributions support corresponding levels of GDP, employment (jobs), wages and taxes.
- Induced economic activity is initiated by the employees in the extended supply chain spending in their local communities.
- The method of estimating this activity is based on inter-industry relationships captured by national and state input-output tables.



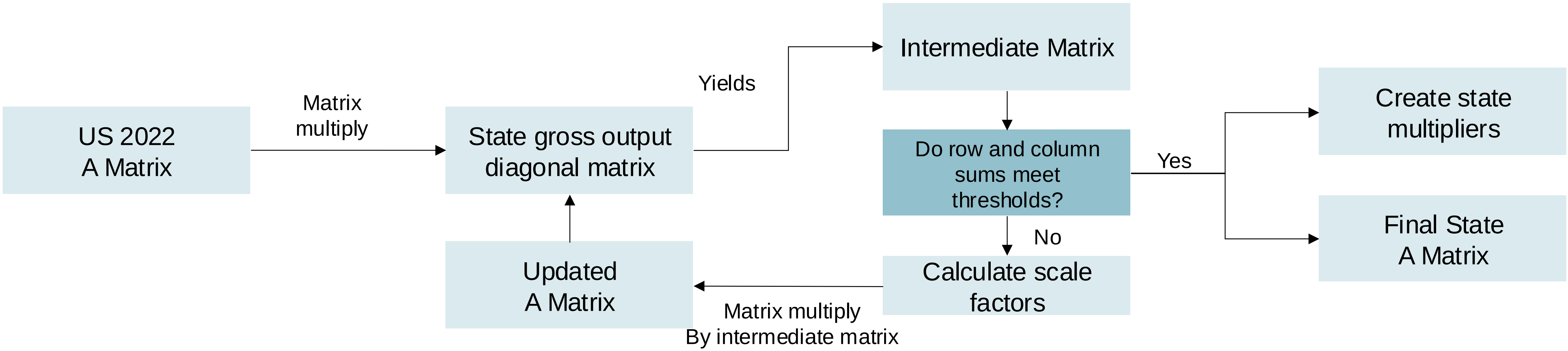
Building the national economic impact model

- IO tables link the buying and selling relationships between producers and consumers within an economy. They underlie all economic impact analyses.
- In essence, IO tables are matrices of inter-industry flows of goods and services produced domestically and imported. Economic transactions occur at the intersection of a column (purchasing activity) and a row (sales activity). All values within the red border of the diagram represent exchanges between industries
- The industry relationships expressed in the IO table are the basis for the multipliers used in calculating the indirect activity initiated by US LNG value chain spending.
- S&P Global Market Intelligence uses its own proprietary data and public data from the Bureau of Economic Analysis and Bureau of Labor Statistics to assemble the state and US models.
- Using the inputs assembled from domestic spending data, the models can estimate the indirect and induced output attributable LNG activity.



Building the state economic impact models

- S&P Global Market Intelligence used a standard matrix balancing process known as the RAS method to transform the BEA's national US models into companion sets of state models.
- The RAS method iteratively scales and rebalances first the rows and then the columns of the Direct Requirements Matrix (a version of the IO table called the A matrix below) until the coefficients converge to a create matrix that produces a balanced response to a targeted level of **regional** output.
- This means that for a targeted level of state output, the sum of direct state intermediate purchases equals the sum of direct state intermediate demand. Once the new, state IO table is balanced and reflects its industry composition, state-specific multipliers are created.



Building the state economic impact models (cont.)

- S&P Global supplemented its state IO tables with a multi-regional input output model (MRIO).
- The MRIO model approach allows estimation of indirect and induced economic effects in states without direct spending by capturing inter-state economic linkages and spillover effects, thus providing a more complete understanding of regional economic dynamics.
- The basis of the MRIO is a gravity model to estimate trade flows. It considers the distance between states and the GDP of the industries involved as independent variables.
- Industry and state-specific interstate trade flow totals are first determined by comparing the total intra-state spending (estimated in the state RAS process) with the proportion of goods imported from outside the US. The state/industry's gross output less intrastate spending and imports equals the total interstate spending. Essentially, all goods/services that are **not** sourced from within the state but **are** sourced from within the country are assumed to be interstate trade flows.

- The formula is displayed below.
- That interstate trade total is distributed among states/industries based on the gravity model coefficients.
- Gs,i = Gross output of state s for industry i
- Is,i = Total intra-state spending in state s for industry i (estimated in the state RAS process)
- Ms,i = Total imports of goods from outside the US for state s and industry i
- Ts,i = Total interstate spending for state s and industry i

The relationship can be expressed as:

$$Ts,i = Gs,i - Is,i - Ms,i$$

US Economic impacts of LNG activity, 2025–2040

Base Case (cumulative real 2024$ or jobs)			
	Total jobs supported (annual avg.)	Gross Domestic Product ($M)	GDP per capita
Total	495,373	1,299,029	3,764
Direct	128,356	470,818	1,364
Indirect	147,401	439,422	1,273
Induced	219,616	388,788	1,126
Halt Case (cumulative real 2024$ or jobs)			
	Total jobs supported (annual avg.)	**Gross Domestic Product ($M)**	**GDP per capita**
Total	101,513	251,447	729
Direct	29,372	89,544	259
Indirect	29,013	85,354	247
Induced	43,128	76,549	222

Data compiled Feb. 10, 2025.
Source: S&P Global Market Intelligence ©2025 S&P Global.

Economic impacts by state in base case, 2025–2040

(cumulative real 2024$ or average annual jobs)

State	Total Jobs Supported	Gross State Product ($M)	GSP per capita
Texas	182,830	599,732	18,282
Oklahoma	33,833	72,146	17,893
Louisiana	29,791	80,563	18,213
New Mexico	24,190	48,483	24,213
California	20,495	49,569	1,236
Pennsylvania	19,422	58,300	4,528
Ohio	16,814	41,526	3,542
Arkansas	14,997	30,163	10,094
Illinois	11,231	26,266	2,168
Florida	10,779	21,028	809
Indiana	7,657	16,593	2,422
New York	7,506	24,801	1,288
Michigan	7,130	13,994	1,425
Minnesota	6,689	11,978	2,017
Tennessee	6,622	10,119	1,360
West Virginia	5,933	14,848	9,046
Georgia	5,795	13,785	1,153
North Carolina	5,292	12,436	1,078
Kansas	5,178	6,203	2,275
Virginia	5,163	8,730	984
Maryland	5,156	8,859	1,378
Wisconsin	4,664	9,468	1,620
Washington	4,646	10,651	1,296
New Jersey	4,351	9,285	978
Colorado	4,235	10,390	1,624

State	Total Jobs Supported	Gross State Product ($M)	GSP per capita
South Carolina	4,066	5,594	1,005
Utah	3,903	6,229	1,687
Missouri	3,767	8,642	1,384
Arizona	3,593	7,316	862
Kentucky	3,509	6,299	1,382
Massachusetts	3,130	9,594	1,326
Alabama	3,075	6,035	1,198
Oregon	2,785	5,208	1,171
Mississippi	2,736	3,746	1,340
Iowa	2,277	4,510	1,451
Nevada	1,819	3,964	1,215
Connecticut	1,507	4,254	1,194
Idaho	1,349	1,918	1,001
Nebraska	1,243	2,695	1,371
New Hampshire	752	1,567	1,122
South Dakota	672	934	1,063
Maine	644	1,151	842
Montana	640	1,161	1,028
North Dakota	535	1,423	2,003
Washington, DC	532	1,649	2,300
Wyoming	503	1,138	1,999
Delaware	467	1,193	1,065
Alaska	438	648	927
Rhode Island	413	1,103	990
Vermont	336	622	994
Hawaii	285	514	356

Data compiled Feb. 10, 2025.
Source: S&P Global Market Intelligence ©2025 S&P Global.

Economic impacts by Congressional District in base case, 2025–2040

(cumulative real 2024$ or average annual jobs)

District	Total Jobs Supported	Gross District Product ($M)	GSP per capita
TX-23	15,274	64,339	93,871
TX-34	10,041	39,892	55,569
TX-01	8,495	33,541	44,047
TX-11	7,334	32,208	43,129
TX-37	6,767	16,744	18,202
TX-24	6,518	17,174	20,061
TX-32	6,323	17,327	21,061
TX-19	5,998	22,005	30,738
TX-18	5,822	19,448	22,204
TX-14	5,708	21,322	24,579
TX-28	5,681	21,851	28,363
TX-27	5,509	20,705	25,905
TX-33	5,371	15,773	18,255
TX-38	5,011	15,733	18,067
TX-07	4,994	14,095	13,906
TX-30	4,865	12,691	15,886
TX-04	4,805	12,678	15,255
TX-13	4,628	15,687	22,347
TX-12	4,519	13,345	12,986
TX-06	4,114	12,715	15,169
TX-35	4,017	10,955	11,063
TX-15	3,963	13,416	16,112
TX-36	3,904	13,336	16,536
TX-17	3,890	13,099	16,702
TX-20	3,869	8,802	9,290
TX-26	3,407	10,588	11,015

District	Total jobs supported	Gross District Product ($M)	GSP per capita
TX-21	3,345	8,452	9,103
TX-10	3,335	10,179	11,839
TX-25	3,334	10,742	13,274
TX-09	3,169	7,315	7,700
TX-02	2,792	9,171	9,003
TX-29	2,703	8,855	10,039
OK-03	8,968	21,770	28,903
OK-01	7,709	14,548	16,304
OK-05	6,553	13,188	15,928
OK-04	5,907	12,910	16,476
OK-02	4,696	9,731	12,553
LA-04	11,048	33,221	45,403
LA-01	5,362	14,391	18,576
LA-03	4,383	12,047	16,993
LA-06	3,363	7,688	9,944
LA-02	3,224	7,493	10,440
NM-02	10,088	21,732	32,111
NM-03	7,743	15,948	23,909
NM-01	6,359	10,803	16,405
PA-09	2,774	10,808	14,643
PA-14	2,688	10,958	15,215
AR-03	4,811	9,500	10,866
AR-04	4,066	8,396	12,421
AR-02	3,657	7,768	10,229
WV-02	3,983	10,684	12,465
WV-01	1,950	4,164	5,309

Data compiled Feb. 10, 2025.
Source: S&P Global Market Intelligence ©2025 S&P Global.

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