# Study of Infrastructure Needed to Expand US LNG Exports to European and Asian Allies

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# Executive Summary of 2023 ICF Infrastructure Study to API

# Overview of ICF Infrastructure Study for API

- The American Petroleum Institute (API) engaged with ICF Resources, LLC to study the infrastructure needed for U.S. LNG Exports to help European and Asian allies further reduce dependence on Russian LNG. This includes:
  - "European Pledge Cases":
    - How much natural gas pipeline infrastructure would be built to meet a "business-as-usual" level of U.S. LNG exports (as anticipated in EIA's 2022 AEO Reference Case)
    - Additional infrastructure might have to be added to accommodate the Task Force** target of about 4.8 Bcf/day more LNG exports to Europe.
  - "Extended Cases":
    - Expand the "European Pledge" case, to analyze LNG demand needed for Asian allies who also are importing LNG from Russia.
    - Additional LNG demand of 12.9 Bcf/day, over and above the U.S. LNG exports in the Reference Case.
  - The "European Pledge Cases" and the "Extended Cases" are together referenced as "Alternate LNG Scenarios" and for each, ICF studied the impacts of pipeline infrastructure buildout.
  - The analysis was conducted by running ICF's Gas Market Model ("GMM") to generate an "AEO Reference Case", the "European Pledge Cases", and the "Extended Cases" with higher exports to Asian allies.
  - Scenario descriptions, modelling details and additional model results are presented in the Appendix to this report.

**https://www.whitehouse.gov/briefing-room/statements-releases/2022/03/25/fact-sheet-united-states-and-european-commission-announce-task-force-to-reduce-europes-dependence-on-russian-fossil-fuels/

# Key Conclusions for "European Pledge Cases" for the Pipeline Buildout Scenario

- LNG exports, for Europe, increase by 4.8 Bcf/day compared to the Reference Case
  - Projected total LNG exports increase to 20.9 Bcf/day by 2030 (+33% vs. Reference Case).
- Pipeline buildout includes all the necessary inter-state and inter-regional pipeline infrastructure that are economically justified to meet the added amounts of LNG exports.
  - Total pipeline capacity buildout towards the Gulf Coast: 3.9 Bcf/day.
- Additional Infrastructure plays a vital role towards price response in Scenario for Pipeline Buildout:
  - 2030 to 2035 period average Henry Hub price with build-out could be $4.24, which is lower than without build-out average price of $4.38.
  - NPV economic benefit of scenario with pipeline buildout is estimated to be USD 30+ billion (nominal) in savings from 2022 to 2045 for gas purchasers.
- North American production responds to support higher export demand
  - Domestic production supplies approximately 90% of incremental exports with pipeline buildout.
  - Remaining gas supply is available through domestic demand reduction, increase in Canadian production and decline in pipeline exports to Mexico.
- Economic Impacts of "European Pledge Cases" with Scenario for Pipeline Buildout
  - Total capital expenditure: USD 63.1 billion (includes capex for LNG export facilities, pipeline projects throughout the supply chain).
  - GDP contribution (direct and indirect): USD 29 billion during 2025-2030
  - Total GDP contribution (including induced economic activity): USD 46 billion during 2025-2030
  - Total employment impact (including induced): 429,000 additional job-years supported during 2025-2030 (this is an average of 71,500 jobs in each year)

**Jobs have been calculated based on number of job-years which are applicable cumulatively due to the period of infrastructure development (2025-2030). Please note that each job corresponds to employment duration of 12-months.*

**https://www.whitehouse.gov/briefing-room/statements-releases/2022/03/25/fact-sheet-united-states-and-european-commission-announce-task-force-to-reduce-europes-dependence-on-russian-fossil-fuels/

# Key Conclusions for "Extended Cases" for Scenarios with and without Pipeline Buildout

- LNG exports, including Asian allies, increase by 12.94 Bcf/day compared to the Reference Case.
  - Projected total LNG exports increase to 29 Bcf/day by 2030 (+90% vs. Reference Case).
- Pipeline buildout scenarios includes various additional pipeline infrastructure that are economically justified to meet the added amounts of LNG exports (see Appendix for details). Total capacity buildout towards the Gulf Coast:
  - 3.0 Bcf/day (with minimal pipeline buildout)
  - 8.9 Bcf/day (with constrained pipeline buildout)
  - 11.4 Bcf/day (with unconstrained pipeline buildout)
- North American production responds to support higher export demand
  - Based on the level of infrastructure development, domestic production supplies approximately 85% to 90% of incremental exports in the "Extended Cases".
  - ICF concludes that as more inter-regional pipelines are built towards the Gulf Coast, gas produced at supply basins become more accessible for incremental exports.
  - As a result, the proportion of domestic gas production increases and the proportion of gas made available through domestic demand reduction decreases.

# Summary of findings in "European Pledge Cases" and "Extended Cases" for Scenarios with and without Pipeline Buildout

| Trade Scenario | Added US LNG Exports (bcfd) | Pipeline Constraints | Inter-regional Pipeline Built (bcfd capacity) | Capital Expenditures on Inter-regional Pipelines (in billion)* | All Capital Expenditures (on liquefaction plants, gathering lines, processing plants, and pipelines) (in billion)* | Relative Henry Hub Prices in 5-year period with Maximum Economic Impact ($/MMBtu)+ | Cumulative Savings for Gas Purchasers w.r.t. no or minimal pipeline buildout scenario between 2022 and 2045 (in billion)* |
|---|---|---|---|---|---|---|---|
| European Pledge Cases | 4.8 | Without pipeline buildout | - | - | USD 58.0 | - | - |
| | | With pipeline buildout | 3.9 | USD 6.3 | USD 63.1 | - $0.14/MMBtu (2030-2035 Average) | USD +30.0 |
| Extended Cases | 12.9 | With minimal pipeline buildout | 3.0 | USD 3.3 | USD 169.0 | - | - |
| | | With constrained pipeline buildout (Inter-regional pipelines not allowed from Marcellus/Utica) | 8.9 | USD 13.6 | USD 180.5 | - $0.28/MMBtu (2027-2032 Average) | USD +80.0 |
| | | With unconstrained pipeline buildout | 11.4 | USD 24.8 | USD 193.4 | - $0.64/MMBtu (2027-2032 Average) | USD +180.0 |

**All Capital Expenditure estimates are in nominal dollars*

*+All Price estimates are in real 2021 dollars*

# Scenario Descriptions & Modelling Details

# Scope of Infrastructure Study for API

- The American Petroleum Institute (API) asked ICF Resources, LLC to perform a study to estimate how much natural gas pipeline infrastructure would be economically justified to meet a "business-as-usual" level of US LNG exports (as anticipated in EIA's 2022 AEO Reference Case) and then what additional infrastructure might have to be added to accommodate the Task Force target of about 4.8 Bcf/day more LNG exports to Europe.
- This analysis was conducted by running ICF's Gas Market Model ("GMM") to generate an "AEO Reference Case" and the "European Pledge Cases" with higher exports to Europe.
- Third iteration incorporates "Extended Cases" with higher exports to Asian allies who also are importing LNG from Russia.
  - ICF has performed a sensitivity analysis between "Extended Cases" to showcase the economic value of additional pipeline capacity out of Marcellus/Utica region towards the Gulf Coast.
- In this presentation, ICF provides the results for the "AEO Reference Case", "European Pledge Cases" and the "Extended Cases".
  - The presentation describes the assumptions used to generate the two "European Pledge cases" and three "Extended Cases" (together referenced as "Alternative LNG Scenarios" in subsequent slides) and summarize the key findings.
  - The focus of the slides is on describing the location and cost of the new gas pipeline infrastructure built in the "Alternate LNG Scenarios" and the LNG export facility expansions that are needed to accommodate the incremental LNG exports for the same.

*Note: "European Pledge Cases" and the "Extended Cases" are together referenced as "Alternate LNG Scenarios"*

# Methodology

- ICF has prepared the "business-as-usual" case by modifying input parameters to the GMM to bring them more in line with the Energy Information Administration's Annual Energy Outlook (AEO) 2022 assumptions and results for items such as world oil prices, domestic natural gas consumption by sector (residential, commercial, industrial and power), and LNG export volumes.
- The "AEO Reference Case" provides the basic information on natural gas production and consumption volumes by node and flows along pipeline corridors.
- The model results also provide information on what natural gas pipeline expansion could be needed to meet domestic needs and support "AEO Reference Case" LNG and pipeline exports.
- All assumptions applied in the GMM to produce the "AEO Reference Case" were kept for the "Alternate LNG Scenarios" except that the US LNG exports would be reset to depict extra demand for US LNG from Europe and Asia.
- In the two "European pledge cases," the extra LNG demand equals the Task Force** Pledge amount to Europe, that is, an extra 4.8 Bcf/day, over and above the US LNG exports that have been calibrated as part of "AEO Reference Case".
- In the three "Extended Cases", the extra LNG demand equals the Task Force** Pledge amount to Europe and ICF's interpretation of what amount of LNG exports need to be sent to Asian allies who also are importing LNG from Russia. That is, an extra LNG demand of 12.9 Bcf/day, over and above the US LNG exports that have been calibrated as part of "AEO Reference Case".
- As with the "AEO Reference Case", ICF ran GMM to estimate natural gas production and consumption volumes by node and flows along pipeline corridors.
- The GMM run result provide information on what natural gas pipeline expansion could be needed (beyond the "AEO Reference Case") to meet the added amounts of LNG exports.

*Note: "European Pledge Cases" and the "Extended Cases" are together referenced as "Alternate LNG Scenarios"*

**https://www.whitehouse.gov/briefing-room/statements-releases/2022/03/25/fact-sheet-united-states-and-european-commission-announce-task-force-to-reduce-europes-dependence-on-russian-fossil-fuels/

# Brief description of "Alternate LNG Scenarios" included in Infrastructure Study for API

- European Pledge Cases
  - "European Pledge Case" (without pipeline buildout) avoids building inter-state and inter-regional pipelines from major supply hubs across U.S. towards the Gulf Coast. Only the pipeline laterals are built that interconnect existing natural gas pipelines to respective LNG Facilities.
  - "European Pledge Case" (with pipeline buildout) includes all the necessary inter-state and inter-regional pipeline infrastructure that is economically justified to meet the added amounts of LNG exports.
- Extended Cases
  - "Extended Case" (with minimal pipeline buildout) avoids building long distance inter-state and inter-regional pipelines from major supply hubs across U.S. towards the Gulf Coast. This case assumes 3 Bcf/day of pipeline infrastructure will be built from supply hubs immediately around the Gulf Coast. Pipeline laterals are built that interconnect existing natural gas pipelines to respective LNG Facilities.
  - "Extended Case" (with constrained pipeline buildout) includes all the necessary inter-state and inter-regional pipeline infrastructure that is economically justified to meet the added amounts of LNG exports but avoids building pipeline infrastructure from Marcellus-Utica towards the Gulf Coast.
  - "Extended Case" (with unconstrained pipeline buildout) includes all the necessary inter-state and inter-regional pipeline infrastructure that is economically justified to meet the added amounts of LNG exports including pipeline builds from Marcellus-Utica towards the Gulf Coast.

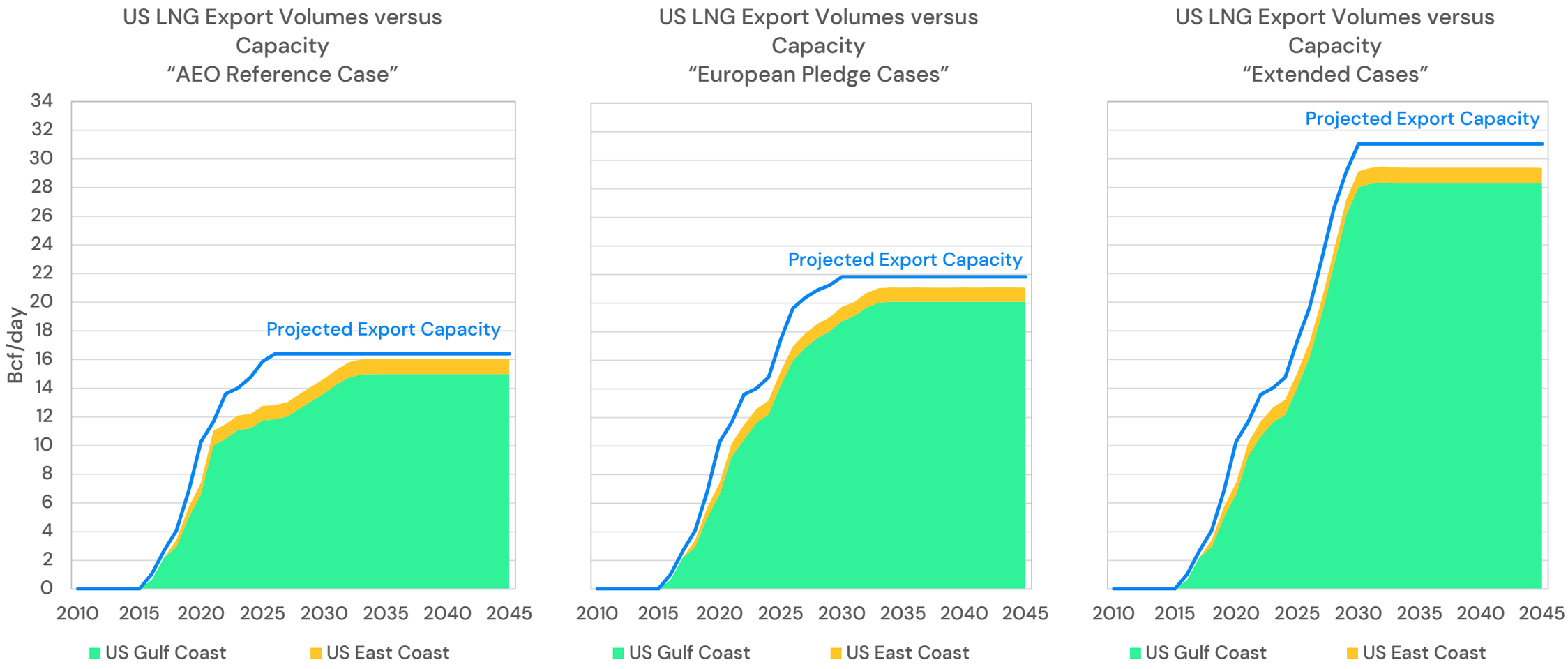
*Note: "European Pledge Cases" and the "Extended Cases" are together referenced as "Alternate LNG Scenarios"*

# Incremental LNG Export Targets in “Alternate LNG Scenarios” beyond “AEO Reference Case” by 2030

| | Incremental LNG Export Targets in “Alternate LNG Scenarios” as compared to the “AEO Reference Case” by 2030 | | | | | |
|---|---|---|---|---|---|---|
| | “AEO Reference Case” | | “European Pledge Cases” | | “Extended Cases” | |
| | Bcf/day | BCM/Year | Bcf/day | BCM/Year | Bcf/day | BCM/Year |
| Incremental LNG Export Volume | 16.06 | 167.3 | +4.80 | +50.0 | +12.94 | +134.75 |
| Incremental Feed gas required for Liquefaction at new export facilities | 1.34 | 14.0 | +0.48 | +5.0 | +1.29 | +13.48 |
| Total Increase in LNG Export Demand | 17.41 | 181.3 | +5.28 | +55.0 | +14.23 | +148.23 |

*Note: “European Pledge Cases” and the “Extended Cases” are together referenced as “Alternate LNG Scenarios”*

# LNG Export Volumes vs. Export Capacity by Case




** LNG Export Volumes do not include the 10% liquefaction fuel loss at the terminal*

*Source: ICF estimates*

# Key Infrastructure Conclusions for “European Pledge Cases”

# Additional Infrastructure added in “European Pledge Cases” beyond “AEO Reference Case”

- ICF assumes that three North American LNG export terminals will be built and/or expanded (over and above the planned LNG facilities in “AEO Reference Case”) to meet the incremental LNG export targets in “European Pledge Cases”.
- These are actual planned liquefaction projects - not hypothetical projects. They are infrastructure projects that are on various stages of application process with Department of Energy (DOE).
  - ICF has included these LNG projects in the projection based on company media reports, investor presentation and news articles.
  - It is possible that another mix of facilities could be built to meet the incremental demand for LNG assumed for this case.
- These three LNG export terminals together add an incremental LNG export capacity of +5.5 Bcf/day in the “European Pledge Cases” by 2030 .
  - Projected LNG export capacity increases to 21.9 Bcf/day by 2030. (+33% vs. AEO Reference Case).
- All the planned LNG Export Facilities are geographically located in the Gulf coast (Texas/Louisiana).

# Summary of LNG Export Facilities in "European Pledge Cases" beyond "AEO Reference Case"

| LNG Export Case | LNG Export Facility Name | Number of Trains+ | Capacity (Bcf/day) | Project Commissioning Date | LNG Export Facility Location | Department of Energy (DOE) Application Status | Liquefaction Plant Capital Expenditure billion USD (nominal) |
|---|---|---|---|---|---|---|---|
| AEO Reference Case | Golden Pass TX | Train 1-3 | 2.5 | Jan 2024 - Jul 2025 | TX | Approved | 10.0 |
| | | | | | | | |
| European Pledge Cases | Plaquemines LNG | Train 1 | 1.79 | Nov-2024 | LA | Approved | 6.4 |
| European Pledge Cases | Corpus Christi "Stage 3" | Train 4 | 1.50 | Nov-2025 | TX | Approved | 9.0 |
| European Pledge Cases | Driftwood LNG | Train 1-3 | 2.2 | Sept 2026 - Sept 2029 | LA | *Approved | 18.0 |
| Total Capacity for planned LNG Export Facilities in "European Pledge Cases" (over and above the "AEO Reference Case") | | | 5.5 Bcf/day | Total Capital Expenditure for planned LNG Export Facilities in "European Pledge Cases" (over and above the "AEO Reference Case") in billion USD (nominal) | | | USD 33.4 billion |

** Driftwood LNG Export facility train 1&2 have received Final Investment Decision (FID) and have begun construction. Train 3 is has not received FID from Tellurian.*

*+ LNG "Train" refers to a series of gas treatment facilities, gas compressors, refrigeration units and various other components that process, purify and convert natural gas to liquified natural gas (LNG). LNG "Train" is also known as a liquefaction unit. They are called "Train" because of the sequential arrangement of the equipment used to process and liquefy natural gas.*

**All Capital Expenditure estimates are in nominal dollars*

# Key Infrastructure Conclusions for “European Pledge Case” (without pipeline buildout)

# Summary of gas pipelines transporting feed-gas in "European Pledge Case" (without pipeline buildout) beyond "AEO Reference Case"

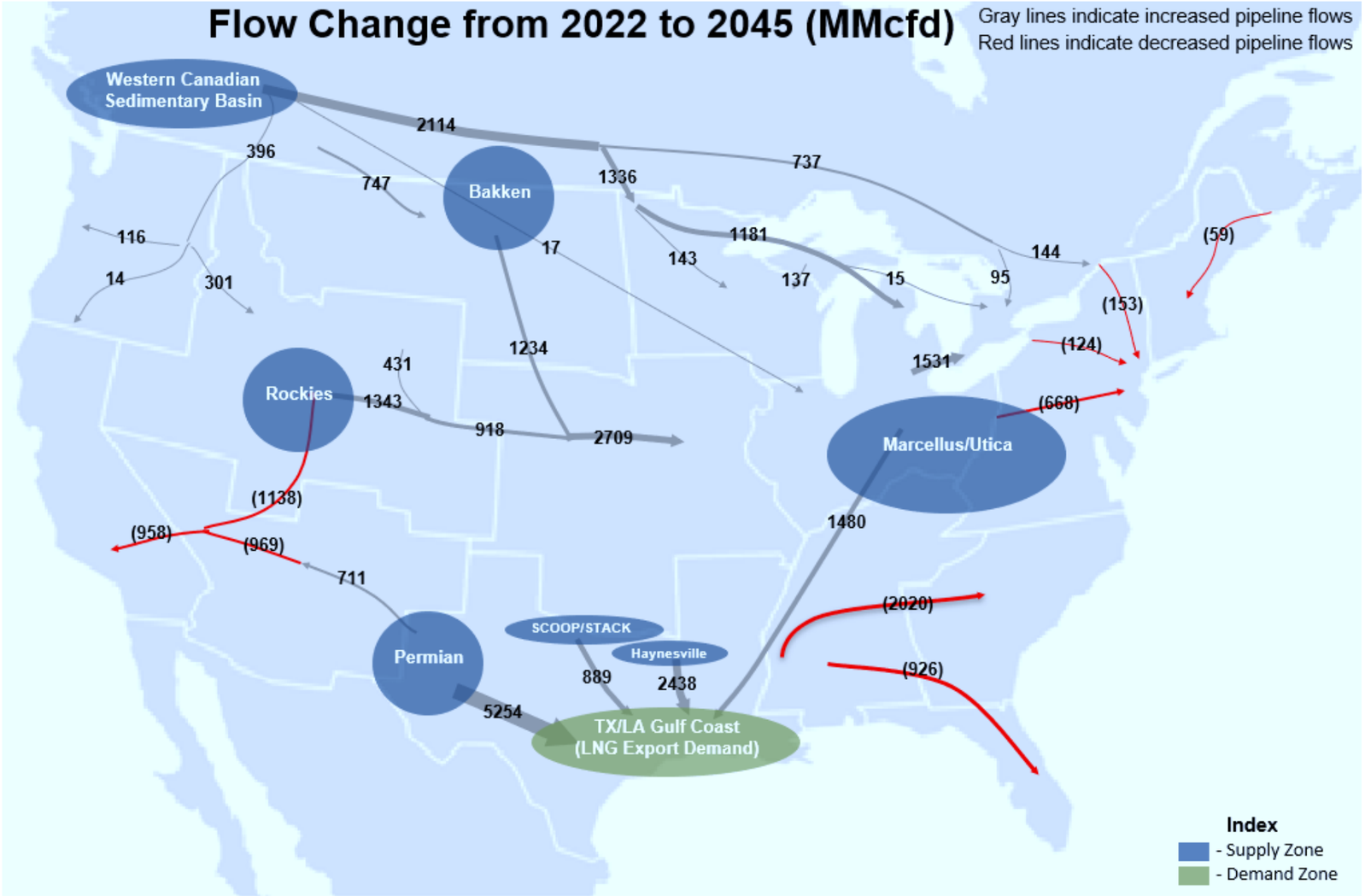
| LNG Export Case | Pipeline Project Name | Gas Supply Destination | In-Service Date | Capacity (MMcfd) | Pipeline Capital Expenditure Million USD (nominal) | Line miles | Pipeline Project Status | Inter/Intrastate | Regulatory Body |
|---|---|---|---|---|---|---|---|---|---|
| AEO Reference Case | Corpus Christi Stage 3 Pipeline Project | Corpus Christi Stage 3, TX | Oct-21 | 1,500 | 193.7 | 22 | In-Service | Intrastate | FERC |
| AEO Reference Case | Golden Pass Pipeline (Reversal) | Golden Pass, TX | Nov-23 | 2,500 | 386 | 69 | FERC-Application | Interstate | FERC |
| | | | | | | | | | |
| European Pledge Case | Gator Express Pipeline | Plaquemines LNG, LA | Jun-23 | 1,970 | 281.9 | 26.8 | Announced | Intrastate | FERC |
| European Pledge Case | Alberta Xpress Project | Sabine Pass, TX | Sep-23 | 165 | 300 | NA | Under Construction | Interstate | FERC |
| European Pledge Case | Driftwood Pipeline Project | Driftwood LNG, LA | May-25 | 4,000 | 1,447.3 | 99.4 | Under construction | Intrastate | FERC |
| Incremental Pipeline Capacity in "European Pledge Case" (over and above the "AEO Reference Case") | | | | 6,135 MMcfd | | | | | |
| Total Capital Expenditure for planned Intra-State and Inter-State Pipelines in "European Pledge Case" (over and above the "AEO Reference Case") in Million USD (nominal) | | | | | USD 2,029.2 Million | | | | |
| Total Line Miles for Pipelines in "European Pledge Case" (over and above the "AEO Reference Case") | | | | | | 126.2 miles | | | |

**All Capital Expenditure estimates are in nominal dollars*
*⁺LPSC: Louisiana Public Service Commission*
*TX RRC: Texas Railroad Commission*

*Source: ICF estimates*

# Long term changes in pipeline corridor flows in “European Pledge Case” (without pipeline buildout)

- “European Pledge Case” (without pipeline buildout) avoids building inter-state and inter-regional pipelines from major supply hubs across U.S. towards the Gulf Coast.
- Marcellus gas production growth could be expected to reverse northward flows thus pushing gas more toward the west and south.
- Longer term Permian, Haynesville and SCOOP/STACK production could primarily be directed to the Gulf Coast.
- Eastward flows out of Western Canada could rise as incremental gas supplies might be required to support demand in Northeast.



# LNG exports result in employment and GDP gains in “European Pledge Case” (without pipeline buildout) beyond “AEO Reference Case”

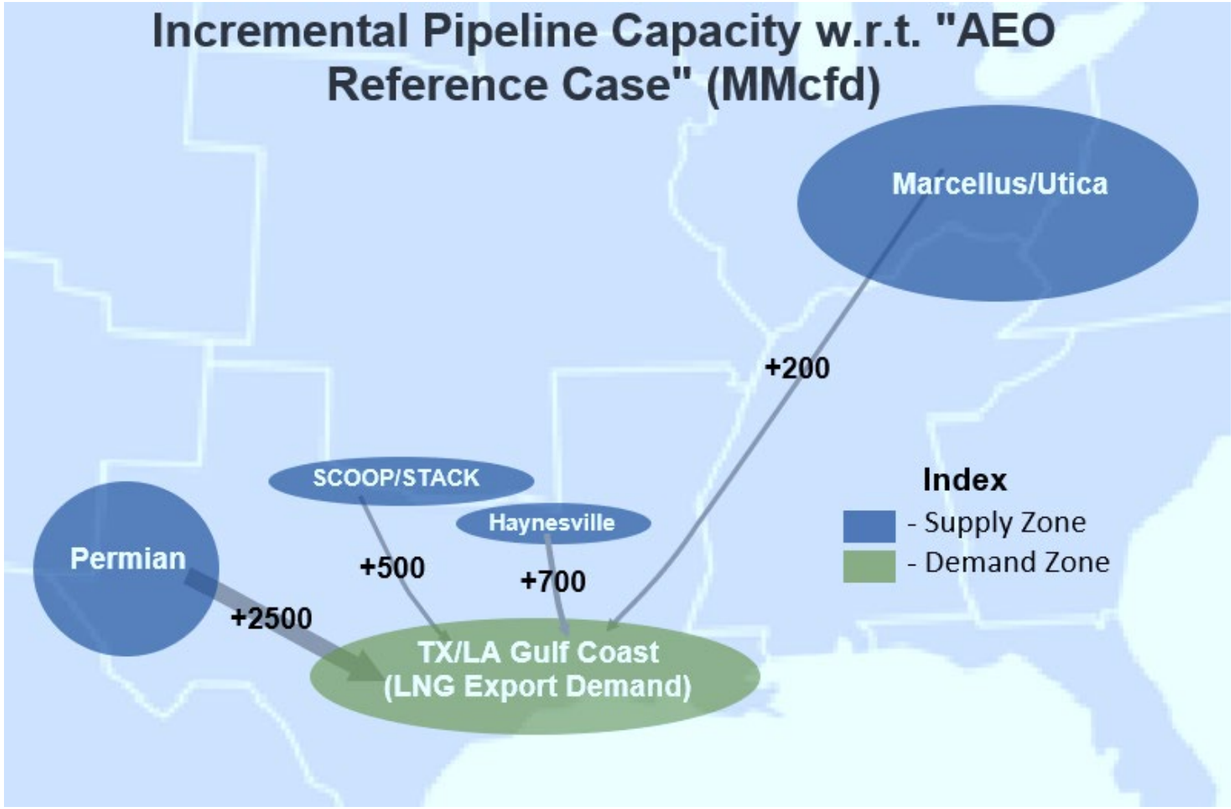
- The USD 58 billion in capital expenditure for liquefaction plants and pipelines estimated for the “European Pledge Case” (without pipeline buildout) could contribute to US GDP and support jobs in the equipment, materials, construction and other US industries.
- These economic impacts could depend on the design of these facilities and portions of equipment, materials and engineering services that are procured from domestic sources.
- ICF estimates that the direct and indirect GDP contribution from this capital expenditures could be approximately USD 47.7 billion during 2022-2045. Adding in the induced economic activity brings the total GDP impact to USD 75.8 billion during 2022-2045.
- The direct and indirect employment impact associated with this expenditure for liquefaction plants and pipelines could be 422,000 jobs* during 2022-2045. Adding in induced jobs brings that total employment impact to 709,000 jobs* during 2022-2045.
- These values do not include the GDP and job impacts from the operation of facilities or the jobs in the natural gas production sector and its related support industries.

**Jobs have been calculated based on number of job-years which are applicable cumulatively due to the period of infrastructure development (2025-2030). Please note that each job corresponds to employment duration of 12-months.*

# Key Infrastructure Conclusions for “European Pledge Case” (with pipeline buildout)

# Pipeline Infrastructure added in “European Pledge Case” (with pipeline buildout) beyond “AEO Reference Case”

- ICF’s natural gas market analysis concludes that the following greenfield/brownfield natural gas pipeline expansion could be needed (beyond “AEO Reference Case”) to meet the added amounts of LNG exports in “European Pledge Case” (with pipeline buildout):
  - 2.5 Bcf/day of new pipeline capacity to transport natural gas from Permian region towards the Gulf Coast
  - 0.7 Bcf/day of new pipeline capacity to transport natural gas from Haynesville region towards the Gulf Coast
  - 0.5 Bcf/day of new pipeline capacity to transport natural gas from SCOOP/STACK region towards the Gulf Coast
  - 0.2 Bcf/day of compressor expansion to transport natural gas from Marcellus/Utica region towards Northern Louisiana



# Summary of gas pipelines transporting feed-gas in "European Pledge Case" (with pipeline buildout) beyond "AEO Reference Case"

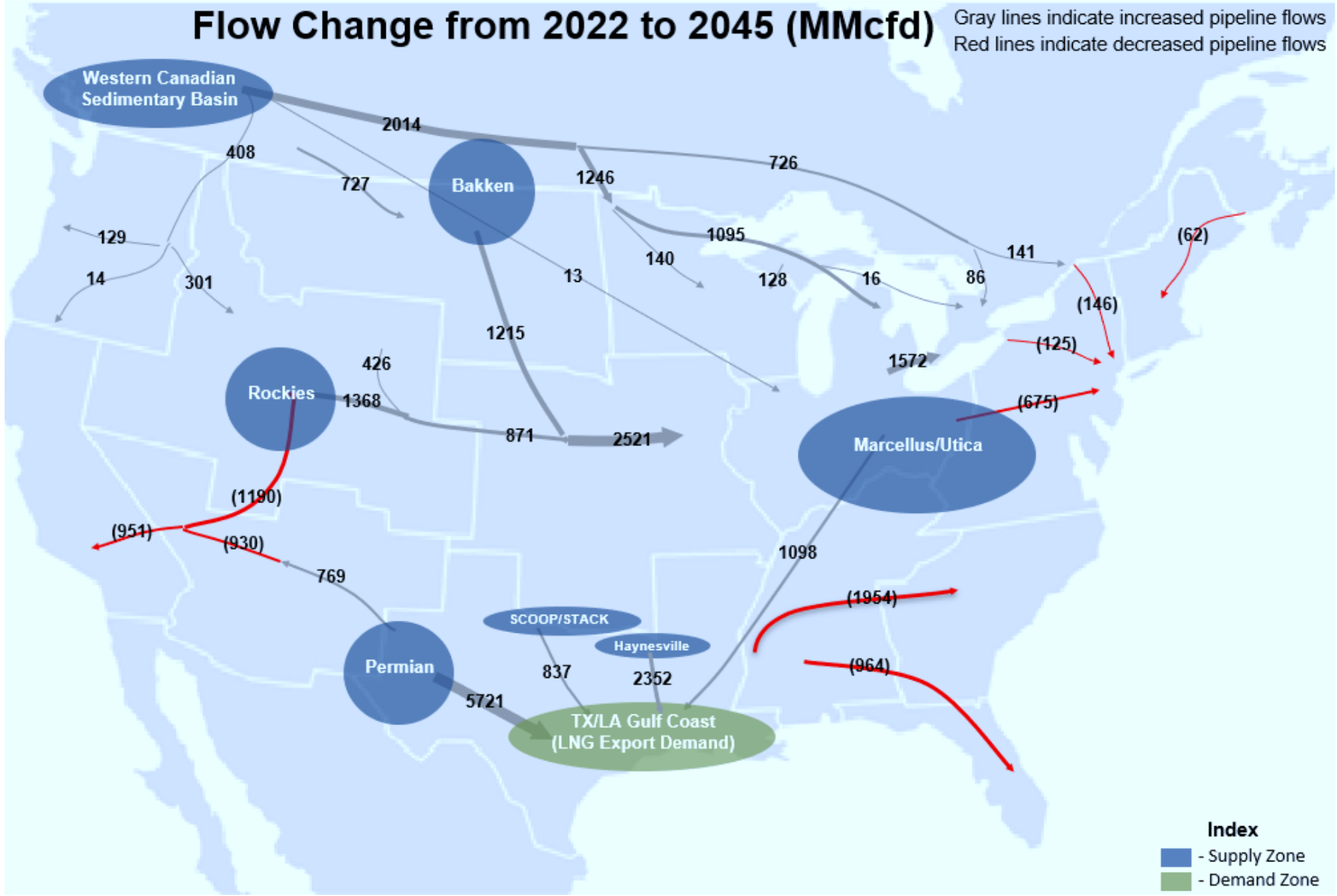
| LNG Export Case | Pipeline Project Name | Gas Supply Destination | In-Service Date | Capacity (MMcfd) | Pipeline Capital Expenditure Million USD (nominal) | Line miles | Pipeline Project Status | Inter/Intrastate | Regulatory Body |
|---|---|---|---|---|---|---|---|---|---|
| AEO Reference Case | Corpus Christi Stage 3 Pipeline Project | Corpus Christi Stage 3, TX | Oct-21 | 1,500 | 193.7 | 22 | In-Service | Intrastate | FERC |
| AEO Reference Case | Golden Pass Pipeline (Reversal) | Golden Pass, TX | Nov-23 | 2,500 | 386 | 69 | FERC-Application | Interstate | FERC |
| | | | | | | | | | |
| European Pledge Case (with pipeline buildout) | Gator Express Pipeline | Plaquemines LNG, LA | Jun-23 | 1,970 | 281.9 | 26.8 | Announced | Intrastate | FERC |
| European Pledge Case (with pipeline buildout) | Alberta Xpress Project | Sabine Pass, TX | Sep-23 | 165 | 300 | NA | Under Construction | Interstate | FERC |
| European Pledge Case (with pipeline buildout) | Louisiana Energy Access Project | Gulf Coast, LA | Apr-24 | 700 | 1,396.5 | 150 | Announced | Intrastate | LPSC+ |
| European Pledge Case (with pipeline buildout) | Matterhorn Express Pipeline Project | Gulf Coast, TX | Sep-24 | 2,500 | 3,412.3 | 411 | Announced | Intrastate | TX RRC+ |
| European Pledge Case (with pipeline buildout) | Driftwood Pipeline Project | Driftwood LNG, LA | May-25 | 4,000 | 1,447.3 | 99.4 | Under construction | Intrastate | FERC |
| European Pledge Case (with pipeline buildout) | SCOOP & STACK Economic build | Gulf Coast, TX | April-26 | 500 | 1,481 | 250 | Not Announced | Interstate | FERC |
| Incremental Pipeline Capacity in "European Pledge Case" (over and above the "AEO Reference Case") | | | | 9,835 MMcfd | | | | | |
| Total Capital Expenditure for planned Intra-State and Inter-State Pipelines in "European Pledge Case" (over and above the "AEO Reference Case") in Million USD (nominal) | | | | | USD 8,319.4 Million | | | | |
| Total Line Miles for Pipelines in "European Pledge Case" (over and above the "AEO Reference Case") | | | | | | 937.2 miles | | | |

*Source: ICF estimates*

**All Capital Expenditure estimates are in nominal dollars*
*+LPSC: Louisiana Public Service Commission*
*TX RRC: Texas Railroad Commission*

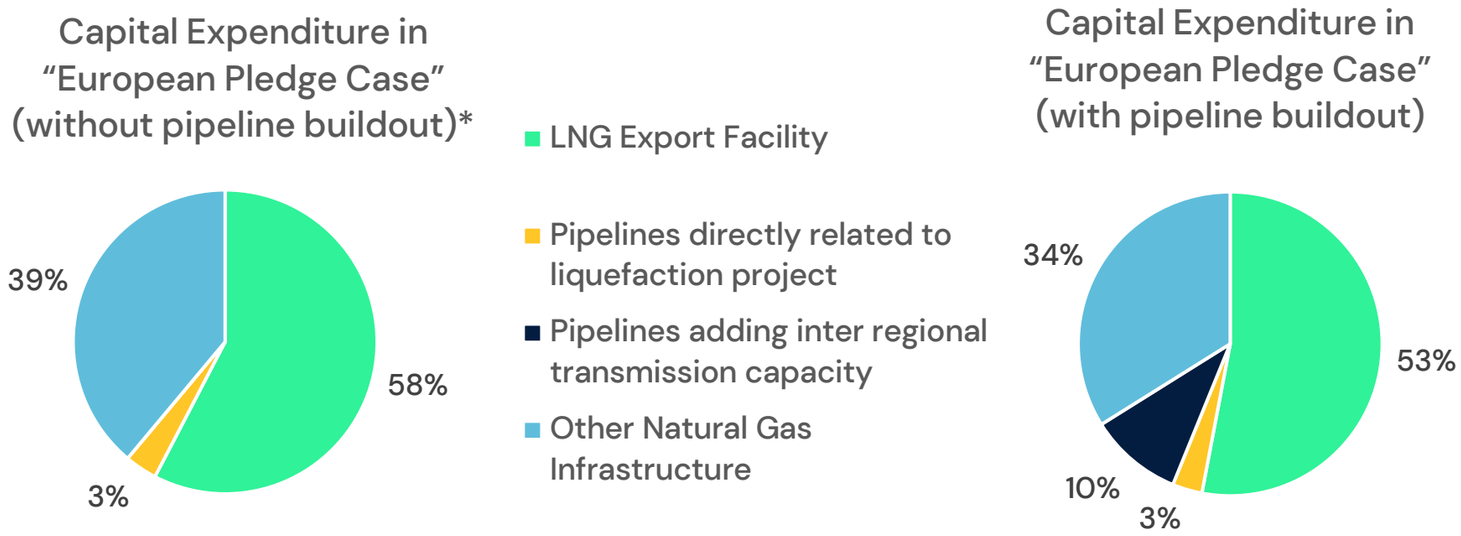
# Long term changes in pipeline corridor flows in “European Pledge Case” (with pipeline buildout)

- “European Pledge Case” (with pipeline buildout) assumes that inter-state or inter-regional pipelines could be needed from Permian, Haynesville and SCOOP/STACK to support export-based demand on Gulf Coast.
- Hence, longer term Permian, Haynesville and SCOOP/STACK production could be directed to the Gulf Coast in greater volumes as compared to “European Pledge Case” (without pipeline buildout).
- Eastward flows out of Western Canada could remain unaffected between the two “European Pledge Cases”.



# Summary of Capital Expenditure to facilitate incremental LNG Exports in "European Pledge Cases" beyond "AEO Reference Case"

| Capital Expenditure Summary Report for "European Pledge Cases" over and above the "AEO Reference Case" | | |
|---|---|---|
| Type of Expenditure (2022-2045) | "European Pledge Case" (without pipeline buildout) in billion | "European Pledge Case" (with pipeline buildout) in billion |
| Capital Expenditure for new LNG Export Facilities | USD 33.4 | USD 33.4 |
| Capital Expenditure of pipelines that are directly related to the liquefaction project | USD 2.0 | USD 2.0 |
| Capital Expenditure of pipeline projects that connect gas supplies to the gas grid and add interregional transmission capacity | - | USD 6.3 |
| Capital Expenditure on other natural gas infrastructure required for production & gathering of natural gas | USD 22.6 | USD 21.4 |
| Total Capital Expenditure for "Alternate LNG Scenarios" (over and above the "AEO Reference Case") | USD 58.0 | USD 63.1 |




Source: ICF estimates

** "European Pledge Case" (without pipeline buildout) avoids building inter-state and inter-regional pipelines from major supply hubs across U.S. towards the Gulf Coast. However, pipeline laterals will be built that interconnect existing natural gas pipelines to respective LNG Facilities. Furthermore, gas gathering lines and gas processing plants will also be built to transport the incremental gas supply from wellhead to existing natural gas pipelines.*

# LNG exports result in employment and GDP gains in “European Pledge Case” (with pipeline buildout) beyond “AEO Reference Case”

- The USD 63.1 billion in capital expenditure for liquefaction plants and pipelines estimated for the “European Pledge Case” (with pipeline buildout) could contribute to US GDP and support jobs in the equipment, materials, construction and other US industries.
- These economic impacts could depend on the design of these facilities and portions of equipment, materials and engineering services that are procured from domestic sources.
- ICF estimates that the direct and indirect GDP contribution from this capital expenditures could be approximately USD 52 billion during 2022-2045. Adding in the induced economic activity brings the total GDP impact to USD 82.6 billion during 2022-2045.
- The direct and indirect employment impact associated with this expenditure for liquefaction plants and pipelines could be 460,000 jobs* during 2022-2045. Adding in induced jobs brings that total employment impact to 772,000 jobs* during 2022-2045.
- These values do not include the GDP and job impacts from the operation of facilities or the jobs in the natural gas production sector and its related support industries.

**Jobs have been calculated based on number of job-years which are applicable cumulatively due to the period of infrastructure development (2025-2030). Please note that each job corresponds to employment duration of 12-months.*

# Key Infrastructure Conclusions for the “Extended Cases”

# Additional Infrastructure added in the “Extended Cases” beyond “AEO Reference Case”

- ICF assumes that eight North American LNG export terminals will be built and/or expanded (over and above the planned LNG facilities in “AEO Reference Case”) to meet the incremental LNG export targets in “Extended Cases”.
- These are actual planned liquefaction projects - not hypothetical projects. They are infrastructure projects that are on various stages of application process with Department of Energy (DOE).
  - ICF has selected these LNG projects based on company media reports, investor presentation and news articles.
  - The incremental LNG demand of the "Extended Cases," of course, could be met by a different mix and scheduling of facilities.
- These eight LNG export terminals together add an incremental LNG export capacity of 14.7 Bcf/day in the “Extended Cases” by 2030.
  - Projected LNG export capacity increases to 31.1 Bcf/day by 2030. (+90% vs. AEO Reference Case).
- All the planned LNG Export Facilities are geographically located in the Gulf coast (Texas/Louisiana).

# Summary of LNG Export Facilities in the "Extended Cases" beyond "AEO Reference Case" (Page 1 of 2)

| LNG Export Case | LNG Export Facility Name | Number of Trains+ | Capacity (Bcf/day) | Project Commissioning Date | LNG Export Facility Location | Department of Energy (DOE) Application Status |
|---|---|---|---|---|---|---|
| AEO Reference Case | Golden Pass TX | Train 1-3 | 2.5 | Jan 2024 - Jul 2025 | TX | Approved |
| | | | | | | |
| Extended Cases | Plaquemines LNG | Train 1-2 | 2.68 | Nov-2024 – Oct 2026 | LA | Approved |
| Extended Cases | Corpus Christi "Stage 3" | Train 4 | 1.50 | Nov- 2025 | TX | Approved |
| Extended Cases | Driftwood LNG | Train 1-5 | 3.65 | Sept 2026 - Sept 2029 | LA | *Approved |

*Table continues next slide.*

** Driftwood LNG Export facility train 1&2 have received Final Investment Decision (FID) and have begun construction. Train 3 is has not received FID from Tellurian.*

*+ LNG "Train" refers to a series of gas treatment facilities, gas compressors, refrigeration units and various other components that process, purify and convert natural gas to liquified natural gas (LNG). LNG "Train" is also known as a liquefaction unit. They are called "Train" because of the sequential arrangement of the equipment used to process and liquefy natural gas.*

**All Capital Expenditure estimates are in nominal dollars*

# Summary of LNG Export Facilities in the "Extended Cases" beyond "AEO Reference Case" (Page 2 of 2)

| LNG Export Case | LNG Export Facility Name | Number of Trains+ | Capacity (Bcf/day) | Project Commissioning Date | LNG Export Facility Location | Department of Energy (DOE) Application Status |
|---|---|---|---|---|---|---|
| Extended Cases | Port Arthur LNG | Train 1-2 | 1.78 | Dec 2026 – Jun 2027 | TX | FERC Application |
| Extended Cases | Freeport | Train 4 | 0.79 | Apr - 2027 | TX | FERC Application |
| Extended Cases | Lake Charles LNG | Train 1-3 | 2.17 | Mar 2028 – Jun 2029 | LA | FERC Application |
| Extended Cases | Cameron LNG | Train 4-5 | 1.32 | Mar - 2029 | LA | FERC Application |
| Extended Cases | Delfin LNG | Train 1-2 | 0.80 | Jul - 2029 | TX | FERC Application |
| Total Capacity for planned LNG Export Facilities in "Extended Cases" (over and above the "AEO Reference Case") | | | 14.7 Bcf/day | | | |

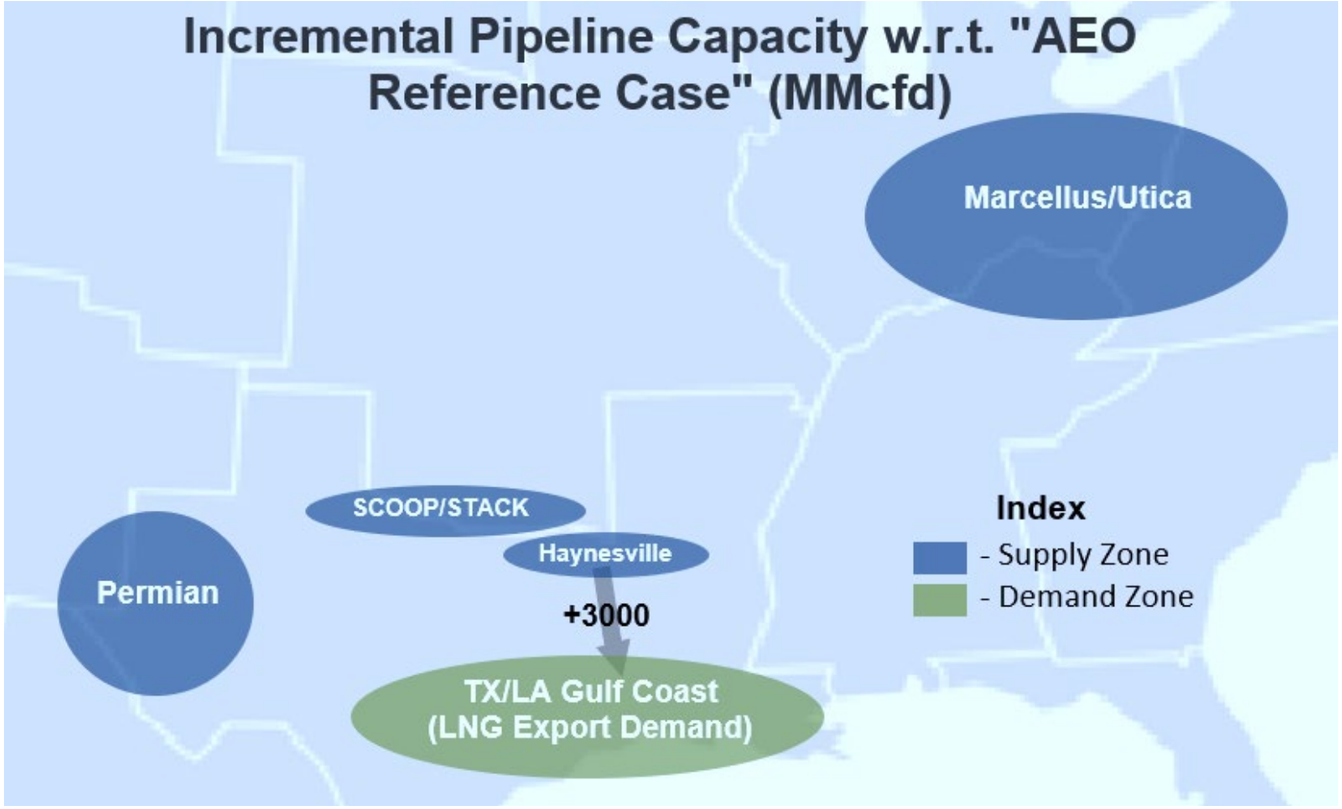
*+ LNG "Train" refers to a series of gas treatment facilities, gas compressors, refrigeration units and various other components that process, purify and convert natural gas to liquified natural gas (LNG). LNG "Train" is also known as a liquefaction unit. They are called "Train" because of the sequential arrangement of the equipment used to process and liquefy natural gas.*

**All Capital Expenditure estimates are in nominal dollars*

# Key Infrastructure Conclusions for “Extended Case” (with minimal pipeline buildout)

# Pipeline Infrastructure added in “Extended Case” (with minimal pipeline buildout) beyond “AEO Reference Case”

- ICF’s natural gas market analysis concludes that the following greenfield/brownfield natural gas pipeline expansion could be needed (beyond “AEO Reference Case”) to meet the added amounts of LNG exports in “Extended Case” (with minimal pipeline buildout):
  - 3.0 Bcf/day of new pipeline capacity to transport natural gas from Haynesville region towards the Gulf Coast



# Summary of gas pipelines transporting feed-gas in "Extended Case" (with minimal pipeline buildout) beyond "AEO Reference Case" (Page 1 of 2)

| LNG Export Case | Pipeline Project Name | Gas Supply Destination | In-Service Date | Capacity (MMcfd) | Line miles | Pipeline Project Status | Inter/Intrastate | Regulatory Body |
|---|---|---|---|---|---|---|---|---|
| AEO Reference Case | Corpus Christi Stage 3 Pipeline Project | Corpus Christi Stage 3, TX | Oct-21 | 1,500 | 22 | In-Service | Intrastate | FERC |
| AEO Reference Case | Golden Pass Pipeline (Reversal) | Golden Pass, TX | Nov-23 | 2,500 | 69 | FERC-Application | Interstate | FERC |
| | | | | | | | | |
| Extended Case (with minimal pipeline buildout) | Gator Express Pipeline | Plaquemines LNG, LA | Jun-23 | 1,970 | 26.8 | Announced | Intrastate | FERC |
| Extended Case (with minimal pipeline buildout) | Alberta Xpress Project | Sabine Pass, TX | Sep-23 | 165 | NA | Under Construction | Interstate | FERC |
| Extended Case (with minimal pipeline buildout) | Driftwood Pipeline Project | Driftwood LNG, LA | May-25 | 4,000 | 99.4 | Under construction | Intrastate | FERC |
| Extended Case (with minimal pipeline buildout) | Venice Extension Project | Plaquemines LNG, LA | Mar-24 | 1,260 | 3 | Announced | Interstate | FERC |
| Extended Case (with minimal pipeline buildout) | Louisiana Connector Project | Port Arthur, TX | Jun-24 | 2,000 | 130.9 | Announced | Interstate | FERC |

*Table continues next slide.*

*Source: ICF estimates*

**All Capital Expenditure estimates are in nominal dollars*
*⁺LPSC : Louisiana Public Service Commission*
*TX RRC: Texas Railroad Commission*

# Summary of gas pipelines transporting feed-gas in "Extended Case" (with minimal pipeline buildout) beyond "AEO Reference Case" (Page 2 of 2)

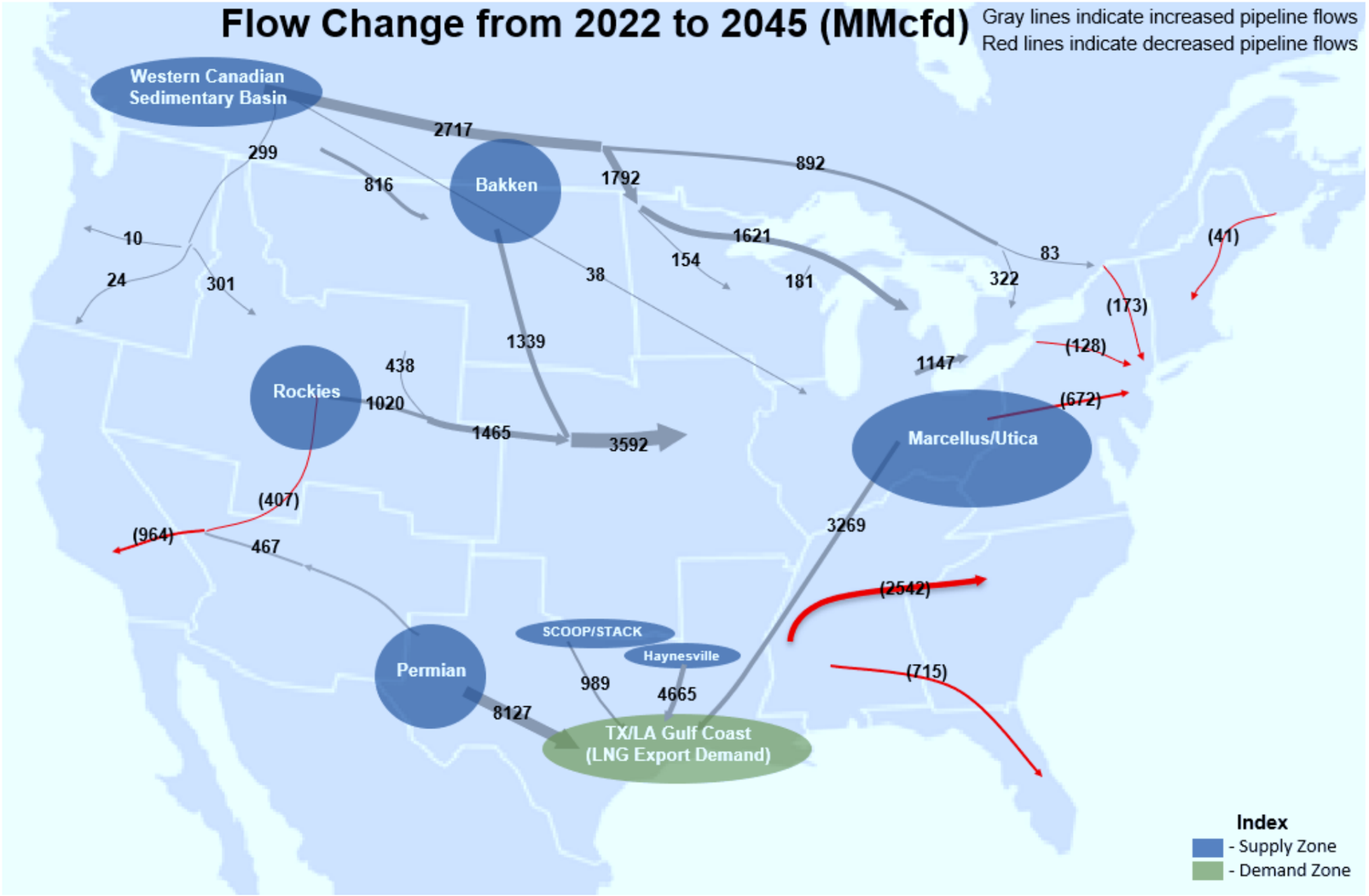
| LNG Export Case | Pipeline Project Name | Gas Supply Destination | In-Service Date | Capacity (MMcfd) | Line miles | Pipeline Project Status | Inter/Intrastate | Regulatory Body |
|---|---|---|---|---|---|---|---|---|
| Extended Case (with minimal pipeline buildout) | Texas Connector Project | Port Arthur, TX | Dec-24 | 2,000 | 34.2 | Announced | Interstate | FERC |
| Extended Case (with minimal pipeline buildout) | Trunkline Pipeline Modifications Project | Lake Charles LNG, LA | Mar-26 | 3,100 | 17.9 | Announced | Interstate | FERC |
| Extended Case (with minimal pipeline buildout) | Haynesville to Gulf Coast Economic Build 1 | Gulf Coast, LA | Nov-27 | 1,500 | 160 | Not Announced | Intrastate | LPSC+ |
| Extended Case (with minimal pipeline buildout) | Cameron Interstate Pipeline Economic Build | Cameron LNG, LA | Feb-29 | 1,500 | 34 | Not Announced | Intrastate | LPSC+ |
| Extended Case (with minimal pipeline buildout) | Haynesville to Gulf Coast Economic Build 2 | Gulf Coast, LA | Nov-27 | 1,500 | 160 | Not Announced | Intrastate | LPSC+ |
| Extended Case (with minimal pipeline buildout) | UTOS Pipeline Economic Build | Delfin LNG | Apr-29 | 2,000 | 30 | Not Announced | Interstate | FERC |
| Incremental Pipeline Capacity in "Extended Case" (with minimal pipeline buildout) (over and above the "AEO Reference Case") | | | | 20,995 MMcfd | | | | |
| Total Line Miles for Pipelines in "Extended Case" (with minimal pipeline buildout) (over and above the "AEO Reference Case") | | | | | 696.2 miles | | | |

*Source: ICF estimates*

**All Capital Expenditure estimates are in nominal dollars*
*+LPSC : Louisiana Public Service Commission*
*TX RRC: Texas Railroad Commission*

# Long term changes in pipeline corridor flows in “Extended Case” (with minimal pipeline buildout)

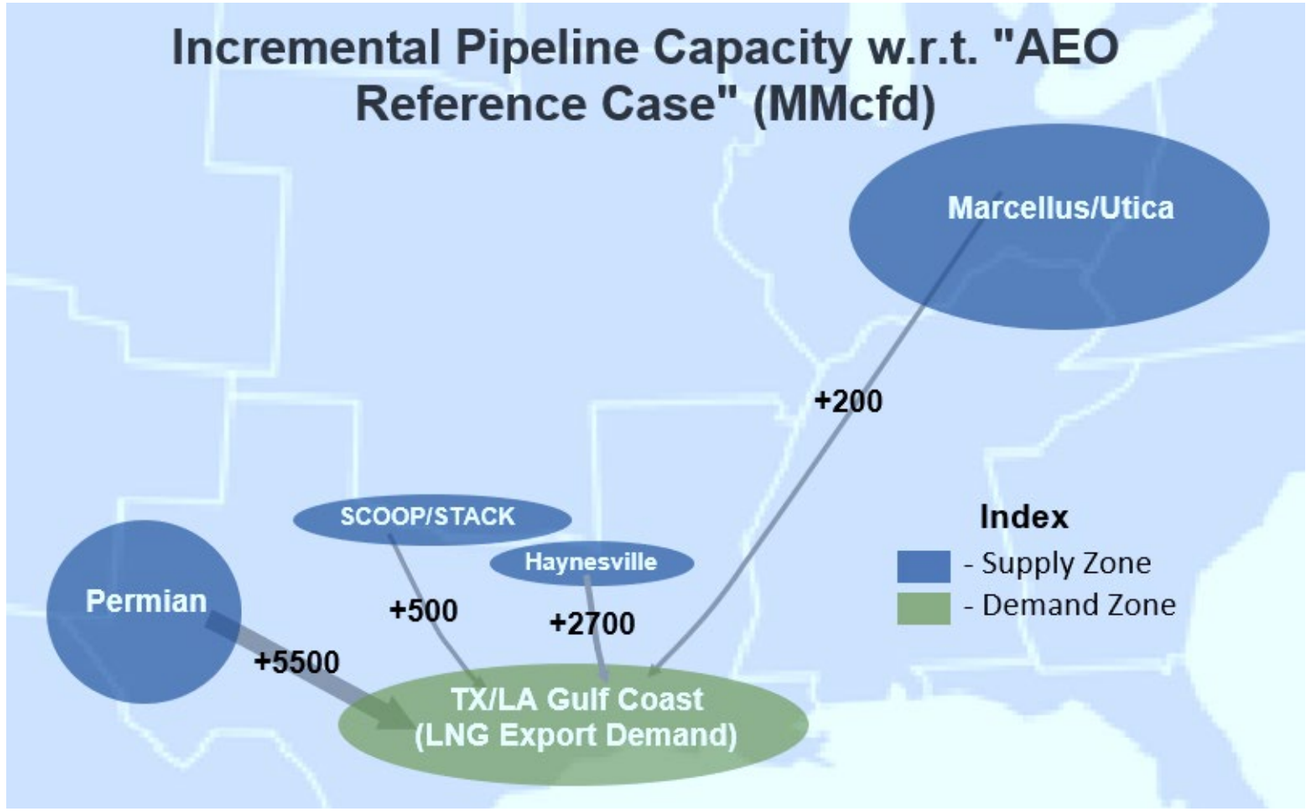
- “Extended Case” (with minimal pipeline buildout) assumes that a minimum of 3 Bcf/day of pipeline capacity could be needed from nearby supply basins to support the export-based demand at Gulf Coast.
- Marcellus gas production growth could be expected to reverse northbound flows thus pushing gas more toward the west and south.
- Longer term Permian, Haynesville and SCOOP/STACK production could be primarily be directed to the Gulf Coast.
- Eastward flows out of Western Canada could rise significantly as incremental gas supplies might be required to support demand in Northeast.



# Key Infrastructure Conclusions for "Extended Case" (with constrained pipeline buildout)

# Pipeline Infrastructure added in “Extended Case” (with constrained pipeline buildout) beyond “AEO Reference Case”

- ICF’s natural gas market analysis concludes that the following greenfield/brownfield natural gas pipeline expansion could be needed (beyond “AEO Reference Case”) to meet the added amounts of LNG exports in “Extended Case” (with constrained pipeline buildout), that assumes no new pipelines out of the Marcellus/Utica can be built:
  - 5.5 Bcf/day of new pipeline capacity to transport natural gas from Permian region towards the Gulf Coast
  - 2.7 Bcf/day of new pipeline capacity to transport natural gas from Haynesville region towards the Gulf Coast
  - 0.5 Bcf/day of new pipeline capacity to transport natural gas from SCOOP/STACK region towards the Gulf Coast
  - 0.2 Bcf/day of compressor expansion to transport natural gas from Marcellus/Utica region towards Northern Louisiana



# Summary of gas pipelines transporting feed-gas in "Extended Case" (with constrained pipeline buildout) beyond "AEO Reference Case" (Page 1 of 2)

| LNG Export Case | Pipeline Project Name | Gas Supply Destination | In-Service Date | Capacity (MMcfd) | Line miles | Pipeline Project Status | Inter/Intrastate | Regulatory Body |
|---|---|---|---|---|---|---|---|---|
| AEO Reference Case | Corpus Christi Stage 3 Pipeline Project | Corpus Christi Stage 3, TX | Oct-21 | 1,500 | 22 | In-Service | Intrastate | FERC |
| AEO Reference Case | Golden Pass Pipeline (Reversal) | Golden Pass, TX | Nov-23 | 2,500 | 69 | FERC-Application | Interstate | FERC |
| | | | | | | | | |
| Extended Case (with constrained pipeline buildout) | Gator Express Pipeline | Plaquemines LNG, LA | Jun-23 | 1,970 | 26.8 | Announced | Intrastate | FERC |
| Extended Case (with constrained pipeline buildout) | Alberta Xpress Project | Sabine Pass, TX | Sep-23 | 165 | NA | Under Construction | Interstate | FERC |
| Extended Case (with constrained pipeline buildout) | Louisiana Energy Access Project | Gulf Coast, LA | Apr-24 | 700 | 150 | Announced | Intrastate | LPSC+ |
| Extended Case (with constrained pipeline buildout) | Matterhorn Express Pipeline Project | Gulf Coast, TX | Sep-24 | 2,500 | 411 | Announced | Intrastate | TX RRC+ |
| Extended Case (with constrained pipeline buildout) | Driftwood Pipeline Project | Driftwood LNG, LA | May-25 | 4,000 | 99.4 | Under construction | Intrastate | FERC |
| Extended Case (with constrained pipeline buildout) | SCOOP & STACK Economic build | Gulf Coast, TX | April-26 | 500 | 250 | Not Announced | Interstate | FERC |
| Extended Case (with constrained pipeline buildout) | Venice Extension Project | Plaquemines LNG, LA | Mar-24 | 1,260 | 3 | Announced | Interstate | FERC |

*Table continues next slide.*

*Source: ICF estimates*

**All Capital Expenditure estimates are in nominal dollars*
*+LPSC : Louisiana Public Service Commission*
*TX RRC: Texas Railroad Commission*

# Summary of gas pipelines transporting feed-gas in "Extended Case" (with constrained pipeline buildout) beyond "AEO Reference Case" (Page 2 of 2)

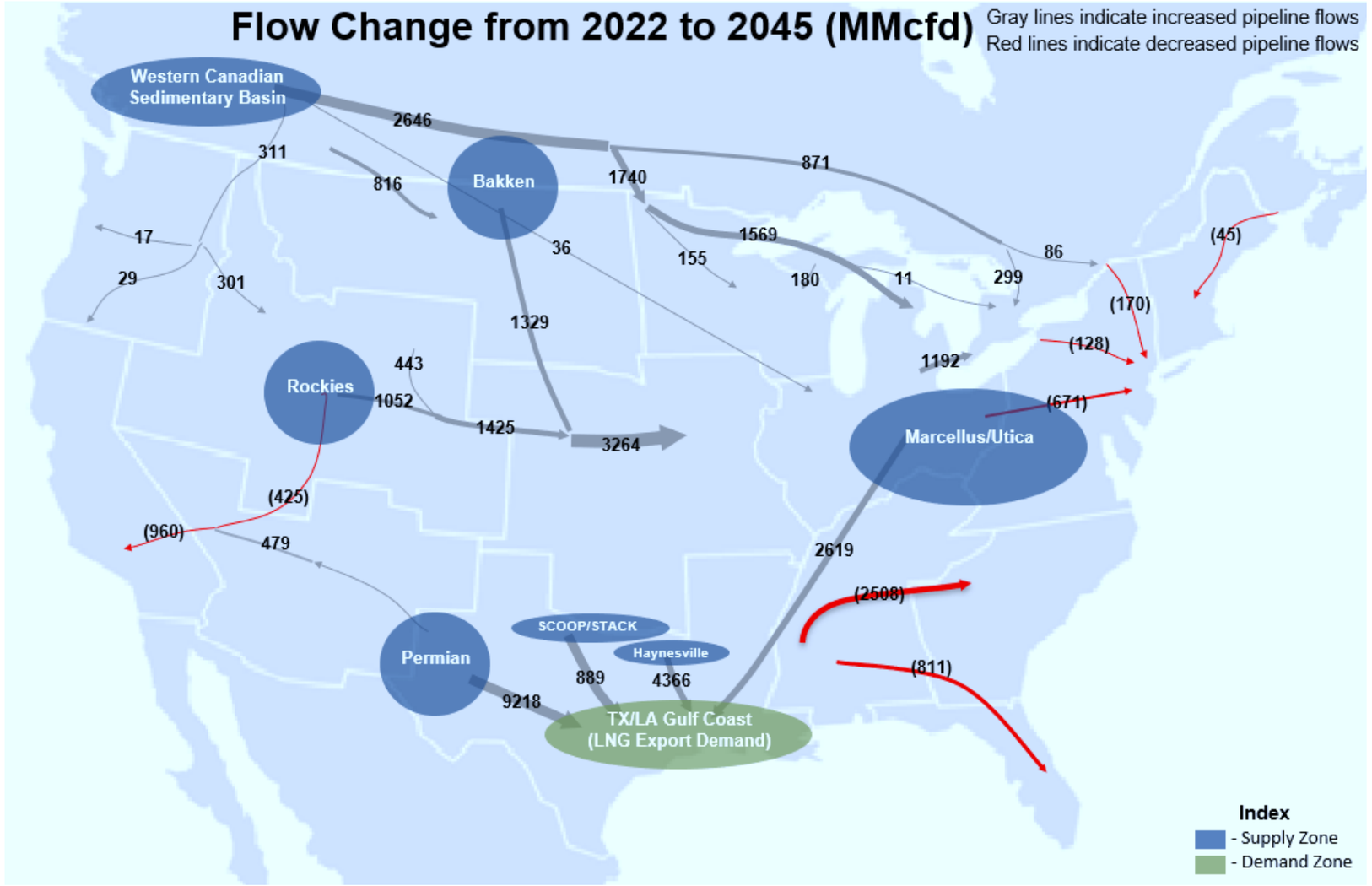
| LNG Export Case | Pipeline Project Name | Gas Supply Destination | In-Service Date | Capacity (MMcfd) | Line miles | Pipeline Project Status | Inter/Intrastate | Regulatory Body |
|---|---|---|---|---|---|---|---|---|
| Extended Case (with constrained pipeline buildout) | Louisiana Connector Project | Port Arthur, TX | Jun-24 | 2,000 | 130.9 | Announced | Interstate | FERC |
| Extended Case (with constrained pipeline buildout) | Texas Connector Project | Port Arthur, TX | Dec-24 | 2,000 | 34.2 | Announced | Interstate | FERC |
| Extended Case (with constrained pipeline buildout) | Trunkline Pipeline Modifications Project | Lake Charles LNG, LA | Mar-26 | 3,100 | 17.9 | Announced | Interstate | FERC |
| Extended Case (with constrained pipeline buildout) | Permian to Gulf Coast Economic Build 1 | Gulf Coast, TX | Apr-27 | 1,000 | 240 | Not Announced | Intrastate | TX RRC+ |
| Extended Case (with constrained pipeline buildout) | Haynesville to Gulf Coast Economic Build | Gulf Coast, LA | Nov-27 | 2,000 | 160 | Not Announced | Intrastate | LPSC+ |
| Extended Case (with constrained pipeline buildout) | Permian to Gulf Coast Economic Build 2 | Gulf Coast, TX | Nov-28 | 500 | 240 | Not Announced | Intrastate | TX RRC+ |
| Extended Case (with constrained pipeline buildout) | Cameron Interstate Pipeline Economic Build | Cameron LNG, LA | Feb-29 | 1,500 | 34 | Not Announced | Intrastate | LPSC+ |
| Extended Case (with constrained pipeline buildout) | UTOS Pipeline Economic Build | Delfin LNG | Apr-29 | 2,000 | 30 | Not Announced | Interstate | FERC |
| Extended Case (with constrained pipeline buildout) | Permian to Gulf Coast Economic Build 3 | Gulf Coast, TX | Apr-31 | 1,500 | 160 | Not Announced | Intrastate | TX RRC+ |
| | Incremental Pipeline Capacity in "Extended Case" (with constrained pipeline buildout) (over and above the "AEO Reference Case") | | | 26,695 MMcfd | | | | |
| | Total Line Miles for Pipelines in "Extended Case" (with constrained pipeline buildout) (over and above the "AEO Reference Case") | | | | 1,987.2 miles | | | |

*Source: ICF estimates*

**All Capital Expenditure estimates are in nominal dollars*
*+LPSC : Louisiana Public Service Commission*
*TX RRC: Texas Railroad Commission*

# Long term changes in pipeline corridor flows in “Extended Case” (with constrained pipeline buildout)

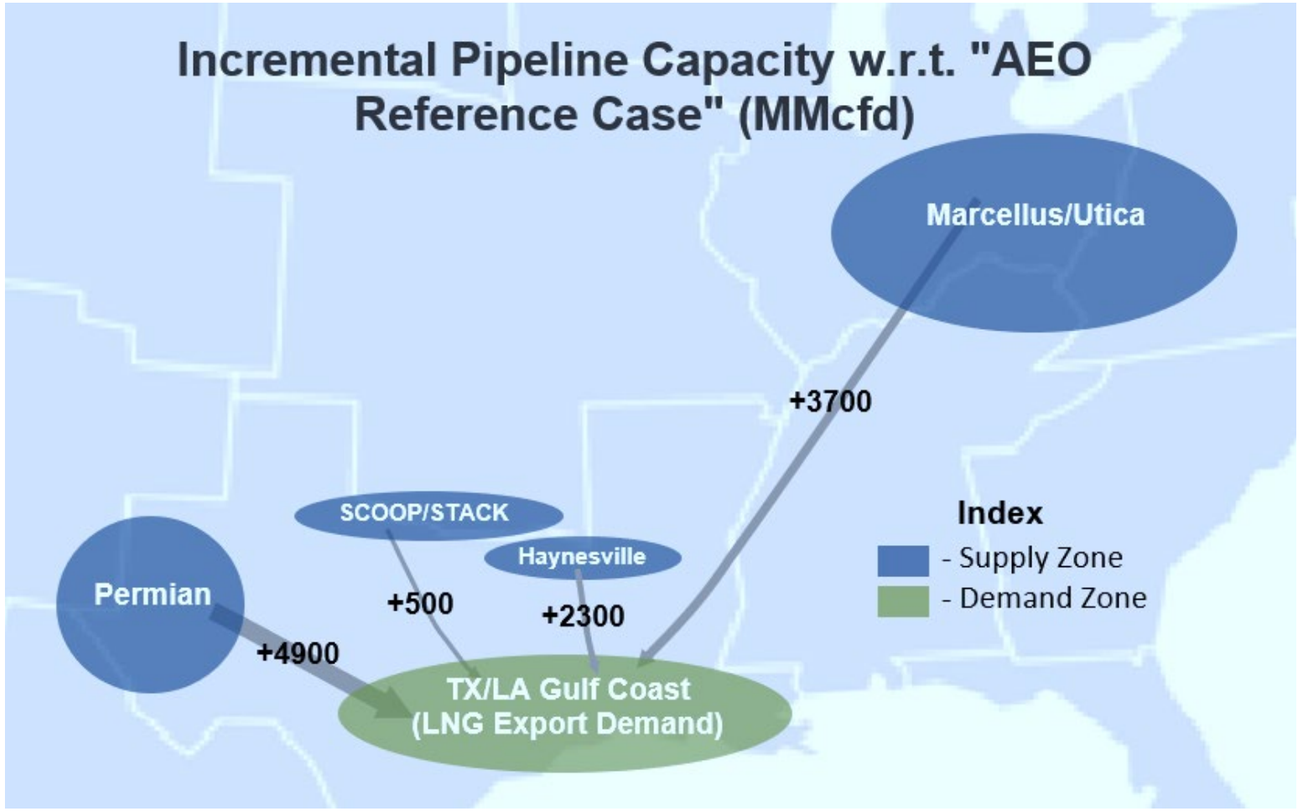
- “Extended Case” (with constrained pipeline buildout) assumes that over 8 Bcf/day of pipeline capacity could be needed from supply basins other than Marcellus/Utica to support the export-based demand at Gulf Coast.
- Hence, longer term Permian and Haynesville production could be directed to the Gulf Coast in greater volumes as compared to “Extended Case” (with minimal pipeline buildout).
- Eastward flows out of Western Canada could remain largely unaffected when compared to “Extended Case” (with minimal pipeline build).



# Key Infrastructure Conclusions for "Extended Case" (with unconstrained pipeline buildout)

# Pipeline Infrastructure added in “Extended Case” (with unconstrained pipeline buildout) beyond “AEO Reference Case”

- ICF’s natural gas market analysis concludes that the following greenfield/brownfield natural gas pipeline expansion could be needed (beyond “AEO Reference Case”) to meet the added amounts of LNG exports in “Extended Case” (with unconstrained pipeline buildout):
  - 4.9 Bcf/day of new pipeline capacity to transport natural gas from Permian region towards the Gulf Coast
  - 2.3 Bcf/day of new pipeline capacity to transport natural gas from Haynesville region towards the Gulf Coast
  - 0.5 Bcf/day of new pipeline capacity to transport natural gas from SCOOP/STACK region towards the Gulf Coast
  - 3.7 Bcf/day of new pipeline capacity to transport natural gas from Marcellus/Utica region towards the Gulf Coast



# Summary of gas pipelines transporting feed-gas in "Extended Case" (with unconstrained pipeline buildout) beyond "AEO Reference Case" (Page 1 of 2)

| LNG Export Case | Pipeline Project Name | Gas Supply Destination | In-Service Date | Capacity (MMcfd) | Line miles | Pipeline Project Status | Inter/Intrastate | Regulatory Body |
|---|---|---|---|---|---|---|---|---|
| AEO Reference Case | Corpus Christi Stage 3 Pipeline Project | Corpus Christi Stage 3, TX | Oct-21 | 1,500 | 22 | In-Service | Intrastate | FERC |
| AEO Reference Case | Golden Pass Pipeline (Reversal) | Golden Pass, TX | Nov-23 | 2,500 | 69 | FERC-Application | Interstate | FERC |
| | | | | | | | | |
| Extended Case (with unconstrained pipeline buildout) | Gator Express Pipeline | Plaquemines LNG, LA | Jun-23 | 1,970 | 26.8 | Announced | Intrastate | FERC |
| Extended Case (with unconstrained pipeline buildout) | Alberta Xpress Project | Sabine Pass, TX | Sep-23 | 165 | NA | Under Construction | Interstate | FERC |
| Extended Case (with unconstrained pipeline buildout) | Louisiana Energy Access Project | Gulf Coast, LA | Apr-24 | 700 | 150 | Announced | Intrastate | LPSC[+] |
| Extended Case (with unconstrained pipeline buildout) | Matterhorn Express Pipeline Project | Gulf Coast, TX | Sep-24 | 2,500 | 411 | Announced | Intrastate | TX RRC[+] |
| Extended Case (with unconstrained pipeline buildout) | Driftwood Pipeline Project | Driftwood LNG, LA | May-25 | 4,000 | 99.4 | Under construction | Intrastate | FERC |
| Extended Case (with unconstrained pipeline buildout) | Venice Extension Project | Plaquemines LNG, LA | Mar-24 | 1,260 | 3 | Announced | Interstate | FERC |
| Extended Case (with unconstrained pipeline buildout) | Louisiana Connector Project | Port Arthur, TX | Jun-24 | 2,000 | 130.9 | Announced | Interstate | FERC |
| Extended Case (with unconstrained pipeline buildout) | Texas Connector Project | Port Arthur, TX | Dec-24 | 2,000 | 34.2 | Announced | Interstate | FERC |
| Extended Case (with unconstrained pipeline buildout) | Trunkline Pipeline Modifications Project | Lake Charles LNG, LA | Mar-26 | 3,100 | 17.9 | Announced | Interstate | FERC |

*Table continues next slide.* *Source: ICF estimates*

**All Capital Expenditure estimates are in nominal dollars*
*[+]LPSC : Louisiana Public Service Commission*
*TX RRC: Texas Railroad Commission*

# Summary of gas pipelines transporting feed-gas in "Extended Case" (with unconstrained pipeline buildout) beyond "AEO Reference Case" (Page 2 of 2)

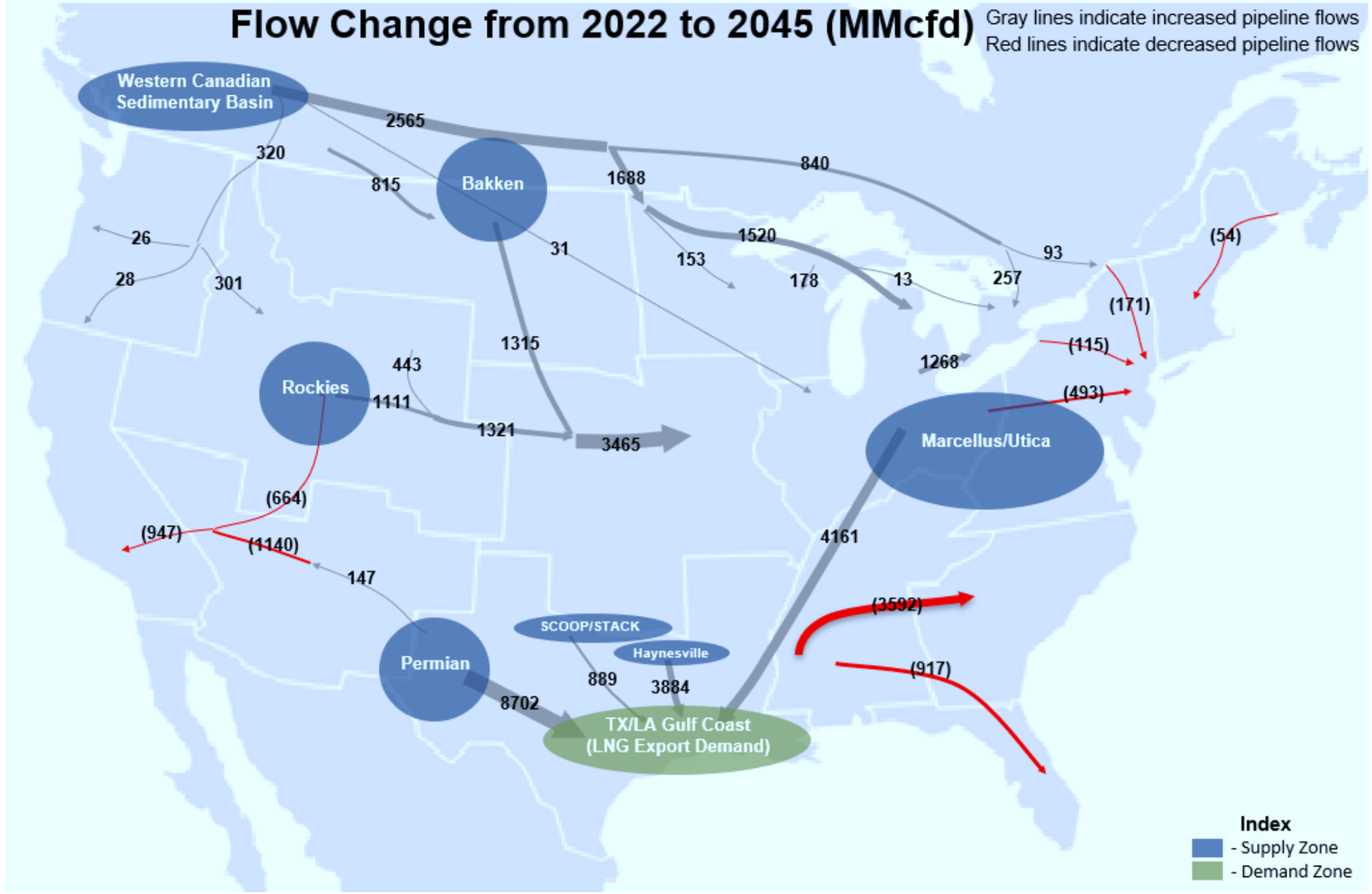
| LNG Export Case | Pipeline Project Name | Gas Supply Destination | In-Service Date | Capacity (MMcfd) | Line miles | Pipeline Project Status | Inter/Intrastate | Regulatory Body |
|---|---|---|---|---|---|---|---|---|
| Extended Case (with unconstrained pipeline buildout) | SCOOP & STACK Economic build | Gulf Coast, TX | Apr-26 | 500 | 250 | Not Announced | Interstate | FERC |
| Extended Case (with unconstrained pipeline buildout) | Permian to Gulf Coast Economic Build 1 | Gulf Coast, TX | Apr-27 | 800 | 240 | Not Announced | Intrastate | TX RRC+ |
| Extended Case (with unconstrained pipeline buildout) | Haynesville to Gulf Coast Economic Build | Gulf Coast, LA | Nov-27 | 1,600 | 160 | Not Announced | Intrastate | LPSC+ |
| Extended Case (with unconstrained pipeline buildout) | Permian to Gulf Coast Economic Build 2 | Gulf Coast, TX | Nov-28 | 300 | 240 | Not Announced | Intrastate | TX RRC+ |
| Extended Case (with unconstrained pipeline buildout) | Cameron Interstate Pipeline Economic Build | Cameron LNG, LA | Feb-29 | 1,500 | 34 | Not Announced | Intrastate | LPSC+ |
| Extended Case (with unconstrained pipeline buildout) | UTOS Pipeline Economic Build | Delfin LNG | Apr-29 | 2,000 | 30 | Not Announced | Interstate | FERC |
| Extended Case (with unconstrained pipeline buildout) | Permian to Gulf Coast Economic Build 3 | Gulf Coast, TX | Apr-31 | 1,300 | 160 | Not Announced | Intrastate | TX RRC+ |
| Extended Case (with unconstrained pipeline buildout) | Eastern Marcellus Economic Build | Existing Interstate Pipeline in VA | Nov-26 | 750 | 480 | Not Announced | Interstate | FERC |
| Extended Case (with unconstrained pipeline buildout) | Western Marcellus Economic Build 1 | Existing Interstate Pipeline in IL | Nov-26 | 700 | 500 | Not Announced | Interstate | FERC |
| Extended Case (with unconstrained pipeline buildout) | Western Marcellus Economic Build 2 | Existing Interstate Pipeline in IN | Nov-29 | 1,150 | 230 | Not Announced | Interstate | FERC |
| Extended Case (with unconstrained pipeline buildout) | Southern Marcellus Economic Build | Existing Interstate Pipeline in TN | Nov-29 | 900 | 330 | Not Announced | Interstate | FERC |
| Incremental Pipeline Capacity in "Extended Case" (with unconstrained pipeline buildout) (over and above the "AEO Reference Case") | | | | 29,195 MMcfd | | | | |
| Total Line Miles for Pipelines in "Extended Case" (with unconstrained pipeline buildout) (over and above the "AEO Reference Case") | | | | | 3,527 miles | | | |

*Source: ICF estimates*

**All Capital Expenditure estimates are in nominal dollars*
*+LPSC : Louisiana Public Service Commission*
*TX RRC: Texas Railroad Commission*

# Long term changes in pipeline corridor flows in “Extended Case” (with unconstrained pipeline buildout)

- “Extended Case” (with unconstrained pipeline buildout) assumes that over 3.7 Bcf/day of pipeline capacity could be needed from Marcellus-Utica to support the export-based demand at Gulf Coast.
- Hence, longer term Marcellus-Utica production could be directed to the Gulf Coast in greater volumes as compared to “Extended Case” (with minimal pipeline buildout).
- With greater proportion of export-based demand now being met from Marcellus-Utica basin, pipeline flows from Permian and Haynesville could be lower compared to “Extended Case” (with constrained pipeline buildout).
- Eastward flows out of Western Canada could be slightly down when compared to “Extended Case” (with minimal pipeline build).



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