



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

PREPARED FOR AMERICAN PETROLEUM INSTITUTE

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Purpose of the Infrastructure Study

On March 25, 2022, the White House announced a joint Task Force with the European Commission to “reduce Europe’s dependence on Russian fossil fuels and strengthen European energy security as President Putin wages his war of choice against Ukraine.” The announcement said this Task Force “will work to ensure energy security for Ukraine and the European Union (EU) in preparation for next winter and the following one while supporting the EU’s goal to end its dependence on Russian fossil fuels.” One specific goal set out in the announcement was that “The United States (US) will work with international partners and strive to ensure additional LNG volumes for the EU market of at least 15 billion cubic meters (bcm) in 2022, with expected increases going forward.” The announcement further states “The European Commission will work with EU Member States toward the goal of ensuring, until at least 2030, demand for approximately 50 bcm/year of additional US LNG that is consistent with our shared net-zero goals. This also will be done on the understanding that prices should reflect long-term market fundamentals and stability of supply and demand.”

According to International Energy Administration (IEA), the EU imported 155 bcm of natural gas from Russia in 2021. This accounted for around 45% of EU gas imports and close to 40% of its total gas consumption. The Task Force’s target of increasing US LNG exports by 50 bcm/year would replace about one-third of the 2021 Russian natural gas imports. Other key actions being contemplated (as stated in IEA’s 10-Point Plan to reduce Europe dependence on Russian energy) include not signing any new gas contracts with Russia; maximizing gas supplies from other sources; accelerating the deployment of solar and wind; making the most of existing low emissions energy sources, such as nuclear and renewables; and ramping up energy efficiency measures in homes and businesses.

The objective of this study was to estimate how much natural gas pipeline infrastructure would be economically justified for three scenarios with different levels of LNG exports. ICF, a consultancy with expertise in oil and natural gas infrastructure, conducted the analysis by using its Gas Market Model (GMM) to generate the three scenarios: a “Base Case,” a “European Pledge Case,” and an “Extended Case.”

First, the study calculated the amount of natural gas pipeline infrastructure necessary to meet a “Base Case” or “business-as-usual” level of US LNG exports, as forecasted in the US Energy Information Administration’s (EIA) 2022 Annual Energy Outlook (AEO) Reference Case. Second, the study estimated the additional infrastructure that would have to be built to accommodate the Task Force target of about 4.8 billion cubic feet/day (Bcf/day) of incremental LNG exports in the “European Pledge Cases.” Furthermore, the study generated “Extended Cases,” which incorporated 12.9 Bcf/day of additional LNG exports (compared to the 2022 AEO Reference Case) to meet the needs of Asian allies that also rely on LNG from Russia.

ICF also performed sensitivity analyses, exploring different levels of natural gas pipeline construction to meet the LNG export demand in the “European Pledge Cases” and “Extended Cases.” These analyses aimed to estimate the economic benefits associated with additional pipeline capacity. Notably, the study revealed that in the “Extended Cases,” substantial economic value could be derived from constructing natural gas pipelines from the

Marcellus/Utica region to the Gulf Coast. The findings of this analysis are presented in the form of briefing slides and this Executive Summary report.

Study Highlights

The “European Pledge Cases” and “Extended Cases” include significant growth in LNG export volumes and an evolution of regional markets across North America in terms of development of new gas supplies and the infrastructure needed to accommodate such growth. In the “European Pledge Cases,” projected growth in LNG export demand equals the Task Force¹ pledge amount to Europe of 4.8 Bcf/day or 33% above the US LNG exports anticipated in AEO Reference Case. In the “Extended Cases,” growth in LNG export demand equals the pledge amount to Europe plus an amount of LNG exports to be sent to Asian allies to offset their LNG imports from Russia. That is, the “Extended Cases” have LNG exports that are 12.9 Bcf/day or 90% above the US LNG exports forecast in the AEO Reference Case.

Below is a brief description of different cases that ICF has included in this infrastructure study. For reference purposes, these cases have been listed in the increasing order of natural gas midstream infrastructure development that would be economically justified to support the new LNG export terminals contained in the respective scenarios. ICF assumed that the new LNG export terminals in each of these cases would be built in the US Gulf Coast region.

Scenario Descriptions

European Pledge Cases

1. **“European Pledge Case” (without pipeline buildout)** avoids building inter-state and inter-regional pipelines from major supply hubs across the US towards the Gulf Coast. The only pipelines that are built are laterals that connect existing natural gas pipelines to the new LNG liquefaction facilities.
2. **“European Pledge Case” (with pipeline buildout)** includes all the interstate and inter-regional pipeline infrastructure that would be economically justified to support the added amounts of LNG exports.

Extended Cases

1. **“Extended Case” (with minimal pipeline buildout)** significantly restricts building long distance inter-state and inter-regional pipelines from major supply hubs across the US towards the Gulf Coast. This case assumes 3 Bcf/day of pipeline infrastructure could be built from supply hubs immediately around the Gulf Coast. Also, pipeline laterals are built to connect existing natural gas pipelines to the new LNG facilities.
2. **“Extended Case” (with constrained pipeline buildout)** includes most of the economically justified inter-state and inter-regional pipeline infrastructure to support the added amounts of LNG exports but avoids building pipeline infrastructure from the Marcellus/Utica region in Pennsylvania, Ohio, and West Virginia towards the Gulf Coast.
3. **“Extended Case” (with unconstrained pipeline buildout)** includes all the economically justified inter-state and inter-regional pipeline infrastructure required to meet the added amounts of LNG exports including builds from the Marcellus/Utica region towards the Gulf Coast.

¹ <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/>

Infrastructure Analysis for the “European Pledge Cases”

LNG Export volumes in the “European Pledge Cases” increase to 20.9 Bcf/day by 2030 which is a 33% increase with respect to the 2022 AEO Reference Case. To achieve these export targets by 2030, ICF assumes that three US LNG export terminals will be built and/or expanded over and above the planned LNG facilities in 2022 AEO Reference Case. These are actual planned liquefaction projects and not hypothetical projects. They are infrastructure projects that are in various stages of application process with US Department of Energy (DOE). ICF has included these LNG projects in the projection based on company media reports, investor presentations, and news articles. It is possible that different facilities could be built to meet the incremental demand for LNG assumed for this case, but they would likely be located in close proximity on the Gulf Coast to the facilities that ICF included. These three LNG export terminals together add an incremental LNG export capacity of 5.5 Bcf/day over the 2022 AEO Reference Case in the “European Pledge Cases” by 2030. This brings the total projected LNG export capacity to 21.9 Bcf/day by 2030 which is a 33% increase with respect to the 2022 AEO Reference Case. All the incremental LNG export facilities are located along the Gulf Coast in Texas and Louisiana.

Various categories of gas midstream infrastructure might be built to support new LNG export terminals in the Gulf Coast. These include:

1. Gas gathering lines, processing plants, and supply laterals to bring incremental natural gas production from the wellhead to major supply hubs.
2. New inter/intra-regional natural gas pipelines to facilitate incremental gas transportation from supply hubs towards the Gulf Coast.
3. Gas pipeline laterals to connect inter/intra-regional gas pipelines to the LNG export facilities.

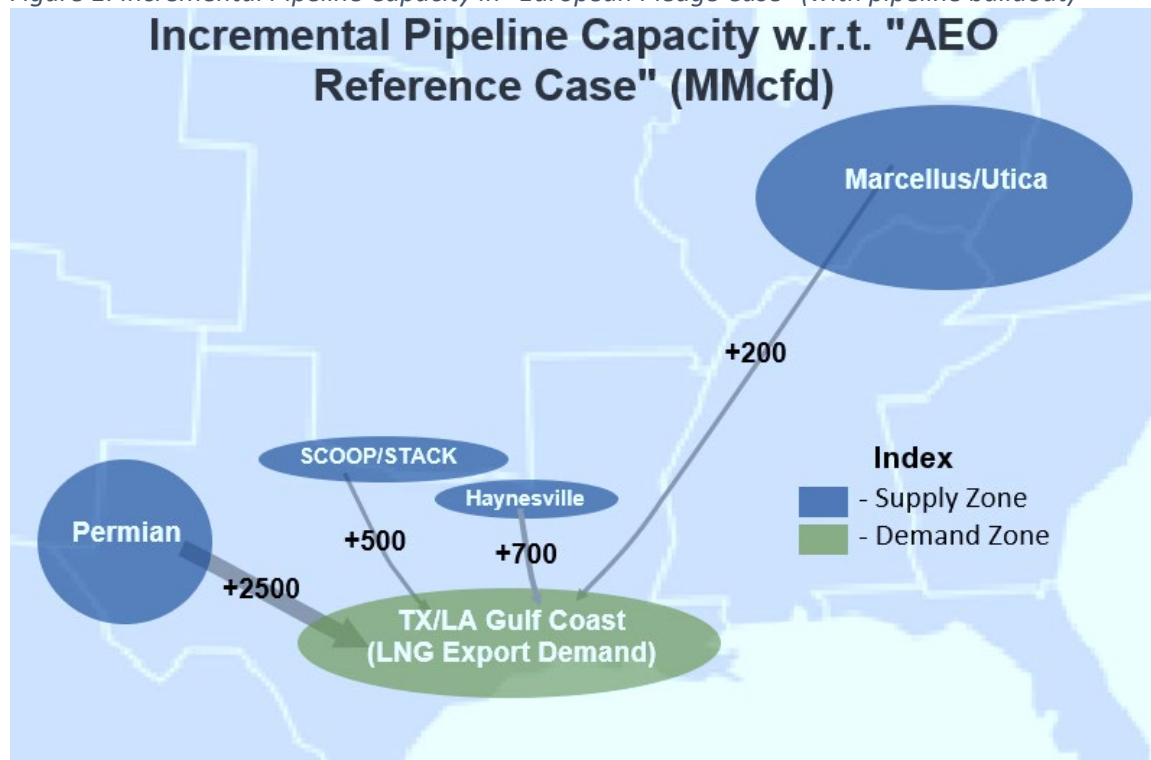
Infrastructure Buildout Results in the “European Pledge Case” (without pipeline buildout)

This case prohibits building inter-state and inter-regional pipelines from major supply hubs across the US towards the Gulf Coast. However, gas pipeline laterals are permitted to connect existing natural gas inter/intra-regional pipelines to the new LNG facilities. Furthermore, gas gathering lines and gas processing plants are also allowed to be built to bring the incremental wellhead gas supply to regional hubs.

Infrastructure Buildout Results in the “European Pledge Case” (with pipeline buildout)

This case includes all the necessary inter-state and inter-regional pipeline infrastructure that would be economically justified to support the added amounts of LNG exports. As shown in Figure 1, ICF’s analysis finds that 3.9 Bcf/day of new natural gas pipeline capacity would be economically justified to meet the added amounts of LNG exports in “European Pledge Case” (with pipeline buildout).

Figure 1: Incremental Pipeline Capacity in "European Pledge Case" (with pipeline buildout)

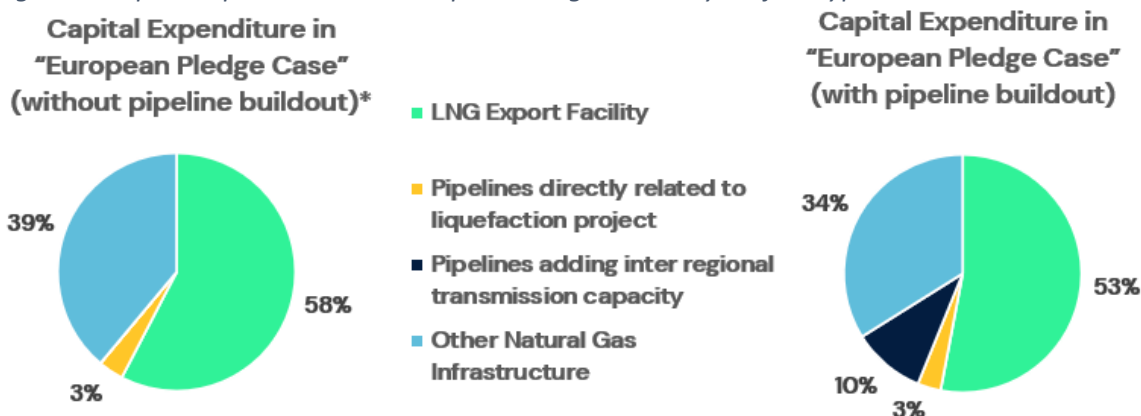


Summary of Capital Expenditure to Facilitate Incremental LNG Exports in the "European Pledge Cases"

Geographically, most of the natural gas infrastructure development will be in the Southwest. The total capital expenditure (CAPEX) is USD 58.0 billion in the case without pipeline buildout and USD 63.1 billion for the pipeline buildout case². In the pipeline buildout scenario, 10% of CAPEX is associated with pipeline projects that connect gas supplies to the inter-state gas transportation system and add inter-regional transmission capacity towards the Gulf Coast. Approximately 53-58% of the above-mentioned CAPEX is associated with building new LNG export facilities; 3% is related to pipeline projects that connect the LNG export facilities with inter/intra-regional pipelines; and 34-39% of the expenditure is associated with gas gathering lines, processing plants, and other midstream infrastructure.

² All capital expenditure estimates are in nominal dollars.

Figure 2: Capital Expenditures in "European Pledge Cases" by Project Type



Key Conclusions for the "European Pledge Case" (with pipeline buildout)

This scenario shows that additional natural gas midstream infrastructure could play a vital role towards price moderation in comparison to the "European Pledge Case" without pipeline buildout. Between 2030 and 2035, natural gas prices at Henry Hub in the scenario with pipeline buildout could average \$4.24/MMBtu³, which is lower than the without pipeline buildout scenario's average price of \$4.38/MMBtu³. Furthermore, ICF estimates that the NPV of the economic benefit of the case with pipeline buildout is greater than USD 30 billion² (nominal) in savings from 2022 to 2045 for gas purchasers.

Employment and GDP Impact for the "European Pledge Case" (with pipeline buildout)

Incremental LNG exports will lead to more employment opportunities and greater GDP gains in the "European Pledge Case" with pipeline buildout. The total CAPEX of USD 63.1 billion² for this case would contribute to GDP and support jobs in engineering, materials, construction, and other industries. The exact economic impacts depend on the design of these facilities and proportion of equipment, materials, and engineering services that are procured from domestic sources. Assuming reasonable values for these parameters, ICF estimates that the direct and indirect GDP contribution from this capital expenditure could be approximately USD 29 billion^{Error! Bookmark not defined.} from 2025 to 2030. Adding in the induced economic activity brings the total GDP impact to USD 46 billion^{Error! Bookmark not defined.} during the same period. The direct and indirect employment impact (including induced jobs) associated with this capital expenditure for liquefaction plants and pipelines could bring additional 429,000 jobs between 2025 and 2030⁴. These estimates 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.

Infrastructure Analysis for the "Extended Cases"

LNG export volumes in the "Extended Cases" increase to 29 Bcf/day by 2030 which is a 90% increase with respect to the 2022 AEO Reference Case. To achieve these export targets, ICF

³ All price estimates are in real 2021 dollars.

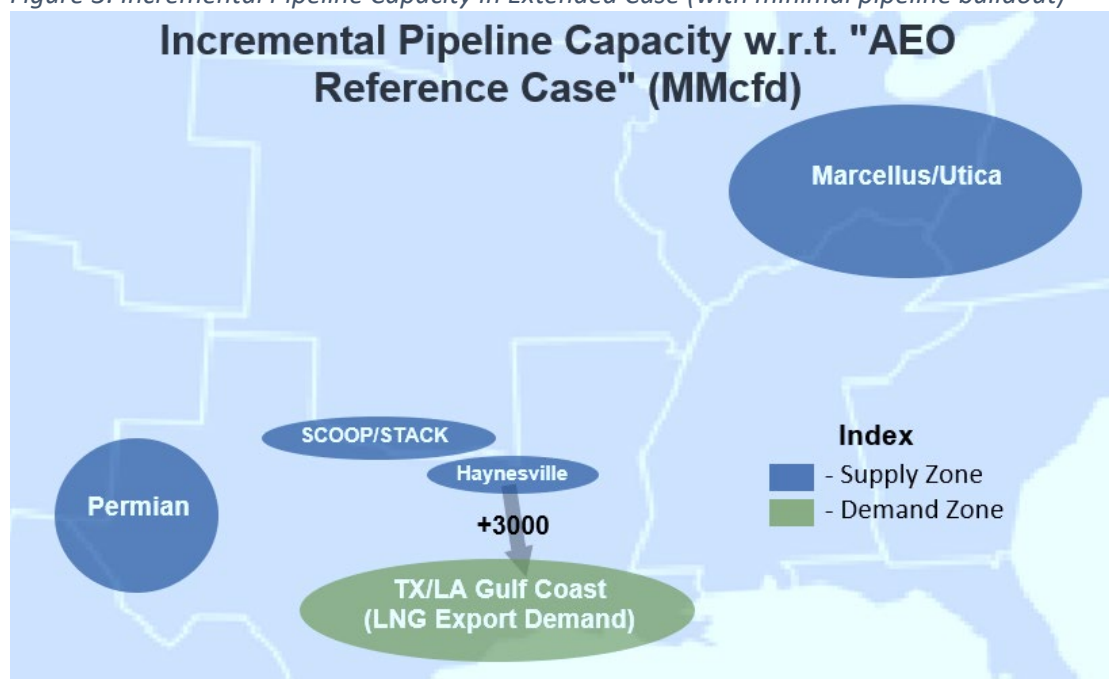
⁴ Jobs have been calculated based on number of job-years which are applicable cumulatively during the period of infrastructure development (2025-2030). Please note that each job corresponds to employment duration of 12-months.

assumes that eight US LNG export terminals will be built and/or expanded over and above the planned LNG facilities in the 2022 AEO Reference Case. As with the other scenarios, these are actual planned liquefaction projects that would be located in the Gulf Coast. These eight LNG export terminals together add an incremental LNG export capacity of 14.7 Bcf/day by 2030. The projected LNG export capacity increases to 31.1 Bcf/day by 2030 which is a 90% increase with respect to the 2022 AEO Reference Case. ICF analyzed the amount of midstream infrastructure that could be built to support this new LNG export capacity using the same infrastructure categories used in the “European Pledge Cases.”

Infrastructure Buildout Results in the “Extended Case” (with minimal pipeline buildout)

This case significantly restricts building long distance inter-state and inter-regional pipelines from major supply hubs across the US towards the Gulf Coast. As shown in Figure 3, this case finds that 3 Bcf/day of pipeline infrastructure could be built from supply hubs immediately around the Gulf Coast. Also, pipeline laterals are built to connect existing natural gas pipelines to the new LNG facilities.

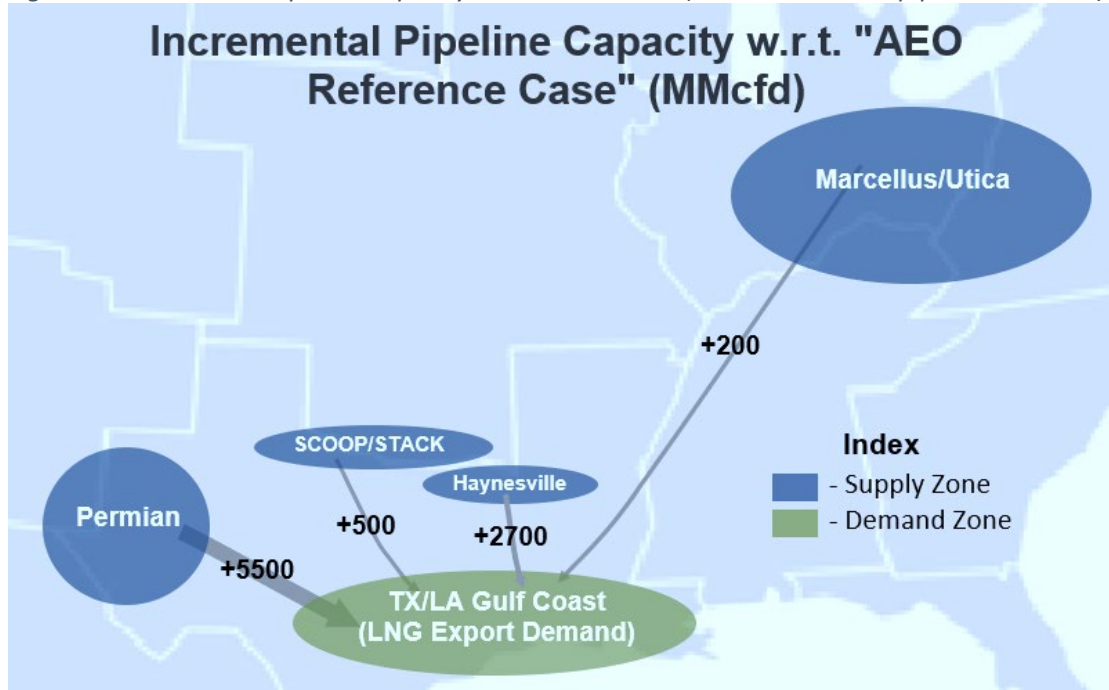
Figure 3: Incremental Pipeline Capacity in Extended Case (with minimal pipeline buildout)



Infrastructure Buildout Results in the “Extended Case” (with constrained pipeline buildout)

This case includes most of the economically justified inter-state and inter-regional pipeline infrastructure required to meet the added amounts of LNG exports but still avoids building pipeline infrastructure from the Marcellus/Utica region towards the Gulf Coast. Under these assumptions, ICF’s natural gas market analysis concludes that 8.9 Bcf/day of new natural gas pipeline capacity could be economically built beyond the 2022 AEO Reference Case to meet the additional LNG export demand, as shown in Figure 4.

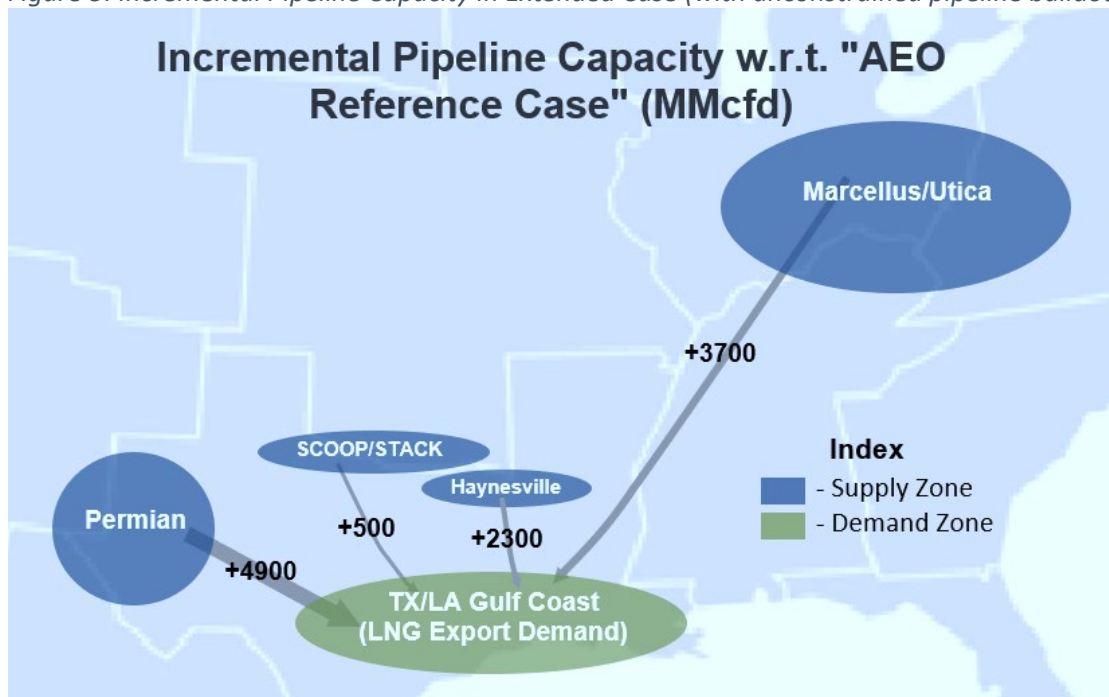
Figure 4: Incremental Pipeline Capacity in Extended Case (with constrained pipeline buildout)



Infrastructure Buildout Results in the "Extended Case" (with unconstrained pipeline buildout)

This case includes all the economically justified inter-state and inter-regional pipeline infrastructure required to meet the added amounts of LNG exports including builds from the Marcellus/Utica region towards the Gulf Coast. As shown in Figure 5, ICF's natural gas market analysis finds that 11.4 Bcf/day of new natural gas pipeline capacity could be built beyond the 2022 AEO Reference Case under this case.

Figure 5: Incremental Pipeline Capacity in Extended Case (with unconstrained pipeline buildout)



Key Conclusions for the “Extended Case” Scenarios

As was true for the “European Pledge” sensitivity analyses, ICF concludes that additional natural gas midstream infrastructure could play a vital role in moderating natural gas commodity price increases in the “Extended Cases.” Between 2027 and 2032, natural gas prices at Henry Hub in the constrained pipeline buildout scenario could average \$0.28/MMBtu³ lower than the minimal pipeline buildout case’s average price. Furthermore, natural gas prices at Henry Hub in unconstrained pipeline buildout scenario could average \$0.64/MMBtu³ lower than the minimal pipeline buildout case’s average price within the same period.

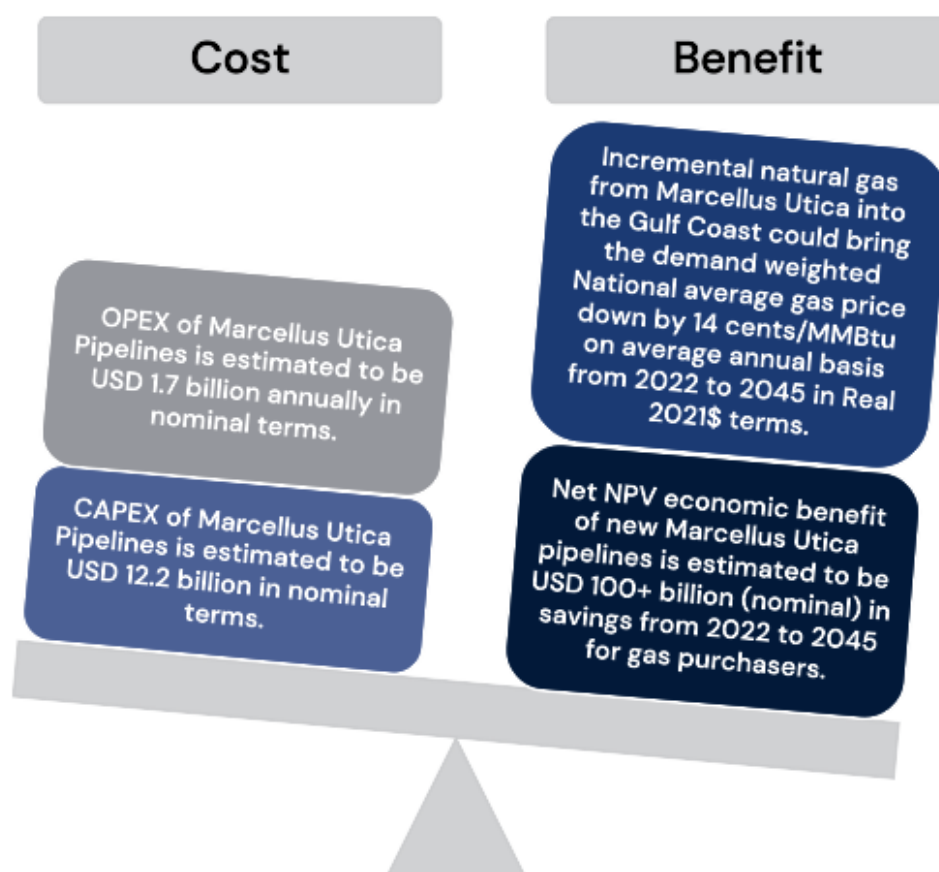
Compared to the minimal buildout sensitivity case, ICF estimates that the NPV of the economic benefit of the case with constrained pipeline buildout is over USD 80 billion² (nominal), measured as savings from 2022 to 2045 for gas purchasers. For the unconstrained pipeline buildout sensitivity case that allows capacity from the Marcellus/Utica, the NPV of the economic benefit within the same timeframe is estimated to be over USD 180 billion² (nominal) compared to gas consumer costs in the minimal buildout sensitivity case.

Cost-Benefit Analysis of Pipeline Infrastructure Built from the Marcellus/Utica Region

Building a new pipeline along the full distance from the Marcellus/Utica region towards the Gulf Coast would be very capital intensive. In order to overcome this financial hurdle, pipeline companies would leverage the bilateral capacity on existing pipeline infrastructure between the Marcellus/Utica region and the Gulf Coast. Therefore, as part of the “Extended Case” (with unconstrained pipeline buildout), ICF expects that supply laterals could be built from the Marcellus/Utica region towards existing inter-state pipelines with southbound capacity towards the Gulf Coast. Furthermore, compressor stations and other pipeline equipment would be modified along the existing inter-state pipelines to facilitate incremental southbound flows towards the Gulf Coast.

Figure 6 illustrates the costs and benefits associated with building pipelines from the Marcellus/Utica towards the Gulf Coast in the unconstrained pipeline buildout case with respect to the constrained pipeline buildout case. Even though the pipelines from the Marcellus/Utica would have USD 12.2 billion capital costs and an annual operating cost of USD 1.7 billion, they would allow less expensive gas to be produced in the region and be delivered to the Gulf Coast. This would help lower demand weighted national average gas prices by USD 0.14/MMBtu, and lead to NPV economic benefit of USD 100 billion from 2022 to 2045.

Figure 6: Cost-Benefit Analysis of Marcellus-Utica Pipeline Infrastructure



Evolution of Regional Natural Gas Markets across North America in the “European Pledge Cases” and “Extended Cases”

In the “European Pledge Cases” and “Extended Cases,” incremental LNG export demand is expected to be located in the Gulf Coast in Texas and Louisiana. However, this increase in demand could create upward pressure on natural gas prices throughout the US. The upward pressure on natural gas prices could prompt upstream oil and natural gas companies operating in the surrounding supply basins to increase drilling activity to meet the incremental demand from the Gulf Coast and somewhat mitigated those price increases.

In the near term, when the new LNG export facilities are coming online and LNG export volumes are ramping up between 2025 and 2030, US natural gas production could lag the new demand from the Gulf Coast for LNG exports. As a result, the US natural gas industry might experience shifts in natural gas pipeline flows, as additional natural gas produced in major basins like the Haynesville on the Texas/Louisiana border, the Permian in West Texas, Eagle Ford in East Texas, the SCOOP/STACK in Oklahoma, and the Marcellus/Utica in Pennsylvania, Ohio, and West Virginia makes its way into the Gulf Coast. Pipeline imports from Canada might also increase to balance the natural gas pipeline flows across the US and could capture a greater proportion of domestic demand in Northeastern markets like New England, New York, and New Jersey. As pipeline imports from Canada increase, upward pressure on gas prices could be experienced in

Canadian regional markets as well. The upward pressure in natural gas prices across Canada would prompt Canadian upstream companies to also increase drilling activity to meet incremental demand for pipeline exports from Canada to the US.

Post-2030, when all the LNG export facilities are online and LNG export volumes are no longer ramping up, gas supply would be expected to catch-up with demand growth, moderating regional gas prices across the US. Both US and Canadian natural gas would contribute to this supply increase.

Concluding Statement

Table 1: Summary of findings in “European Pledge Cases” and “Extended Cases” with and without pipeline buildout illustrates the costs and benefits associated with various trade scenarios. Between the two “European Pledge Cases,” ICF concludes that building 3.9 Bcf/day of inter/intra-regional pipeline capacity could decrease natural gas prices at Henry Hub by \$0.14/MMBtu during the five-year period when the economic impact from rising LNG export volumes is expected to be greatest. Between 2022 and 2045, the lower natural gas prices that result from building the additional midstream infrastructure could translate into over USD 30 billion in cumulative savings for natural gas purchasers with respect to the no pipeline buildout case. For the two “Extended Cases,” building 11.4 Bcf/day of inter/intra-regional pipeline capacity in the unconstrained pipeline buildout case shows a similar potential to lower natural gas prices at Henry Hub by \$0.64/MMBtu during the five-year period when the economic impact from rising LNG export volumes is expected to be greatest. In this case, new midstream infrastructure could translate to over USD 180 billion in cumulative savings for gas purchasers between 2022 and 2045 compared to the minimal pipeline buildout case.

A robust reserve of economically recoverable oil and natural gas resources across the US and Canada and the capability of upstream industry to efficiently tap into those resources to ramp up natural gas production to meet incremental demand requirements in the Gulf Coast, play a pivotal role in moderating the natural gas price environment for both the “European Pledge Cases” and “Extended Cases.”

The level of midstream infrastructure development determines the ease with which incremental natural gas production from supply basins can be transported to the Gulf Coast and makes natural gas produced at all supply basins more accessible. This would lead to a smaller impact on natural gas prices at trading hubs across North America and a smaller impact on natural gas consumers. The greater investment in midstream infrastructure development would also lead to employment opportunities across the US in engineering, materials, construction, and other industries, and result in greater GDP gains.

Table 1: Summary of Findings in the “European Pledge Cases” and “Extended Cases” with and without Pipeline Buildout

Trade Scenario	Added US LNG Exports (bcfd)	Pipeline Constraint Sensitivity	Inter-regional Pipeline Built (bcfd capacity)	Capital Expenditures on Inter-regional Pipelines (in billion)	Total Capital Expenditures (in billion)	Relative Henry Hub Prices in 5-year period with Maximum Economic Impact (\$/MMBtu)	Cumulative Savings for Gas Purchasers (in billion)
European Pledge Cases	4.8	Without pipeline buildout	-	-	USD 58.0	-	-
		With unconstrained 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	USD 3.3	USD 169.0	-	-
		With constrained pipeline buildout	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

Notes for table: All capital expenditure estimates are in nominal dollars. Total capital expenditures include liquefaction plants, gathering lines, processing plants, and pipelines. All price estimates are in real 2021 dollars. Cumulative savings for gas purchasers is with respect to no or minimal pipeline buildout sensitivity cases between 2022 and 2045.