



The Role of Natural Gas in the Transition to a Low-Carbon Economy

Executive Summary of the INGAA Foundation Flagship Study

BUILDING A WORLD OF DIFFERENCE®



Black & Veatch Management Consulting, LLC

INGAA Foundation Flagship Study Objectives

Renewable Generation Growth

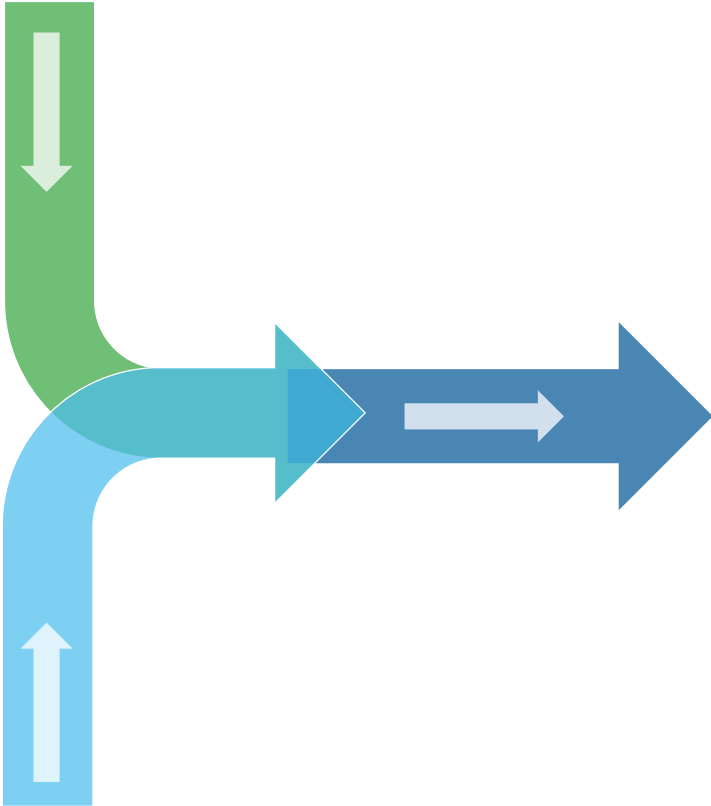
Growth in renewable generation has increased the need for dispatchable generation capacity that can quickly ramp up and down, altering the amount, timing and duration of natural gas needed to support the power generation sector.

How will pipelines and storage facilities be utilized to facilitate renewable energy growth?

Global Gas Market

North America’s entrance to the global LNG and energy market is expected to continue to grow over the analysis period and have a sustained impact on future natural gas infrastructure needs.

How much incremental infrastructure and intra-day services will be needed to support the LNG and pipeline export growth?



Future Roles for Natural Gas

The INGAA Foundation is seeking to understand the future roles of natural gas and natural gas infrastructure in a lower carbon economy for a 20-year analysis period and the challenges and opportunities for the natural gas industry to fulfill these roles.



Jointly Developed by The INGAA Foundation and Black & Veatch Management Consulting, LLC

The INGAA Foundation thanks the Flagship study steering committee for its oversight and guidance.

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The INGAA Foundation, Inc.



Brief Overview of Black & Veatch



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and water industries.



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in 110+ offices.



\$3.5 Billion

revenue in 2018



7,000 Active Projects

worldwide on six
continents.



100+ Years

experience.
Founded in 1915.





Today's Discussion

- **Current Roles of Natural Gas**
- **Study Scenarios**
- **Key Findings & Opportunities for Natural Gas**
- **Questions**



Current Roles of Natural Gas

RESIDENTIAL & COMMERCIAL



- Residential and commercial customer growth remains steady at 0.98% CAGR and 0.42% CAGR, respectively over the past 10 years.
- Low and stable gas supply costs combined with high conversions costs will continue to make electrification initiatives challenging

INDUSTRIAL



- Industrial use remains over 30% of the US gas demand
- Low natural gas prices reduce the cost to manufacture plastics and chemicals, making US petrochemical industry more competitive in the international marketplace

Current Roles of Natural Gas

POWER GENERATION



- Natural gas-fired generation accounted for 36 percent of the total generation mix in 2018
- Recent growth attributed to the retirement of coal and oil-based generation resources, reduced 60% of CO₂ from the electric sector between 2005 and 2017.¹

EXPORTS

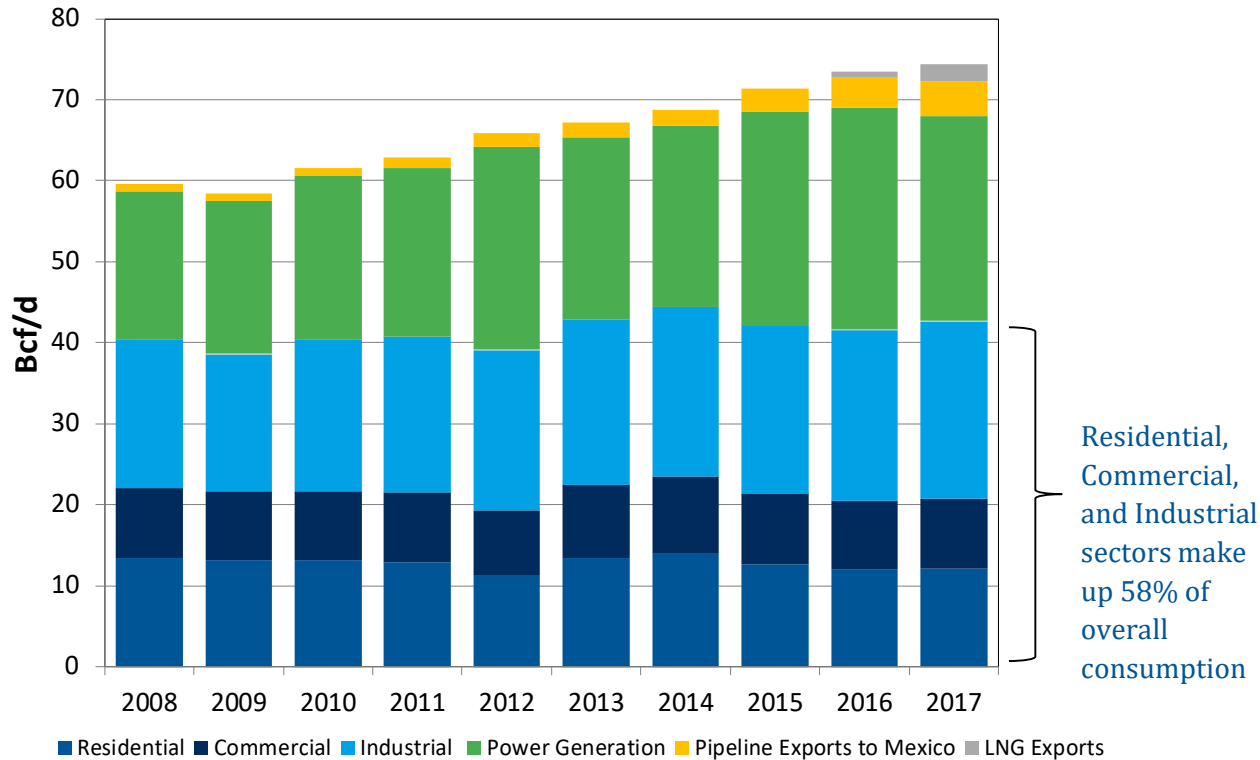


- Pipeline exports to Mexico and LNG exports have represented growth sectors for natural gas, responsible for 48% of pipeline capacity additions over the past 6 years

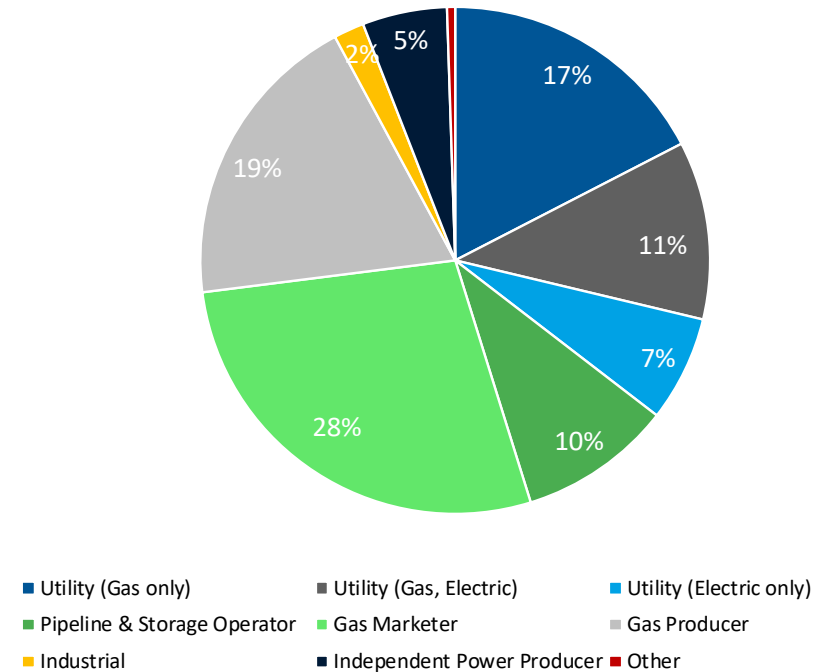
¹ https://www.eia.gov/environment/emissions/carbon/pdf/2017_co2analysis.pdf

Current Roles of Natural Gas and Interstate Pipelines

Historical Natural Gas Consumption by Sector (2008-2017)



FERC Gas Transmission Capacity Holder (% of MDQ)





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Black & Veatch Examined Two Possible Scenarios for Transitioning to a Low-Carbon Economy

Balanced Future

Sustained/steady transition to a low carbon economy



- ✓ RPS goals met on schedule
- ✓ Sustained growth of battery storage additions to meet mandates
- ✓ Strong second wave of LNG and pipeline exports
- ✓ Economic based investment decisions

Rapid Renewables Transition

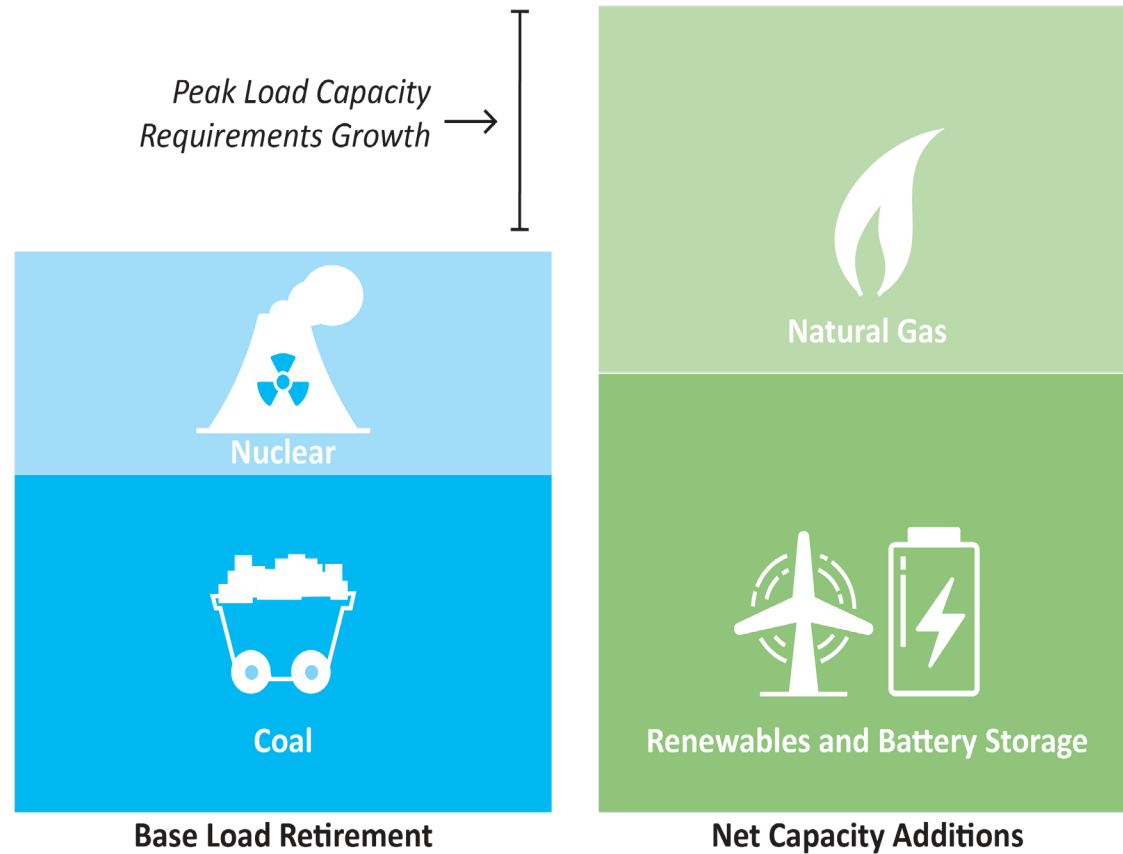
Global acceleration to carbon reduction



- ✓ Minimum 50% RPS targets
- ✓ Accelerated battery storage growth
- ✓ Operational and under construction LNG terminals only
- ✓ Policy or technology driven investment decisions



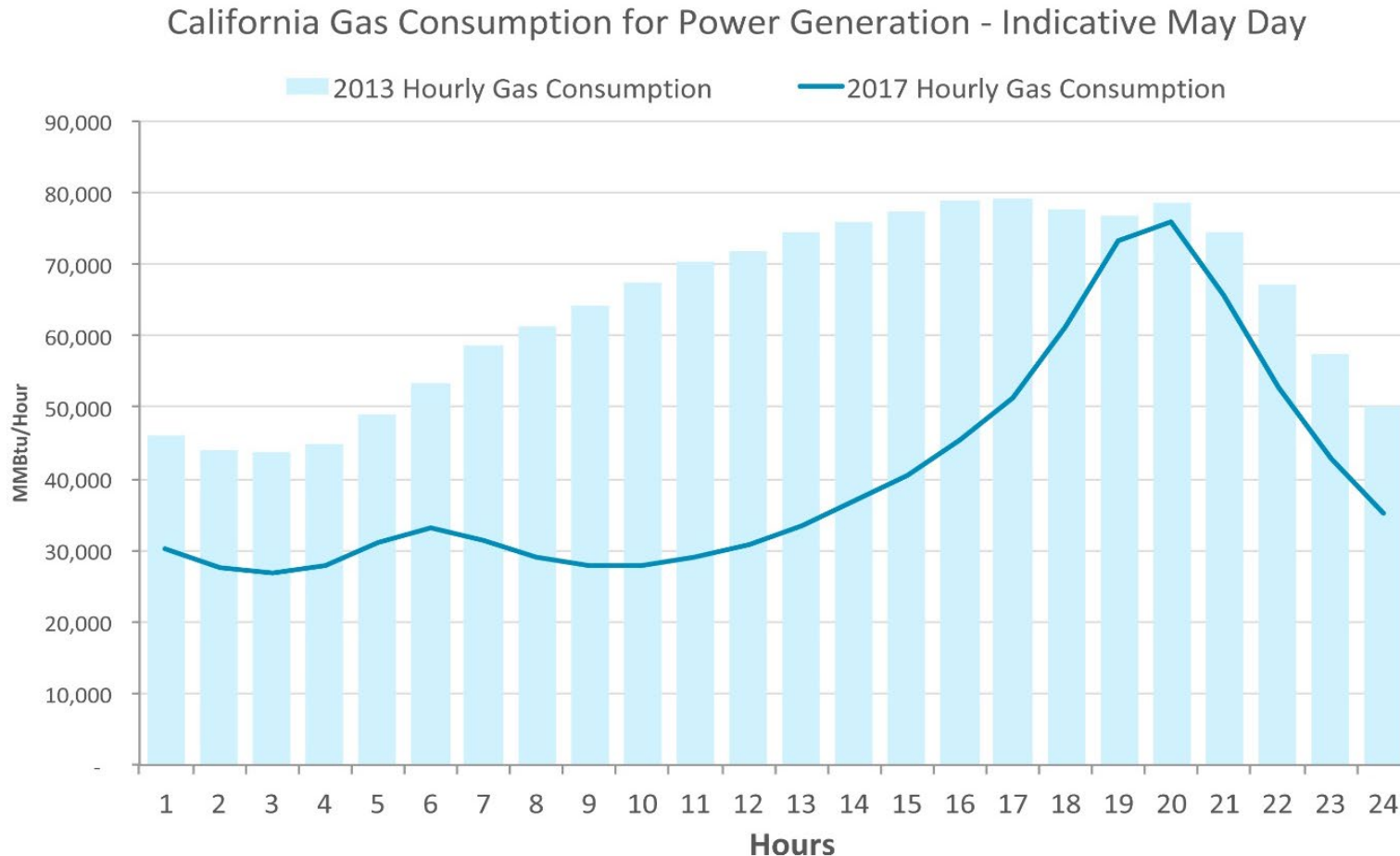
Key Drivers: Retiring Coal and Nuclear Power Generation Capacity in the Next 20 Years



- 82 GW of coal capacity will be retired between 2020 and 2040 because of economic pressures and operators' strategic portfolio realignment
- Nuclear power plants accounting for 48 GW of capacity will reach the end of their 60-year operating licenses during this period.
- Natural gas will continue to play an essential role in replacing this base load capacity



Key Drivers: Growing Renewables Change the Nature of Gas Consumption and Infrastructure Needs

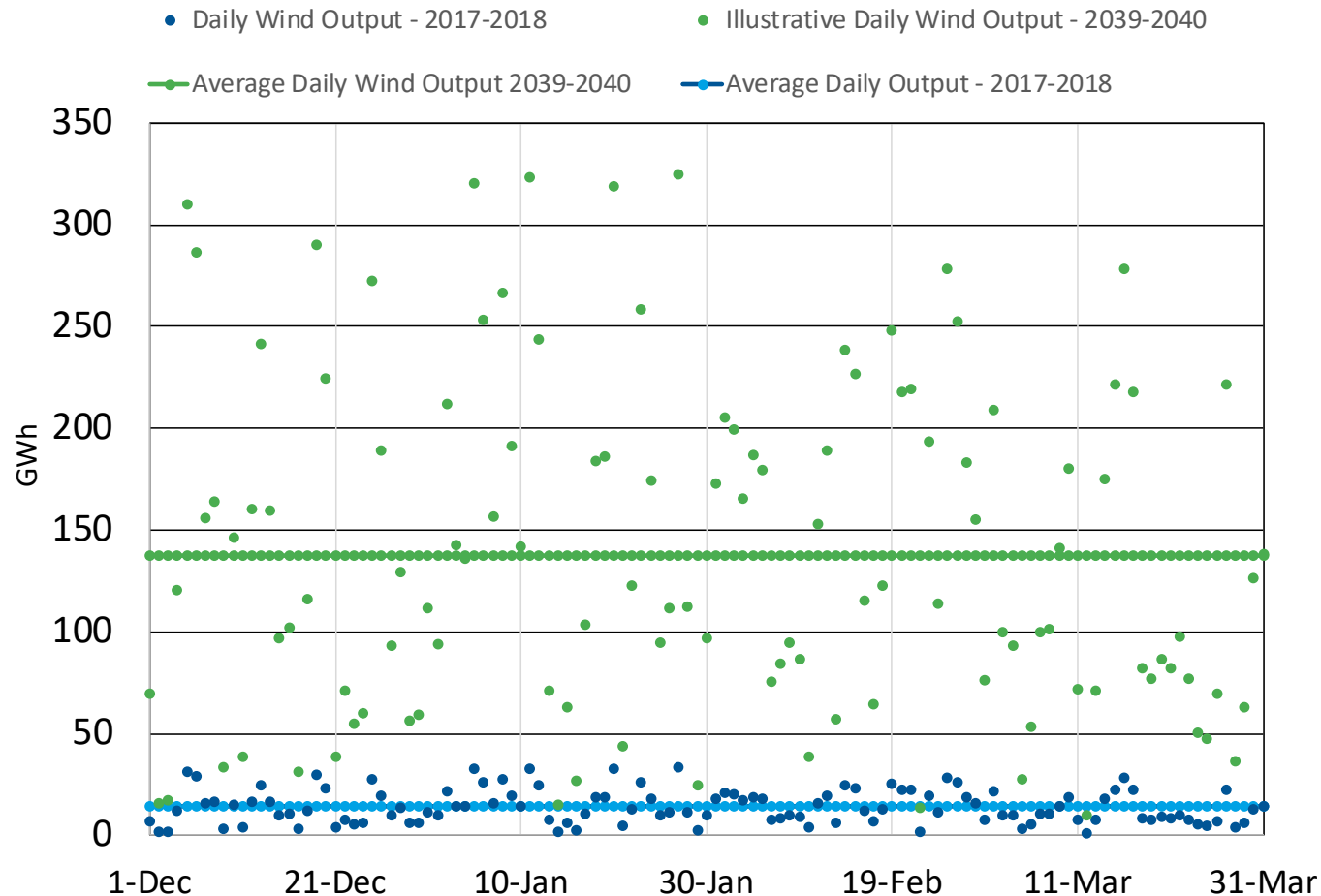


- **Dramatic increase in the late afternoon ramping requirements when electric demand is high, but the availability of solar generation declines**



Key Drivers: Growing Dependency on Wind Generation Will Lead to Larger Daily Swings in Dispatchable Energy Needs

Historical and Projected Daily NYISO Wind Output

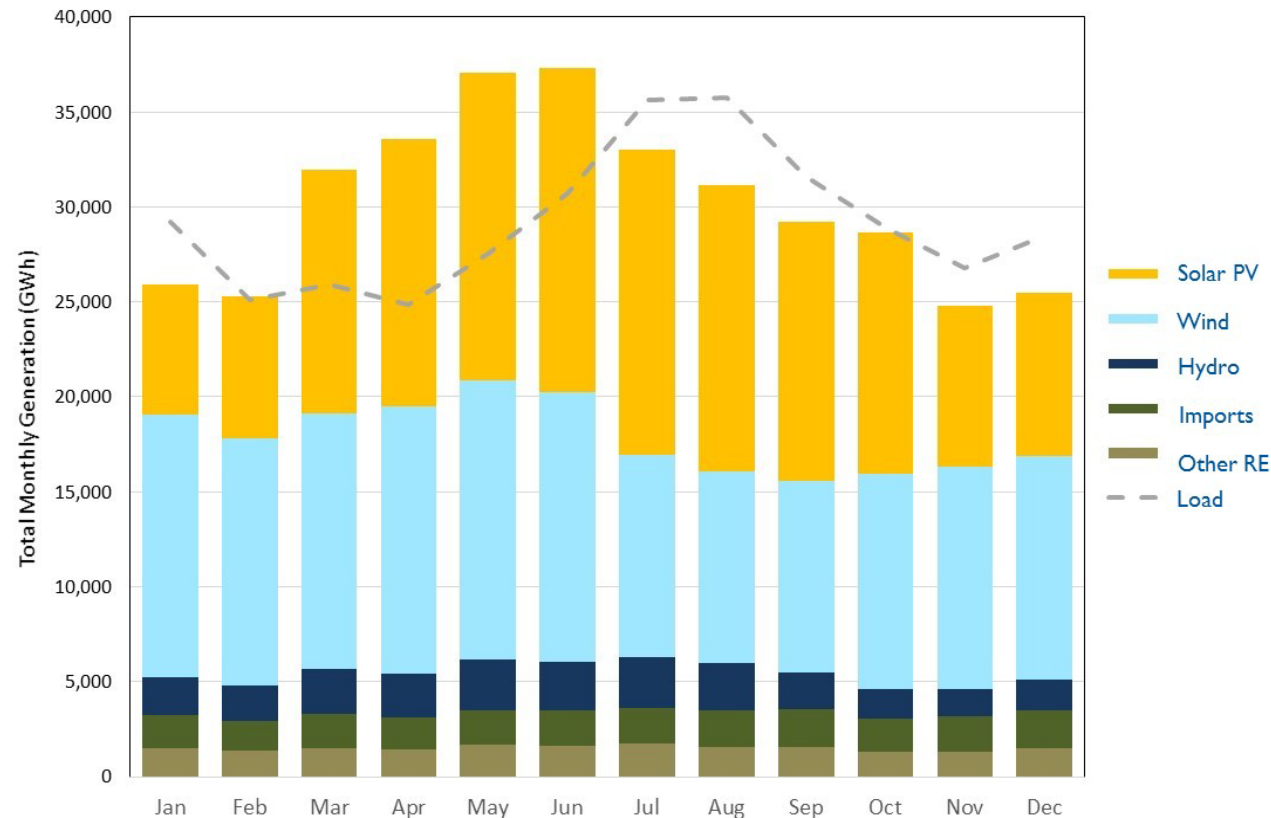


- In 2017-2018, wind contributed 10.7 GWh or 3% of electricity generated for the day
- By 2040, average daily wind generation could reach 138 GWh during the same peak winter months, representing over 40 percent of electricity generated for the day.
- The day-to-day output could easily range from 70 GWh to 210 GWh.

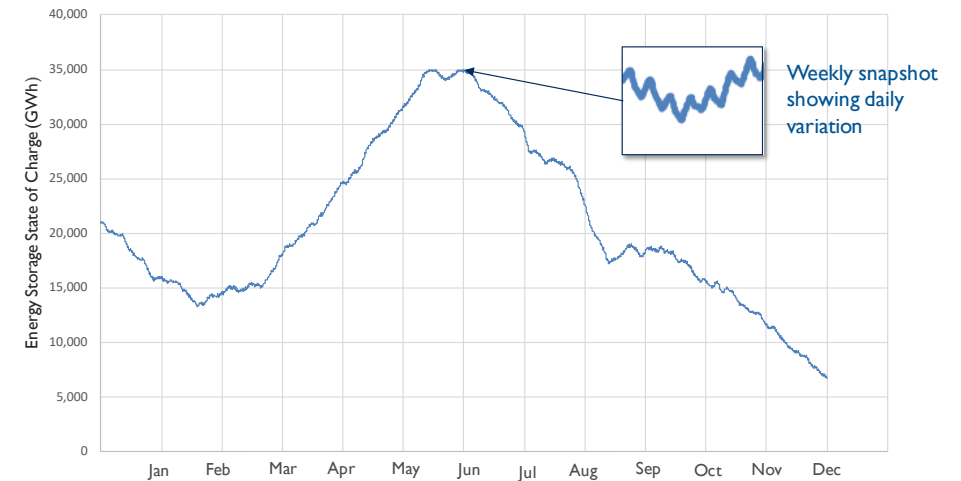


Key Drivers: Misalignment of Renewable Resources Will Necessitate Seasonal Energy Storage - Beyond the Current Battery Storage Capabilities

California Renewable Energy and Load Balance - 2045



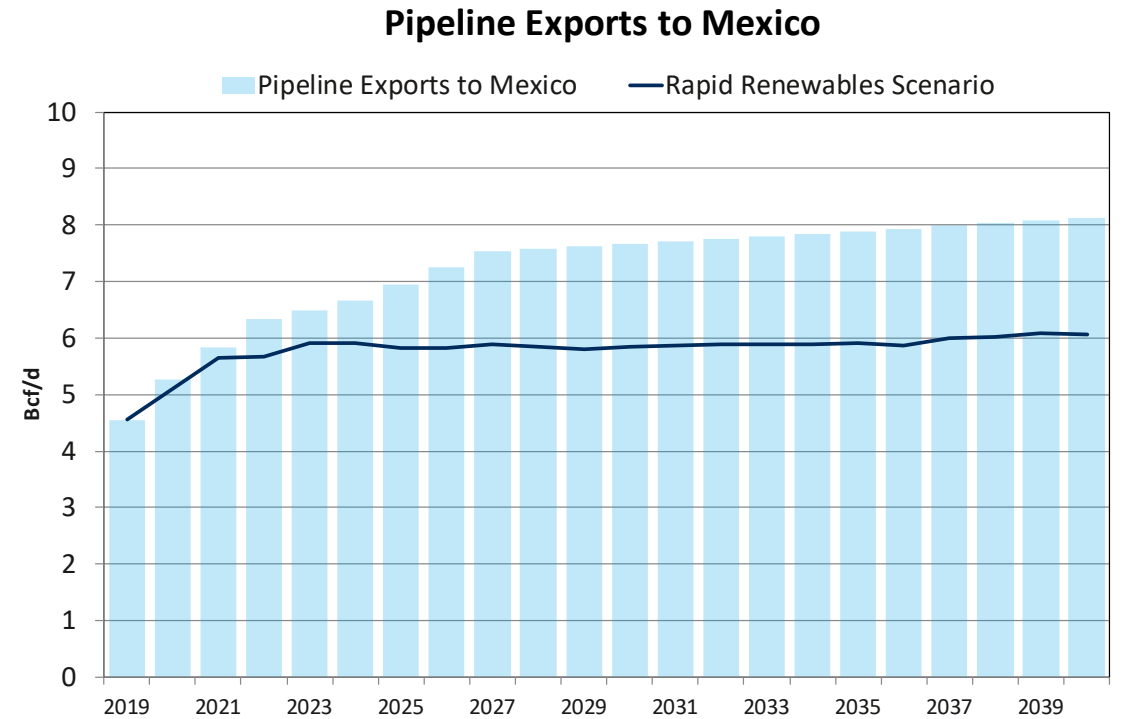
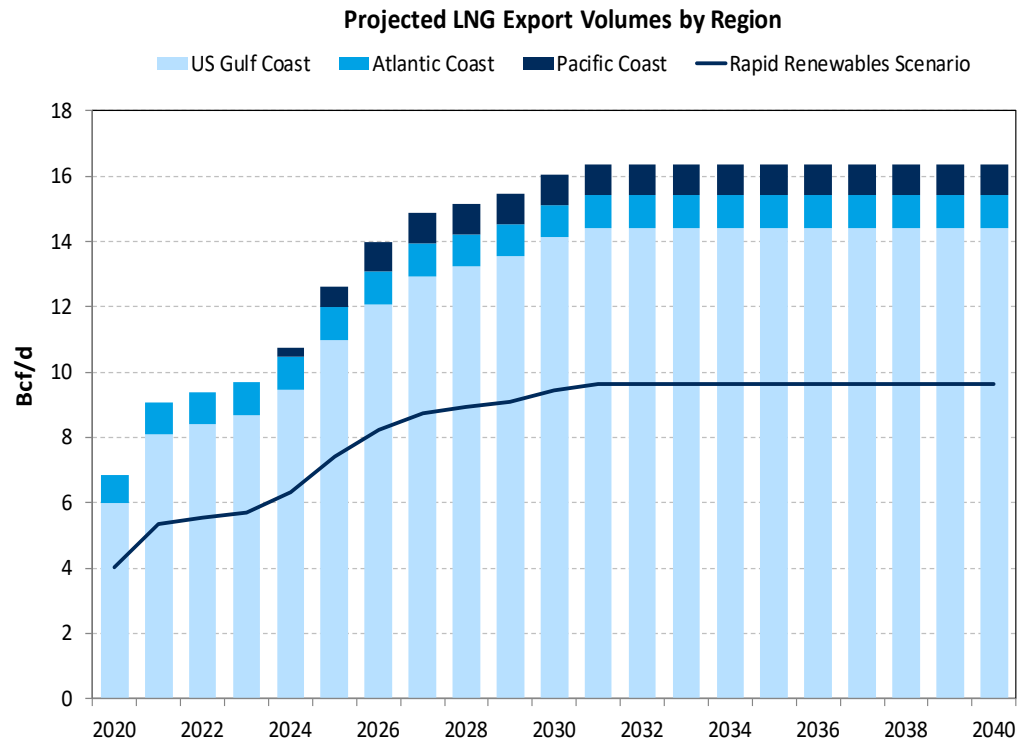
Seasonal Energy Storage



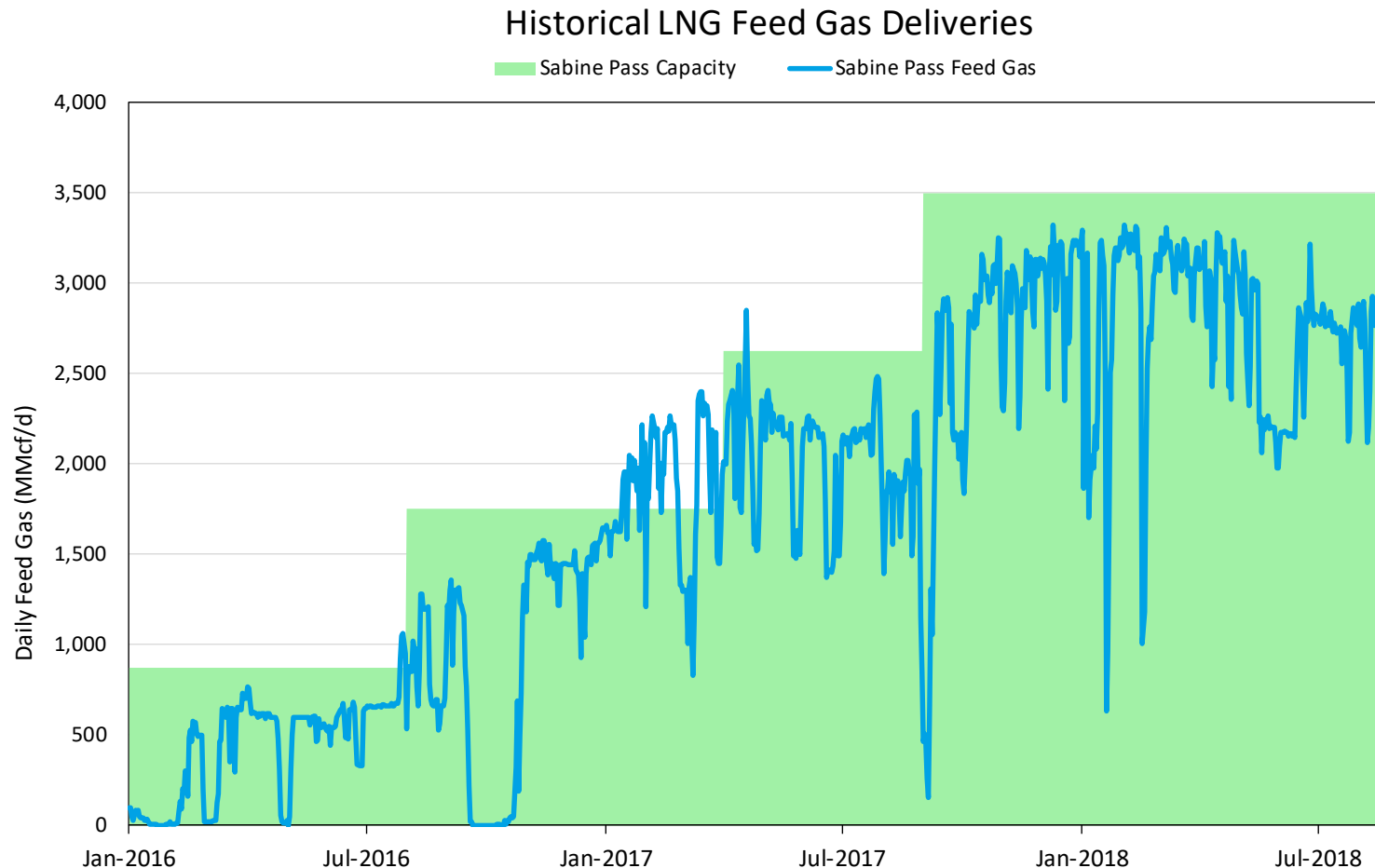
- Energy storage will remain more expensive than gas peaking capacity
- Capacity degradation remains a challenge



Key Drivers: LNG Exports and Pipeline Exports to Mexico Expected to Drive Incremental Pipeline Needs



Key Drivers: LNG Export Facilities Will Require Additional Flexibility to Mitigate Train Trips and Major Weather Events



- An onshore gas turbine driven LNG facility is expected to be available ~96.5% of the year
- There can be significant variations in daily gas needs driven by train trips, weather or seasonality of demand
- Flexible services are needed to help manage and mitigate the variability in feed gas needs





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Summary of Key Findings



In the Balanced Future Scenario:

- ✓ Highly efficient natural gas-fired power generation will be an important replacement for retiring coal and nuclear generation baseload capacity.
- ✓ U.S. natural gas demand is expected to grow significantly from LNG exports and exports to Mexico.
- Existing natural gas pipeline infrastructure will continue to experience increased utilization, and incremental infrastructure of 21 Bcf/d will be needed regionally to meet demand growth over the next 20 years.
- ✓ Natural gas pipelines that can provide flexible services to LNG terminals and power generators will create growth opportunities for the natural gas industry.

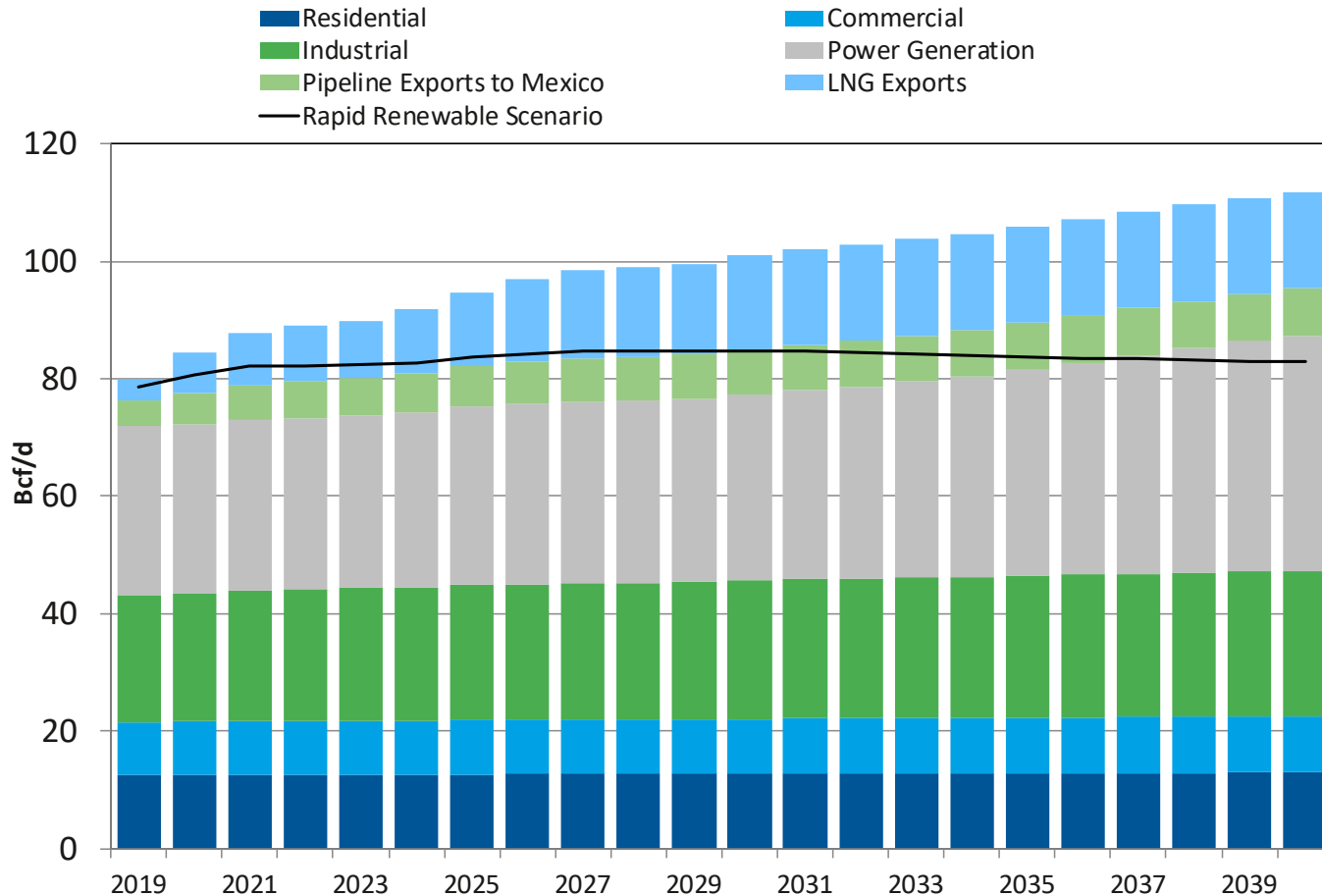


In the Rapid Renewables Transition Scenario:

- ✓ The electric generation resource mix will be more uncertain on a day-to-day basis.
- ✓ LNG exports and pipeline exports to Mexico will continue to utilize the existing gas pipeline transportation network at high load factors.
- ✓ Residential, commercial, and industrial demand remain close to 50 percent of the total US consumption by 2040.
- ✓ Natural gas demand will be sustained at current consumption levels. Existing natural gas infrastructure continues to be utilized, and selective new infrastructure will be needed.



Forecasted Future Needs: Gas Opportunities led by LNG Exports, Pipeline Exports to Mexico, and Power Generation

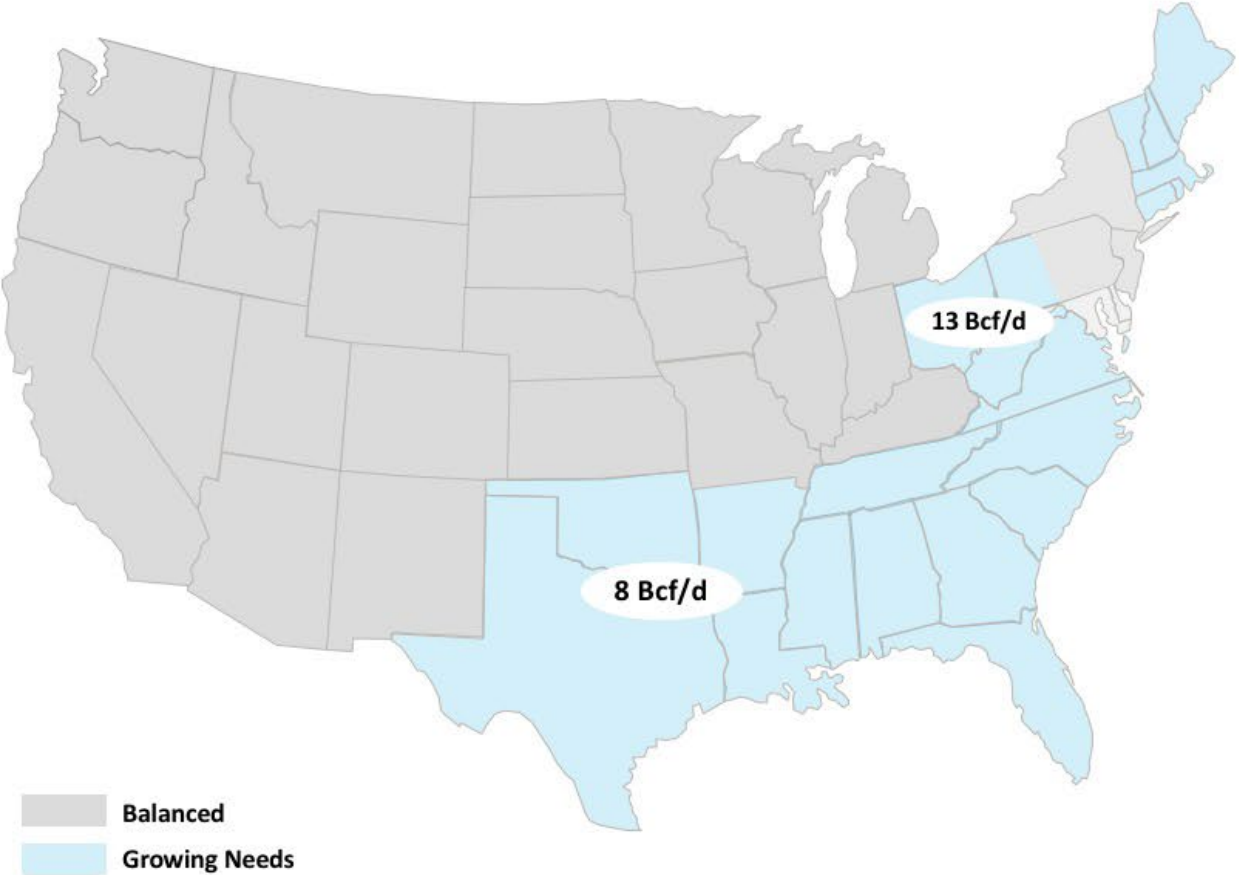


Balanced Future			
Demand By Sector	2020	2030	2040
Residential	12.6	12.8	13.0
Commercial	9.0	9.3	9.6
Industrial	21.9	23.6	24.7
Power Generation	28.7	31.7	40.0
LNG Exports	6.9	16.1	16.3
Pipeline Exports to Mexico	5.3	7.7	8.1
Total (Bcf/d)	84	101	112

Rapid Renewables Transition			
Demand By Sector	2020	2030	2040
Residential	12.6	12.2	11.9
Commercial	9.0	8.7	8.5
Industrial	21.6	21.2	20.8
Power Generation	28.5	27.4	25.9
LNG Exports	4.0	9.4	9.6
Pipeline Exports to Mexico	5.1	5.8	6.1
Total (Bcf/d)	81	85	83



Balanced Future - Regions with Growing Infrastructure Needs

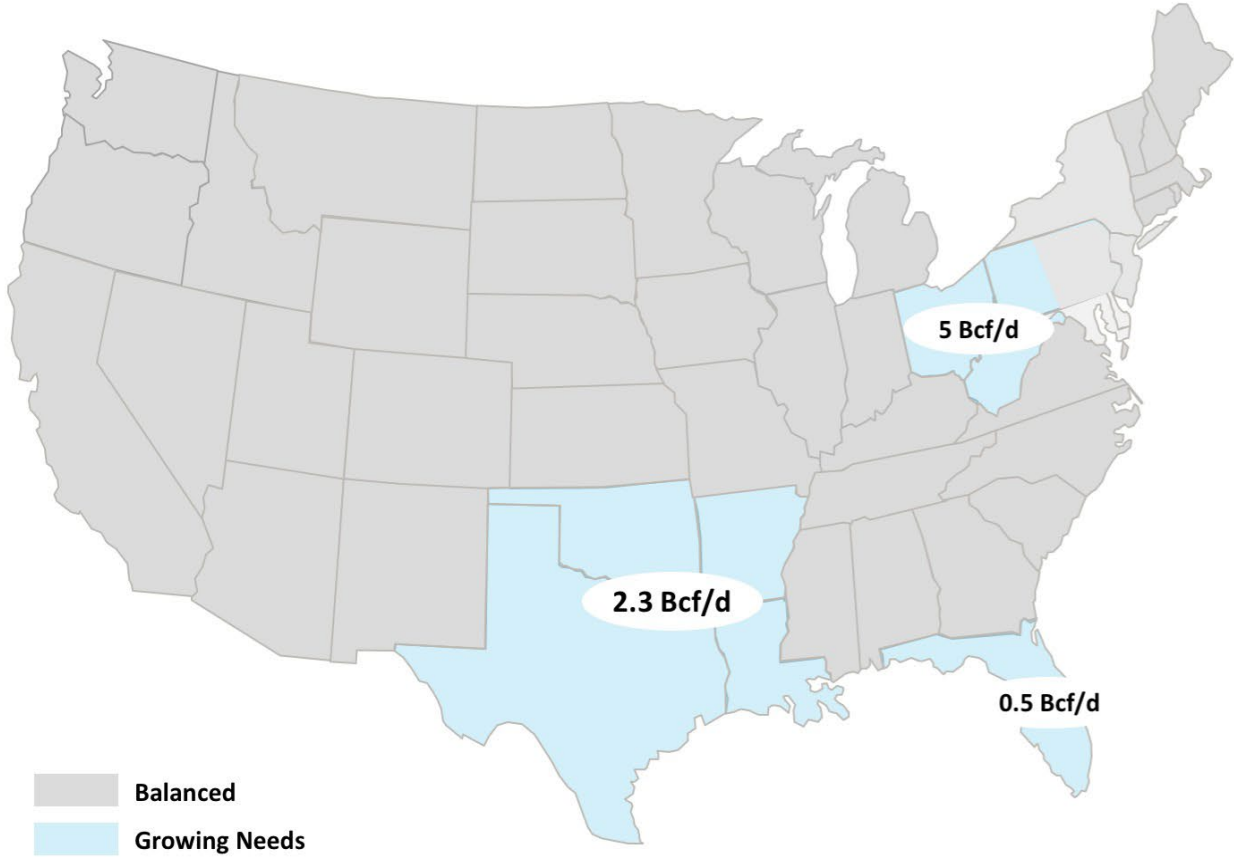


Capacity Additions (Bcf/d)	2020-2025	2026-2030	2031-2035	2036-2040
Marcellus/Utica	5.0	3.0	3.3	2.0
Destination Market				
Gulf Coast	4.0	2.0	2.0	1.0
Southeast	1.0	0.5	0.5	1.0
New England	0.0	0.0	0.3	0.0
Florida	0.0	0.5	0.5	0.0

Capacity Additions (Bcf/d)	2020-2025	2026-2030	2031-2035	2036-2040
Permian Capacity	3.0	2.0	1.5	1.5
Destination Market				
Gulf Coast	2.5	1.5	1.0	1.0
Mexico	0.5	0.5	0.5	0.5



Rapid Renewables Transition - Regions with Growing Infrastructure Needs



Capacity Additions (Bcf/d)	2020-2025	2026-2030	2031-2035	2036-2040
Marcellus/Utica	2.0	1.0	1.0	1.0
Destination Market				
Gulf Coast	2.0	1.0	0.5	1.0
Florida	0.0	0.0	0.5	0.0

Capacity Additions (Bcf/d)	2020-2025	2026-2030	2031-2035	2036-2040
Permian Capacity	0.75	0.75	0.75	0.0
Destination Market				
Gulf Coast	0.75	0.75	0.75	0.0
Mexico	0.0	0.0	0.0	0.0

Additional Opportunities for Natural Gas

ADDITIONAL OPPORTUNITIES

UNDERLYING TREND

Small-Scale Gas Transportation Services:

- LNG Trucking
- Distributed Generation/Microgrids
- Non-Utility Customers

New potential customers or value chain to serve may result from trends favoring distributed generation and transportation.

LNG Hourly/Daily Balancing or Supply Put Option

LNG terminals will require additional midstream services to handle train trips, weather or other factors impacting feed gas to the terminal.

Hourly Rate Structure to Account for Variability & Time of Use

Hourly rate structure that will allow pipelines to allocate costs based on when customers need gas supply the most and to the customers who need it the most.

Alternatively, pipelines should be permitted to price based on the value of the service instead of the cost to provide the service.

Renewable Reliability Service

Gas generation remains a competitive solution to manage renewable variability.

Pricing options for differentiated, high-value reactive load following products can be explored.



Conclusions

- **Uncertainty about the future is not new for natural gas or any other energy source - Over the next two decades, global market forces and regional policy initiatives may change how we think about the role of natural gas**
- **Natural gas pipeline infrastructure is expected to continue serving both traditional sectors like residential, commercial, and industrial, and evolving sectors like power generation, LNG exports and pipeline exports**
 - **Rising gas demand and production levels could spur the need for new gas pipeline infrastructure of up to 21 Bcf/d**
- **Evolving demand requires flexible, dispatchable services that support the journey towards a lower carbon economy and a global gas market – opportunities for gas lie in facilitating this journey**
- **Safe, economic and flexible natural gas will remain a significant contributor to the energy portfolio and economic growth of the United States**



Questions

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Thank You

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