Energy Industry Fundamentals

Natural Gas 201: Supply, Consumption, Production, Operations, and Pricing

Eric Burgis, Energy Solutions Center

This unit is part of Energy Solutions Center's: Energy Industry Fundamentals Training Program

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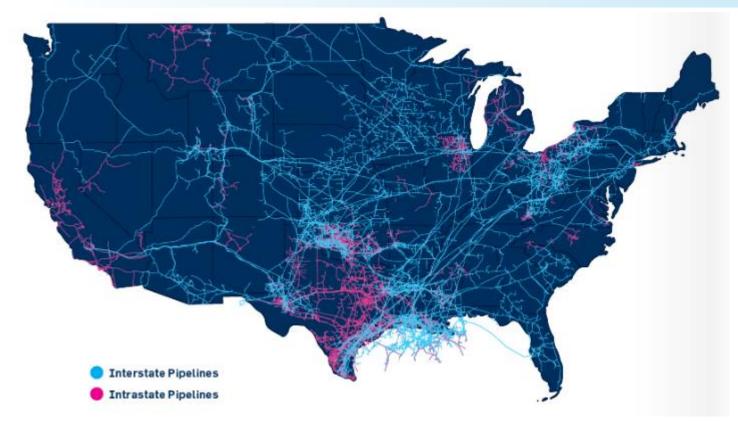
Presentation Outline

- Supply
- Distribution
- Natural Gas Consumption
- Production
- Pipeline Operation
- Pricing
- Metering
- LNG Exports

Natural Gas Supply
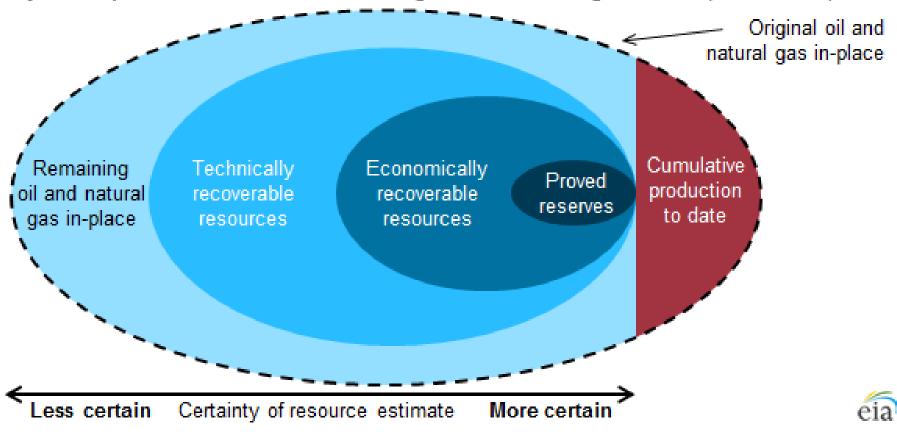
Interstate Pipeline Network

Interstate Pipelines
Intrastate Pipelines

- 2.6 million mile underground system

- ~2.2 million LDC, ~300,000 Transmission

Source: AGA Playbook

Resources & Certainty

Stylized representation of oil and natural gas resource categorizations (not to scale)

Original oil and natural gas in-place

Remaining oil and natural gas in-place

Technically recoverable resources

Economically recoverable resources

Proved reserves

Cumulative production to date

Less certain   Certainty of resource estimate   More certain
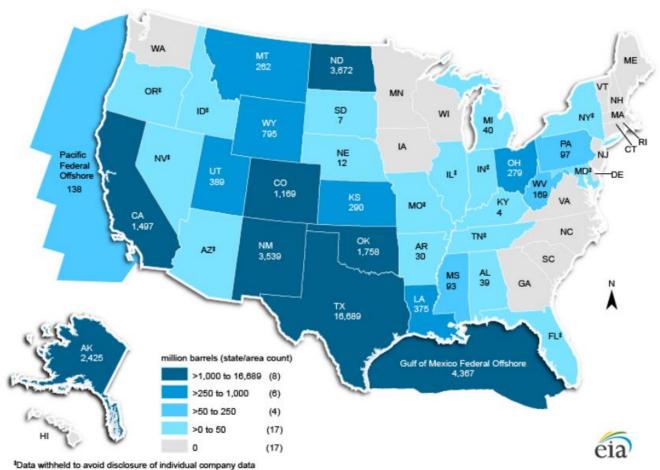
https://www.eia.gov/todayinenergy/detail.php?id=17151

U.S. Proved Reserves

Figure 14. Proved reserves of U.S. crude oil and lease condensate by state/area, 2020

2020 U.S. proved reserves of crude oil and lease condensate: 38,212 million barrels

‡Data withheld to avoid disclosure of individual company data

Source: U.S. Energy Information Administration, Form EIA-23L, *Annual Report of Domestic Oil and Gas Reserves*

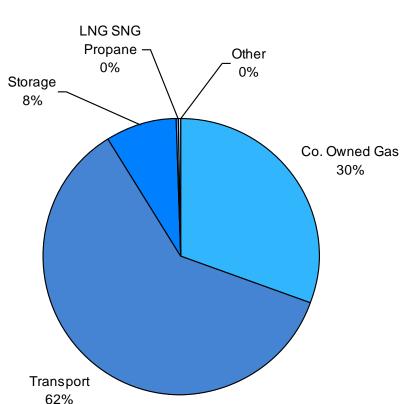https://www.eia.gov/naturalgas/crudeoilreserves/pdf/usreserves.pdf

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U.S. Production, Imports & Exports (Million Cubic Feet)
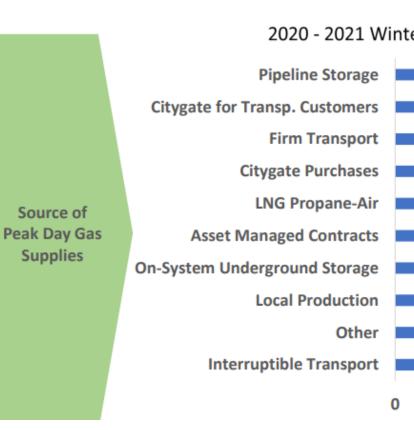
	U.S. Gas Imports or Production	U.S. Gas Exports
Pipeline Canada	2,784,438	937,124
Pipeline Mexico	1,718	2,154,457
LNG Total	21,587	3,560,818
CNG Canada	217	211
U.S. Gross Withdrawals & Production	41,666,118	

https://www.eia.gov/dnav/ng/ng_move_expc_s1_a.htm
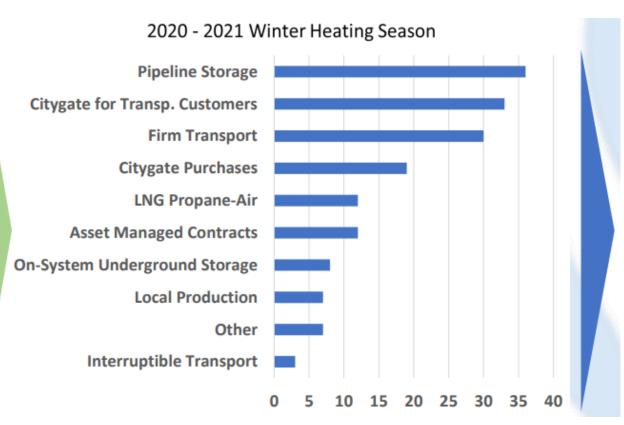
Typical LDC Gas Supply Management

Annual Profile

- LNG SNG Propane 0%
- Other 0%
- Storage 8%
- Co. Owned Gas 30%
- Transport 62%
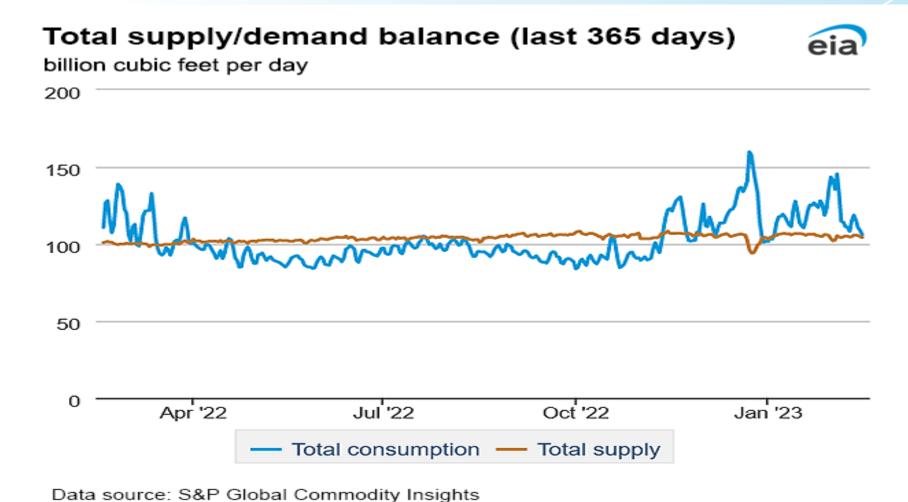
Source: Energy Information Administration, AGA Survey

Source of Peak Day Gas Supplies

2020 - 2021 Winter Heating Season

- Pipeline Storage
- Citygate for Transp. Customers
- Firm Transport
- Citygate Purchases
- LNG Propane-Air
- Asset Managed Contracts
- On-System Underground Storage
- Local Production
- Other
- Interruptible Transport

0 5 10 15 20 25 30 35 40

https://www.aga.org/wp-content/uploads/2023/01/WHS-2020-2021-Jan-23-Presentation.pdf

ESC

Gas Supply & Demand

Total supply/demand balance (last 365 days)
billion cubic feet per day

Total consumption — Total supply

Data source: S&P Global Commodity Insights

EIA: Natural Gas Weekly

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Gas Supply Management

- Gas Supplier Options
  - Intrastate pipeline
  - Producer
  - Marketer
  - Company-owned production
- Gas Contract Options
  - Length
  - Pricing
    - Indexed (monthly, weekly)
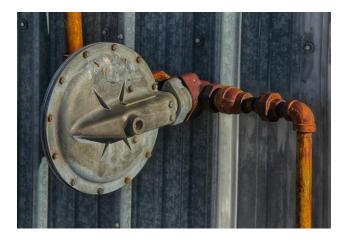   - Fixed
    - Spot
    - Hedged (NYMEX)

Distribution Operations

Distribution Operations

- Supply Management

- Gate Stations
  - Odorant
  - Pressure reduction

- Construction

Supply Management

- Represents how the industry works – the supply chain for natural gas from the identification of resources to the end user

- System must be redundant

  - Redundancy within the US natural gas supply chain enables critical components to continue to operate in case of disruptions to the system

- Resiliency of the system

  - The redundancy of components and the resiliency of the system design inhibit traditional chokepoints in the natural gas supply chain

Gate Stations

- The "city gate" station is the place where the long-distance pipeline connects with the gas utility's own delivery system

- Before distribution the gas pressure is lowered so gas can travel safely through the distribution mains

- The utility will add Mercaptan – a non-toxic odor (similar to rotten eggs) so it's easy to smell a natural gas leak

- The local gas utility delivers natural gas through a system of underground pipelines "mains" that are the pipes that carry gas from the city gate station to the customer

ESC

Construction

- Utilities study their gas pipeline system to be sure it meets service & security expectations

- Except for gas service lines, the pipe used in natural gas pipeline systems can range in size from 2 inches to 42 inches in diameter

- Natural gas distribution systems have been constructed from many different materials including cast iron, steel, copper, and plastic pipe

- Plastic pipe is most commonly installed today for gas distribution systems

ESC

Construction

- Much of the main line construction is bid out to contractors when the work involves new installation or replacement/retrofit of the piping network
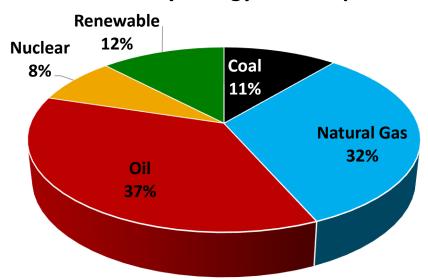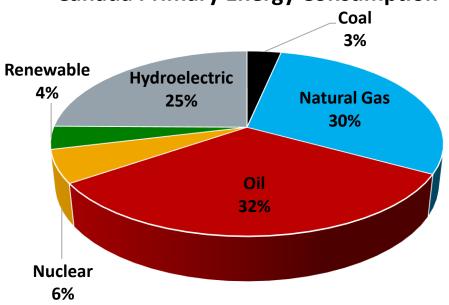
Natural Gas Consumption

Total Energy Consumption

- Natural Gas accounts for almost 1/3rd of U.S. & Canadian primary energy consumption.

U.S. Primary Energy Consumption

- Coal 11%
- Natural Gas 32%
- Oil 37%
- Nuclear 8%
- Renewable 12%

Canada Primary Energy Consumption

- Coal 3%
- Natural Gas 30%
- Oil 32%
- Nuclear 6%
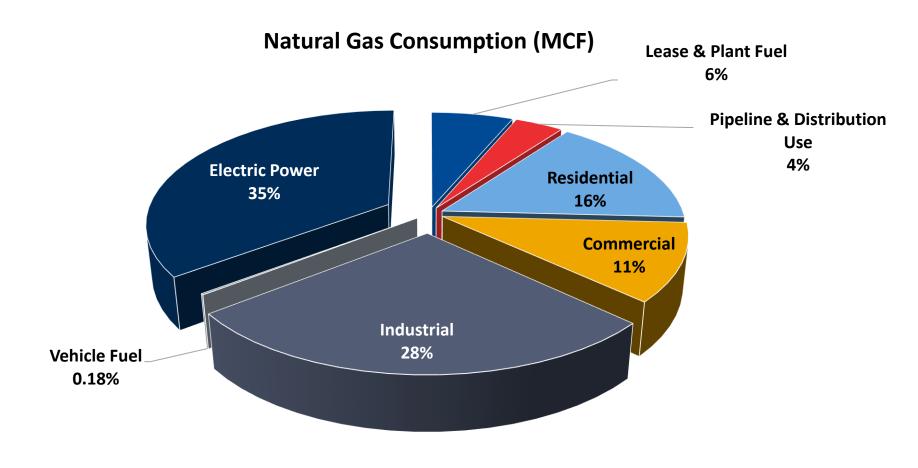- Renewable 4%
- Hydroelectric 25%

Electricity that is generated using fossil fuels is a secondary source of energy
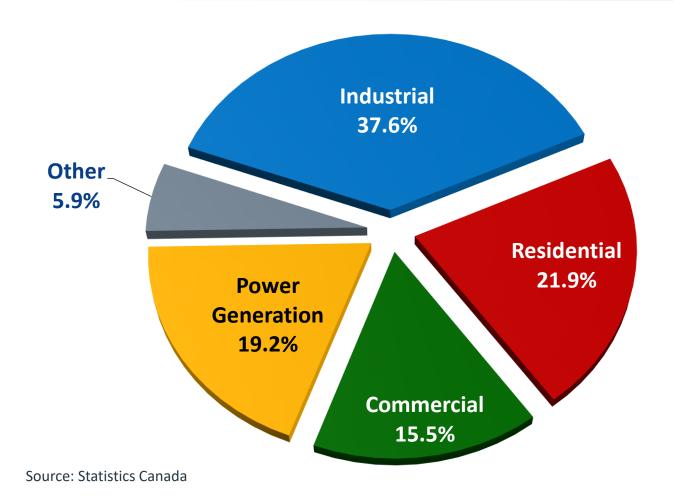
Source: Dept. of Energy, Energy Information Administration & Statista.com

Natural Gas Consumption – U.S.

Natural Gas Consumption (MCF)

- Lease & Plant Fuel 6%
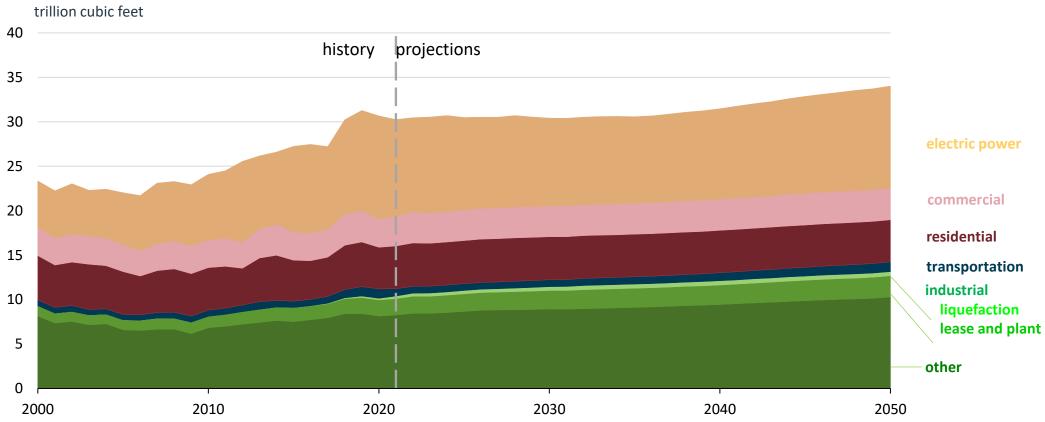- Pipeline & Distribution Use 4%
- Residential 16%
- Commercial 11%
- Electric Power 35%
- Industrial 28%
- Vehicle Fuel 0.18%

http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm
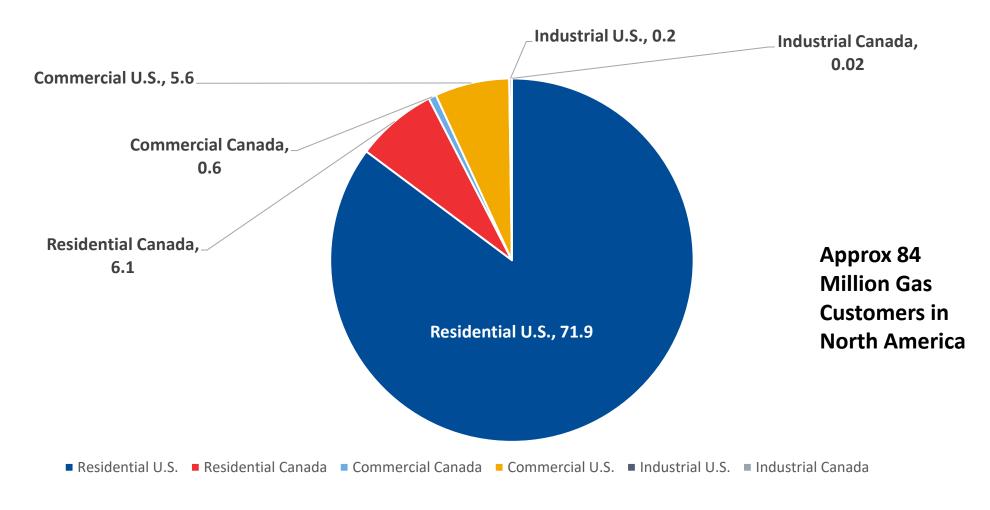
Natural Gas Consumption - Canada

Source: Statistics Canada

Number of U.S. & Canadian Consumers (Millions)

Industrial U.S., 0.2

Industrial Canada, 0.02

Commercial U.S., 5.6

Commercial Canada, 0.6

Residential Canada, 6.1

Residential U.S., 71.9

Approx 84 Million Gas Customers in North America

■ Residential U.S.   ■ Residential Canada   ■ Commercial Canada   ■ Commercial U.S.   ■ Industrial U.S.   ■ Industrial Canada

Natural Gas Consumption Growth

Natural gas consumption
Reference case
trillion cubic feet

history | projections

- electric power
- commercial
- residential
- transportation
- industrial
- liquefaction
- lease and plant
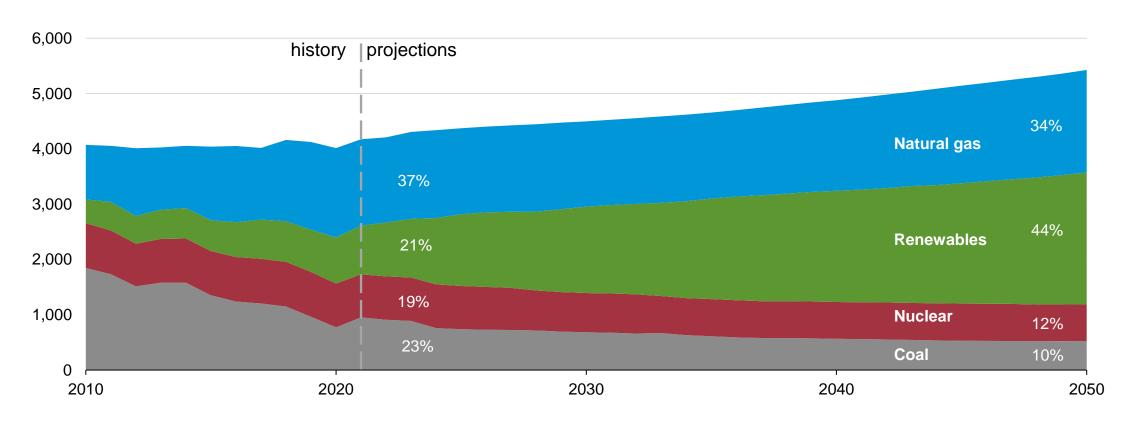- other

EIA's Annual Energy Outlook

Electric Generation Shifted from Coal to Gas & Renewables

U.S. electricity generation from selected fuels
AEO Reference case
billion kilowatthours

history | projections

Natural gas — 34%
37%
Renewables — 44%
21%
Nuclear — 12%
19%
Coal — 10%
23%

EIA's Annual Energy Outlook
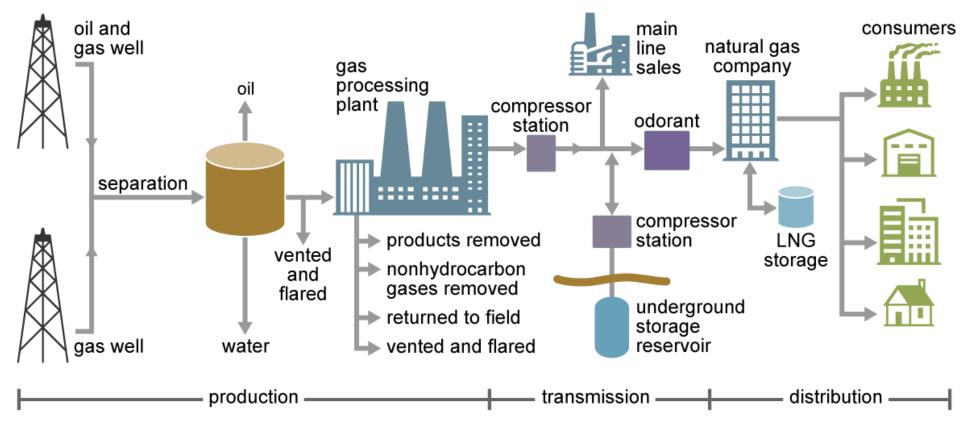
Gas Production

Natural Gas Production & Delivery
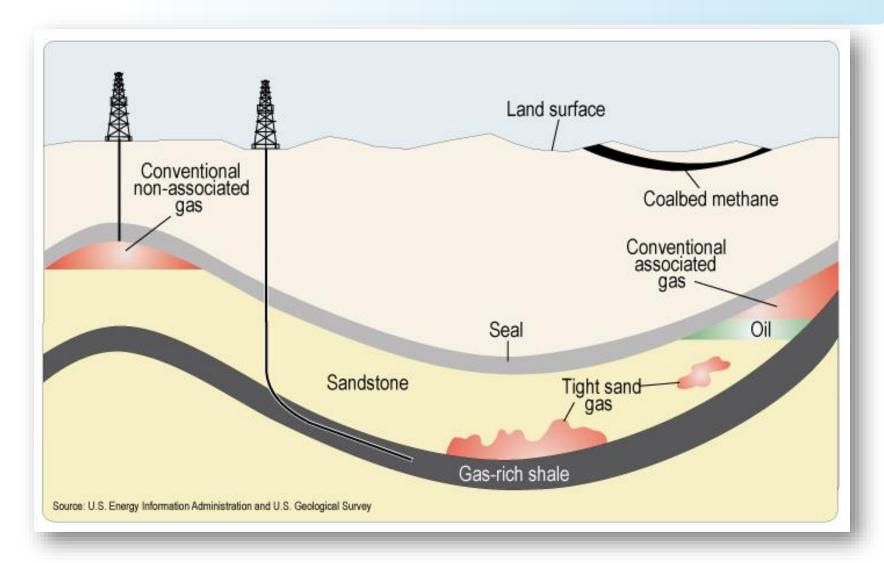
Source: U.S. Energy Information Administration

Marketed Natural Gas Production

Source: U.S. Energy Information Administration and U.S. Geological Survey

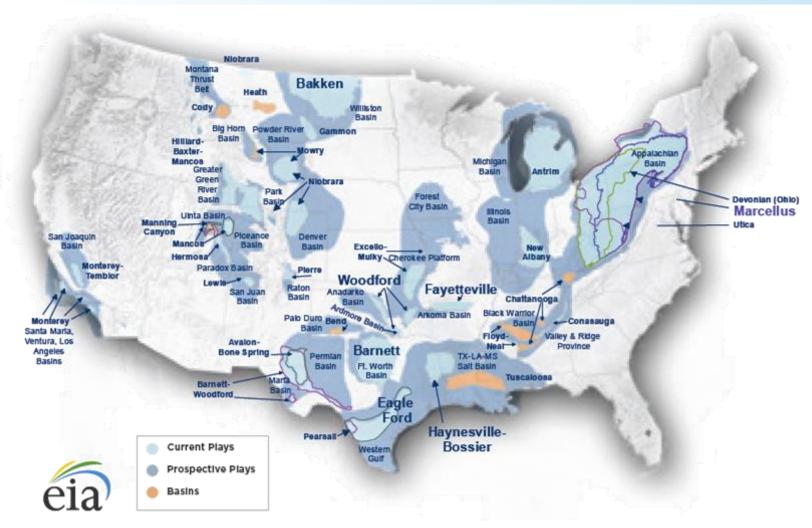# Outcrop – Utica Shale
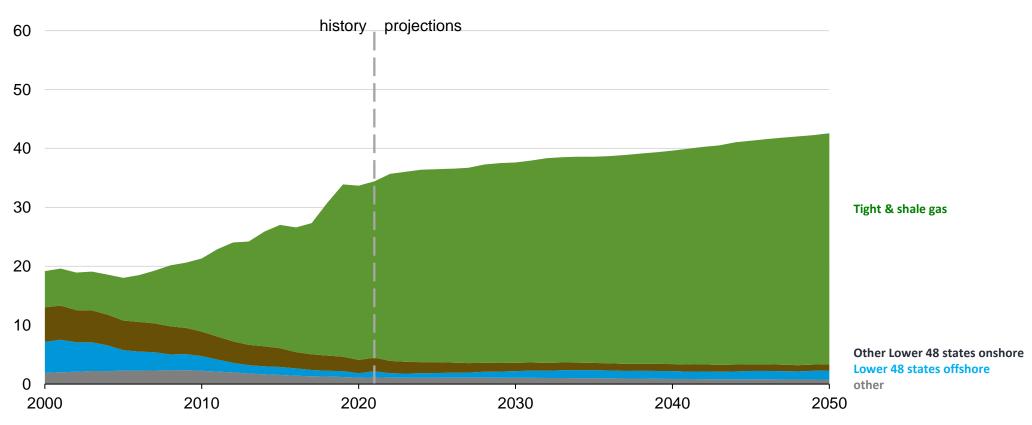

Source: www.wikipedia.org/wiki/Utica_Shale.

Domestic Abundance

U.S. Natural Gas Production, 2000-2050

Dry natural gas production natural gas supply case

Reference case
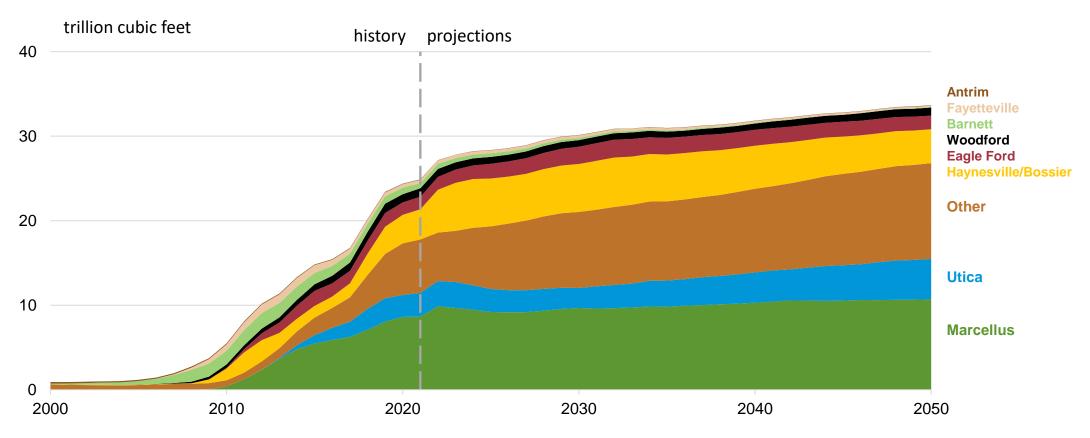trillion cubic feet

history | projections

Tight & shale gas

Other Lower 48 states onshore
Lower 48 states offshore
other

Note: *Tight and shale* gas includes tight gas, shale gas, and natural gas from tight oil formations.

EIA's Annual Energy Outlook

Shale Gas Production

Dry natural gas production by selected shale play
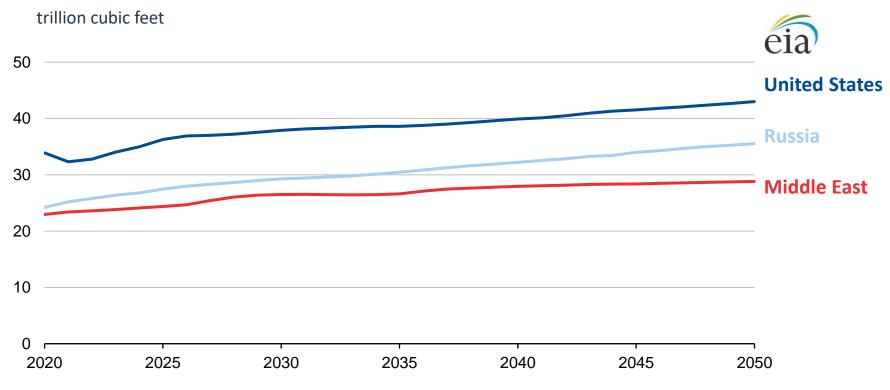
trillion cubic feet

Note: *Other* includes natural gas production from other tight oil formations.

Worldwide Natural Gas Production

Natural gas production, select regions

trillion cubic feet

United States

Russia

Middle East

Source: U.S. Energy Information Administration, International Energy Outlook 2021 (IEO2021) Reference case

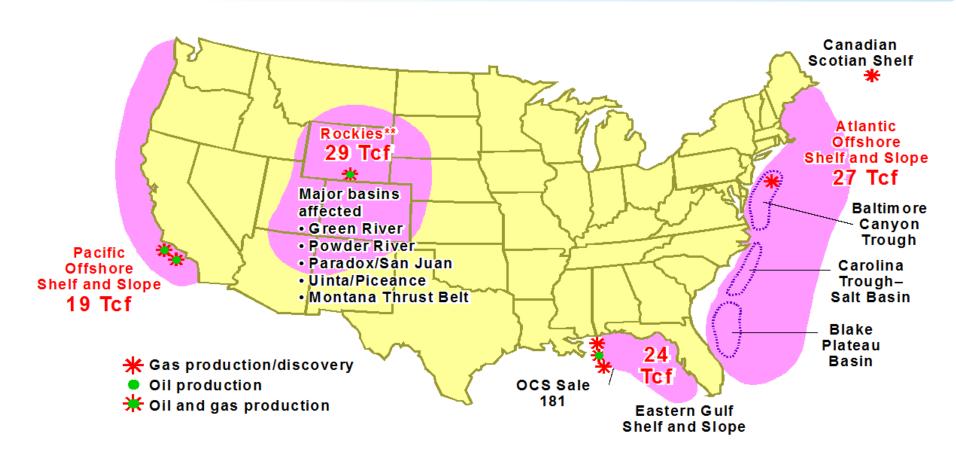# More than 100 Years of Supply

PRODUCTION
Volume of gas produced from proved reserves — 34.5 Tcf

Additional 2.5 Tcf — LNG and pipeline gas from Canada

CONSUMPTION
Volume consumed by all users — 30.7 Tcf

RESERVES
Known quantities of gas associated with wells drilled, completed and producing — 473.3 Tcf

3,368 Tcf (Trillion Cubic Feet)

POTENTIAL RESOURCES
Technically recoverable sources of gas not yet discovered

2023 AGA Playbook, https://playbook.aga.org/natural-gas-data

Undiscovered Gas

Canadian Scotian Shelf

Atlantic Offshore Shelf and Slope
27 Tcf

Rockies**
29 Tcf

Major basins affected
• Green River
• Powder River
• Paradox/San Juan
• Uinta/Piceance
• Montana Thrust Belt

Baltimore Canyon Trough

Carolina Trough–Salt Basin

Blake Plateau Basin

Pacific Offshore Shelf and Slope
19 Tcf

24 Tcf

* Gas production/discovery
● Oil production
* Oil and gas production

OCS Sale 181

Eastern Gulf Shelf and Slope

Source: Cambridge Energy Research Associates
Note: 207 Tcf have restrictions or are off limits
99 Tcf are off limits for exploration and development
An additional 108 Tcf of the Rockies gas resources are available with restrictions

Alaskan Potential

World-class Gas Treating Plant for CO2 removal

NGL Extraction Plant

Designed Over 5,000 Miles of Pipeline
- 52": 2,000 to 2,500 psig
- 24-28 Compressor Stations
- Over 1,200 Stream Crossings
- Over 1,500 Road Crossings
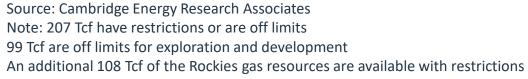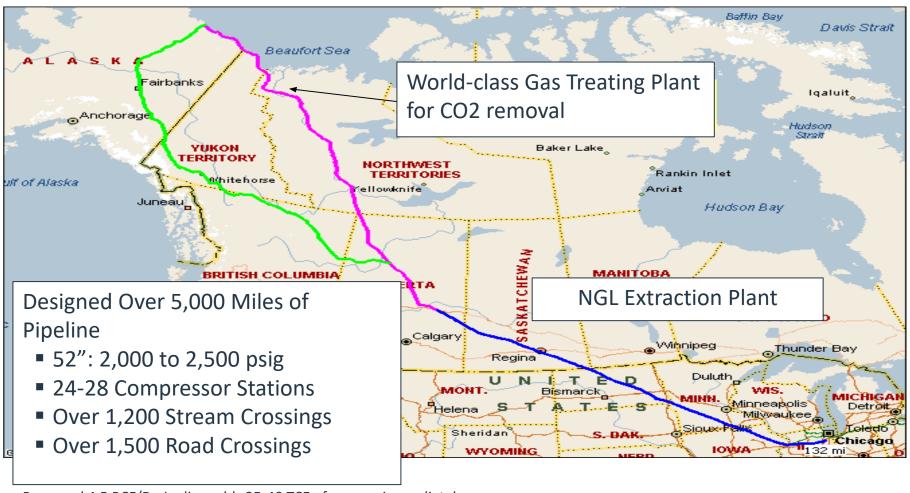
Proposed 4.5 BCF/D pipeline adds 35-40 TCF of reserve immediately

Methane Hydrates

- 10,000 TCF U.S. alone

- The DOE/NETL program has a project portfolio that includes field and laboratory efforts aligned with the research areas described above. Current projects are designed to fill remaining gaps in the program, while pushing methane hydrate R&D to the next level.
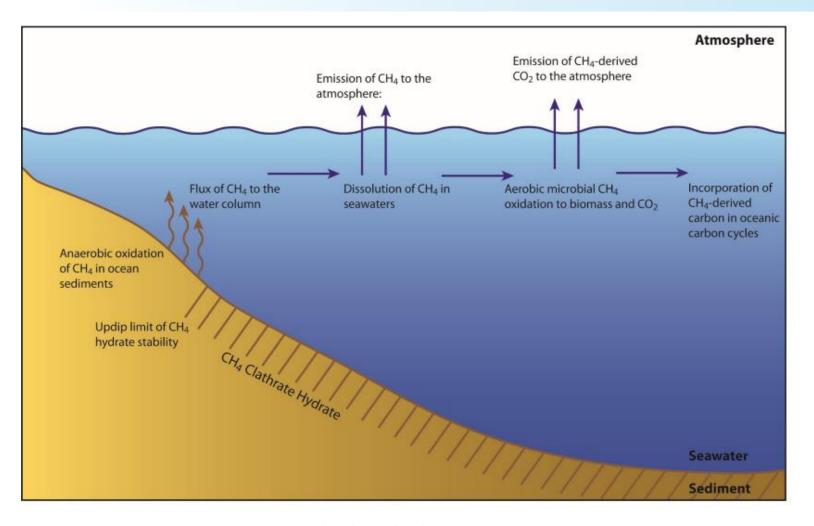

Gas hydrate piece, from the subduction zone off Oregon

Source: DOE NETL R&D Program 2020, https://www.netl.doe.gov/sites/default/files/2020-02/NETL-Methane-Hydrate-Program-2000-2020.pdf
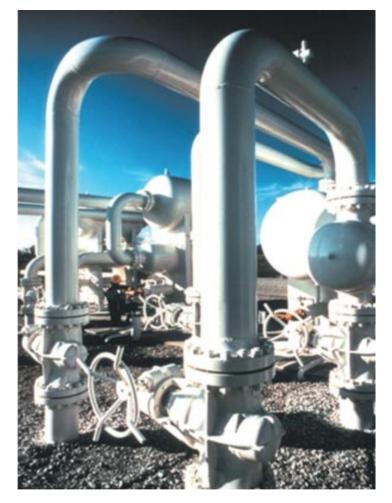
Methane Hydrates

Natural Gas Pipeline Operation

Operations

- Pipeline Operations
  - Compression
  - Maintenance
  - Underground Storage
- Distribution Operations
  - Gate Stations
  - Mains and Services
  - Metering

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Gas Compressor Station

- Compressor stations are facilities that assists the transportation process of natural gas from one location to another
- Natural gas, transported through a gas pipeline, needs to be re-pressurized at intervals of about 40 to 100 miles
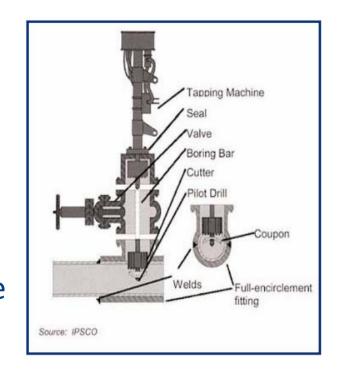
Pipeline Maintenance

- Hot taps reduce Methane Emissions
  - A new branch connection can be added to existing gas line while the pipeline remains in service.
  - Attaches a branch connection and valve to the main pipeline.
  - Cut-out a section of the main pipeline wall through the valve to connect the branch to the main pipeline.

Source: IPSCO

Source: Williamson Industries Inc.

https://www.epa.gov/sites/default/files/2017-07/documents/june-charlotte-pipeline.pdf

Pipeline Maintenance ....continued

- ## Composite Wraps
  - Can be performed without taking pipeline out of service
  - Repair is quick and less costly than replacement or sleeve options
  - Eliminates venting associated with replacement

- ## Cast Iron Joint Sealing Robots

- Robotic system inserted into live 15 to 31 cm diameter cast iron distribution lines to seal leaking joints with an anaerobic sealant.

- No service disruption and minimal excavation

https://www.epa.gov/sites/default/files/2017-07/documents/june-charlotte-pipeline.pdf

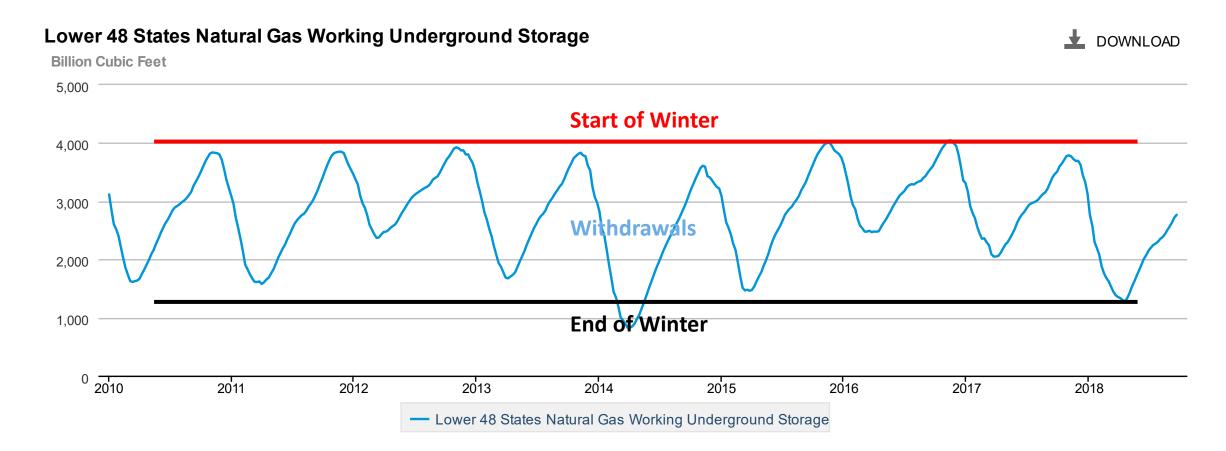Source: Armor Plate

Source: ConEdison

Natural Gas Underground Storage

https://atlas.eia.gov/apps/all-energy-infrastructure-and-resources/explore

Natural Gas in Underground Storage

Lower 48 States Natural Gas Working Underground Storage

Billion Cubic Feet

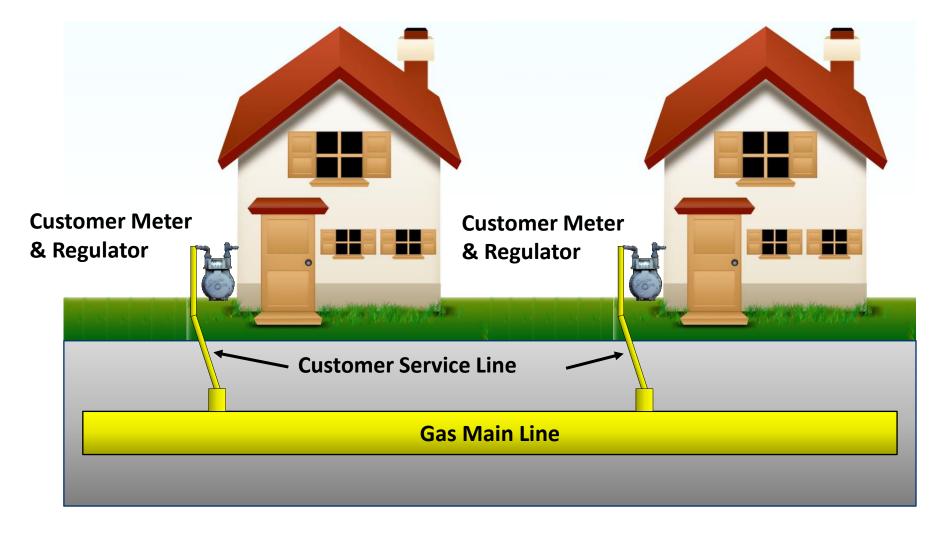Source: U.S. Energy Information Administration

Gate Stations

- Facility typically is owned and operated by a municipality or local gas utility and interconnects the long-distance interstate pipeline with a local distribution network
- City gate stations are composed of valves, pipes, and pressure reduction devices to allow gas to be delivered safely to customers
- Odorant is often added at the City gate Station

northshoregasdelivery.com

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Mains and Services

Customer Meter & Regulator

Customer Meter & Regulator

Customer Service Line

Gas Main Line

Natural Gas Pricing

Historical Pricing

Henry Hub Natural Gas Spot Price
Dollars per Million Btu

http://www.eia.gov/dnav/ng/hist/rngwhhdd.htm

Pricing to LDC

- Rate of return regulated by FERC
  - Traditional contracts with set rates
  - Capacity release market
- Types of contracts/services
  - Firm
  - Interruptible
  - Transportation
  - Other
- Factors impacting returns
  - Demand - weather
  - Competition from other pipelines
  - New construction
  - Conservation

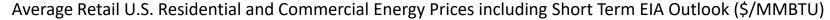This Photo by Unknown Author is licensed under CC BY-SA-NC
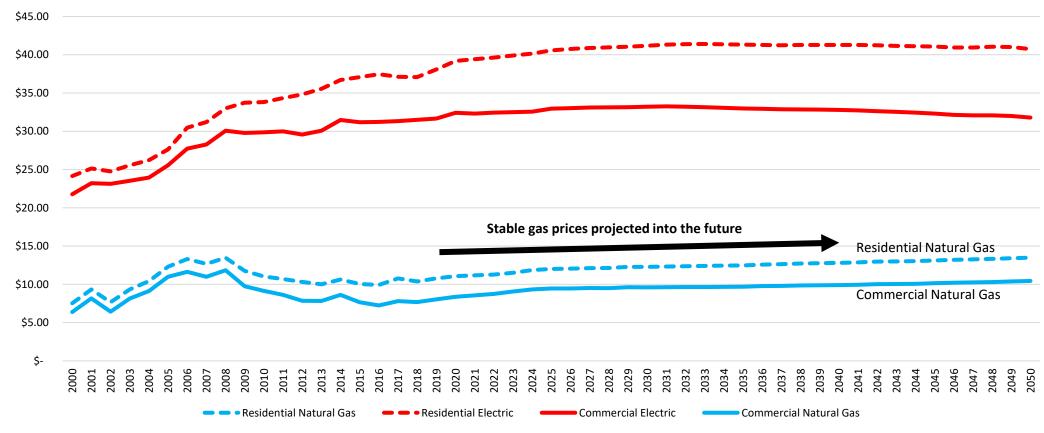
Pricing to Consumer

- Regulated pricing (supply and transportation)
  - Firm
  - Interruptible
- Deregulated pricing (transportation only)
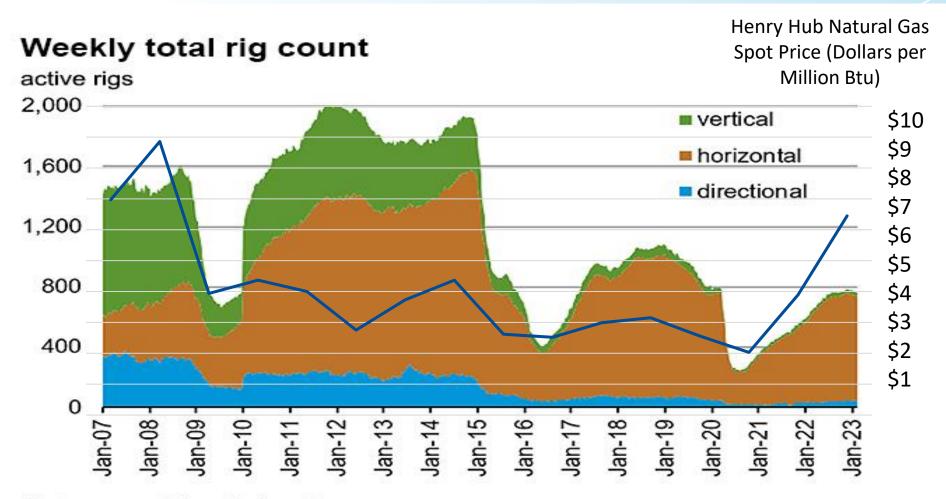 - Firm
  - Interruptible

Market Stability

Average Retail U.S. Residential and Commercial Energy Prices including Short Term EIA Outlook ($/MMBTU)

Stable gas prices projected into the future

Residential Natural Gas

Commercial Natural Gas

Legend: Residential Natural Gas — Residential Electric — Commercial Electric — Commercial Natural Gas

EIA STEO

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Rig Count Versus Spot Price

Henry Hub Natural Gas Spot Price (Dollars per Million Btu)

Weekly total rig count
active rigs

vertical
horizontal
directional

Data source: Baker Hughes Company

https://www.eia.gov/naturalgas/weekly/

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Metering

Meter Types

- Diaphragm/bellows meters

- Rotary meters

- Turbine meters

- Orifice meters

- Ultrasonic flow meters

Diaphragm/Bellows Meter

- Most common type of positive displacement gas meter used for residential and small commercial installations
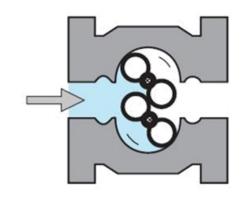- Meter has two or more chambers formed by movable diaphragms

American Meter Company

Rotary Meter

- Highly machined precision instrument capable of handling higher volumes and pressures than diaphragm meters

- Within the meter, two figure "8" shaped lobes, the rotors (also known as impellers or pistons) spin in precise alignment

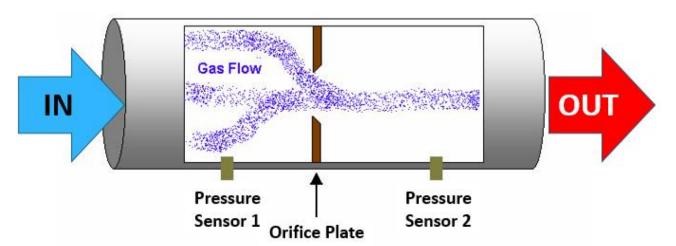- With each turn, they move a specific quantity of gas through the meter

Turbine Meter

- Turbine gas meters infer gas volume by determining the speed of the gas moving through the meter

- Because the volume of gas is inferred by the flow, it is important to have good flow conditions

https://sensus.com/products/mark-ii/

Orifice Meter

- Orifice gas meters consist of a straight length of pipe inside which a precisely known orifice creates a pressure drop, thereby affecting flow

- These are a type of differential meter, all of which infer the rate of gas flow by measuring the pressure difference across a deliberately designed and installed flow disturbance
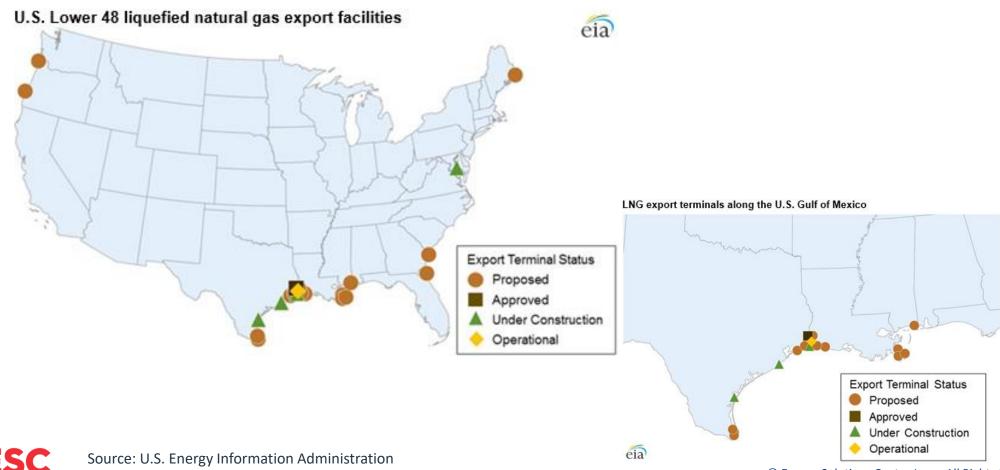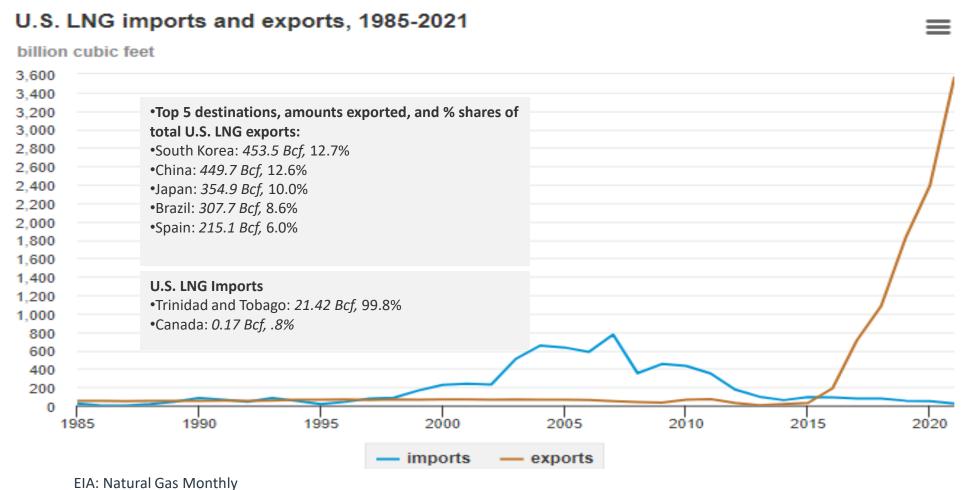

IN

Gas Flow

OUT

Pressure Sensor 1

Orifice Plate

Pressure Sensor 2

LNG Exports

LNG Exports

U.S. LNG Export Terminals Proposed, Approved, Under Construction, and Operational

Source: U.S. Energy Information Administration

U.S. Natural Gas Imports & Exports

U.S. LNG imports and exports, 1985-2021
billion cubic feet

•**Top 5 destinations, amounts exported, and % shares of total U.S. LNG exports:**
•South Korea: *453.5 Bcf,* 12.7%
•China: *449.7 Bcf,* 12.6%
•Japan: *354.9 Bcf,* 10.0%
•Brazil: *307.7 Bcf,* 8.6%
•Spain: *215.1 Bcf,* 6.0%

U.S. LNG Imports
•Trinidad and Tobago: *21.42 Bcf,* 99.8%
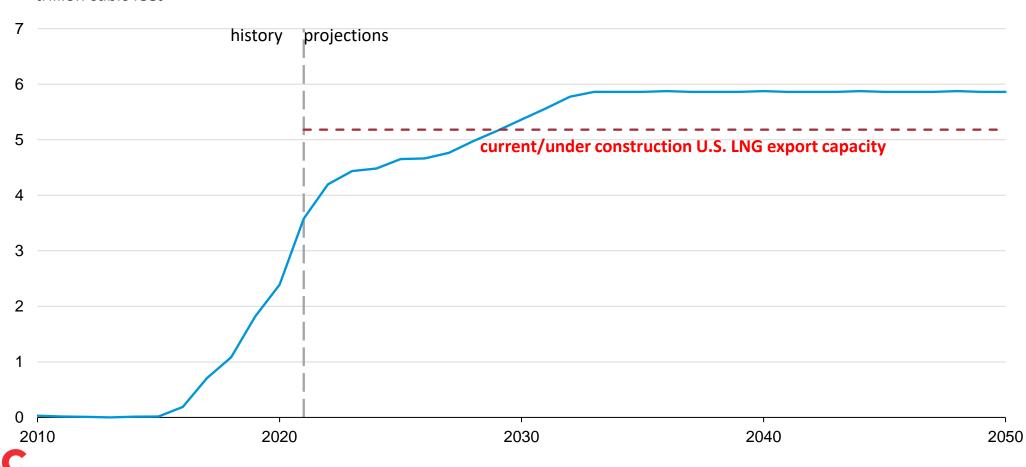•Canada: *0.17 Bcf,* .8%

EIA: Natural Gas Monthly

U.S. LNG Exports & Capacity

Liquefied natural gas (LNG) exports and capacity

AEO2022 Reference case
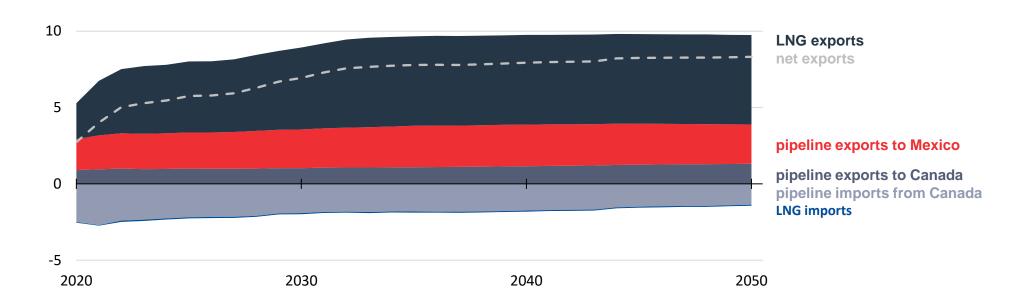
trillion cubic feet

EIA's Annual Energy Outlook

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U.S. Imports and Exports

Natural gas trade, AEO2022 natural gas supply case

Reference case
trillion cubic feet

LNG exports
net exports

pipeline exports to Mexico

pipeline exports to Canada
pipeline imports from Canada
LNG imports

EIA's Annual Energy Outlook

Thank You

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SOLUTIONS
CENTER

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Washington, DC 20001

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