ENERGY SOLUTIONS CENTER

Energy Industry Fundamentals

The Value of Natural Gas

Eric Burgis, Energy Solutions Center

Topics

- **Value of Natural Gas**
  - Affordable
  - Availability, Abundance, Comfort & Convenience
  - Resiliency
  - Gas Power to balance renewable electric
- **Carbon footprint**
  - What it is and why it matters
  - Decarbonization overview
  - Source to Site Energy Efficiency

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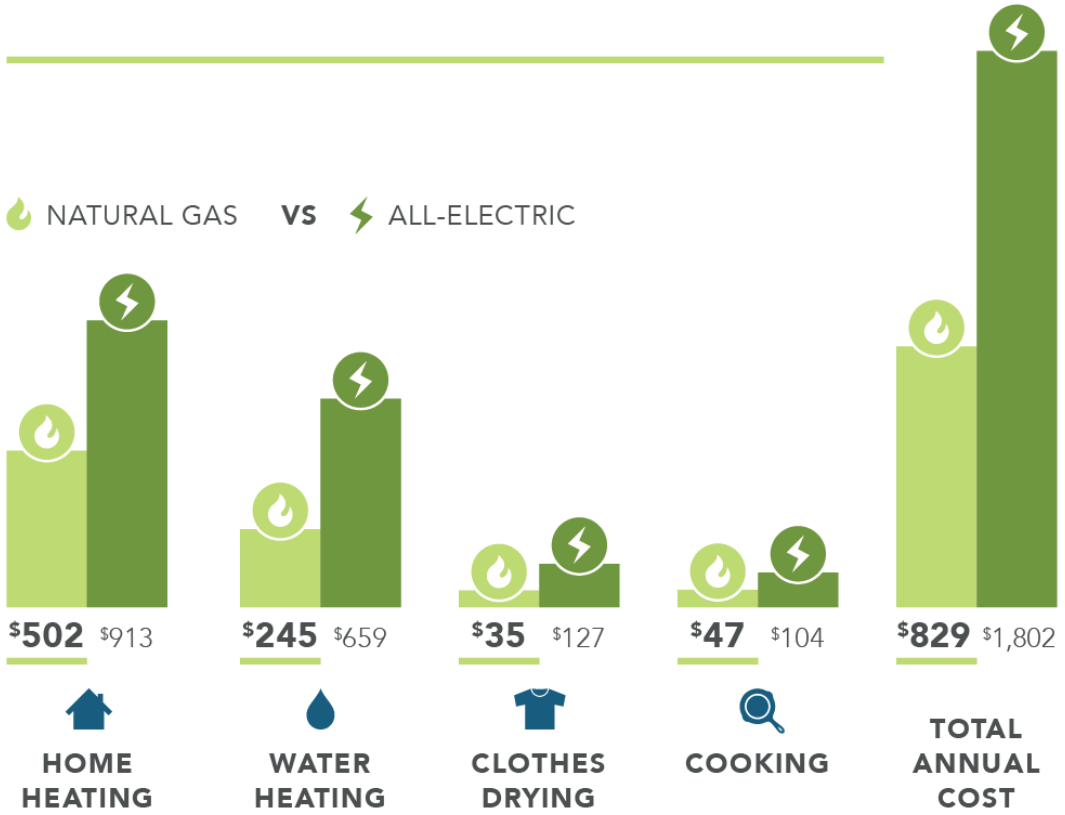
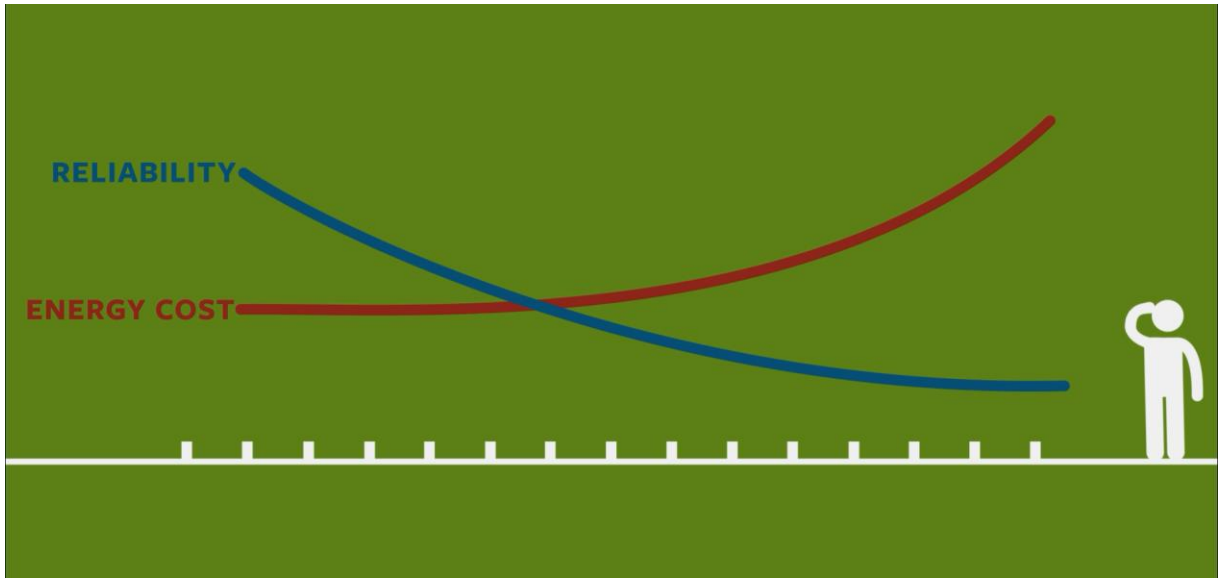
Value of Natural Gas

Natural Gas: An Affordable Energy Source

Natural Gas Delivers Comfort & Convenience at Half the Cost



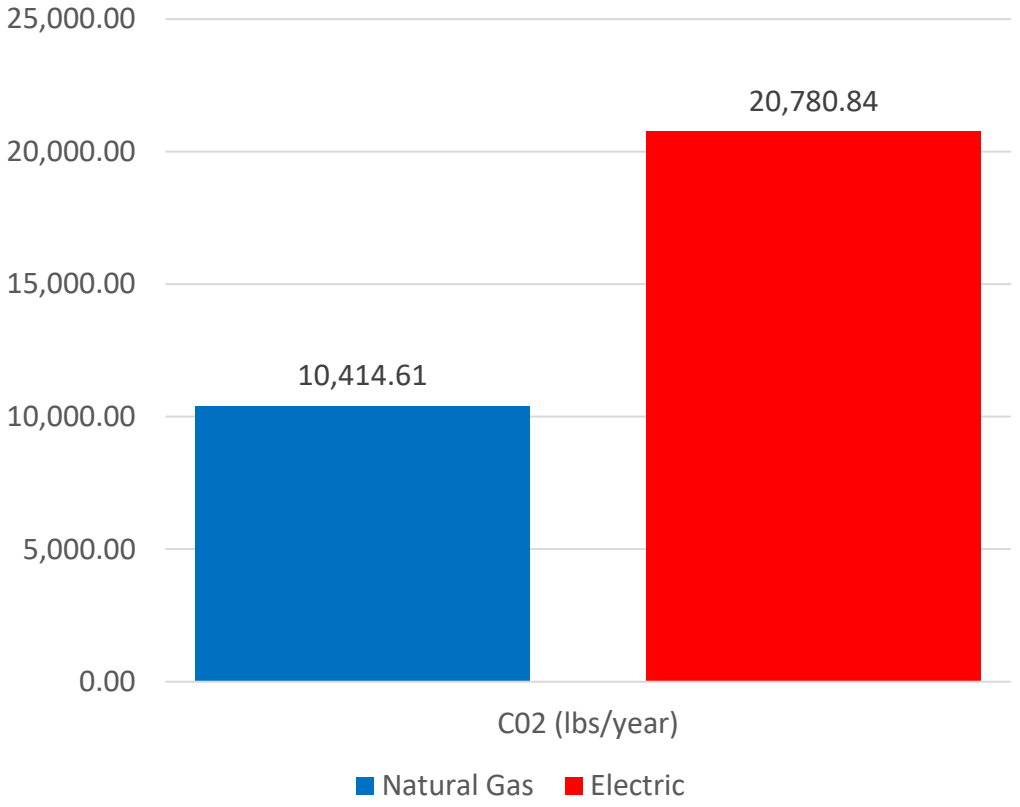
Maintaining Natural Gas Infrastructure is Important for Affordability and Reliability in a Clean Energy Future



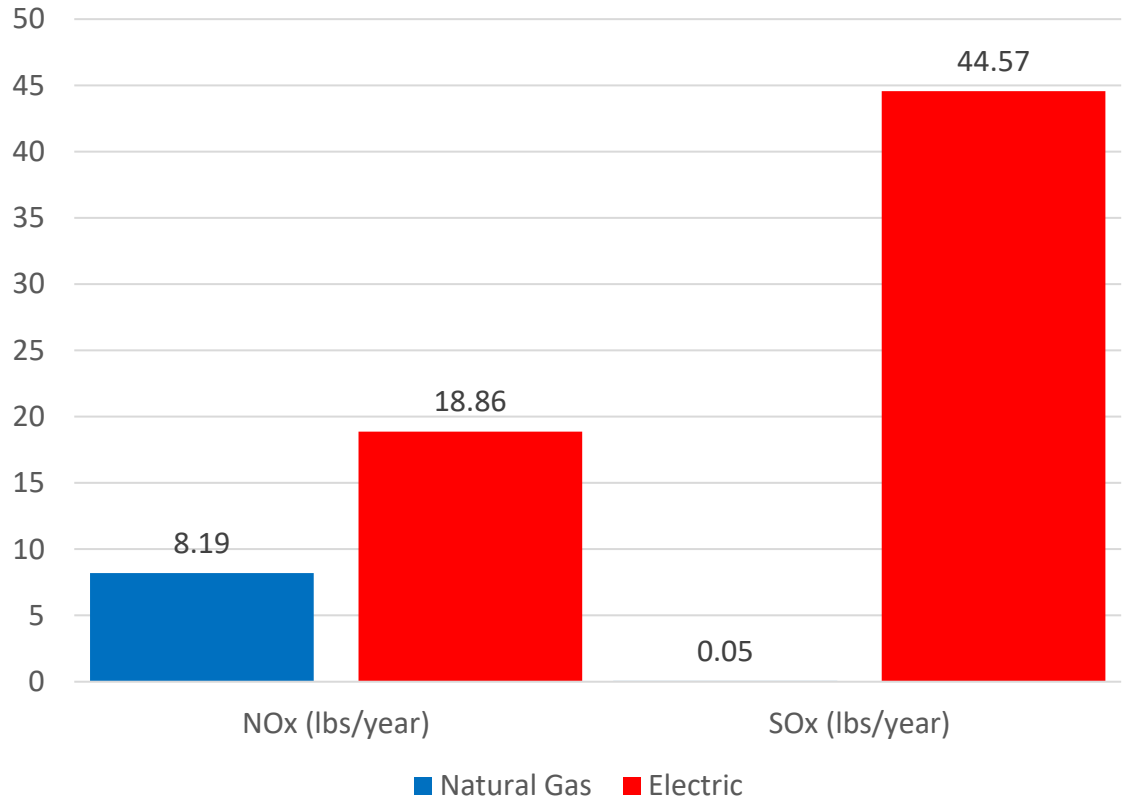
Graph generated from Residential Energy Calculator. Assumptions: U.S. average 2000 square foot home four occupants; eight dryer loads/week; meals prepared on range/cook-top/oven; 92% (AFUE) efficient natural gas furnace vs. medium efficiency heat pump (9.5 HSPF); high-performing natural gas tank water heater (0.62 EF) vs. high-performing tank electric water heater (0.95 EF); average U.S. energy rates of $0.93 per CCF of natural gas and $0.13 per kilowatt-hour of electricity.

Natural Gas Homes may Lower Greenhouse Gas Emissions more than Electric Appliances

CO_2 Emissions



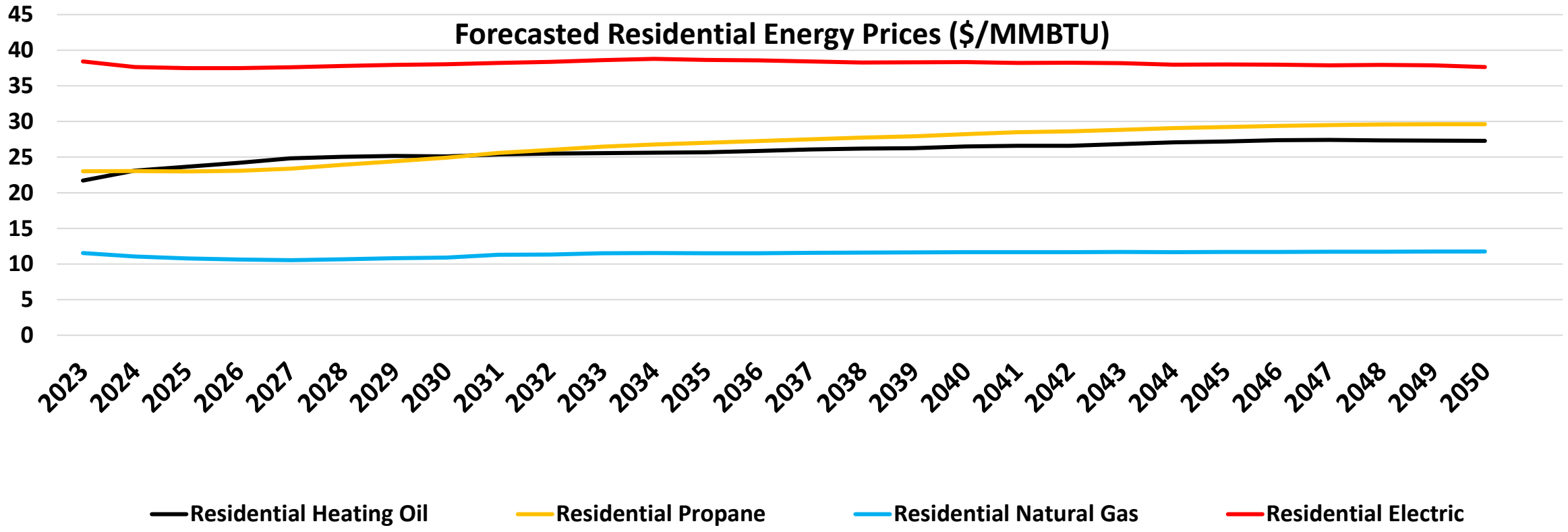
NO_x & SO_x Emissions



Graphs generated from Residential Energy Calculator. Assumptions: U.S. average 2000 square foot home four occupants; eight dryer loads/week; meals prepared on range/cook-top/oven; 92% (AFUE) efficient natural gas furnace vs. medium efficiency heat pump (9.5 HSPF); high-performing natural gas tank water heater (0.62 EF) vs. high-performing tank electric water heater (0.95 EF).

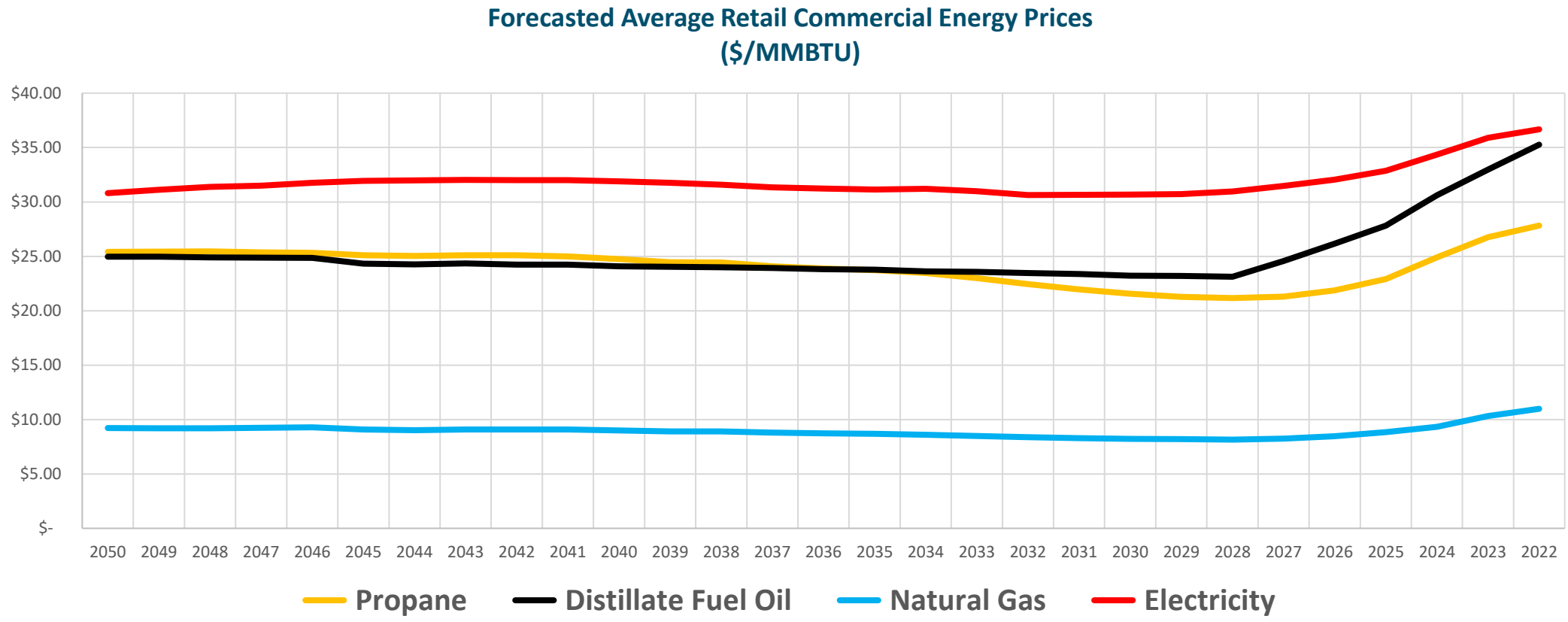
Stable, Long-term Supply has the Ability to Keep Residential Natural Gas Prices Affordable

Natural gas is forecasted to cost less than other forms of energy well into the future. Natural gas is projected to cost approximately one-third less than other forms of energy into the future on a $ per million BTU basis.



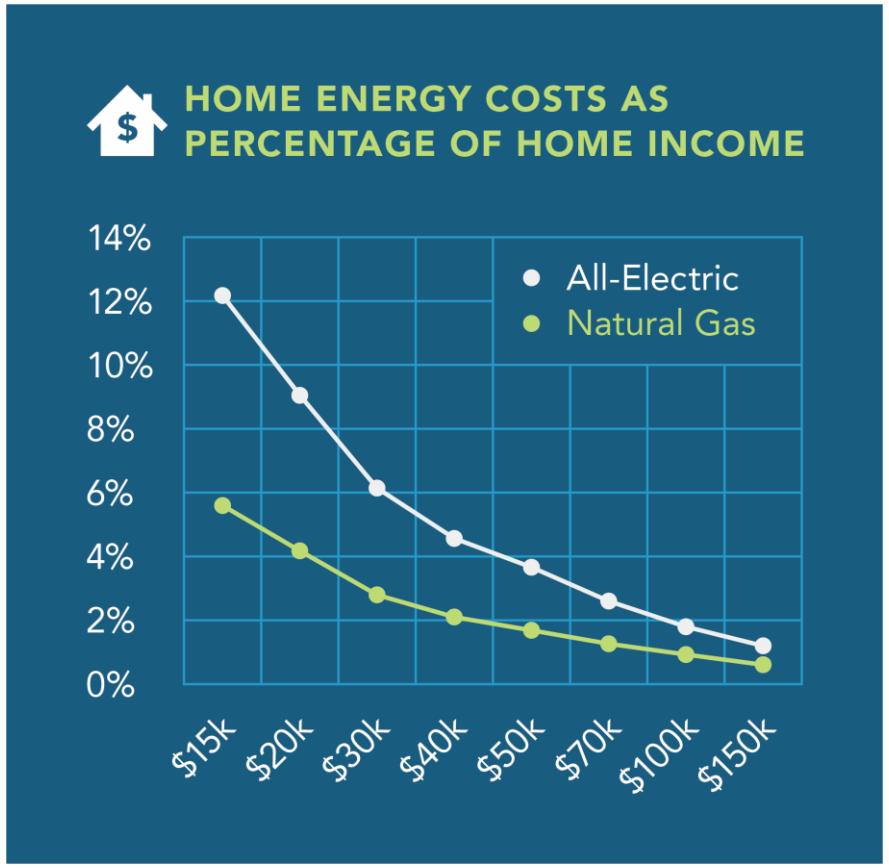
Source: https://www.eia.gov/outlooks/aeo/data/browser/#/?id=3-AEO2020&region=1-0&cases=ref2020&start=2019&end=2050&f=A&linechart=ref2020-d112119a.3-3-AEO2020.1-0&map=ref2020-d112119a.4-3-AEO2020.1-0&sourcekey=0

Retail Commercial Natural Gas Prices are also Expected to be Far Less Expensive than Alternatives into the Future



Source: U.S. EIA, Annual Energy Outlook 2023. https://www.eia.gov/outlooks/aeo/data/browser/#/?id=3-AEO2023&region=1-0&cases=ref2023&start=2021&end=2050&f=A&linechart=ref2023-d020623a.3-3-AEO2023.1-0~ref2023-d020623a.4-3-AEO2023.1-0~ref2023-d020623a.5-3-AEO2023.1-0~ref2023-d020623a.6-3-AEO2023.1-0~~~~&map=ref2023-d020623a.4-3-AEO2023.1-0&ctype=linechart&sourcekey=0

Energy Affordability is Critical for Low-income Households



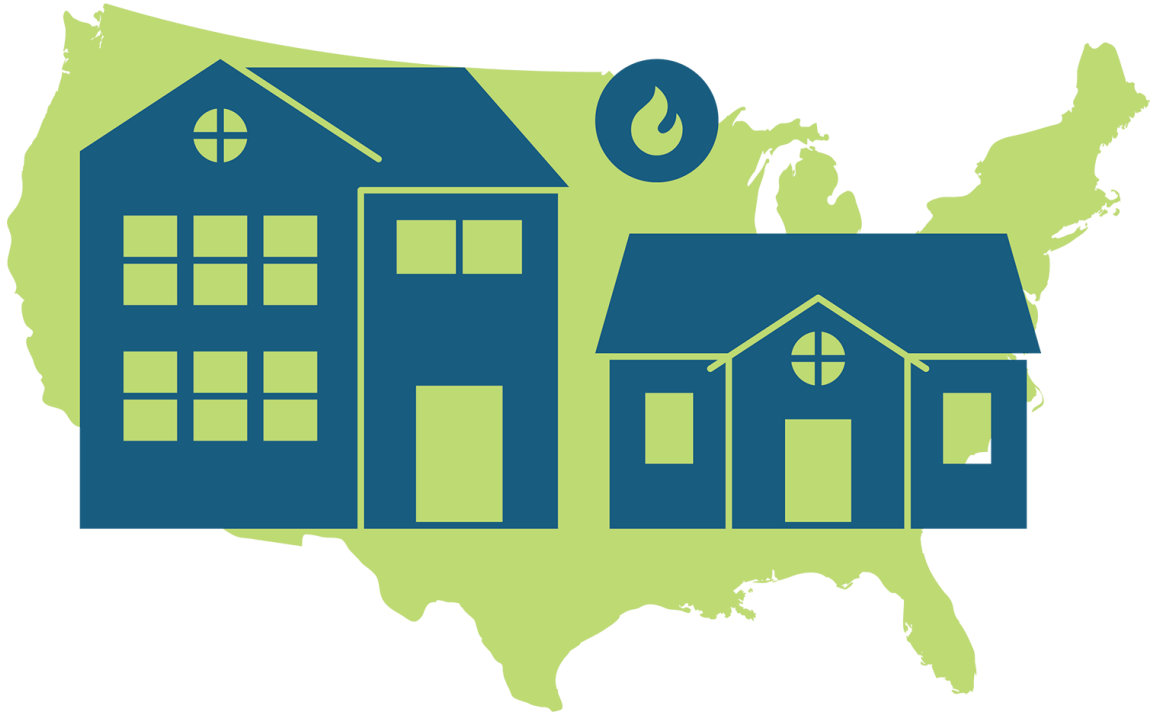
Per ACEEE, a household that spends more than 6% of its income on energy has a high energy burden, and those that spend more than 10% have a severe energy burden. A quarter of low-income households have an energy burden higher than 14%.* This energy burden is amplified by the higher cost of electricity.

* ACEEE https://www.aceee.org/sites/default/files/pdfs/ACEEE-01%20Energy%20Burden%20-%20National.pdf

Natural Gas Provides Real Value to Consumers, Commerce, and Industry

North America's Fuel Source

Natural gas is the fuel source that can meet North America's growing demand for energy – today, and far into the future.*



- ✓Abundant
- ✓Available
- ✓Affordable

* https://www.aga.org/policy/economy/supply/ 2 https://www.aga.org/news/news-releases/natural-gas-act-offers-clear-pathway-to-american-energy-abundance

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Natural Gas Strengthens North America's National Security and Supports the Economy

- Natural gas is a domestic fuel source.
- Natural Gas strengthens our national security by limiting our reliance on foreign oil.
- Over 4 million U.S. jobs are connected to the natural gas industry.[1]
- In Canada, 1/3 of energy needs are met with natural gas.[2]

1 https://www.aga.org/news/news-releases/natural-gas-act-offers-clear-pathway-to-american-energy-abundance/

2 https://www.capp.ca/economy/canadian-economic-contribution/

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Abundant Supply Drives Affordable Pricing

- Natural Gas prices are determined by supply and demand.
- Abundant supply drives affordable pricing.
- With more than 100 years of supply available, North America has abundant natural gas resources to maintain price stability even with increased demand.
- Natural gas can be extracted in several ways and future supply is expected to be sufficiently robust to cover demand across all sectors.

https://www.aga.org/natural-gas/reliable/

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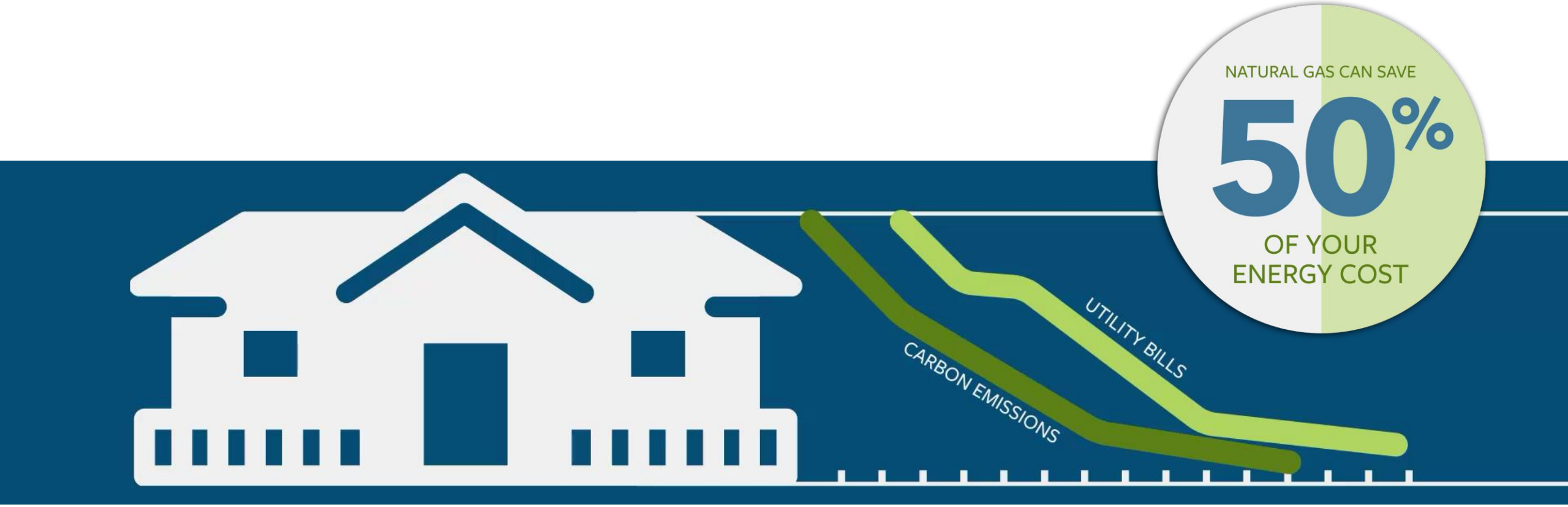
Lower Utility Bills and Reduced Carbon Emissions with Natural Gas



Resiliency Delivers Energy Reliability & Price Stability

- ✓Adequate supply and stable gas costs
- ✓400 active storage facilities
- ✓2.6 million miles of underground transmission and distribution pipelines

Source: AGA

Natural Gas Improves Quality of Life

More comfortable heating

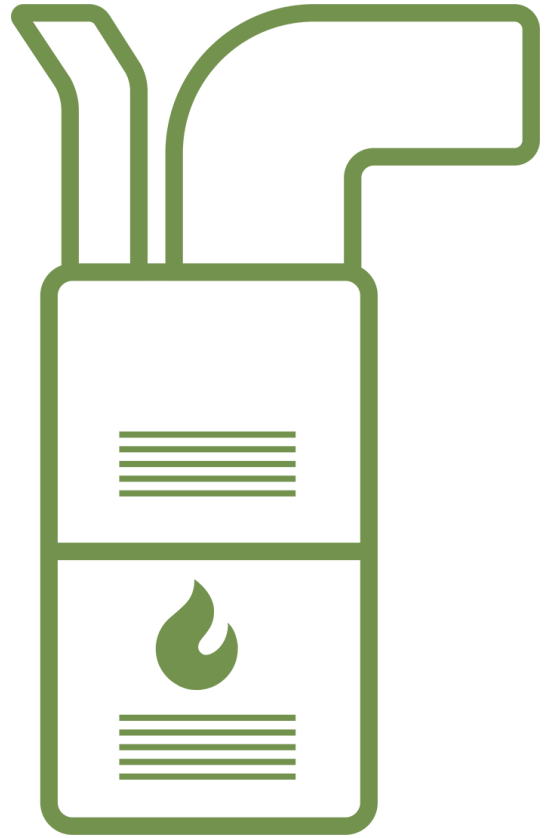
More hot water

Better cooking control

Natural Gas Provides Better Home Heating

Natural gas furnaces provide several advantages over other heating equipment:

- A gas furnace circulates much warmer air.
- Provides a faster startup time.
- Gas heat is more affordable.
- In colder climates, natural gas furnaces perform significantly better than an electric heat pump.



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Gas Water Heaters Save Money and Provide More Hot Water

- Gas water heaters cost less to operate than alternatives per Energy Guide labels.
- Gas water heaters have higher first hour ratings.
- Recovery rates are much higher with gas. A 40-gallon gas tank water heater has a similar first hour rating to that of a 60-gallon electric tank water heater.
- More hot water and faster recovery times help reduce the risk of a cold shower.*

* https://www.aga.org/natural-gas/in-your-home/water-heaters/

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Homeowners and Chef's Prefer Cooking with Gas

- Highly efficient, easy to clean, and reliable
- Instant heating and precise cooking temperatures
- It costs approximately half as much to cook with a natural gas range as with a similar electric range

https://www.aga.org/natural-gas/in-your-home/cooking/

Natural Gas Equipped Homes Sell at a Premium

The NAHB September 2021 Survey of Single-Family Home Builders found that across all respondents, homes with natural gas are valued 21% higher on average than homes that are not equipped with natural gas.*

Buyers are attracted to the cost savings, convenience and comfort of natural gas, but also to the incredible versatility of gas for exciting home features including a fireplace hearth, outdoor firepit, cooling, exterior lighting, clothes drying and more.

*The NAHB September 2021 Survey of Single-Family Home Builders

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Natural Gas Paving the Way for a Resilient Energy Future

From the abundance and diversity of supply to its inherent physical properties and strong distribution system, natural gas is a reliable and resilient energy source.

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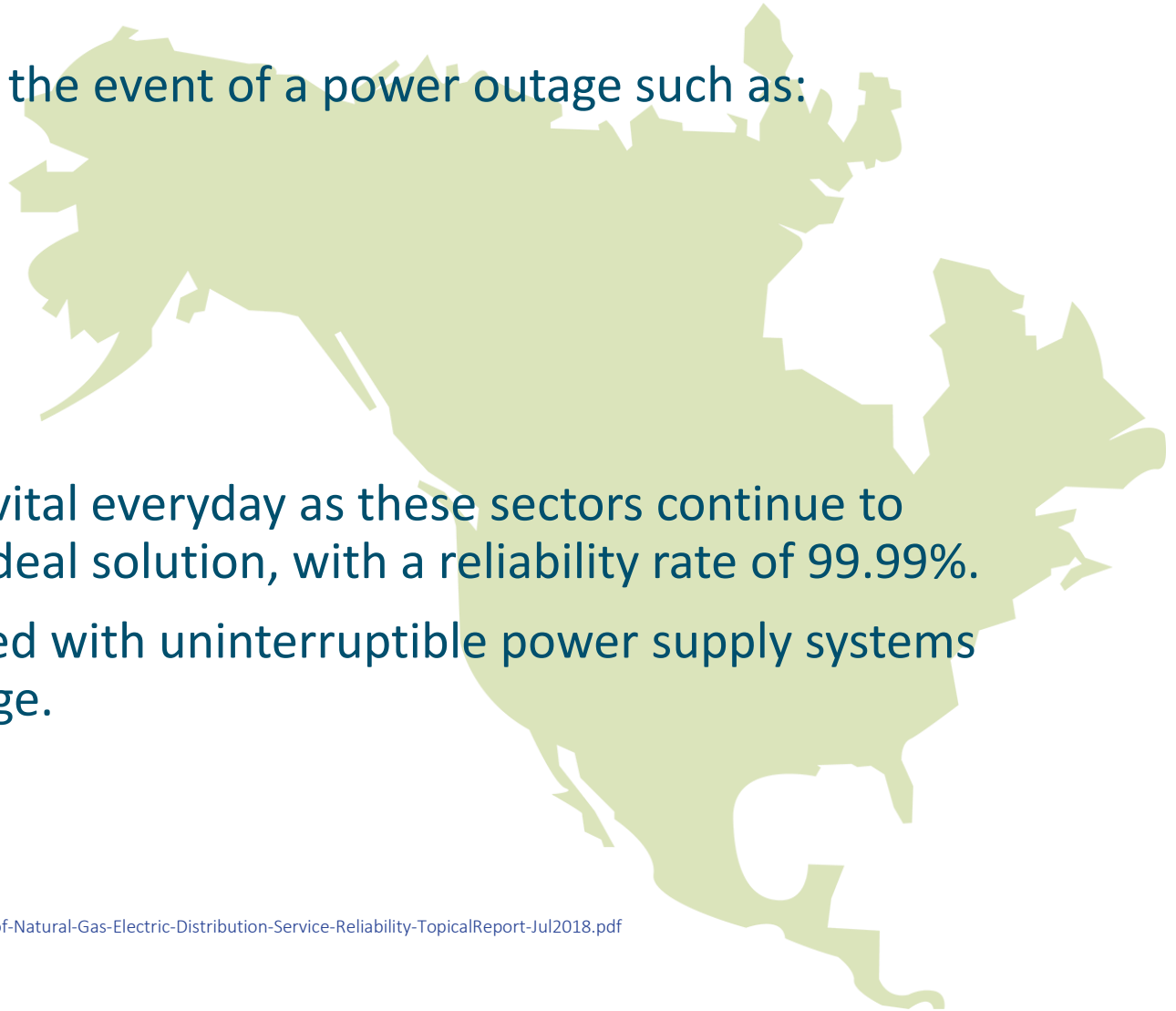
North American Critical Functions Rely on Natural Gas



- Critical Operations that are at risk in the event of a power outage such as:
  - Transportation
  - Communication
  - Emergency services / 911
  - Banking
  - Healthcare
  - Water supply
- Dependable energy becomes more vital everyday as these sectors continue to interconnect. Natural gas offers an ideal solution, with a reliability rate of 99.99%.
- Onsite natural gas generation coupled with uninterruptible power supply systems has the lowest potential for an outage.

https://www.gti.energy/wp-content/uploads/2018/11/Assessment-of-Natural-Gas-Electric-Distribution-Service-Reliability-TopicalReport-Jul2018.pdf

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Count on Natural Gas when Harsh Weather Strikes

Natural gas as an energy source offers fundamental resilience characteristics that make delivery more dependable during storms and other extreme weather.

Natural gas can be compressed for easy storage and transportation, making natural gas systems physically resilient.

Because natural gas is delivered through a system of underground pipelines*, it is protected from the elements and far less affected by above ground conditions, making it less prone to outages.

* https://www.eia.gov/energyexplained/natural-gas/delivery-and-storage.php

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Natural Gas is a Reliable Backup Fuel Source

When the electrical grid goes down, natural gas is an excellent fuel source for powering backup generators.

Half of all American homes rely on natural gas for their primary source of space and water heating.*

* https://www.eia.gov/energyexplained/natural-gas/use-of-natural-gas.php

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Gas is a Solution to Balance Intermittent Power from Renewable Energy

As the nation's energy mix continues to add more renewable energy sources, natural gas can provide stability to make up shortfalls in the electric grid when renewable power generation cannot meet demand. Spikes in usage or a lack of wind or sunshine lead to considerable challenges for renewable power sources.

Natural gas is the most cost-effective fuel for meeting marginal power needs, and natural gas-powered facilities can ramp up quickly when needed.

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Investments in Resiliency and Environmental Impact

Natural gas utilities spend $22 billion every year on infrastructure improvements that lead to safer, cleaner, and more reliable gas. These investments have led to 40% fewer pipeline incidents over the past decade.*

* https://www.aga.org/research/fact-sheets/pipeline-safety/

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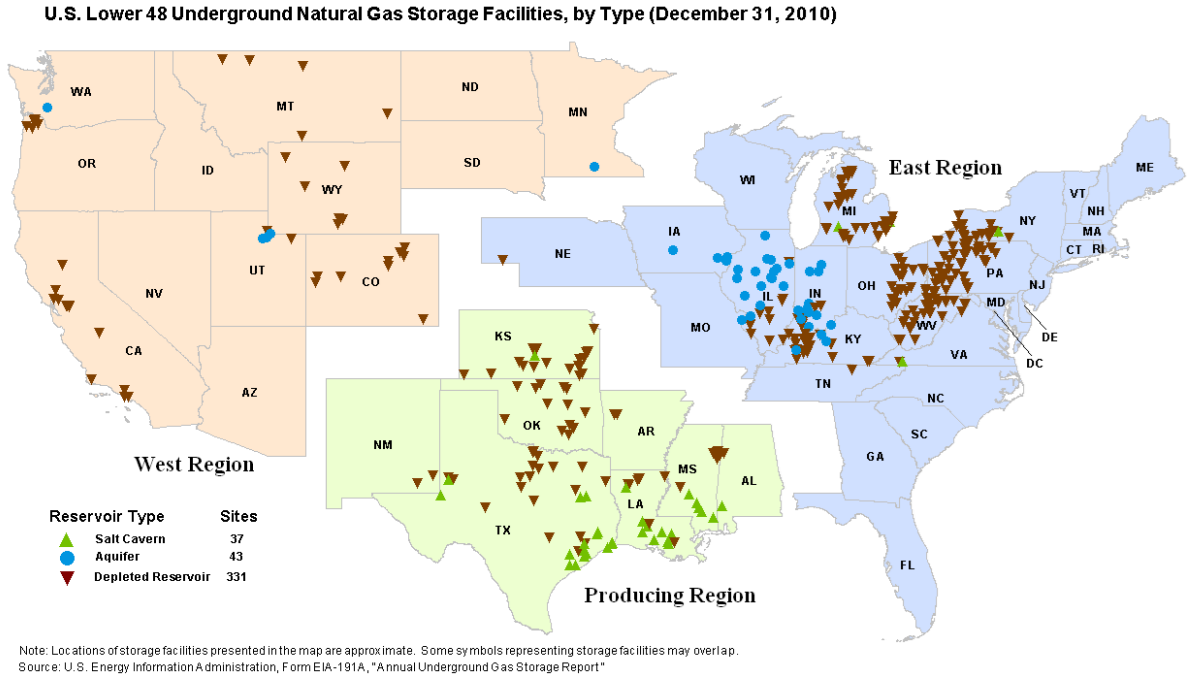
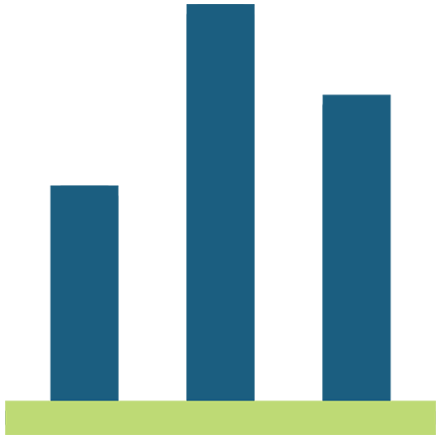
Natural Gas is Stored Underground for Added Protection

Natural gas production is relatively constant throughout the course of the year. Since it is easy to store, adapting fuel distribution to meet fluctuating energy demands is straightforward and uncomplicated. With approximately 400 active storage facilities in 30 states, natural gas is available when it is needed most and protected underground from weather related issues.*



*https://www.energyinfrastructure.org/energy-101/natural-gas-storage

Natural Gas is...



STABLE & BALANCED

Natural gas can provide stability to make up for shortfalls in the electric grid.

SAFE & RELIABLE

Natural gas infrastructure improvements have led to 40% fewer pipeline incidents.

COST-EFFECTIVE

Natural gas is the most cost- effective fuel for meeting marginal power needs.*

*https://www.ingaa.org/File.aspx?id=38583© Energy

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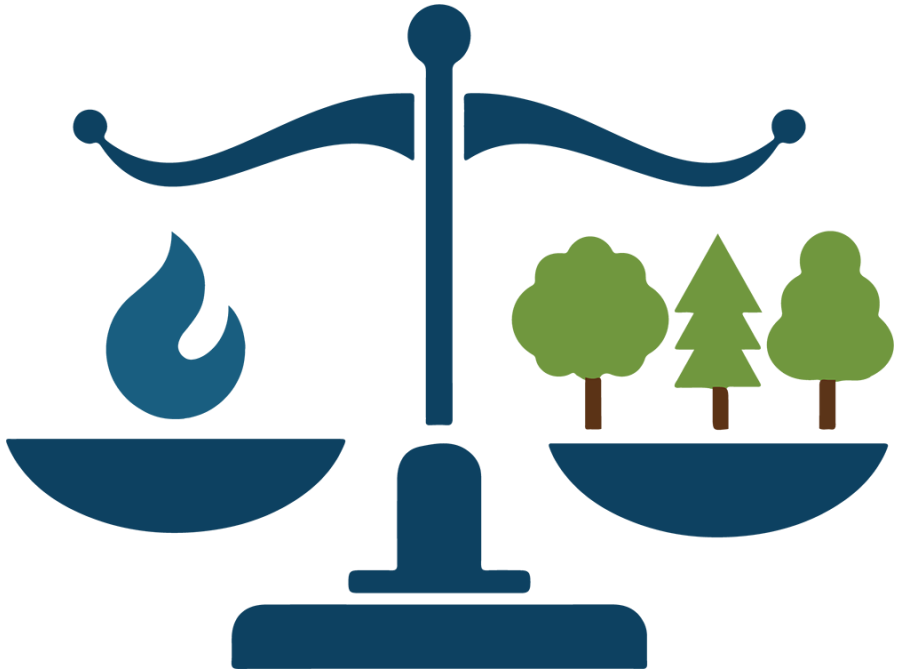

Balancing Power and Variable Renewables with Gas

Flexible grid resources, such as natural gas and energy storage, can help manage the intermittency and variability of renewable energy resources, and minimize costs associated with a low-carbon power grid.

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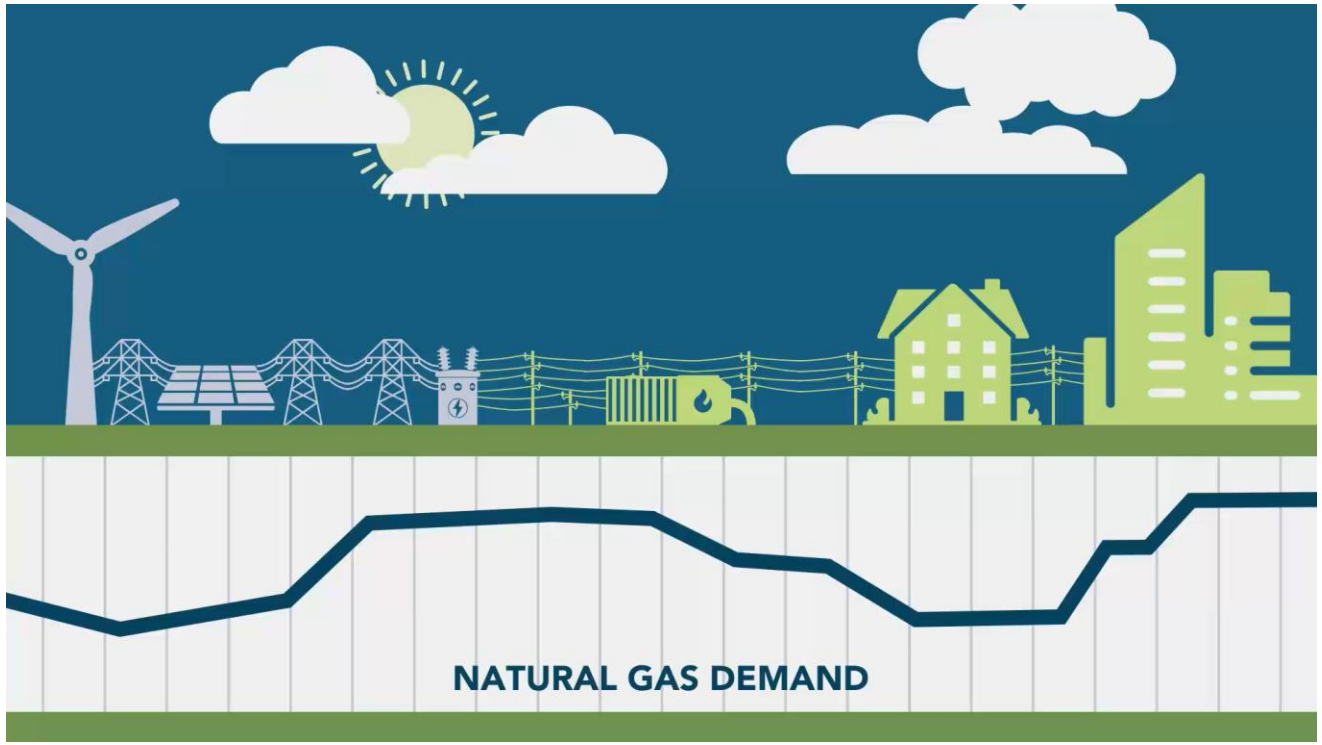
Planning for a High Renewable Energy Future

In order to ensure system flexibility, utilities will need to balance the intermittent and variable energy output of solar & wind power with other, more reliable, energy generation technologies whose power output can quickly ramp up or down.

Gas and storage resources can quickly adjust their output to compensate for changes in renewable power output and ensure a reliable and continual balance between supply and demand.



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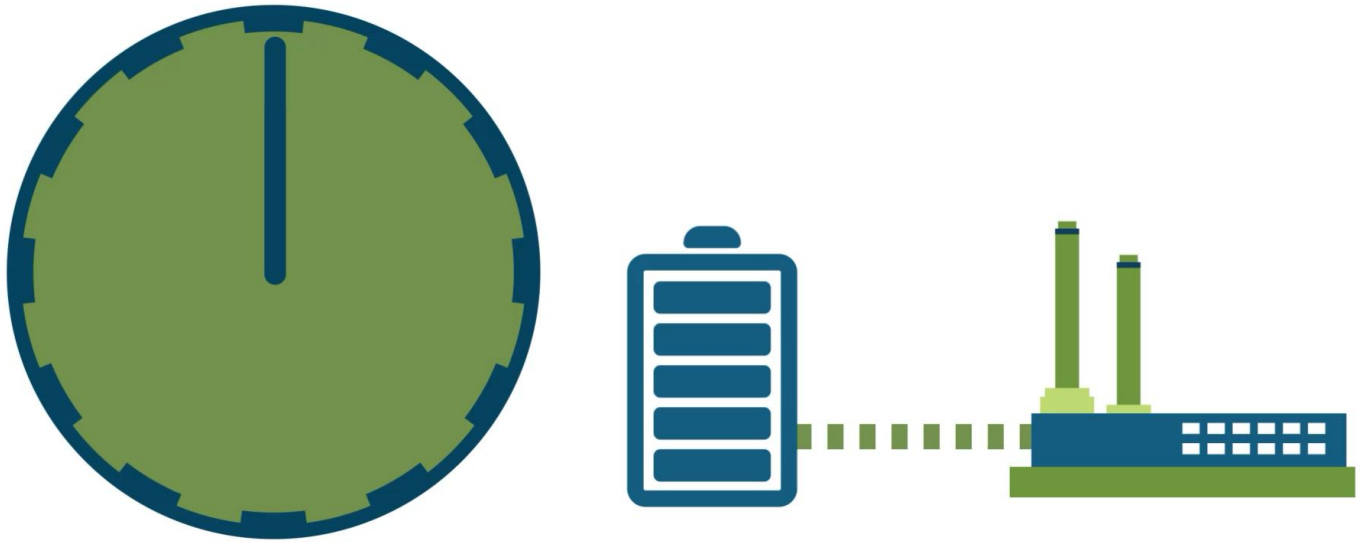
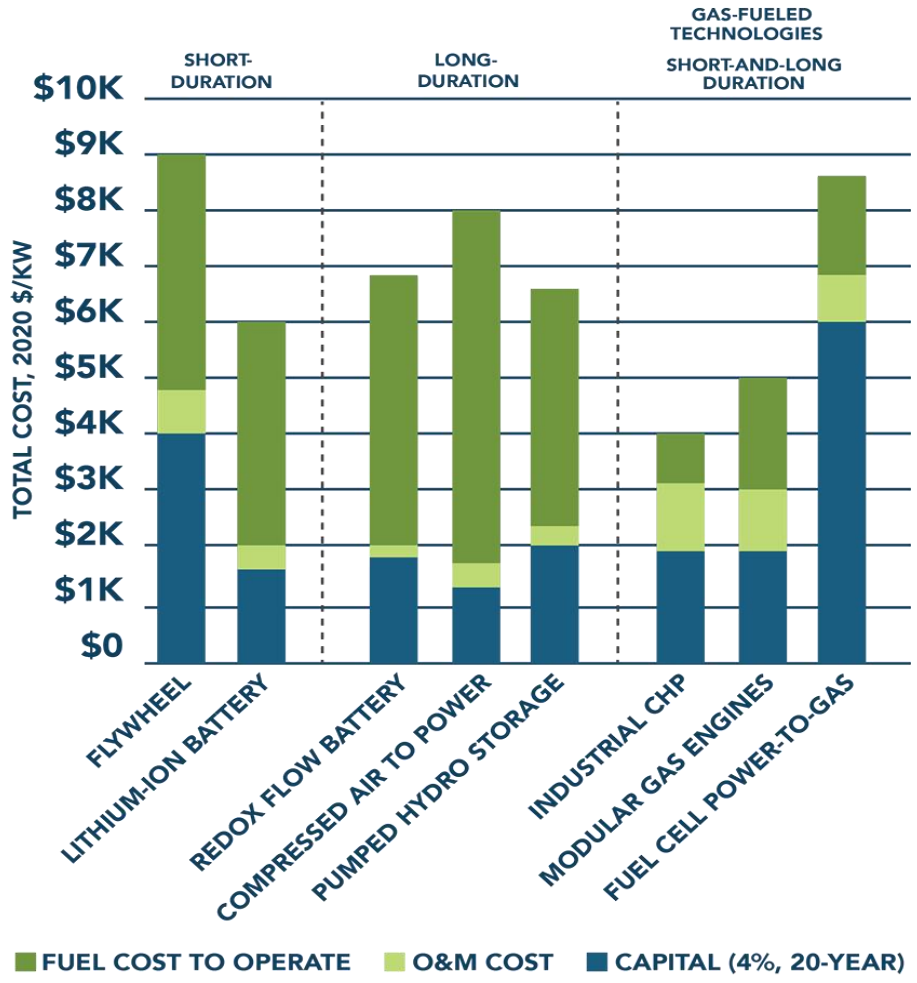
Types of Flexible Grid Resources

Energy storage technology options are generally divided into two categories: short duration (< 4 hours) and long duration (> 4 hours). Gas-fueled technologies, can be more commercially viable than other energy storage options.



20-YEAR LIFE CYCLE COST ANALYSIS



Source: ICF, Energy Storage Comparison Analysis with Gas-Fueled Technology

Natural Gas as an Option for Flexibility

While grid-scale energy storage systems develop and become more cost-effective, utilities can use gas-fueled technologies to balance variable renewable energy output.

- Start-up times of about 3-5 minutes
- Combined heat & power and gas engine generators have the lowest lifecycle costs compared to electric storage technologies
- Fueling with renewable natural gas provides flexibility and greenhouse gas (ghg) reductions
- Potentially can be retrofitted to use hydrogen*
- Supports long-term storage of hydrogen
- Maximum utilization, cost-effective, reliable and resilient

*https://www.2g-energy.com/products/hydrogen

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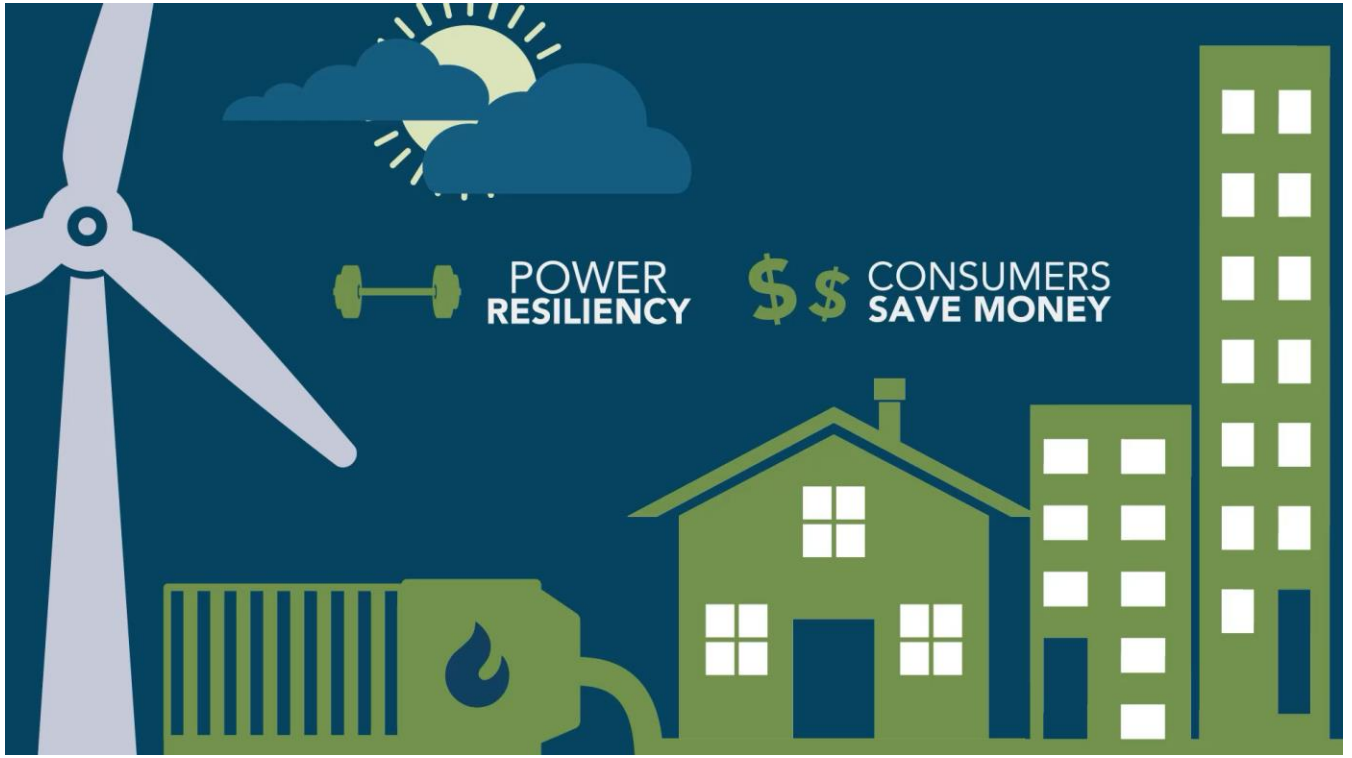
Flexible Grid Resources Minimize Cost of Decarbonization and Enhance Resiliency

Variable renewable energy resources will likely play a large role in decarbonized electricity system, pairing these resources with flexible natural gas power generation resources will minimize the cost of the low-carbon transition. Incorporating flexible natural gas generation resources that can provide power resiliency during periods of low renewable energy output and will help reduce future electricity prices and save consumers significant amounts of money.[1,2]



[1] Progress in Energy, Role and Value of Flexibility in Facilitating Cost-Effective Energy System Decarbonization, 2020
[2] Joule, The Role of Firm Low-Carbon Electricity Resources in Deep Decarbonization of Power Generation, 2018

Natural Gas Emissions Will Drop in the Future as Lower Carbon Gases are Blended into the Natural Gas Distribution System

Renewable Natural Gas Reduces Carbon Emissions

Renewable natural gas (RNG) from biomass helps to meet America's growing demand for a low-carbon, affordable, and reliable fuel. RNG is fully compatible with conventional natural gas and the existing pipeline infrastructure.

Hydrogen's Role in the Low-Carbon Economy

Hydrogen will play a key role in the transition to a clean energy economy across many sectors. Hydrogen does not release greenhouse gas emissions during combustion and can generate electricity, fuel vehicles, and provide heat for homes, businesses, and industry. Hydrogen produced from the reformation of biomass/waste, including renewable natural gas (RNG), can be considered carbon neutral. Hydrogen produced with fossil fuels can also be considered carbon neutral when paired with carbon capture, utilization, and storage (CCUS) technology. And Hydrogen produced with renewable electricity is also carbon neutral.

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Flexible Combined Heat and Power Systems

One way utilities can cost-effectively balance the intermittency of variable renewable energy is by leveraging Combined Heat & Power (CHP) systems at commercial & industrial sites.

- Flexible CHP systems provide electricity and thermal energy for heating, processes or other plant operations.
- Flexible CHP systems provide additional generation capacity that can be used when the grid demand increases and/or renewable resources are not available.

Carbon Footprint

Understanding carbon footprints is critical to reducing carbon emissions.

What is a **Carbon Footprint**

and how does that impact us?

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What is a Carbon Footprint?

- A carbon footprint is a measure of the amount of greenhouse gases produced from human activities, usually measured in units of carbon dioxide (CO2).
- A carbon footprint quantifies the amount of emissions released by routine activities, such as generating electricity, driving, farming, and manufacturing.
- Calculating carbon footprints for individuals and businesses is critical to making informed decisions on how to reduce carbon emissions.

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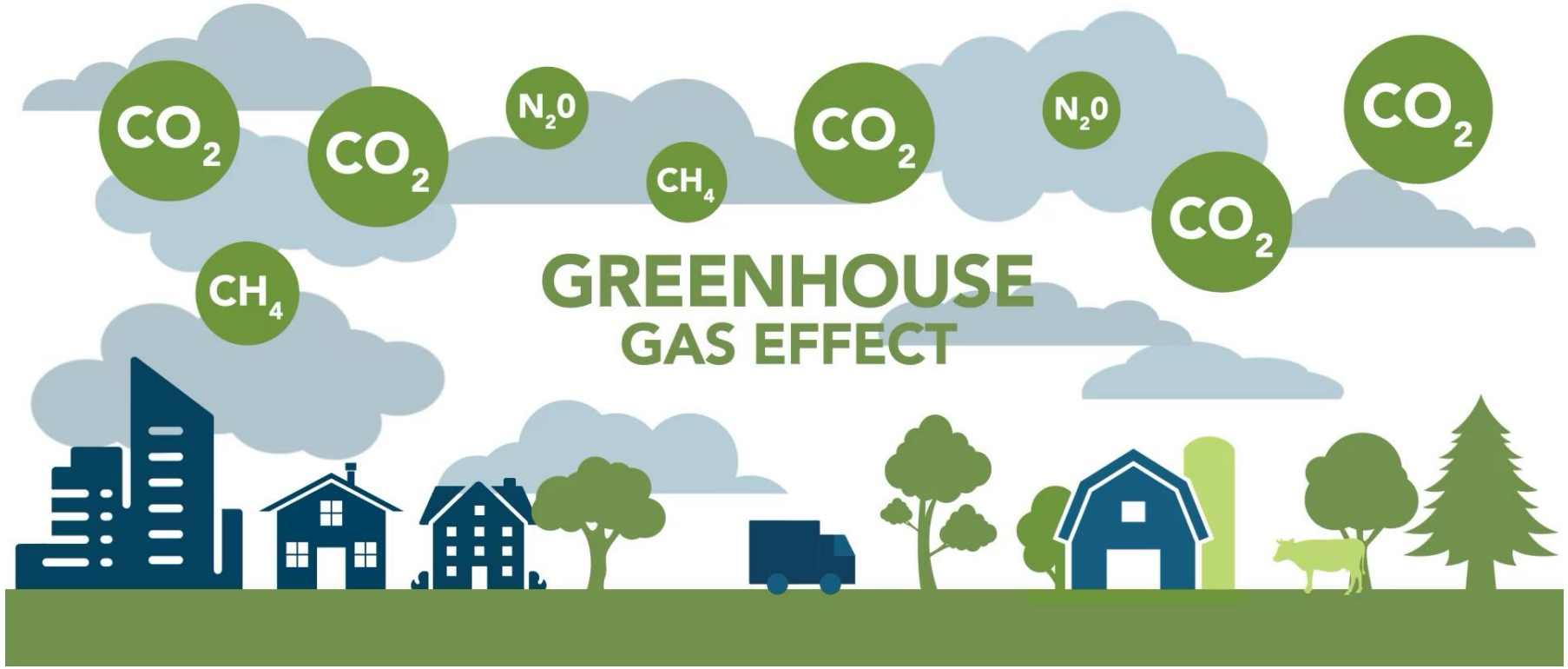
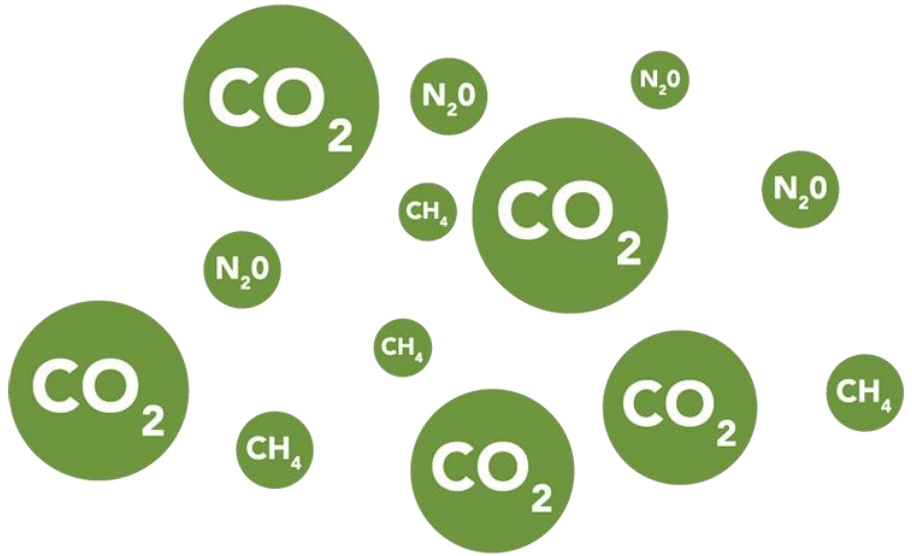
Greenhouse Effect

The greenhouse gas effect results from the presence of carbon dioxide, methane, nitrous oxide, and other greenhouse gases in our atmosphere.



Greenhouse Gas Effect

- These gases trap reflected solar radiation from the sun to insulate the earth and stabilize atmospheric temperatures.
- Increasing concentration of greenhouse gases from human activities has intensified the effect, resulting in more heat being trapped, higher average global temperatures, and climate change.
- Two times more CO2 is being emitted than can be naturally sequestered*.



* https://www.co2.earth/global-co2-emissions

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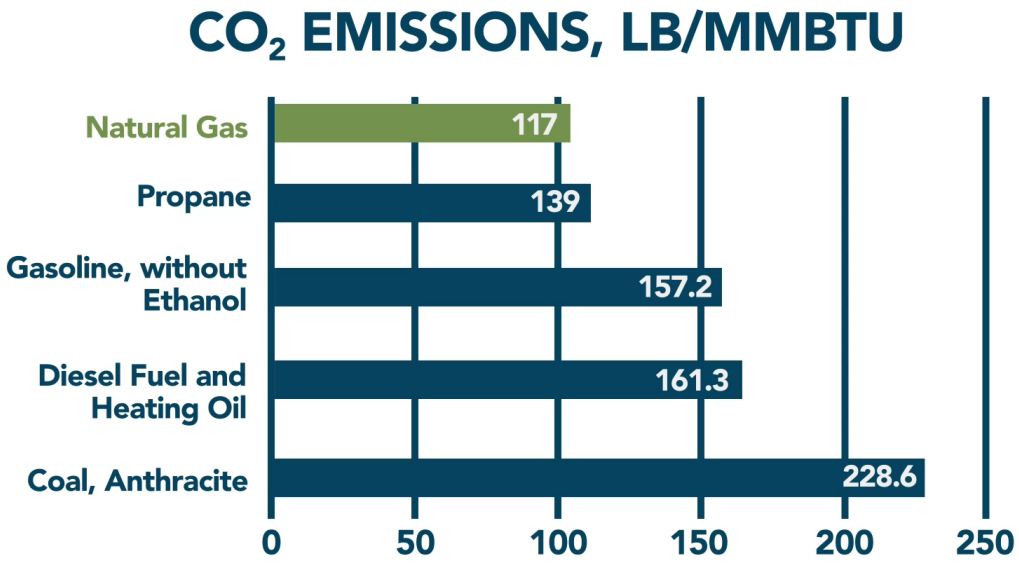
Carbon Content of Different Fuel Sources

- The carbon intensity (i.e., the amount of CO2 emitted per unit of energy consumed) of natural gas is lower than all other fossil fuels.
- Natural gas has replaced coal as the top fuel in the U.S. electricity sector is one of the main reasons why this sector has been able to reduce its emissions over the last 10 years.*

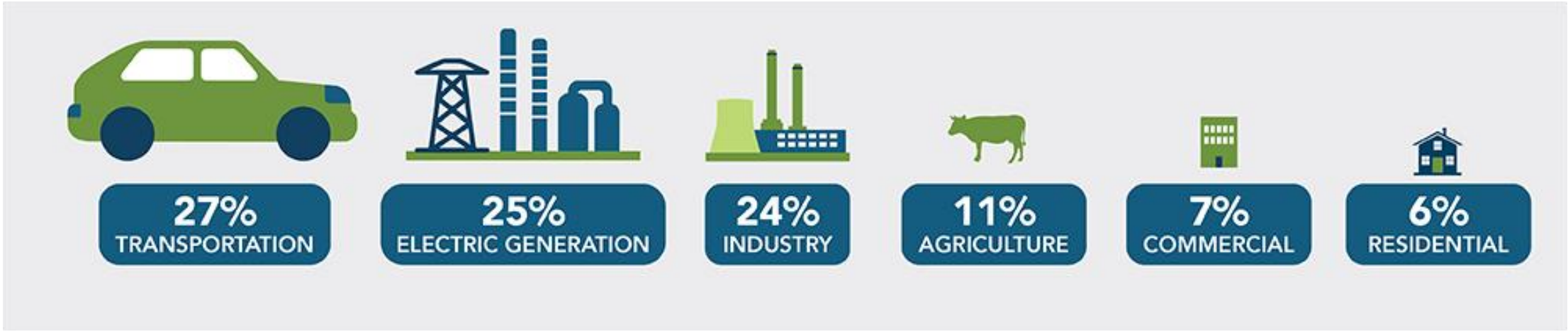


Source: EIA, Carbon Dioxide Emissions Coefficients

*U.S. EPA, Sources of Greenhouse Gas Emissions, 2022

Greenhouse Gas Emissions By Sector

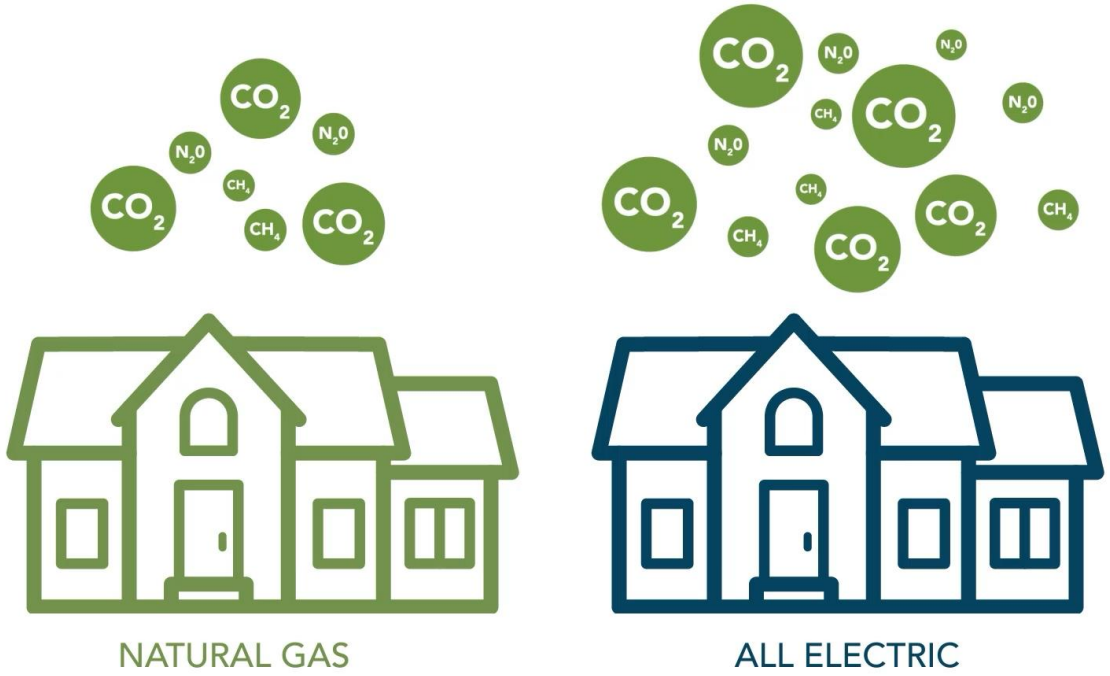
~75% of greenhouse gas emissions in the United States comes from the transportation, electricity generation, and industrial sectors, with the rest coming from agricultural operations and commercial and residential buildings. Plus, over half of energy consumption in U.S. households is used for space heating and cooling.*



*Total U.S. Greenhouse Gas Emissions by Economic Sector in 2020

Energy Use in Households

- Over half of energy consumption in U.S. households is used for space heating and cooling.*
- When considering source emissions and electricity system losses, households with natural gas appliances may produce fewer greenhouse gas emissions than those with all-electric appliances.



*U.S. EIA, Use of Energy Explained, 2021

GHG EMISSION CATEGORIES

Greenhouse gas emissions can be categorized into three different groups based on when and where they are emitted across the value chain of a good or service. These categories include:*

Scope 1-Direct Emissions

Scope 1 emissions are any direct emissions from the activities of an organization. This includes burning fossil fuels for heat or burning gasoline to power a vehicle

Scope 2-Indirect Emissions

Scope 2 emissions are indirect emissions associated with the production of electricity, heat, and steam purchased by an organization. These emissions are indirectly released as a result of the organization's operations.

Scope 3-Other Indirect Emissions

Scope 3 emissions refer to any other indirect emissions throughout the value chain. This includes emissions released when purchasing, transporting, and disposing of materials, goods, and services.

*U.S. EPA, Scope 1 and Scope 2 Inventory Guidance, 2021

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Natural Gas is Key to a **Low Carbon** Energy Future

Natural gas emits significantly less CO2 than other fossil fuels and is a major part of the solution as we work towards a low carbon future.

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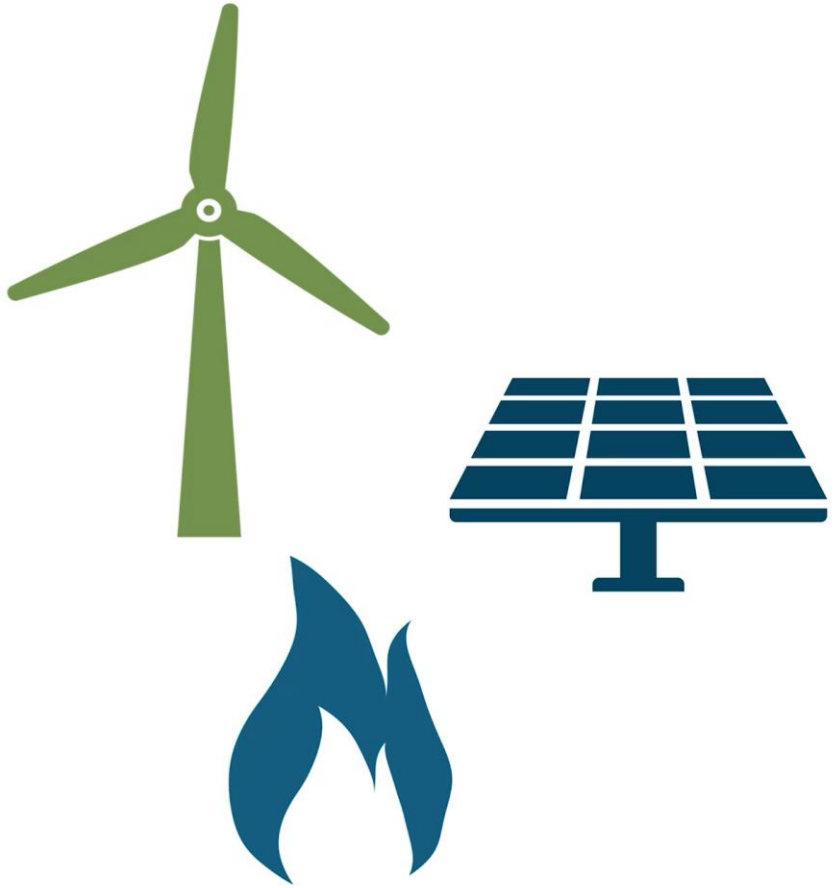
Natural Gas Offers Reliability And Stability

- Natural gas offers reliability, resiliency, and stability to the energy system, especially in peak energy demand periods.
- Natural gas is less expensive and a solution to allow renewable research and advancements to continue and thrive.
- Developments in wind and solar power are reducing the carbon footprint of the electric grid.
- These low-carbon energy sources require additional electric storage to offset the irregular power generated by solar or wind turbines.



Upgraded Natural Gas Pipelines Reduce Emissions By 73%[1]

- Better systems management[2]
- Diligent preventative maintenance
- Enhanced leak detection repair

According to the U.S. Environmental Protection Agency, from 1990 to 2018, upgraded pipelines have cut methane emissions from the gas transmission and distribution system by 73%

1 aga.org/news/news-releases/gas-utilities-support-methane-reduction-innovations/
2 https://www.aga.org/sites/default/files/legacy-assets/our-issues/Rewriting-Our-Energy Future/Documents/Rewriting%20Our%20Energy%20Future%20WEB%20FINAL.pdf

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Direct Consumption Of Natural Gas Maximizes Efficiency And Lowers Emissions

Direct use of natural gas for heating, cooling, water heating, cooking, and clothes drying cuts carbon emissions by almost 50%. Direct use is more efficient than consuming gas-fired electricity from the grid.[1]

Direct Consumption is 92% Efficient[1]

Households with natural gas appliances produce 22% fewer overall greenhouse gasses compared to electric-only homes.[2]

1 https://playbook.aga.org/reliable

2 https://playbook.aga.org/environment/

Carbon-Neutral Renewable Energy

Renewable Natural Gas Reduces Carbon Emissions

Displacing carbon emitting gas with carbon neutral gas significantly lowers total greenhouse gas emissions.[1]

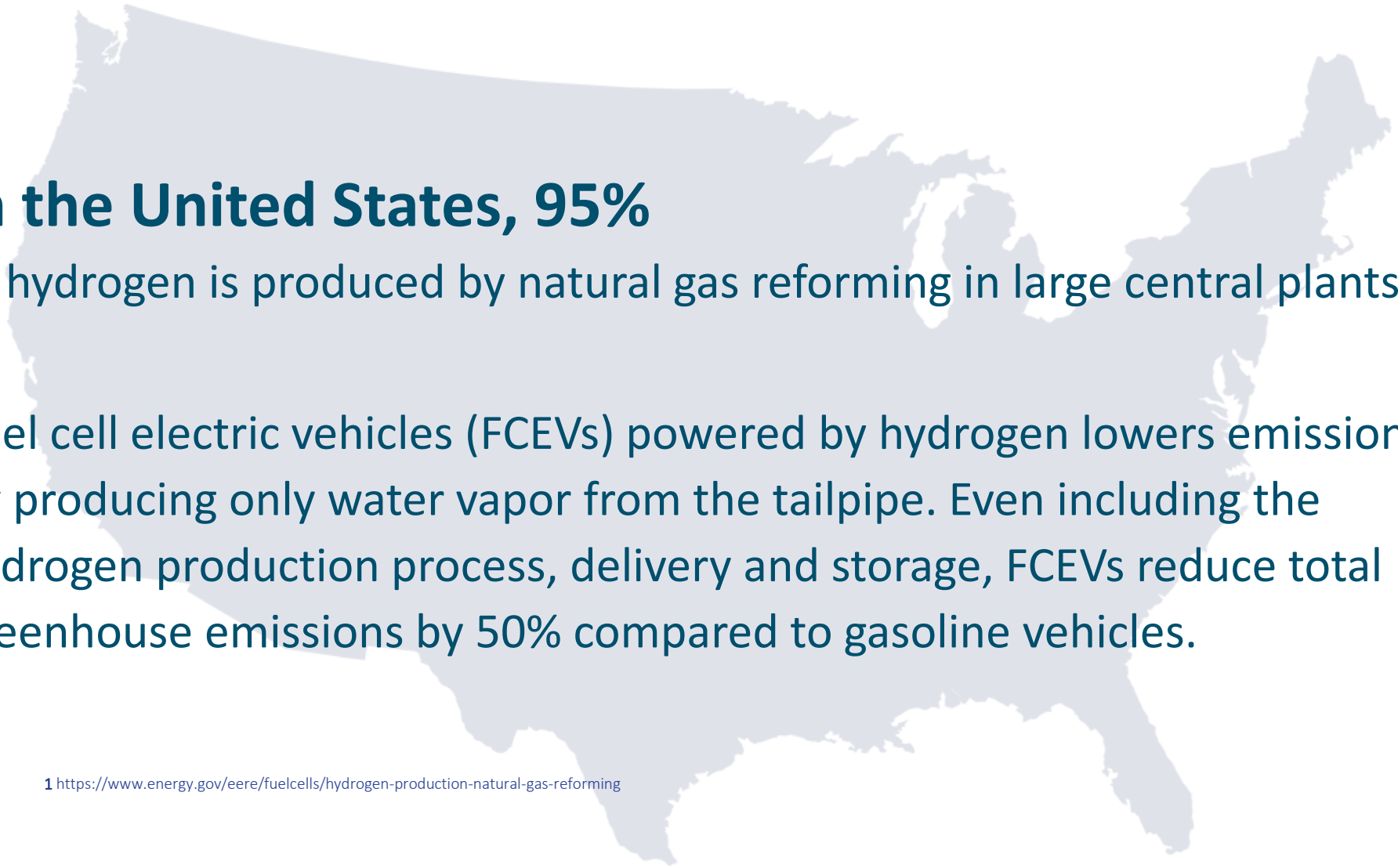
Biogas Refining from Existing Sources Converts Methane into Carbon-Neutral Renewable Energy[2]

- The capture of biomethane at wastewater treatment plants, agricultural waste, waste processing facilities and landfills, prevents methane release into the environment.

1 gasfoundation.org/wp-content/uploads/2019/12/AGA_3894-RNG-2-Pager_V-11.pdf

2 https://gasfoundation.org/wp-content/uploads/2019/12/AGA_3894-RNG-2-Pager_V-11.pdf

Hydrogen Produced from Reforming Natural Gas Powers Fuel Cells



In the United States, 95%

of hydrogen is produced by natural gas reforming in large central plants.[1]

Fuel cell electric vehicles (FCEVs) powered by hydrogen lowers emissions by producing only water vapor from the tailpipe. Even including the hydrogen production process, delivery and storage, FCEVs reduce total greenhouse emissions by 50% compared to gasoline vehicles.

1 https://www.energy.gov/eere/fuelcells/hydrogen-production-natural-gas-reforming

ESC

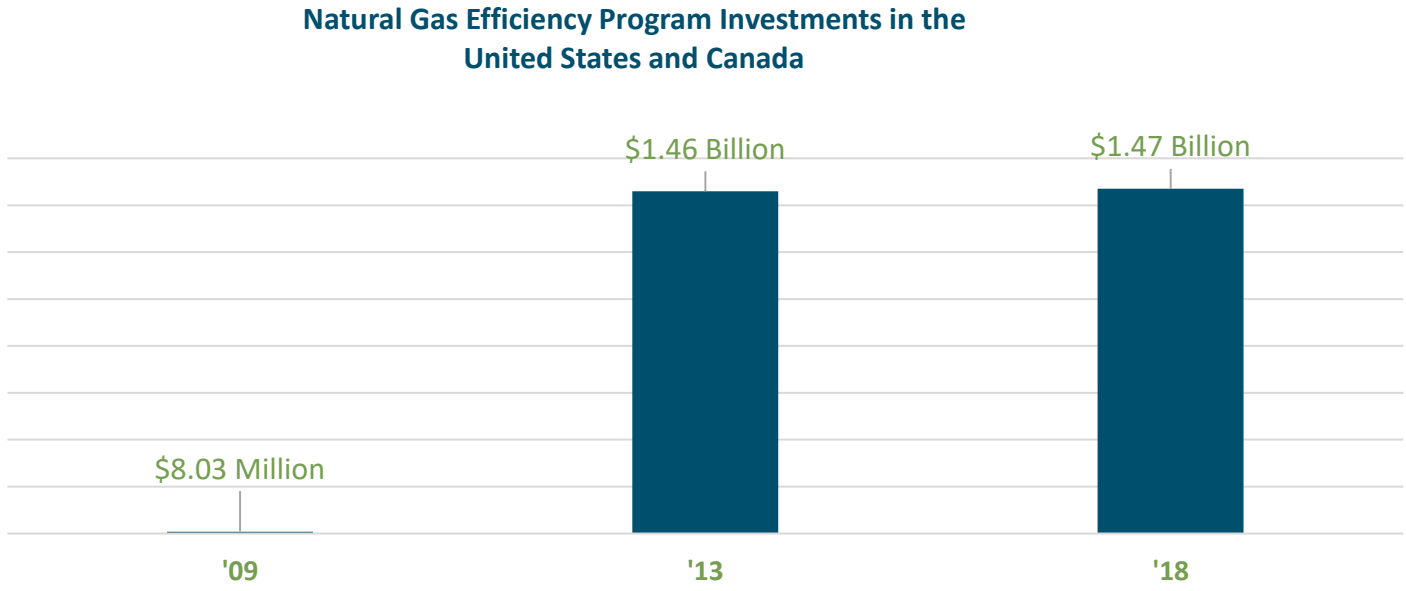
Gas Heat Pumps are Reliable & Save Energy

- Natural Gas Heat Pumps (GHP) function on similar principles as electric heat pumps with added performance and comfort during very cold weather.
- GHPs can extract heat from air, ground, or water sources.
- Gas Heat Pumps exceed 100% efficiency for heating.
- GHPs generally produce lower CO2 emissions compared to conventional systems.
- Some GHPs use low to 0 Global Warming Potential (GWP) refrigerants.

ESC

Energy Efficiency Programs

American and Canadian utilities funded almost $1.5 billion U.S. for gas efficiency programs that helped customers reduce their carbon footprint by 2.25 million metric tons of avoided CO_2. That is equivalent to almost 490,000 passenger vehicles taken off the road or over 270,000 homes' energy use for one year. [1]

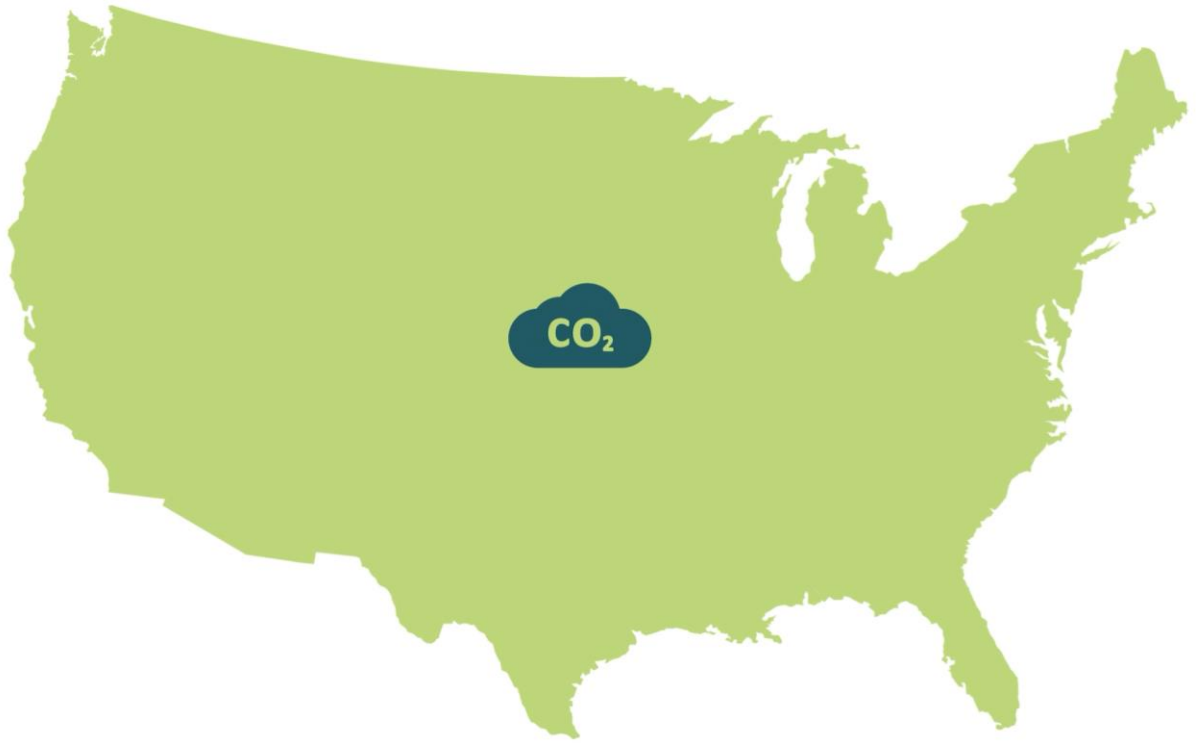


Source: https://dailyenergyinsider.com/news/26350-natural-gas-utilities-invested-1-47b-in-energy-efficiency-programs/

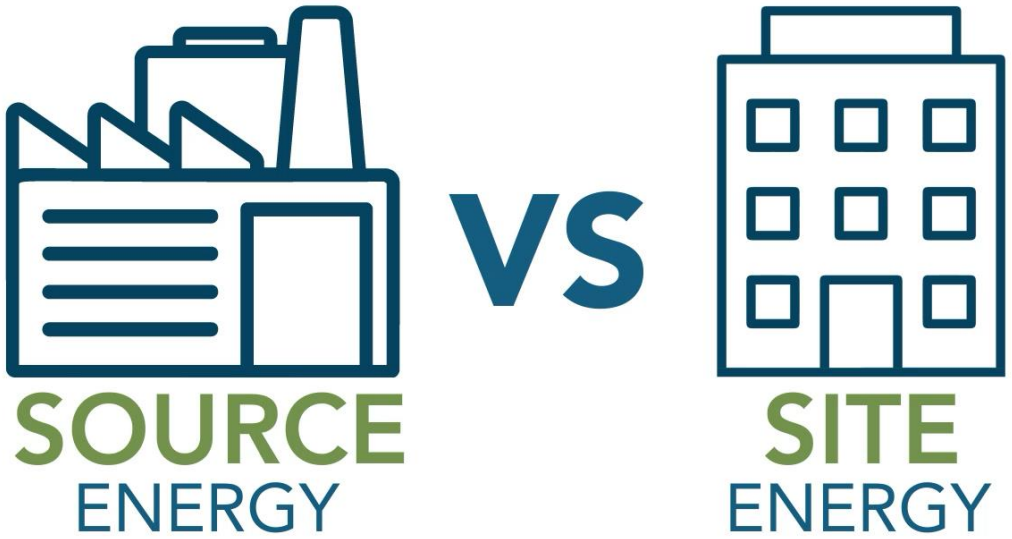
1 https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Carbon Capture and Carbon Sequestration Remove CO2 from the Atmosphere

- Carbon capture technology for natural gas fired power plants already exists.
- Department of Energy models show that technology improvements will lead to significant adoption.* Carbon sequestration is possible by piping CO_2 fertilizer into greenhouses for storing carbon in plants, using for industrial processes and goods, or injecting carbon dioxide deep below the Earth's surface to trap the carbon permanently below the impermeable seal.



*https://www.energy.gov/sites/prod/files/2017/01/f34/Carbon%20Capture%20Opportunities%20for%20Natural%20Gas%20Fired%20Power%20Systems_0.pdf

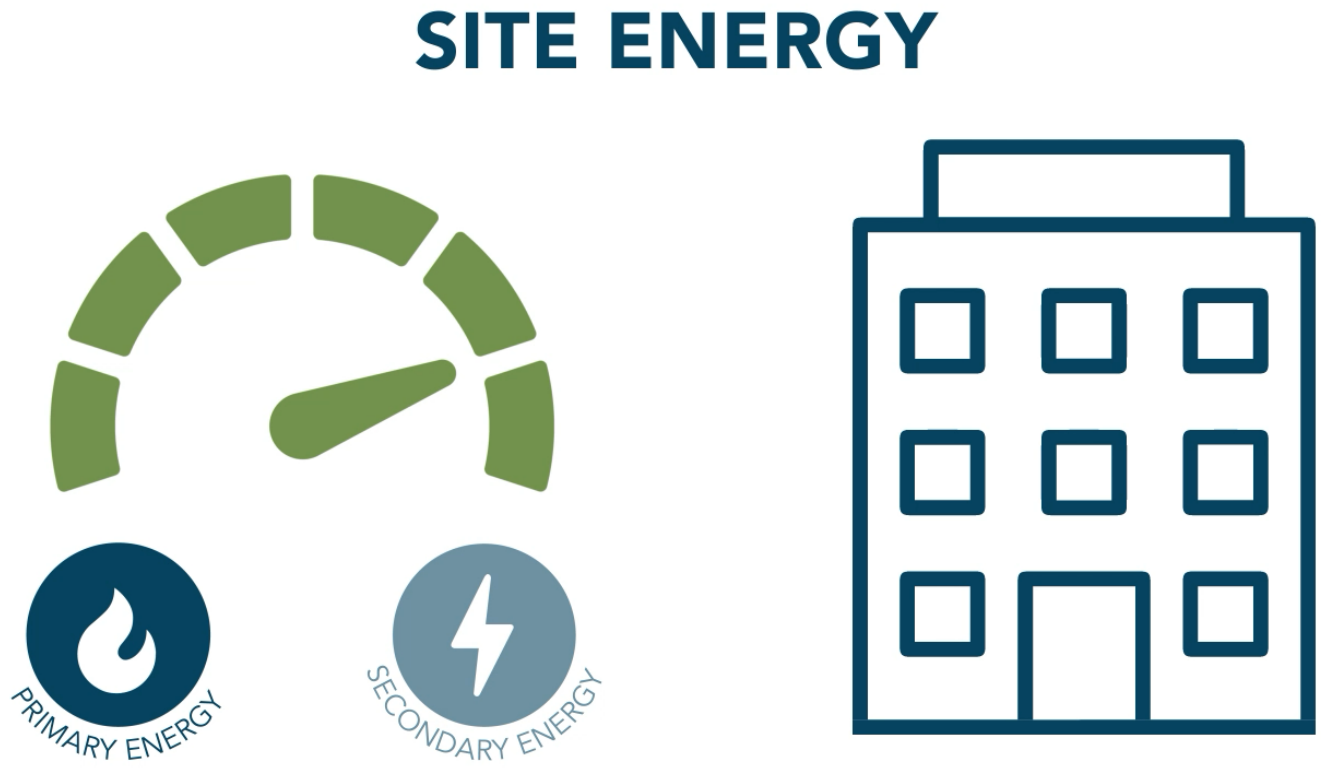


Source vs. Site Energy Solutions

When discussing energy efficiency, decarbonization, and greenhouse gas accounting, the terms source energy and site energy are often used. What is the difference between source and site energy?

Site Energy

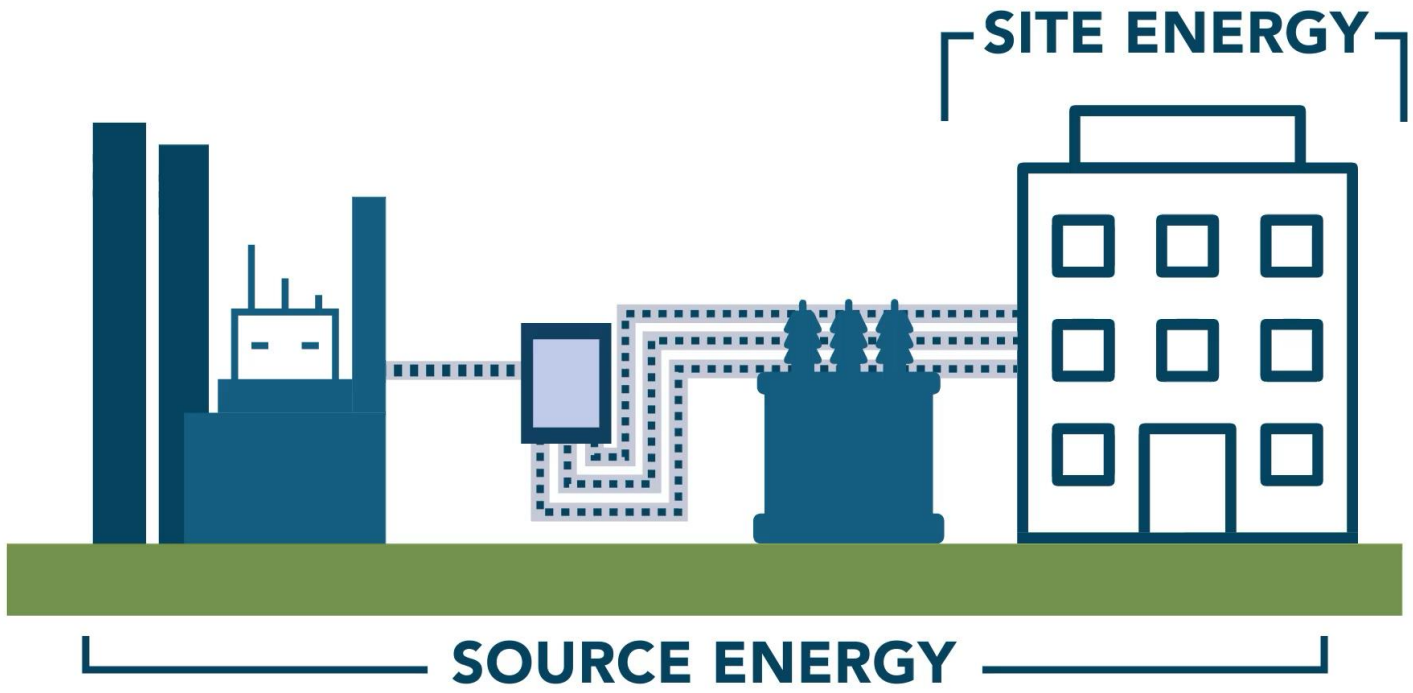
- The amount of energy metered at the point of use (e.g. consumed by a building)
- Refers to both primary energy (natural gas or fuel consumed on site) and secondary energy (heat or electricity created from raw fuel)



Source: EPA Energy Star

Source Energy

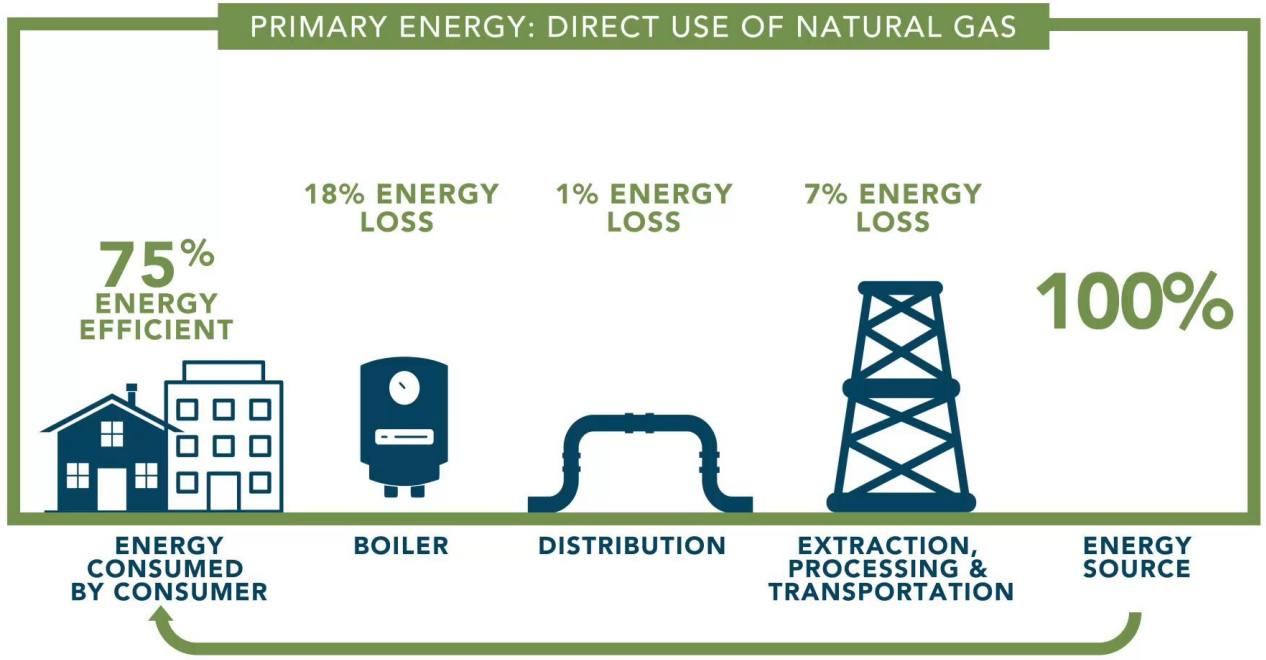
- The amount of primary energy consumed in supplying secondary energy to a building
- Has a larger scope (the amount of energy produced at a power source for a given end use)
- Less efficient than site energy
- The power generation, transmission, and delivery of source energy to the site results in losses.



Source: EPA Energy Star

Natural Gas as a Primary Energy Source

- Natural gas is the most widely used fuel for primary energy in the U.S.
- Energy consumed for extraction, processing, transportation and distribution reduces the efficiency of direct natural gas usage by approximately 8%[1]
- It's combusted and often connected to a furnace or boiler system to heat air, water or steam (with a typical efficiency of 82%)
- Direct use of natural gas is 75% energy efficient[2]



1 www.aga.org
2 https://www.icf.com/

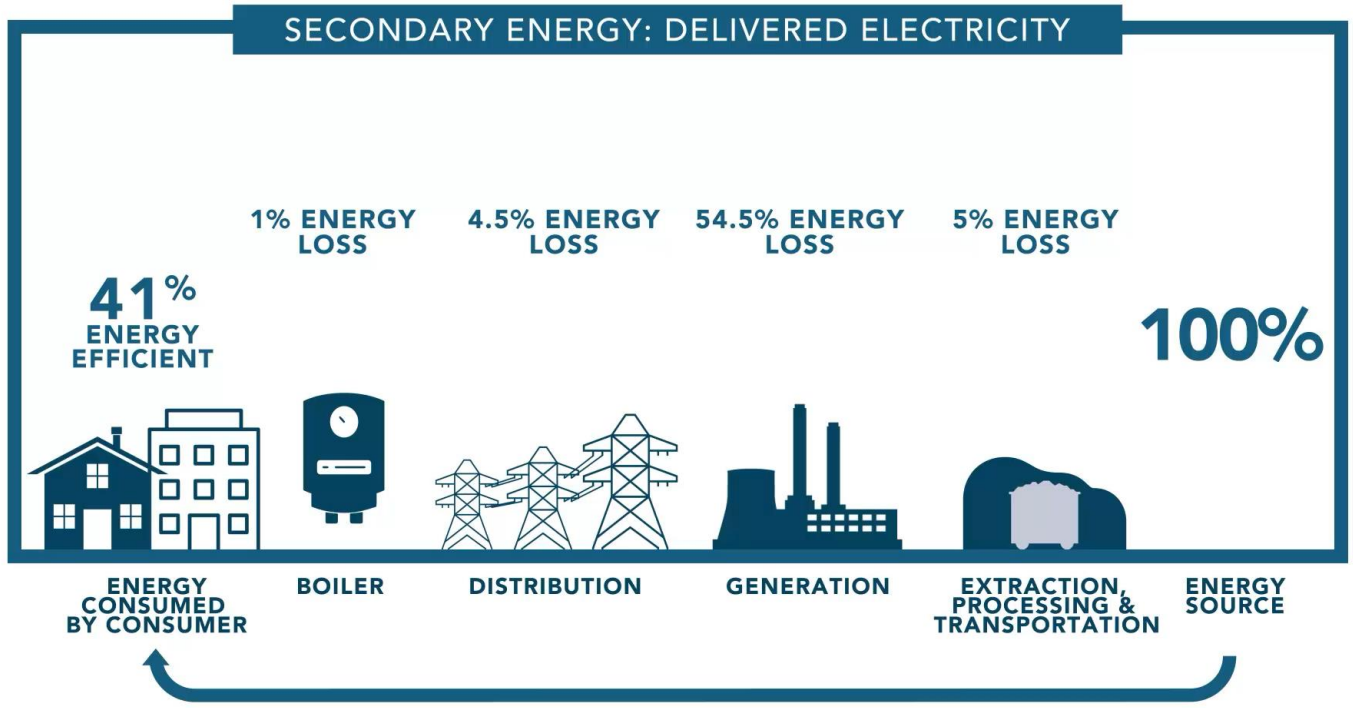
Natural Gas as Secondary Energy Source

- Approximately 5% of the source energy used to produce electricity is lost in extraction, processing, and transportation of that source energy.
- Natural gas is combusted and connected to turbines or engines which generate electricity that is transmitted via power lines
- More than half the remaining energy is lost as heat to the atmosphere during electric generation
- Additional losses occur during electric distribution and conversion to heat for use in a building
- Delivered electricity generated by natural gas is 41% energy efficient[2]

2 https://www.icf.com/

Primary versus Secondary Energy

- Energy required for secondary energy (via electricity production) is nearly double that of primary energy.
- Losses from electricity generation and delivery tend to result in higher source energy emissions compared to direct use of natural gas.



Direct use of Gas vs Electric for Heating

Losses from electricity generation and delivery tend to result in higher source energy emissions compared to direct use of natural gas.

	Energy Used (MMBtu)	Energy Required (MMBtu)	On-Site CO_2 Emissions (lbs)	Off-Site CO_2 Emissions (lbs)	Total CO2 Emissions (lbs)
Gas Boiler Direct Use of Natural Gas	1,000	1,220	142,317	11,385	153,702
Electric Boiler eGRID Non-Baseload	1,000	1,010	0	458,016	458,016

Thank You

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