



GLOBAL NATURAL GAS INSIGHTS • 2019 EDITION

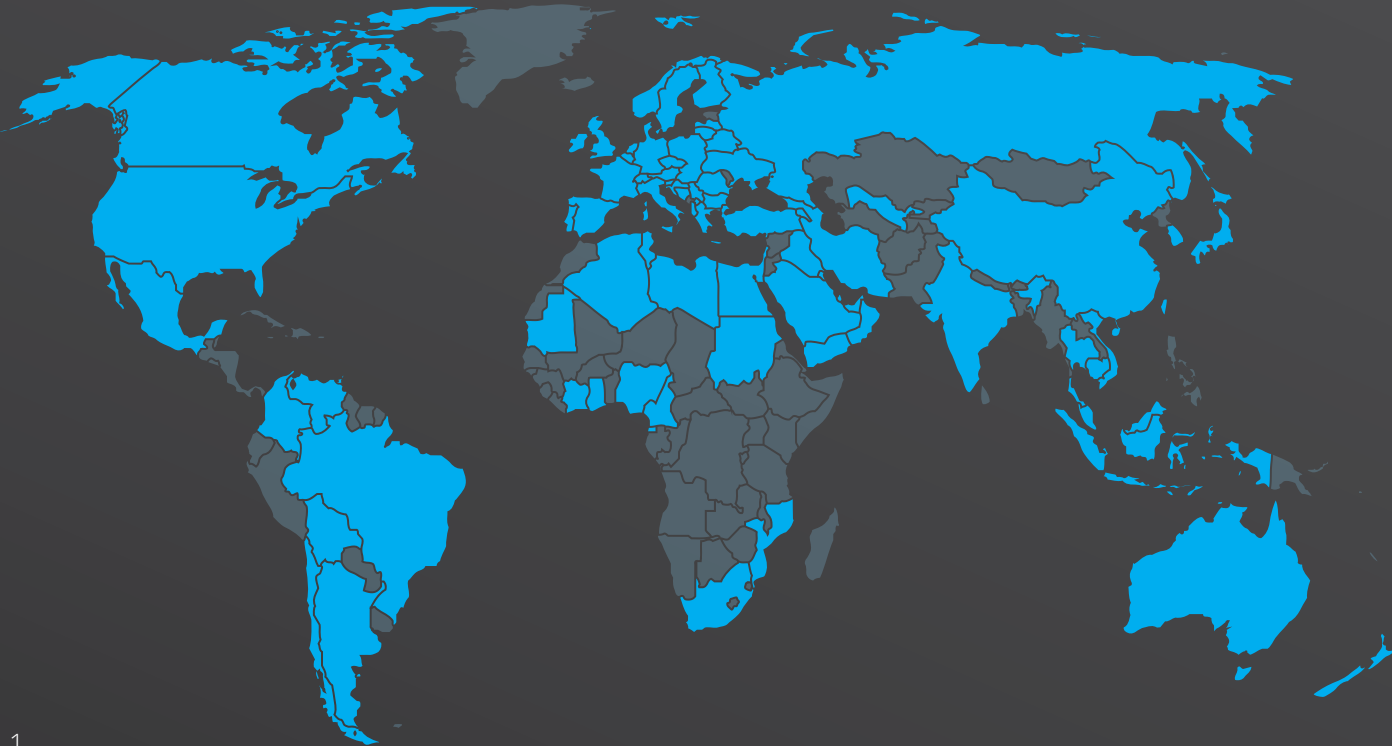
Sustainable Future Powered by Gas





IGU Membership represents over **95 percent** of the global gas industry across all five continents and covers the full value chain.

89 Charter members, 14 Premium Associate Members and 61 Associate members. The member countries are marked in blue (June, 2019).



A message from...

The International Gas Union is pleased to present the second edition of the Global Natural Gas Insights.

This handy booklet summarizes the value of natural gas for meeting the most pressing global energy, climate, and economic challenges.

The 2019 edition contains the latest information on natural gas and its role in helping economies grow, lifting people out of poverty, and cleaning up the environment, while supporting reliable access to modern energy.

This edition also contains a special section on methane emissions, and the opportunities that their further reductions present for the industry.

Natural gas is the fastest, most economical way to the sustainable energy future.



JOE KANG

President, International Gas Union



LUIS BERTRÁN RAFECAS

Secretary General, International Gas Union

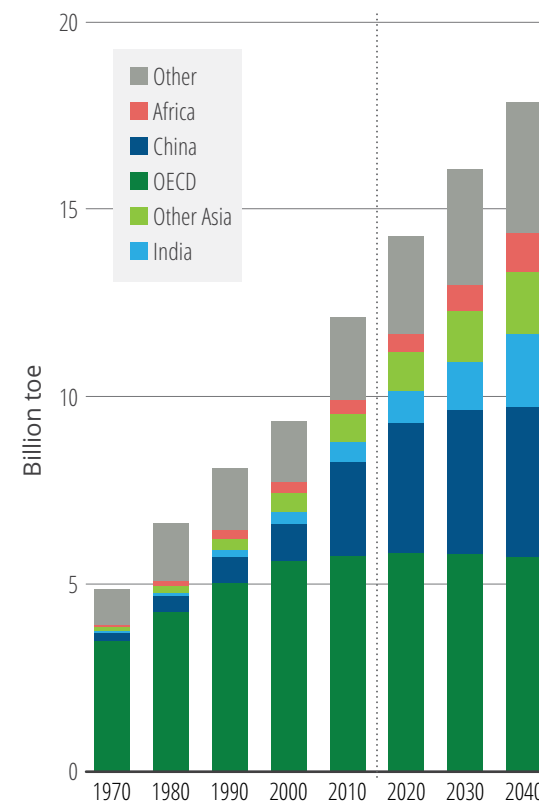
Sustainable Future Powered by Gas

Global energy demand is growing, together with the urgency to reduce emissions and pollution, while rapid changes in the global energy mix are putting a premium on energy security and reliability.

Finding a way to supply energy to more people, while maintaining good air quality, protecting the climate, and ensuring affordability is one of the biggest challenges of our time. Because it is clean, abundant, affordable and flexible, gas can effectively address this challenge.

Gas will provide sufficient energy securely, affordably, and sustainably wherever it is needed.

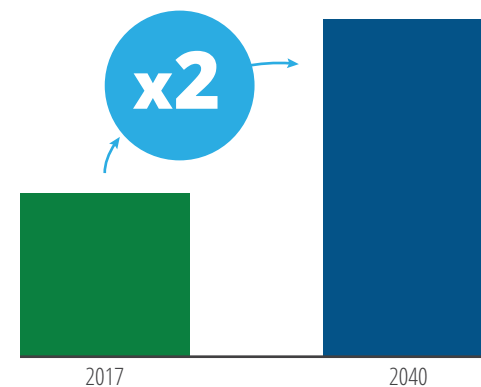
World Primary Energy Demand by Region



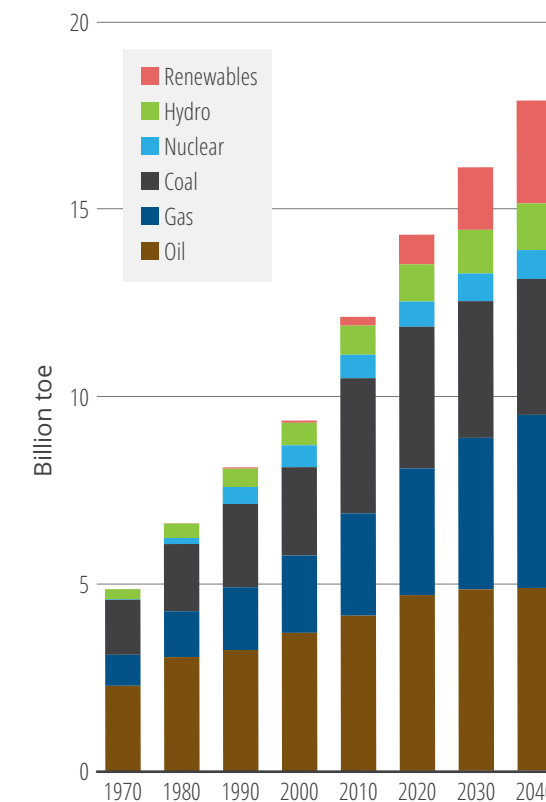
The world will need increasingly more energy, and large efficiency improvements will be necessary to achieve sustainability.

Efficiency gains will result in a slower pace of energy consumption growth; than in the previous decades, but that still means energy consumption increases by about a third in the next 20 years. Without deliberate policies, coal will continue to supply a significant part of it.

Increase in global GDP, 2017-2040



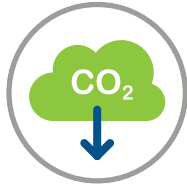
World Primary Energy Demand by Fuel



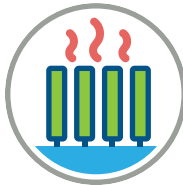
The Ideal Fuel to Energize Growing Cities



Air Pollution: nearly zero Sulphur Dioxide, low Nitrogen Oxide, and no Particulate Matter emissions



GHG Emissions: 40%-50% less than coal and 20% less than oil

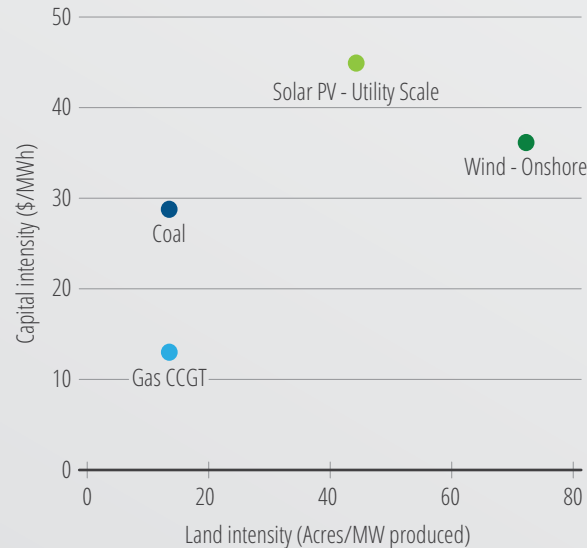


Heat Intensity: The most heat intensive and highest efficiency hydrocarbon fuel source



Scalability: Ease of adding customers once infrastructure is developed

Land requirements for power generation



Natural gas plays a unique role as a source of energy for cities

The world will have 2.5 billion more people, and around two thirds of the world's population is expected to live in cities by 2050.

It will require building the equivalent of a new city of more than 1 million people every week for the next three decades.

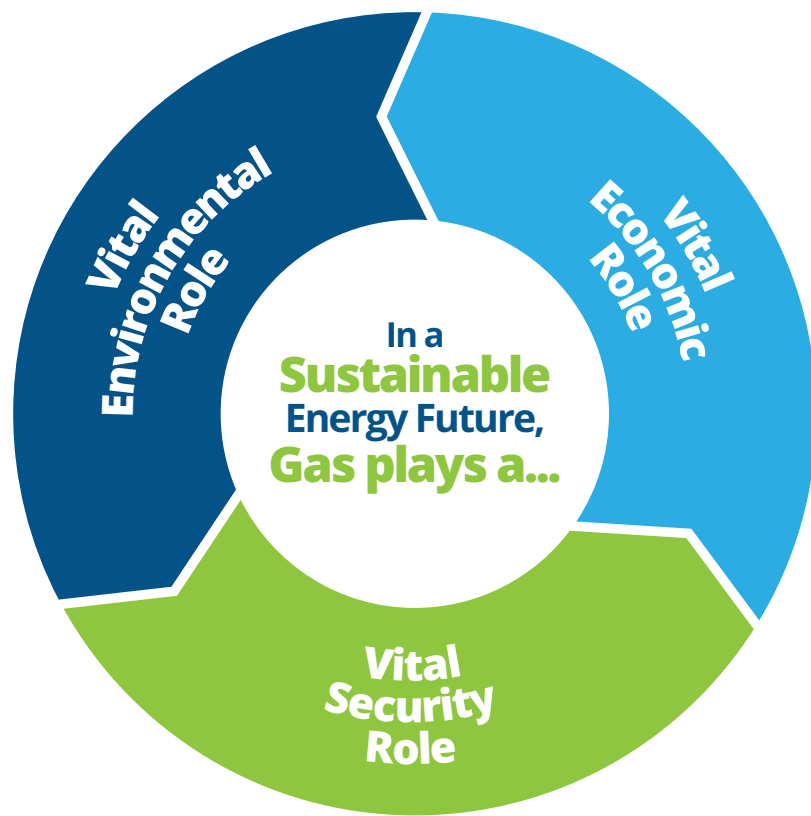
Such dramatic growth in urban centers will result in greater energy demand, both directly from cities, and indirectly from greater urban economic activity, and gas is ideally positioned to meet it.

As the most heat intensive fuel, compared with coal or oil, gas supports the high heat requirements of urban buildings and industrial processes, while at the same time, ensuring clean air and lower GHG emissions.

It offers further emissions reduction potential, through increasing efficiency, combined heat and power applications, and injection of renewable gases or hydrogen.

At the same time, the development of gas infrastructure provides a flexibility advantage, enabling smooth growth of urban economies, because once pipeline networks are established, adding more customers is relatively quick and cost-efficient.

**Gas is a
Critical
component
of the
Sustainable
Energy Future**



Natural Gas plays a Vital
Environmental Role
in the Sustainable
Energy Future

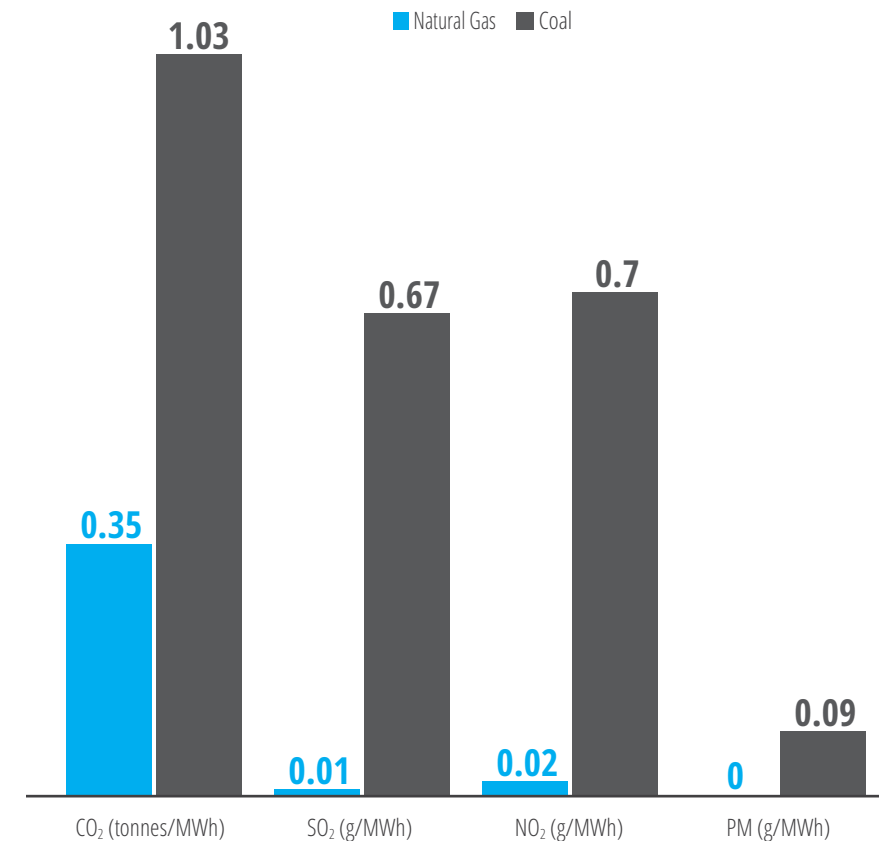
The Energy to Act Now for a **Cleaner** Environment

Natural gas supports two important requirements of a sustainable energy system. It helps to reduce harmful air pollutants and carbon emissions today, while complementing the development of renewables, and other innovative low-carbon energy technologies, which further promote clean air and reduce emissions.

In generating electricity, from production through to use, natural gas produces around half of the Greenhouse Gas Emissions (GHG), compared to coal.

Compared to coal-fired plants, modern natural gas plants also emit less than a tenth of Sulphur oxides, a quarter of nitrogen oxides, and essentially no particulate matter or heavy metals.

Coal vs. Gas Emissions from 1 MWh of Generated Power



Enables Clean air



4.2 million deaths every year as a result of exposure to ambient (outdoor) air pollution



3.8 million deaths every year as a result of household exposure to smoke from dirty cookstoves and fuels



91% of the world's population lives in places where air pollution exceeds WHO guideline limits

Air pollution continues to be the world's single greatest immediate environmental risk to health.

Air pollution affects the vast majority of global population; however, its heaviest burden falls on the most vulnerable members of society – the elderly, children, and those with health issues. It also tends to be much more severe in the developing world.

According to the WHO, in 2016 air pollution was responsible for 7 million premature deaths, and almost 600,000 of those were children, under the age of 5.

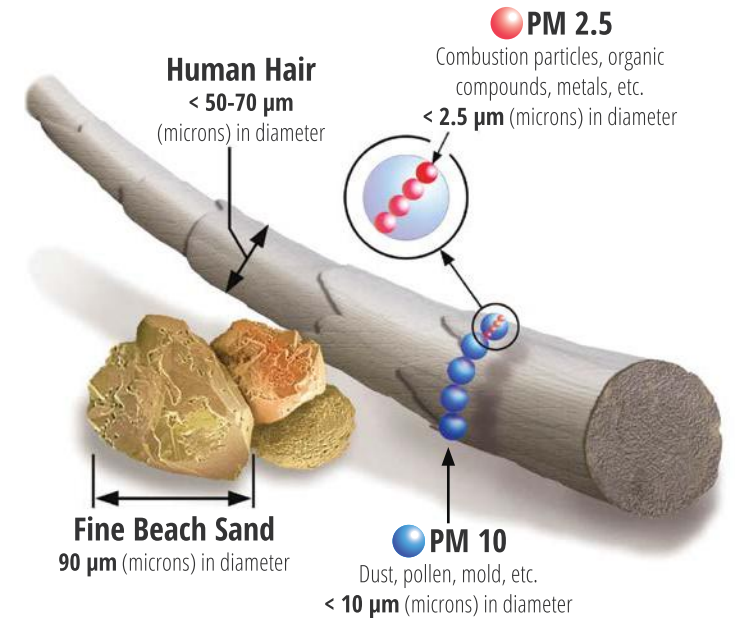
Particulate Matter Pollution

The major components of air pollution are a combination of gases and dust particles that have detrimental human health and environmental consequences.

Particulate matter, or PM, is one of the most common and dangerous pollutants.

According to the US Environmental Protection Agency (EPA), PM contains microscopic solids, or droplets, that are so small that they can be inhaled and cause serious health problems. Some particles, less than 10 micrometers in diameter, can get deep into lungs; and some may even get into the bloodstream. Particles less than 2.5 micrometers in diameter, also known as PM2.5, pose the greatest risk to health.

The WHO has recognized PM as a carcinogen since 2013.



Source: EPA

Natural Gas Cleans Up City Air

NEW YORK



69% SO_x ↓

NYC Converted 30% of heavy fuel burning buildings to natural gas & achieved 69% reduction in SO_x concentration within 4 years

TORONTO



90% PM & SO_x ↓

Removal of coal from power generation resulted in reductions in PM₁₀, SO_x & NO_x of 90%, 91% and 65% from 2004 levels, and reductions in premature deaths and hospitalization by 76% & 60%.

SANTIAGO



58% PM_{2.5} & 39% PM₁₀ ↓

Gradual fuel switch process started with air quality regulations by the government. Even the partial substitution of coal and diesel with gas resulted in notable air improvements, with significant future opportunities to do more.

SHANGHAI



27% PM_{2.5} ↓

City coal to gas substitution was first by enabling grid interconnections, and second by incentivizing switching to gas and designating coal-free zones. The results were notable reductions in SO_x and PM.

DUBLIN



90% PM ↓

Severe pollution problem existed in the 1980's due to coal use. Increased use of natural gas (75% of residential demand) resulted in 80-90% reduction in PM emissions.

ISTANBUL



98% SO₂ ↓

Banning lignite coal and gradually replacing it with natural gas for residential heating resulted in reduction of PM concentration levels by 50% and SO₂ by 98% (from 220 µg/m³ to 5) in under a decade.

URUMQI



75% PM_{2.5}, 50% SO₂
73% pollution-related cancer ↓

Coal to gas heating switch completed in just two years, with funding support from the World Bank and government policy alignment. Comparisons between respective heating seasons air quality and subsequent health data revealed huge immediate improvements.

BERLIN

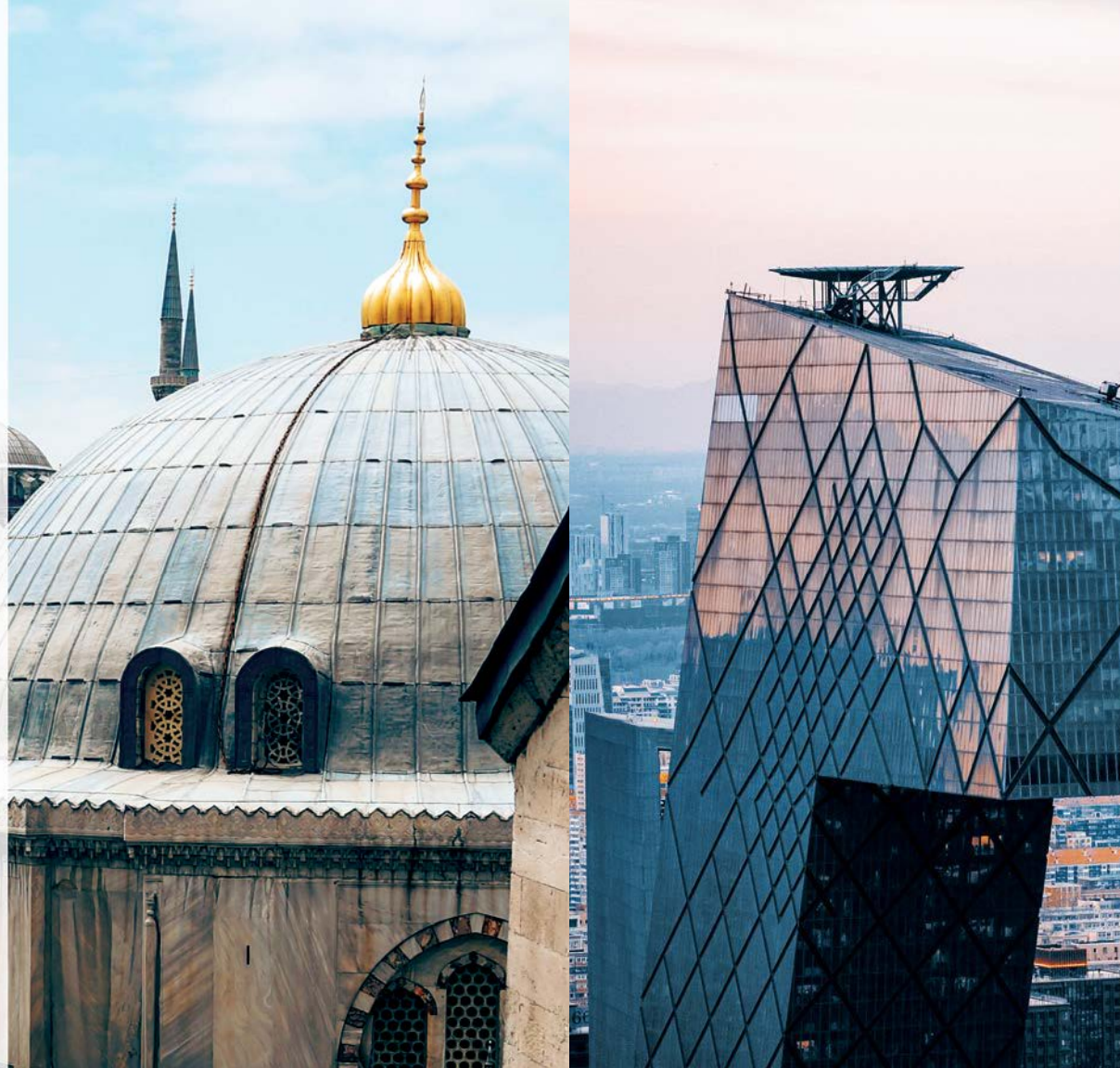
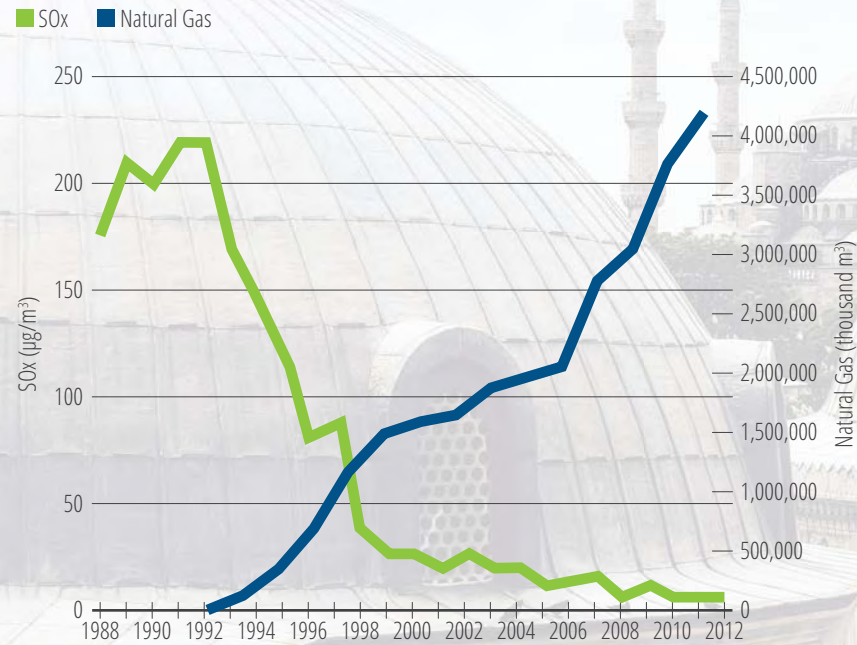


95% SO_x,
83% PM ↓

1990-2012 share of natural gas in city's primary energy grew from 17% to 41% resulting in reductions in SO_x, NO_x, and PM₁₀ by 95%, 76%, and 83% from 1989 levels.

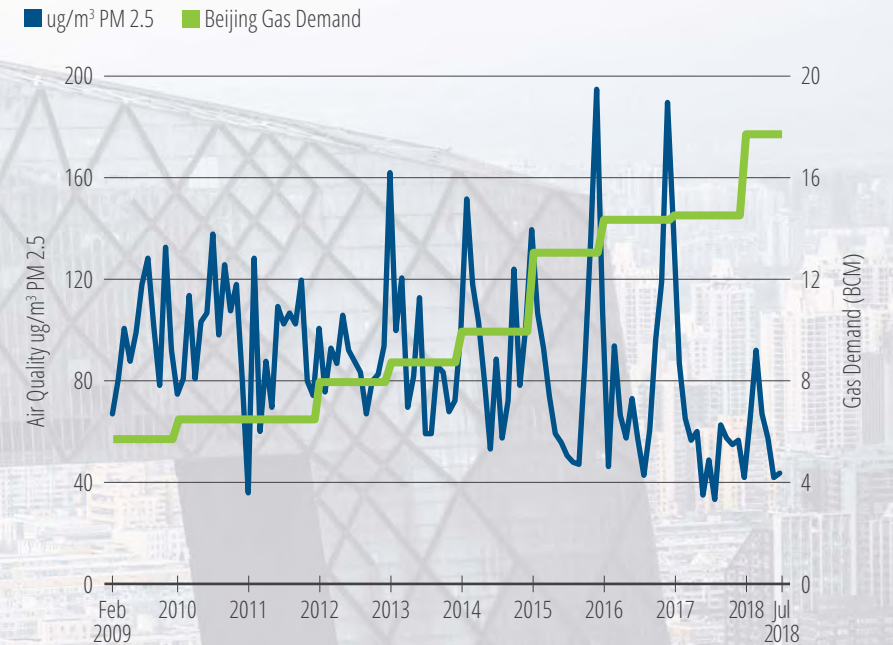
Istanbul

Improving Air Quality



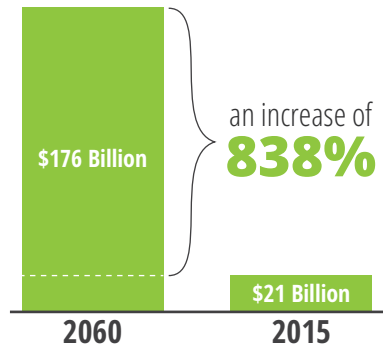
Beijing

Improving Air Quality



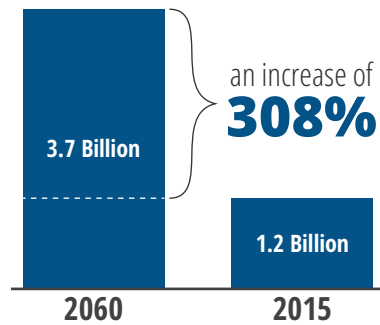
Air pollution has **real** economic costs

Annual global cost of pollution was estimated at **USD 3.8 trillion** in 2015 and projected to go up to **USD 30 trillion** in 2060



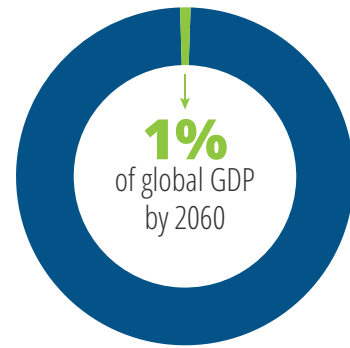
Health Expenditures

Air pollution-related healthcare costs projected to reach USD\$176 billion by 2060



Labour Productivity

3.7 billion Lost Working Days in 2060 of productivity costs



Global Economy

Combined losses from lost productivity, health expenditures, and agricultural yields to reach 1% of global GDP

Breakdown of **Air Pollution** Costs



Natural Gas **Fights** Climate Change

The Big Win: Paris Agreement

At a landmark UN climate conference in Paris, in 2015, 197 world leaders agreed to work towards keeping the global rise in temperature to well below 2°C above pre-industrial levels, to avoid the more serious effects of climate change. The world is already around halfway to that 2°C limit.

Getting to a sustainable energy future will require a continuous effort to reduce carbon intensity, increase efficiency, deploy more renewables, and clean transport. Gas is a tool that can do all these things.

The world is now at a critical point, when the measures undertaken over the coming five years will determine the feasibility of meeting the Paris Agreement target. To meet the climate commitments, renewables and gas will need to remain the fastest growing energy sources, substituting coal generation.

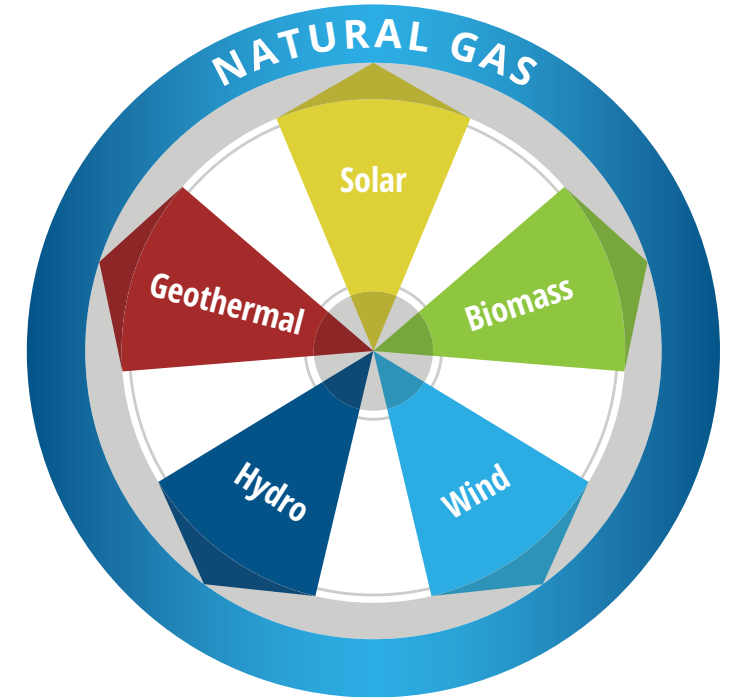
This is a priority of global proportions.



PARIS2015
UN CLIMATE CHANGE CONFERENCE

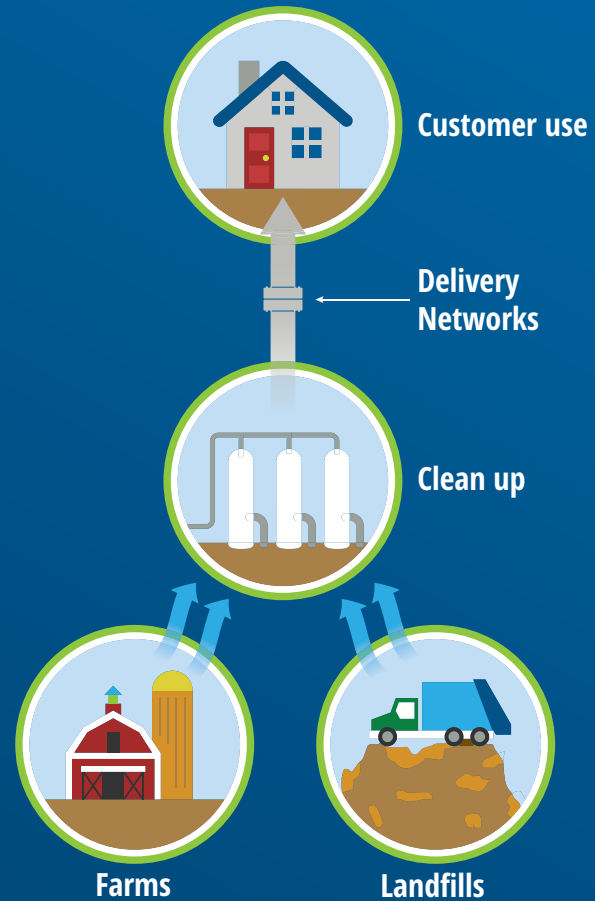
The flexibility, price, and performance characteristics of natural gas make it a critical component for the energy system transformation.

- It is a highly efficient, clean, and the most flexible energy source that can be used across all sectors of the global economy: to generate electricity, energize essential industrial processes, heat homes and fuel transport.
- Natural gas helps address the challenge of seasonal and daily output variability of wind and solar energy.
- Small scale natural gas technologies can be integrated with renewables and support remote microgrids to offer dependable and efficient hybrid systems.
- Natural gas infrastructure provides a backbone for efficient transport of renewable gases, and hydrogen and allows the integration of more renewables into the energy system.



Natural Gas Can Be Carbon Free

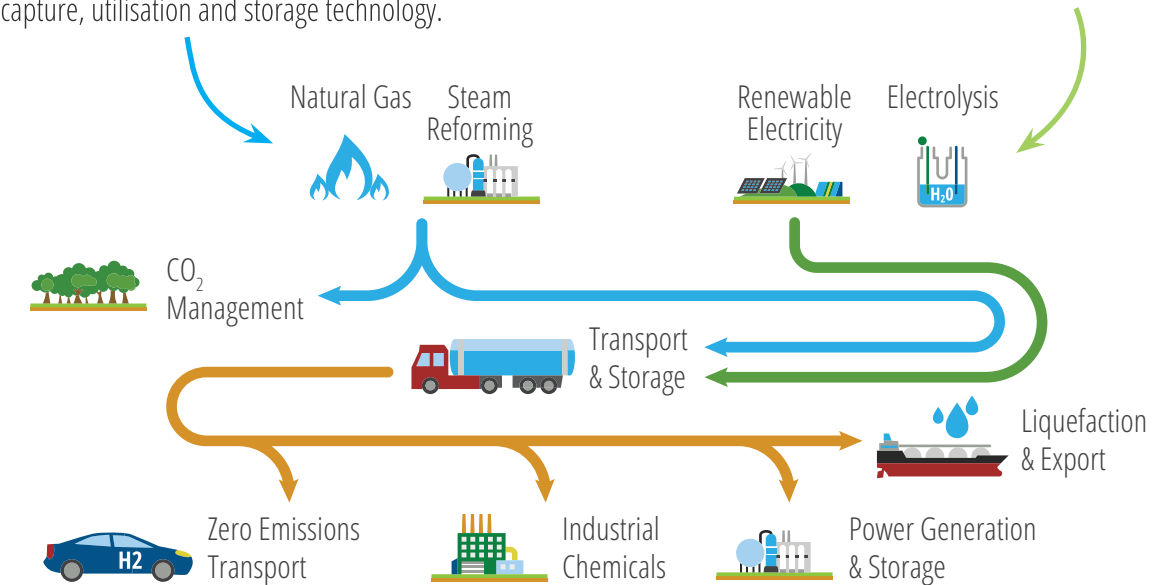
Biogas or Renewable Gas is a source of renewable energy produced from the fermentation of organic waste. It is a renewable supplement for natural gas and can be used for electricity and heat production, as well as for fuelling vehicles.



Hydrogen is a versatile energy carrier that can have a great variety of uses across the entire energy sector.

Blue Hydrogen is made from natural gas through the process called steam methane reforming (SMR). Through this process, hydrogen is separated from CO₂, which is then captured and stored, or used in other ways combined, with carbon, capture, utilisation and storage technology.

Green Hydrogen is produced using renewable generation through electrolysis, with water and renewably generated electricity as feedstock resource.



Carbon Capture Utilisation and Storage

Natural gas paired with carbon capture and storage technologies is practically a carbon-free fuel, as 90% of the emissions are removed, and the remaining 10% could be offset with renewable gases.

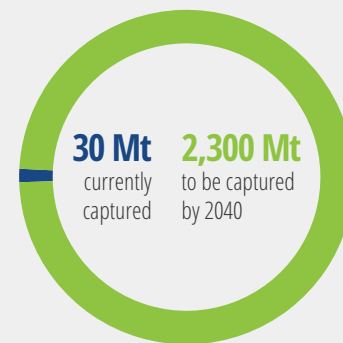
Carbon capture and storage (CCS) is the name given to a set of technologies that capture and store CO₂ deep underground, preventing its release into the atmosphere. It can be used to reduce CO₂ emissions from both the power and industrial sectors.

Carbon capture, utilisation and storage (CCUS) includes the use of CO₂ for enhanced oil recovery, agriculture, and the production of building materials.

Both the International Energy Agency (IEA) and the International Panel on Climate Change (IPCC) underlined the importance of these critical technologies for meeting climate targets, but the world is falling alarmingly short of the efforts needed to develop them.

CCS Contribution

In the IEA 2018 Sustainable Development Scenario (SDS), CCS accounts for **7%** of the cumulative emissions reductions needed globally to 2040. This implies a rapid scale-up of CCS deployment, from around **30 million tonnes (Mt)** of CO₂ currently captured each year to **2,300 Mt per year by 2040.**



1. Capture:

CO₂ capture separates CO₂ from gas, before it is emitted, using a chemical solvent. The captured CO₂ is separated from the solvent and compressed into a liquid form for transport.

2. Transport:

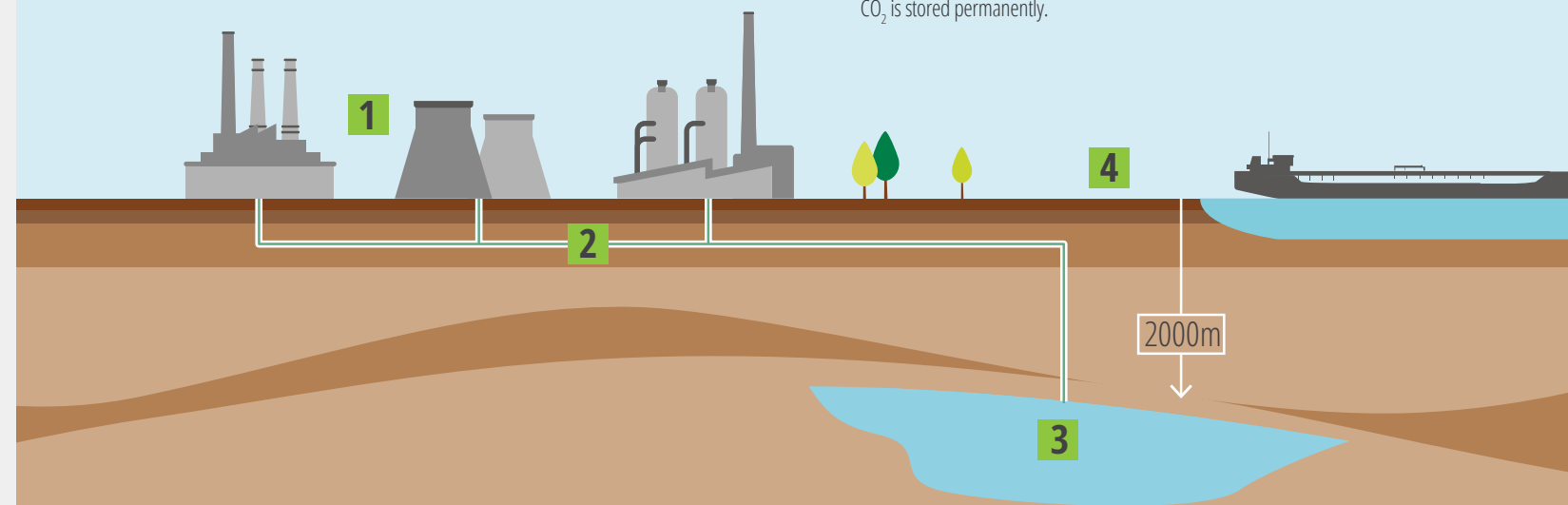
CO₂ is generally pumped through a pipeline, taking the CO₂ from the industrial site where it has been produced, to its storage site which may be onshore or offshore.

3. Storage:

CO₂ is injected deep underground into the microscopic spaces in porous rocks. A layer of the impermeable rock, called a cap rock, lies directly above the porous rocks ensures that the CO₂ remains there permanently.

4. Measuring, monitoring and verification:

Monitoring of storage sites takes place within the storage reservoir, as well as at the injection well, where sensors can detect small changes in pressure or CO₂ levels. In addition, a number of monitoring technologies can be incorporated within the geosphere, biosphere and atmosphere surrounding the storage site to make sure the CO₂ is stored permanently.



Natural Gas Helps Conserve Water

Natural gas-fired power plants consume **less than 50%** of the water needed for coal-fired electricity generation. Coal requires substantial water volumes at every stage – from mining and washing the coal to burning it in power plants and treating the combusted waste.

Coal production accounts for around 7% of all water use globally.



INDIA

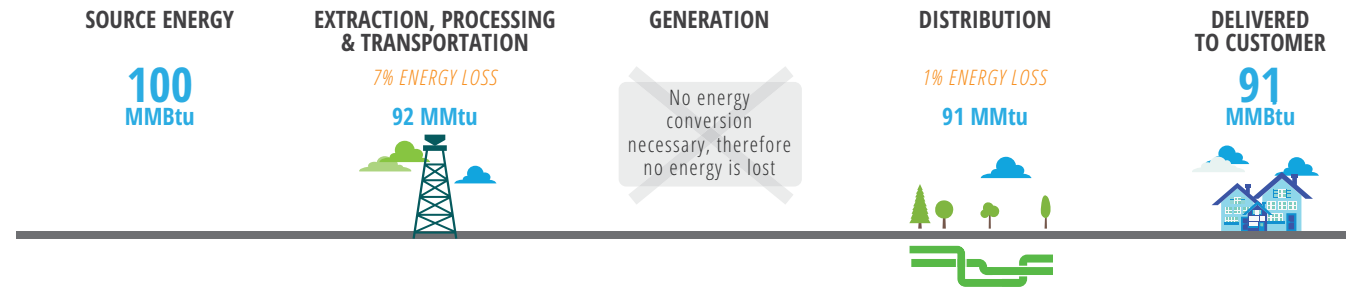
In 2050, India may be the most populous country with 17% of the global population, but only 4% of the world's fresh water.

This is already having an impact on farmers in Maharashtra state, where there is tension between the use of water for agriculture and energy. Several coal-fired power plants have reduced operations, sometimes for months, because of a lack of water.

Gas Enables Energy Efficiency

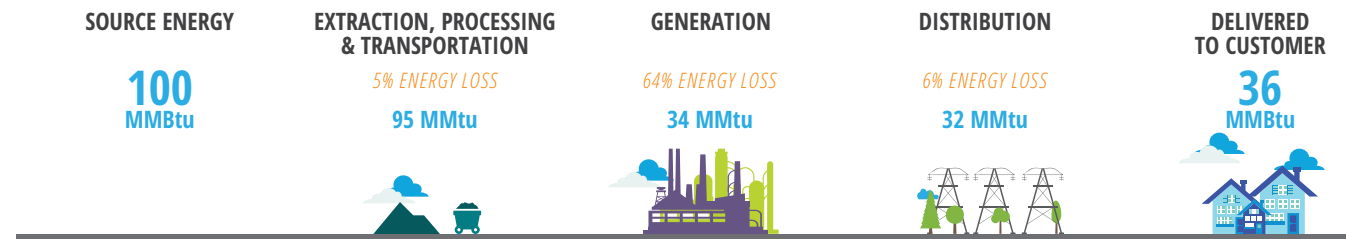
Direct Use of Natural Gas

From the place where it is extracted from the ground, to appliances in your home, natural gas achieves **91% energy efficiency**.



Converting to Electricity

Converting natural gas into electricity to power comparable electric end-use products only maintains 36% of usable energy. This is because of the significant amount of energy lost on the journey from production to customer.

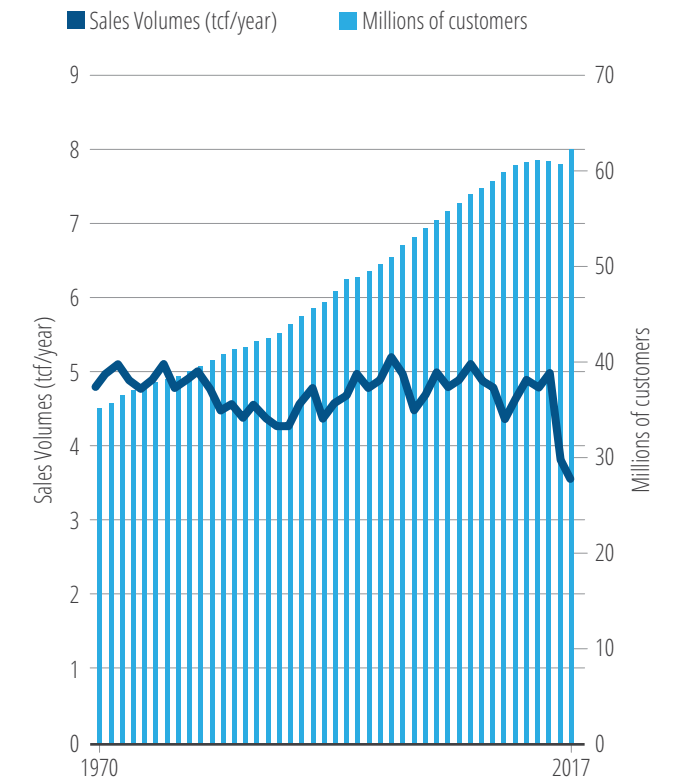


Energy efficiency is a critical resource, needed to achieve a sustainable global energy system, while allowing for continued growth and improvement in living standards. It is necessary for mitigating climate change and meeting social and environmental needs of the world's growing populations.

Natural gas affords extremely high levels of energy efficiency, thanks to its high energy content and heat intensity.

Continued improvements in efficiency of end use technologies are resulting in a substantial reduction in the consumption of gas per customer, without impact on comfort and reliability.

For example, the average American home consumes 40% less natural gas than it did 40 years ago. Since 1970, the decrease in natural gas use per residential and commercial customer has averaged one percentage point per year.



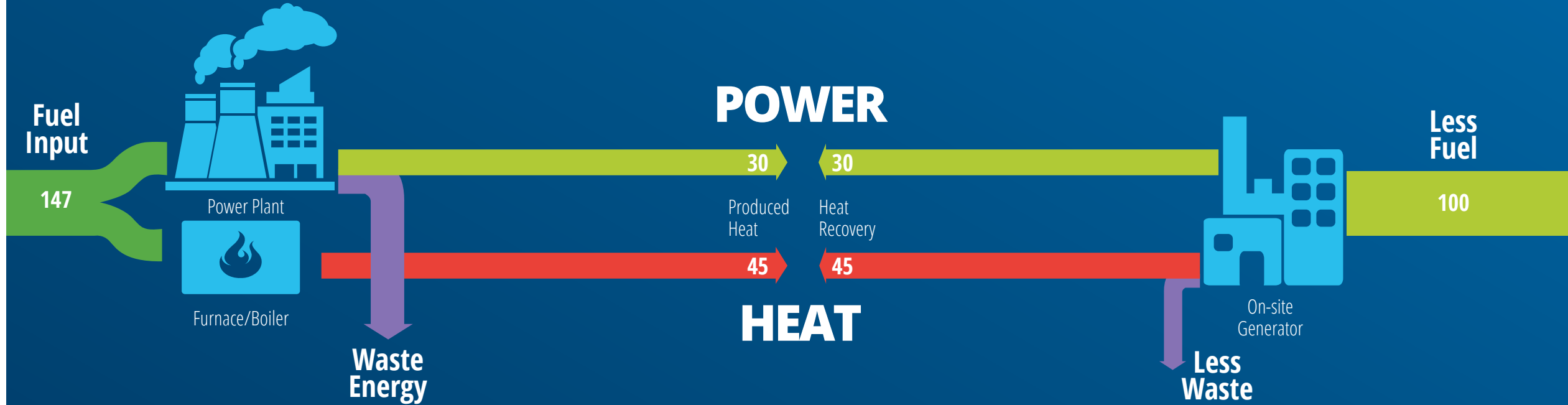
Smarter Infrastructure

Natural gas can be applied in Combined Heating and Power systems (CHP) and Combined Cooling and Heating Power systems (CCHP). CHP generates electricity while also capturing usable heat in one single, highly efficient process.

CHP generates electricity while also capturing usable heat in one single, highly efficient process.

Smarter city planning that incorporates infrastructure to accommodate distributed gas heat with power generation (CHP) offers significant gains in efficiency and helps to reduce air pollution and greenhouse gas emissions associated with coal-fired power. CHPs can also help improve the resilience of a city in times of crisis and keep the lights on, when the main electric grid is down.

Separate Production of Electricity and Heat
Total efficiency: 51%





Fuels Clean Transportation

Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG) mobility can deliver cost-effective solutions to reduce the emissions of pollutants and noise in applications related to short, medium, and long distance transport of persons and goods.

Proven and commercially available technologies exist for passenger, return-to-base commercial, heavier transport vehicles, rail and marine transport applications.

LNG use for heavy duty transport fuel is quickly growing, as countries like China and the U.S. are looking to take advantage of its economic and environmental benefits.

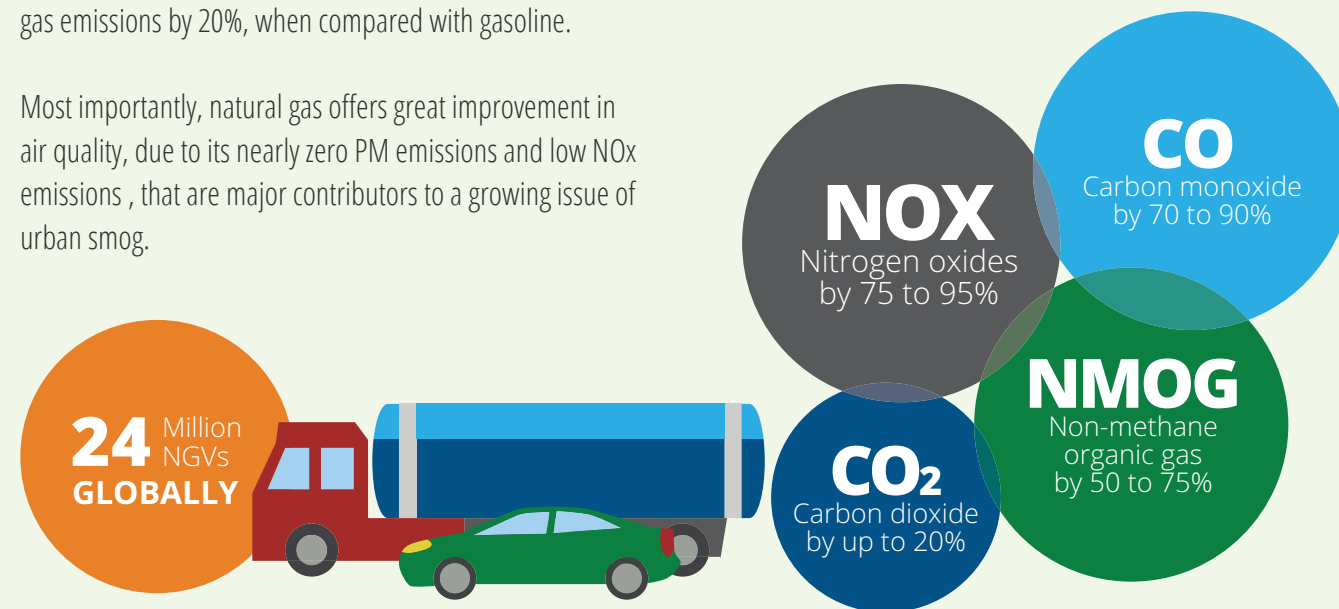
Reducing emissions from road transport

The increasing use of natural gas in transportation is contributing to significant long-term cost savings, while greatly improving air quality.

For example, natural gas fuelled vehicles emit up to 95% less PM and up to 70% less NOx, compared with the European emission standards.

As a transportation fuel, natural gas can reduce greenhouse gas emissions by 20%, when compared with gasoline.

Most importantly, natural gas offers great improvement in air quality, due to its nearly zero PM emissions and low NOx emissions, that are major contributors to a growing issue of urban smog.

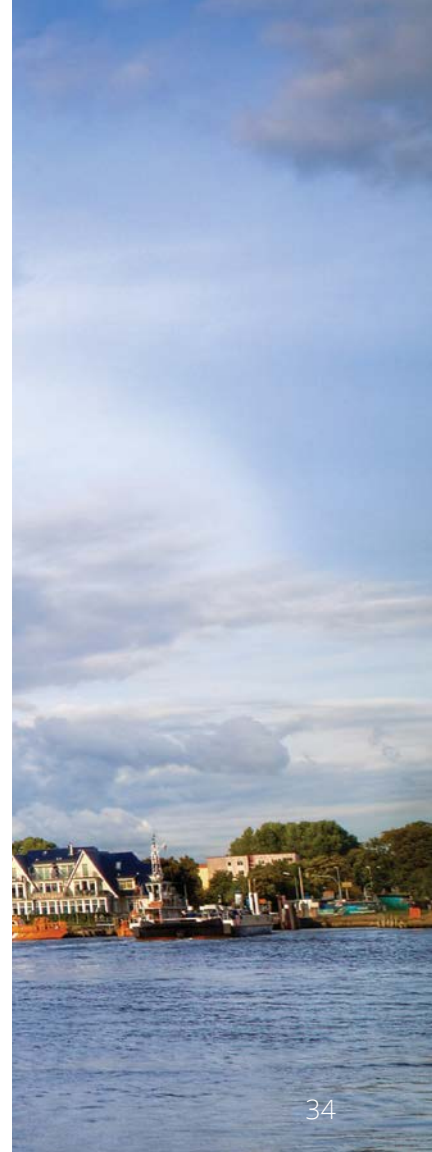
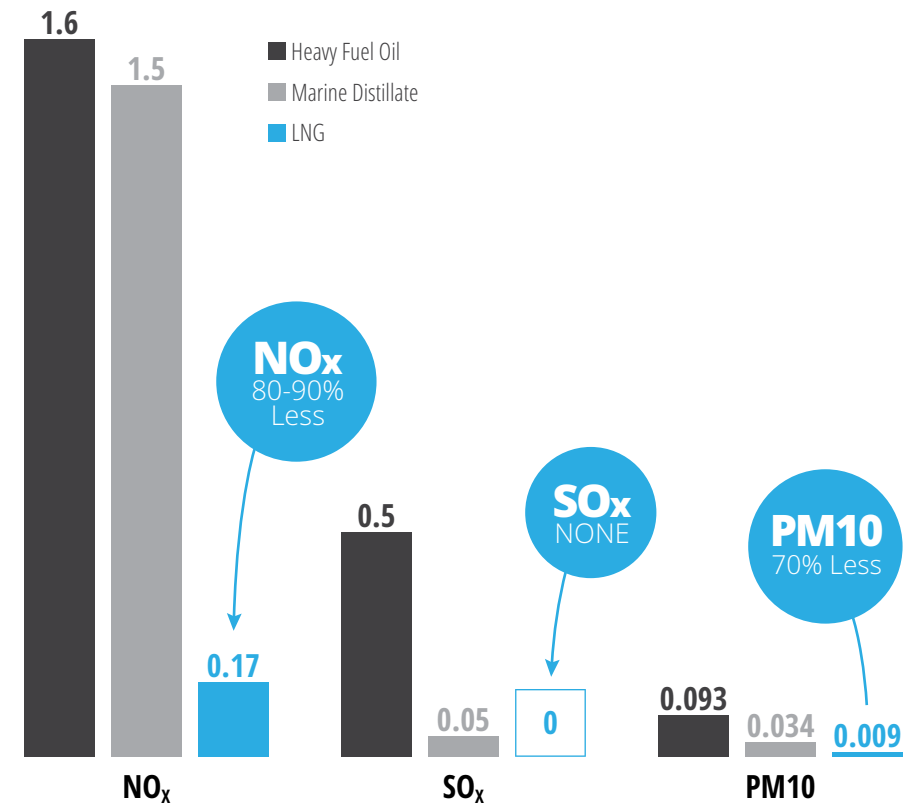




Delivering Clean Marine Transport

LNG is a low emissions marine fuel allowing operators to meet International Maritime Organisation's Sulphur and Nitrogen Oxides emissions targets.

Switching to LNG for Marine Fuel Will Deliver Clean Air at Sea (g/MJ)



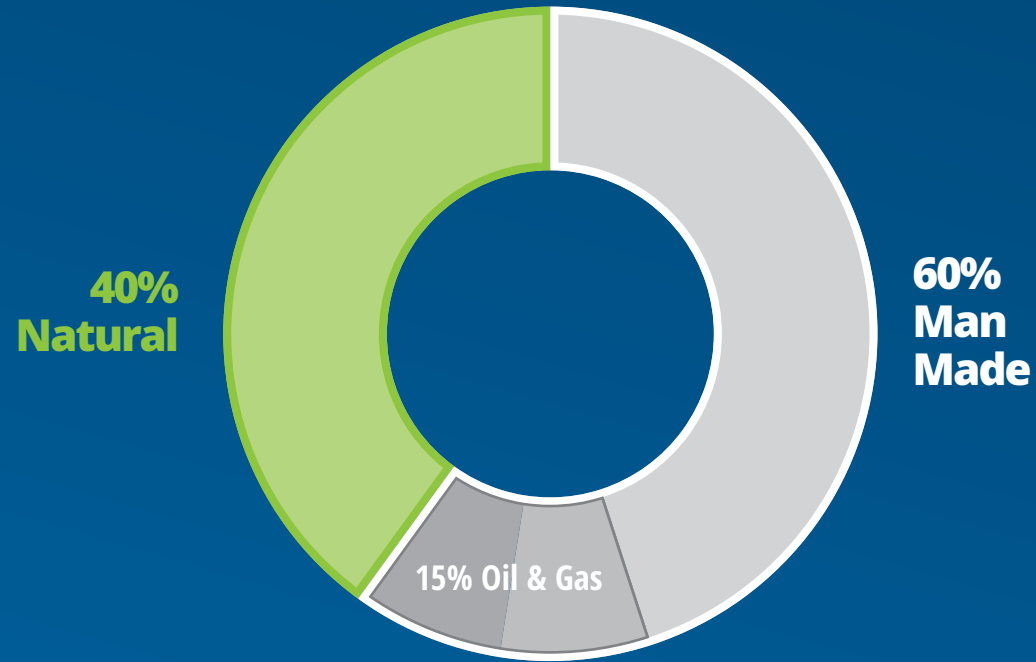
LNG for Shipping

- Around 80% of world trade in goods is by ship. This trade is expected to increase by nearly 50% by 2030.
- The International Maritime Organization has made progress in agreeing to limit Sulphur oxide and Nitrogen oxide emissions from ships.
- Compared to heavy oil, natural gas combustion produces up to 80% less nitrogen oxides and virtually no Sulphur oxide.
- Switching from heavy fuel oil to LNG can reduce greenhouse emissions by to 21%-11% in a two-stroke/four stroke engine
- LNG also has a lower unit cost compared with low Sulphur heavy fuel oil or low Sulphur diesel fuel.



Methane Emissions

World Methane Emissions Breakdown



Building a Culture of **Non-Tolerance to Leaks** throughout Natural Gas Operations

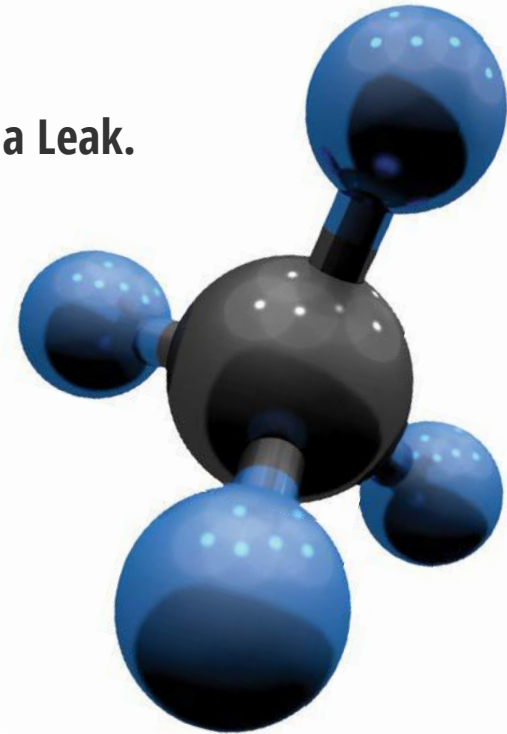
Why It is So Important to Not Walk Away from a Leak.

Methane is a Potent Gas

Even though methane has a short life, it has a stronger greenhouse effect than CO₂ and a significant impact on the short-term global warming effect.

Mitigating and eliminating methane emissions from the natural gas value chain provides an opportunity to help secure a sustainable energy future, in which natural gas will play a vital role.

It also makes good commercial sense and contributes to safety measures.



The Methane Emissions Opportunity

Mitigation of methane emissions will play an important part in meeting global GHG reduction efforts.

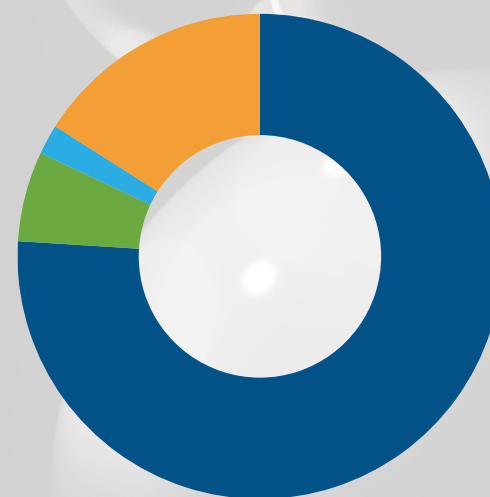
Methane is the second most important GHG after CO₂. Its greenhouse gas effect is stronger in the short-term. However, its life in the atmosphere is also much shorter – 12.4 years – in contrast to centuries for CO₂.

Roughly 40% of total methane emissions come from natural (biogenic) sources, such as wetlands, while the other 60% are human-made (anthropogenic).

The largest source of man-made methane emissions is agriculture, followed by fossil fuels and industrial activity.

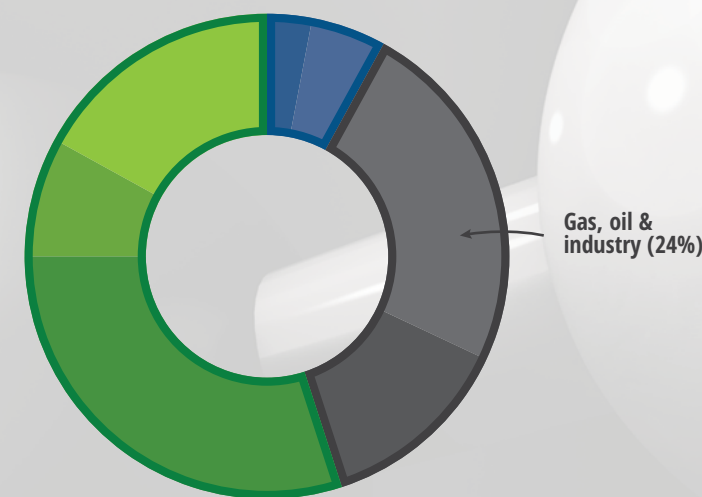
Combined, the oil and gas industry contribute roughly a quarter of the world's man-made methane emissions, and based on the 2017 assessment by the International Energy Agency, these are split roughly equally between oil and gas.

Global Anthropogenic GHG Emissions (2012)



- Carbon Dioxide (76%)
- Nitrogen Oxides (6%)
- F-Gas (2%)
- Methane (16%)

Anthropogenic Methane Emissions by Source (Mt, 2012)



- Biomass & Biofuel 30 Mt
- Fossil Fuels 134 Mt
- Agriculture & Waste 197 Mt
- Biofuel burning (3%)
- Biomass burning (5%)
- Coal Mining (13%)
- Enteric Fermentation & Manure (30%)
- Rice Cultivation (8%)
- Landfills & Waste (17%)

Source: Saunio et al, 2016

Methane Emissions in the Natural Gas Sector

Natural gas combustion is highly efficient in its end-use applications, like providing energy for cooking and heating, industrial use, fuelling transport, or producing electricity. Methane emissions occur in different segments of the supply chain, and can happen during extraction, storage, production, transport, or distribution. As no two systems are alike, this can vary greatly by geography and operator.

Owing to the vastness of natural gas infrastructure, the exact quantification of emissions can be challenging. Thus, the industry uses a combination of direct measurement and sophisticated estimation techniques to extrapolate methane emissions across its infrastructure.

Based on the IEA 2017 assessment, the natural gas sector is responsible for about half (42 Mt) of the total oil and gas methane emissions, or about 7-8% of the total Global Methane Emissions.





Identification and Elimination of Methane Emissions from its Operations is a **Top Priority for the Natural Gas Industry.**

There is a long history of industry efforts to minimize methane emissions across its value chains.

The practice has originated in routine safety requirements and operational efficiency improvements.

More recently, the industry began to further strengthen work in this area, with the intent of accelerating its environmental goals and minimizing the carbon footprint of natural gas.

Several large industry participants have also announced voluntary methane emissions reduction targets.

Join the **Action!**

In addition to individual company efforts, there are several collaborative industry initiatives to improve understanding the scale of methane emissions, potential sources, and opportunities for reductions.

Some of the most known global examples include:



Methane Guiding Principles

On 22 November 2017, eight companies signed a set of Guiding Principles on Reducing Methane Emissions across the Natural Gas Value Chain.

Since then, the initiative has grown to include 32 signatories and supporting organisations, all committed to a single goal of delivering reductions in methane emissions in the natural gas sector.

Signatories



Supporting Organisations



The Guiding Principles

- 1 Continually reduce methane emissions
- 2 Advance strong performance across gas value chains
- 3 Improve accuracy of methane emissions data
- 4 Advocate sound policies and regulations on methane emissions
- 5 Increase transparency

Guidelines for Best Available Techniques



Natural Gas Star Programme
Recommended technologies to reduce methane emissions



Oil and Gas Methane Partnership
Technical partnership documents



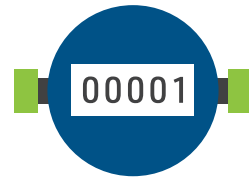
Engineering Design and Construction

Systematically minimise methane emissions



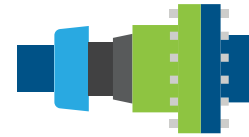
Flaring

Reduce methane emissions from flaring



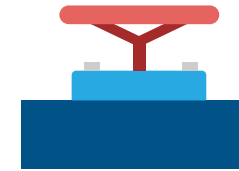
Energy use

Reduce methane emissions that result from energy use



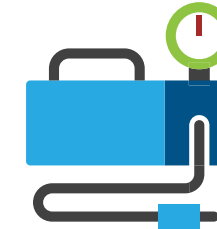
Equipment Leaks

Reduce methane emissions from fugitives and wells



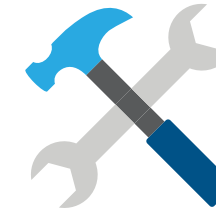
Venting

Reduce methane emissions from processes and cold venting



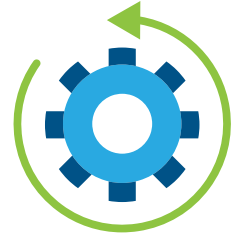
Pneumatic Equipment

Reduce methane emissions from natural gas driven pneumatic equipment



Operational Repairs

Reduce methane emissions related to equipment repairs



Continual Improvement

Systematically improve methane management

We are working Together to Deliver a Sustainable Future Powered by Gas!

The IGU urges all of our members, partners, and stakeholders to join the collaborative efforts in reducing methane emissions from the gas value chain and to enhance data accuracy and transparency.

As the global voice of gas, with membership spanning all five continents, the IGU is keenly aware of the differences in approaches toward achieving this shared goal of

reducing methane emissions across the regions. We understand varying capacities across operators in different geographies, economies, and with greatly different financial means.

We therefore encourage our members to reach out, regardless of where they are now, and we will work to connect them with the right resources.



Natural Gas plays a Vital **Economic Role** in the Sustainable Energy Future

Sustainable and Affordable Development

In the same year as the Paris Agreement on climate cooperation, the world leaders also adopted a complementary Sustainable Development Agenda.

“The 17 Sustainable Development Goals (SDGs) are the world’s best plan to build a better world for people and our planet by 2030. Adopted by all United Nations Member States in 2015, the SDGs are a call for action by all countries - poor, rich and middle-income - to promote prosperity while protecting the environment. They recognize that ending poverty must go hand-in-hand with strategies that build economic growth and address a range of social needs including education, health, equality and job opportunities, while tackling climate change and working to preserve our ocean and forests.”

- UN



The UN recognizes that

energy is “central to nearly every major challenge and opportunity the world faces today. Be it for jobs, security, climate change, food production or increasing incomes, access to energy for all is essential.”

Thus, providing access to modern and clean energy is a critical component of the international sustainable development agenda and an international priority.

Gas and the Sustainable Development Goals

1 & 10: Poverty & Inequality

Gas is flexible, efficient, and a low-emission fuel for growth, needed to eradicate poverty.

2: Eliminate Hunger and Achieve Food Security

Gas is an important input into fertilizer production.

3 & 15: Health and Quality of Life

Natural Gas does not pollute the air, unlike most other fuels that are being used by the least-well-off today. Gas enhances the quality of life, as a universal fuel source for comfort in homes and businesses, meeting the needs for heating and cooling, lighting and cooking.

4: Education

Gas supplies the modern energy, heating, cooling, and lighting, needed for schools to run and for students to learn.

5: Gender Equality

Gas provides clean and efficient cooking fuel, that relieves women of carrying as much as 25-50 kg of wood to feed their families.

6: Clean Water

Energy is an input for water sanitation, and certain forms of energy, like coal, have adverse impacts on water. Gas is a safe fuel, not soluble in water, and perfectly suited to power sanitation facilities.

8 & 9: Decent Work and Economic Growth; Resilient infrastructure

Gas is a productive and efficient form of energy that is also a feedstock for many high value industries. Gas infrastructure is resilient, sustainable, and valuable as a long-term asset for supporting renewables and ensuring reliability.

12: Sustainable consumption

Substituting use of traditional biomass with natural gas helps reduce deforestation.

13: Urgent action on climate change

A significant portion of emissions can be eliminated and/or avoided immediately, by substituting coal with gas. In the longer term, with the help of complementary technologies, such as biogas and CCUS, gas can become carbon-free.

14: Oceans, seas, and marine resources

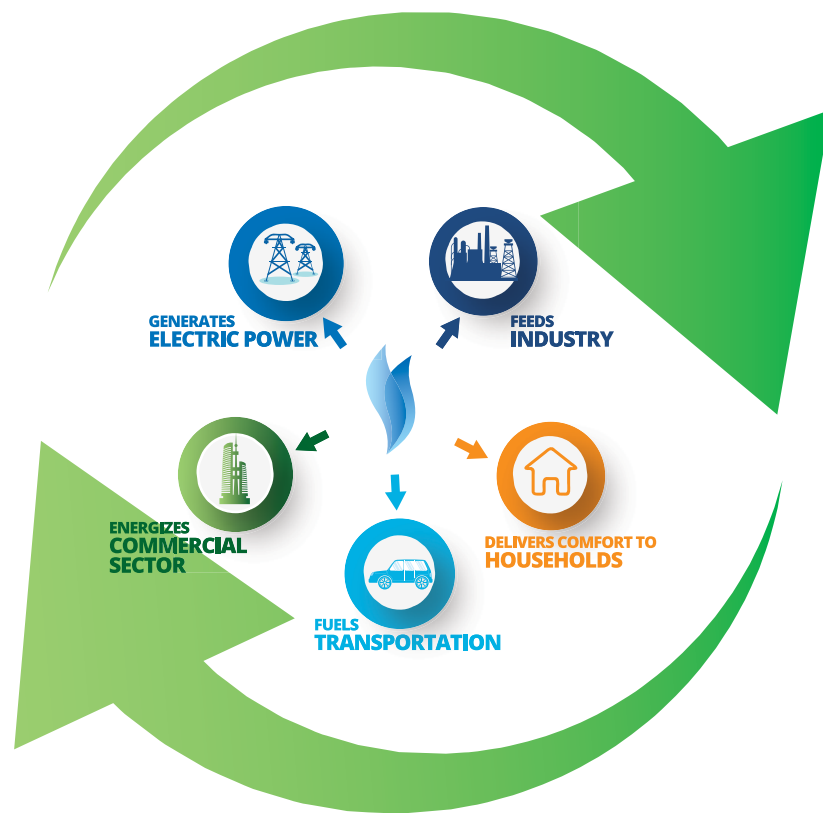
Use of LNG as marine fuel, instead of diesel, nearly eliminates harmful pollution and reduce emissions.



Gas Fuels Industry, Increases Productivity, and Safeguards the Environment

Natural gas can fuel the engine of the entire economy, while delivering immediate climate change action.

As a highly efficient, flexible and secure energy source, natural gas is a powerful driver of economic development. It also acts as an irreplaceable power system reliability resource, and the latter is critical for industries and economies to grow smoothly.



Key Feedstock for Industry

Natural gas is a clean, reliable, efficient, and economical energy source for electricity generation, heating and hot water supply, cooking fuel and motor fuel. Because of these attributes, it serves as a key feedstock for industry, across a range of sectors – from agriculture to chemicals – natural gas enables the manufacture of life-enhancing products.



Healthcare

All specialized medical gases, and much of the pharmaceutical industry rely on natural gas as either feedstock or as a key part of the lifecycle.



Chemicals

Fertilizers that keep our food growing start with natural gas.



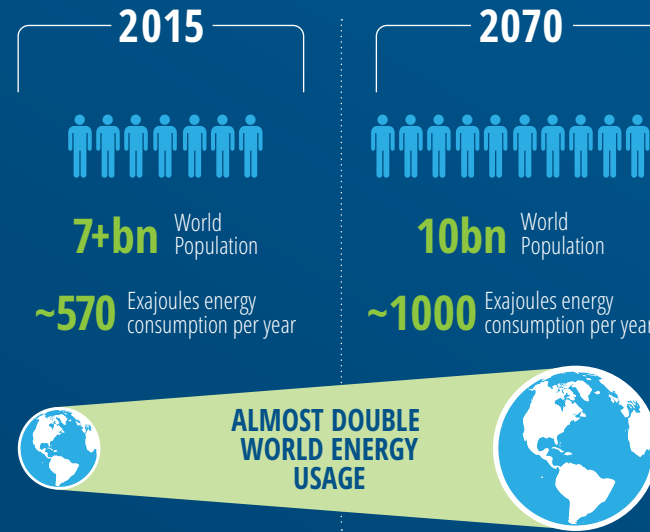
Construction

Natural gas is a vital component in the creation of cement mixes. Modern safety and ultra-thick / thin glasses would be impossible to create without high-tech, gas-fired forges.

Providing More and Better Energy

As more communities climb out of poverty, including energy poverty, energy consumption will grow, both in the households and businesses.

Gas is the ideal fuel for this growth and a driver of economic development, because it is a flexible, clean, and highly-efficient source of energy.



46% of the world's population lives on less than **\$5.50/DAY**

>25% of the world's population lives on less than **\$3.20/DAY**

10% of the world's population lives on less than **\$1.90/DAY**

As developing economies continue to grow and livelihoods of their residents improve, they will need more and better energy.

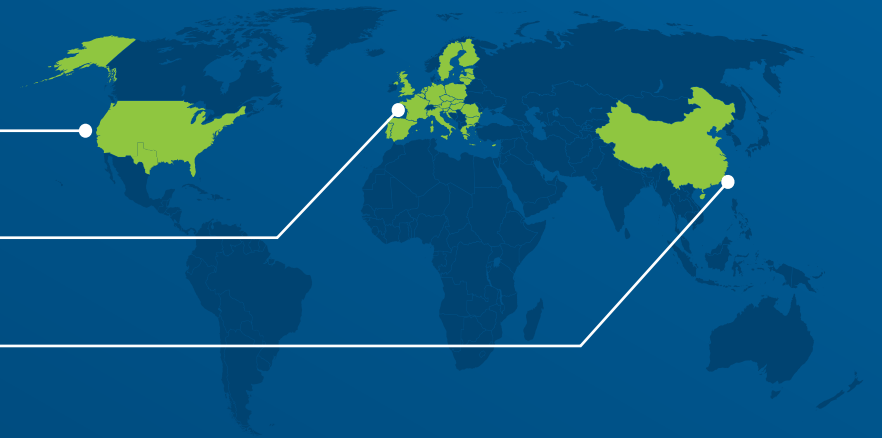
In fact, energy is the necessary key for unlocking this development and lifting people out of poverty.

An average of about 100 gigajoules of primary energy per person is required to fuel the energy-based services that support the decent quality of life.

Average current primary energy use

Gigajoules per person per year

300
150
100





Reliable and Affordable Solution

On average, gas-fired power plants can be built twice as fast as coal and nuclear plants, cost less to build and are cheaper to maintain.

Gas is also cheaper than diesel by direct cost, and even more so if the indirect costs of pollution and detrimental health impacts are considered.

The flexibility benefits that natural gas brings to the energy system also help to reduce costs of integrating the growing

share of renewables, needed for meeting emissions reductions targets.

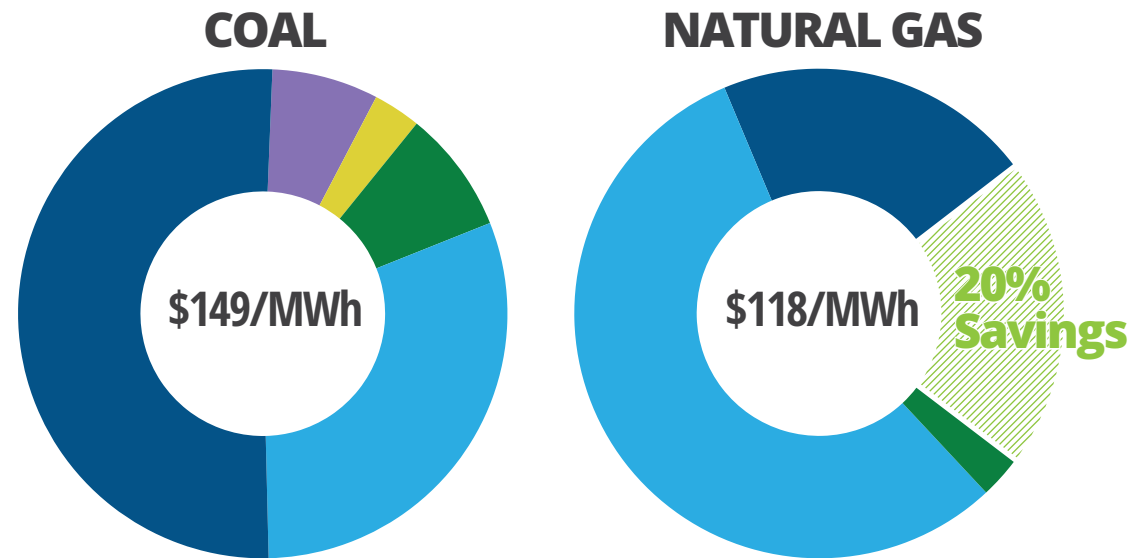
Transforming energy systems is an extremely capital-intensive undertaking, and doing so at an accelerated pace, set by the Paris Agreement, will put further pressure on budgets.

Natural gas offers a flexible, efficient, and an affordable solution to this challenge, allowing economies to continue growing.

Gas is more affordable than coal, when the full costs of climate change and pollution are taken into account.

Philippines Power Generation Example (2015, @40% Capacity)

■ Construction & Fixed Costs ■ Fuel Costs ■ GHG Emissions Associated Costs ■ Desulphurization ■ Air Pollution Costs (Health)





Energizing Remote Communities

Globally almost a billion people have no access to electricity. Hundreds of millions more live with unreliable or expensive power, which poses a key barrier to economic development in emerging economies.

Significant progress has been made over the last decade in increasing access, which reached 87% in 2016. However, progress has also been very uneven, and vast parts of Africa and Asia continue to lack any access to electricity. Access in rural areas is also much lower, than in urban.

Southern Asia and sub-Saharan Africa have the largest deficits in electricity access.

According to the recent SDG progress report, the outlook for electrification shows that the world is not yet on track to achieve universal access by 2030.

Close to 3 billion people do not have clean cooking facilities

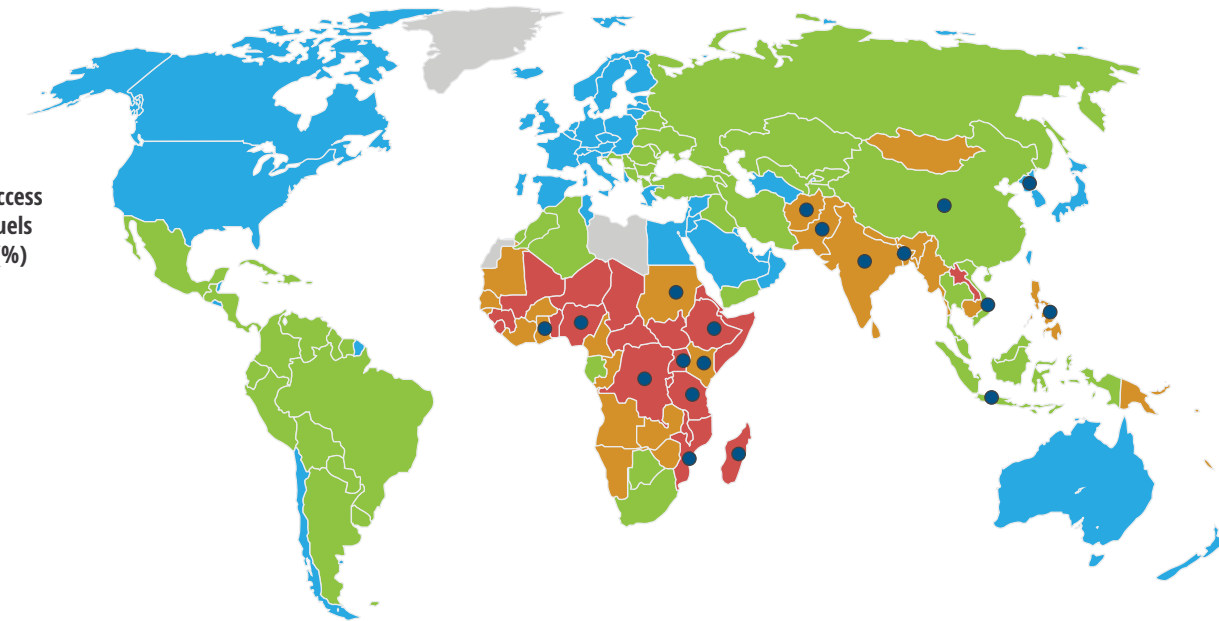
Every year, 3.8 million people die prematurely from illnesses caused by dirty cookstoves and fumes from solid fuels in the home, such as firewood and charcoal.

Access to clean modern energy is a basic human necessity, consistent with the UN SDG7. Natural gas is a safe and efficient fuel, which does not produce harmful fumes and air pollution, and it is perfectly suited to meet this vital human need.

Advances in small scale LNG and distributed energy technologies are unlocking new opportunities for energizing communities where no existing energy delivery infrastructure is in place.

Population with access to clean cooking fuels and technologies (%)

- Less than 10
- 10-49
- 50-99
- 100
- Data not available
- Top 20 Access Deficit Countries

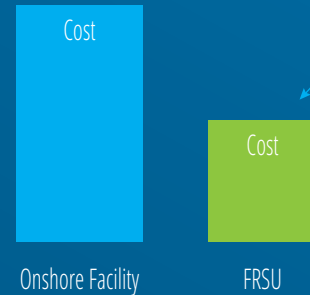


Floating LNG Technologies

Extending Access

- Floating Storage and Regasification technologies (or FSRU's) are an exciting technological breakthrough for energy access. They provide an affordable, fast and flexible way to get access to natural gas supplies.
- Developing countries that lack existing infrastructure need to develop their gas markets gradually. One way of doing so is to establish a base consumer, such as a power plant, and then gradually expand infrastructure from there.
- LNG-to-power projects are being pursued in Ghana, Namibia, Senegal and South Africa to create a domestic gas market.
- FSRUs are scalable, fast to deploy and require substantially less (sunk) capital than an onshore terminal or a large cross-border import pipeline project
- The relative ease of moving floating facilities (both FSRU and FLNG) means they can easily be redeployed, which reduces risk for investors and lowers the hurdles for access to finance that are important considerations for developing countries.
- This technology can help developing countries to shift from more costly oil products, or more polluting, coal to gas when this would otherwise not be possible or economically viable.

The cost of a new FSRU including the necessary auxiliary facilities can be **up to 50% lower** than that of an onshore facility while LNG tanker conversions into receiving terminals are even cheaper.



Source: IEA 2017





Natural gas will play a critical role in the energy transformation of the industrial sector.

Industry accounted for a third of global energy use and 19% of all global CO₂ emissions in 2017, according to the IEA.

Global industrial gas demand is projected to increase by 40% by 2040, in the IEA's Sustainable Development Scenario. Overall, industry will account for the largest share in primary energy demand growth to 2040.

Reducing energy demand and emissions from the industrial sector, without compromising economic and social development goals, will require effective implementation of energy efficiency strategies, switching to lower-carbon fuels and raw materials, and the best available technologies, such as carbon capture, use and storage.

Switching industrial boilers from coal to gas can make a significant contribution to reducing costs and emissions, while improving local air quality. This is true for light and heavy industries alike.

Today, half of all iron and steel continues to be produced by reducing iron ore in emission-intensive coal-fired furnaces. In cement production, more than 90% of the energy used is fuel combustion. Using gas instead of coal to heat these furnaces can result in half the CO₂ emissions and almost no Sulphur oxide emissions.



A Commercial Opportunity for Governments

For countries with large domestic natural gas resources, the impact of developing and bringing substantial additional volumes of natural gas on stream can be economically transformational.

The employment multiplier of the oil and gas industry is greater than 3. That means that for every job in the natural gas sector, 3 or more are created elsewhere in the economy.

In addition to the positive impacts from direct sector employment and the related economic multipliers, natural gas is a key feedstock material for a number of lucrative manufacturing industries, including fertilizers and petrochemical products.

Unlocking the value of natural gas resources can significantly improve the prosperity of a developing economy.

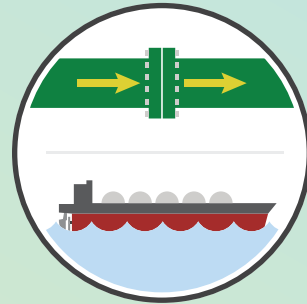
Natural Gas is Vital
for a Secure Sustainable Energy Future

Natural gas is an abundant, secure, and flexible energy source.



Availability

There are sufficient global deposits widely distributed across the world to meet projected demand.



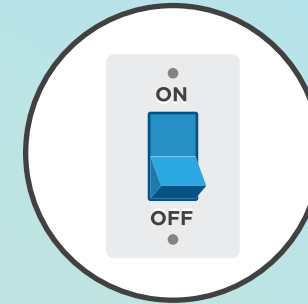
Accessibility

A dependable global network of pipelines and a booming LNG market make access to gas easy and secure.



Affordability

Gas is an affordable source of energy that enables balance between meeting environmental challenges and continuing to grow the economy.



Reliability

Gas is a highly reliable source of energy, with an advanced infrastructure delivering over 99.9% reliability, while LNG and storage provide dependable long-term security of supply.

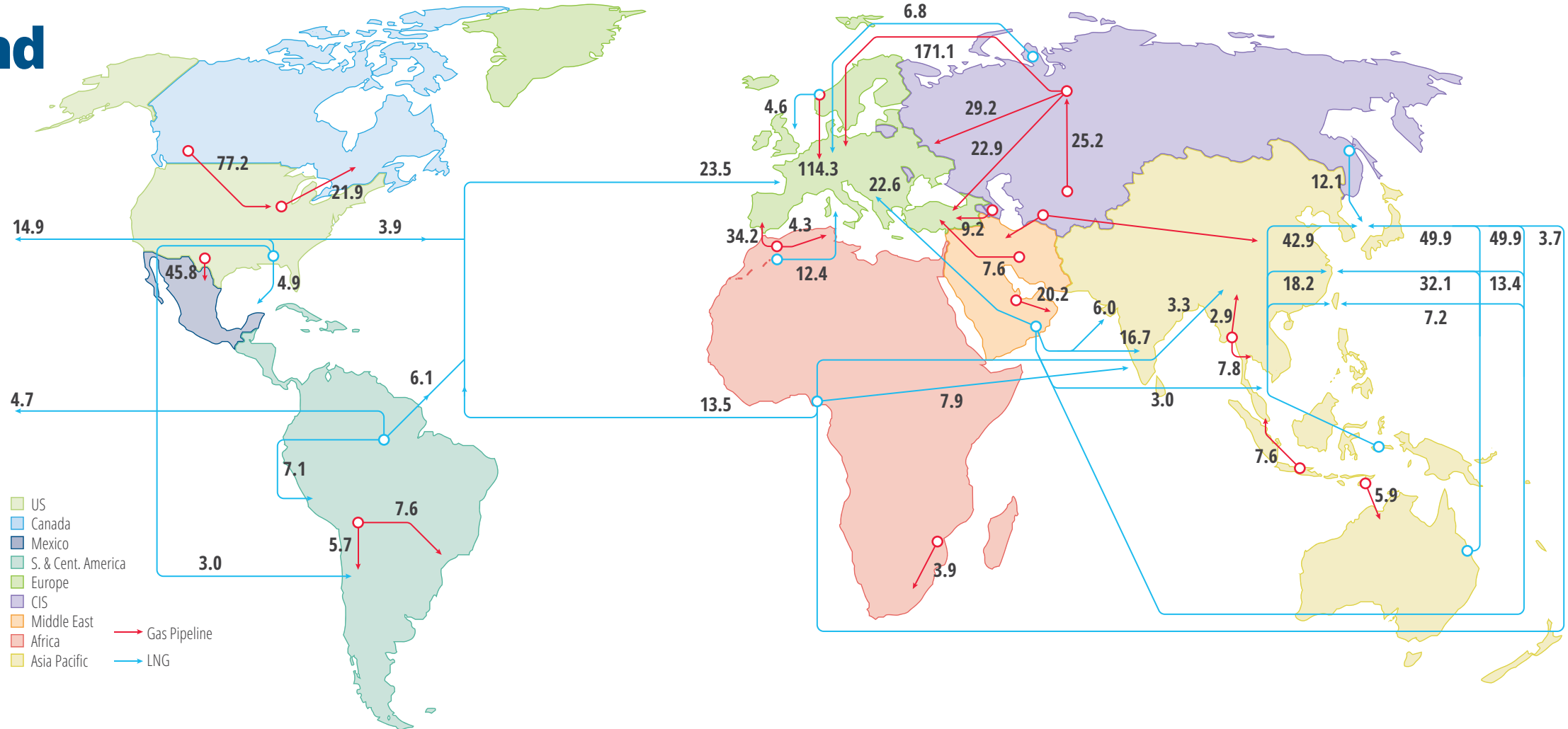
Global Gas Trade and Its Many Conduits

Natural gas can be transported by pipeline, ship, or truck to where it is needed, whether for heating, electricity generation, or for powering industry, buildings and transport.

Pumped through pipelines, gas can be cost-effectively transported over long distances. The total length of the world's natural gas pipelines would stretch to the Moon and back eight times.

When pipelines cannot cost-effectively reach consumers, natural gas can be cooled to become liquid and shipped.

New and existing pipelines combined with rapid growth of Liquefied Natural Gas (LNG), and new sources of natural gas from both conventional and unconventional resources, are increasing global energy supply, security, diversity and flexibility.



The Basics of LNG

Liquefied Natural Gas or LNG is a clear, colourless, and non-toxic liquid, which results from cooling natural gas to $-162\text{ }^{\circ}\text{C}$ ($-260\text{ }^{\circ}\text{F}$).

The cooling process shrinks the volume of the gas by 600 times.

In its liquid phase, LNG will not ignite. This allows it to be shipped safely and efficiently on specially designed vessels.

After arriving at its destination, LNG returns to its gaseous phase and delivered to natural gas customers through local pipelines. It can also be used directly as a liquid in certain applications, avoiding the need to re-gasify. Small-scale LNG applications, like trucking and supplying remote communities, are also beginning to see uptake.

LNG is a time-tested technology that has enabled safe transportation of natural gas to remote markets for over 50 years.



Exploration

Gas Production & Liquefaction Facilities

Shipping

LNG Import & Regasification Terminals

Extracted gas is processed, purified, and then cooled to -162°C , turning into a liquid.

Reduced in volume 600-fold, the liquid gas is stored in very large tanks, from which it is loaded and shipped.

When the liquid gas shipment arrives at its end-use destination, it is unloaded and stored in import terminals.

Later, the liquid gas is reheated and delivered to customers via the pipeline network.

LNG may also be used directly, as a fuel in certain applications, such as shipping

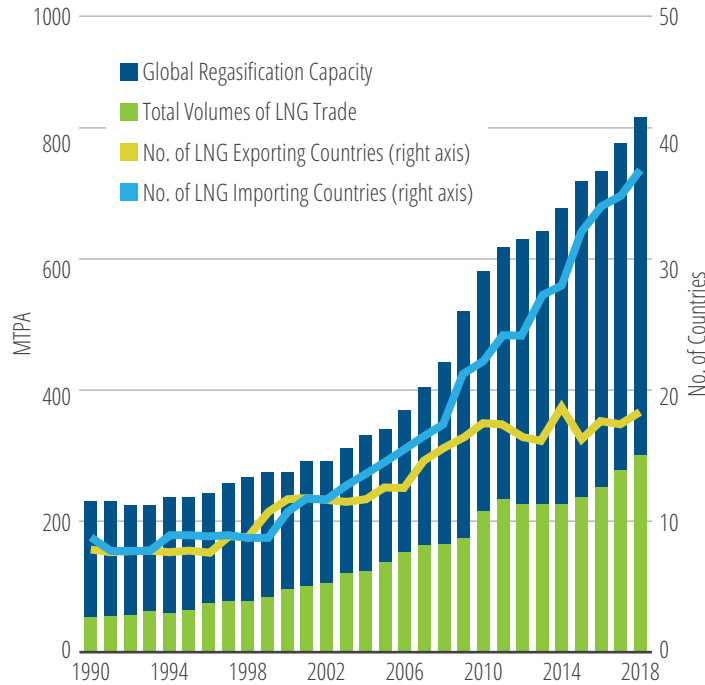
LNG Bridges the Distance between Supply and Demand

The flexibility value of LNG is increasing market liquidity and enhancing security of supply.

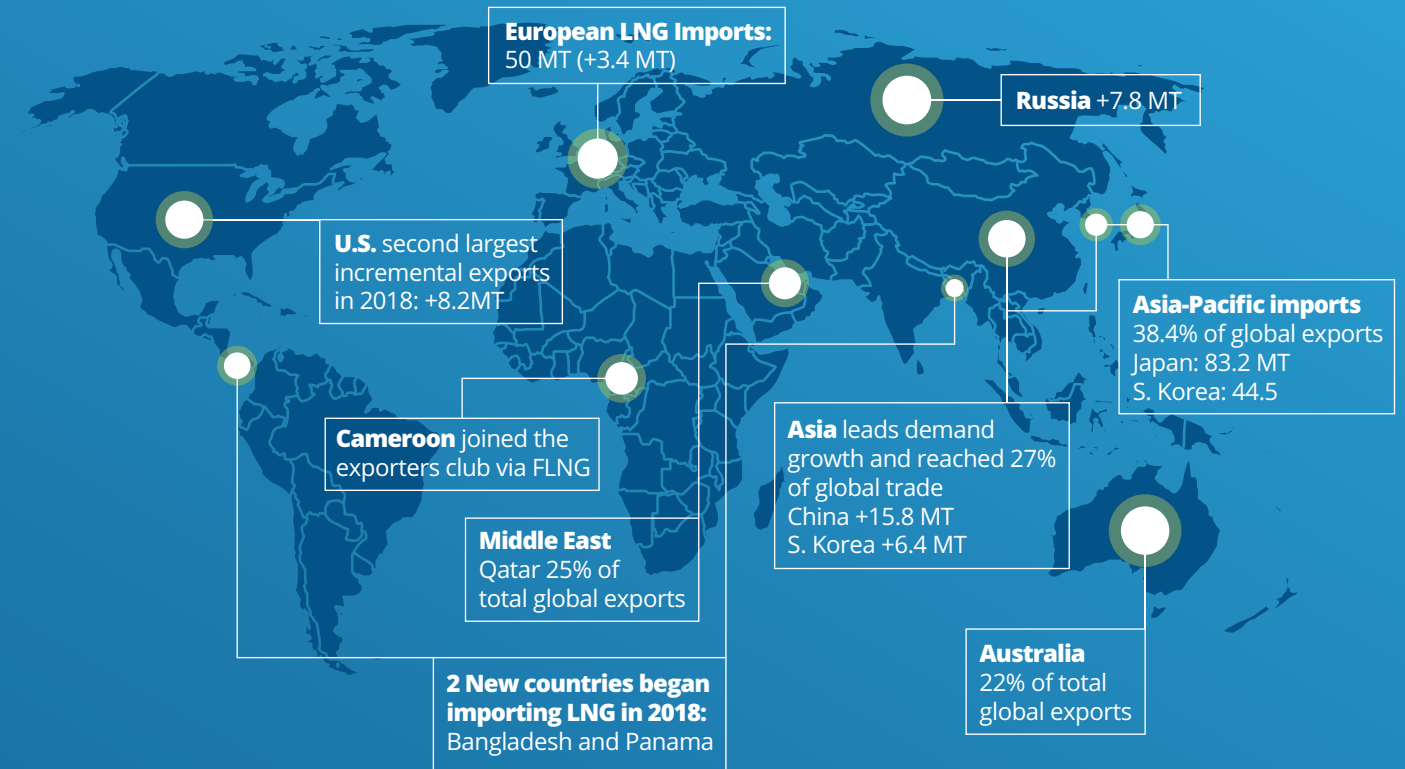
Technology cost reductions and unlocking of new supplies resulted in a tremendous growth in the global LNG market, tripling in size since 2000.

Today, LNG already accounts for over 10% of total global gas supply, and this share will continue to increase, providing secure and flexible energy. A third of that trade was on a non-long-term contract basis in 2018.

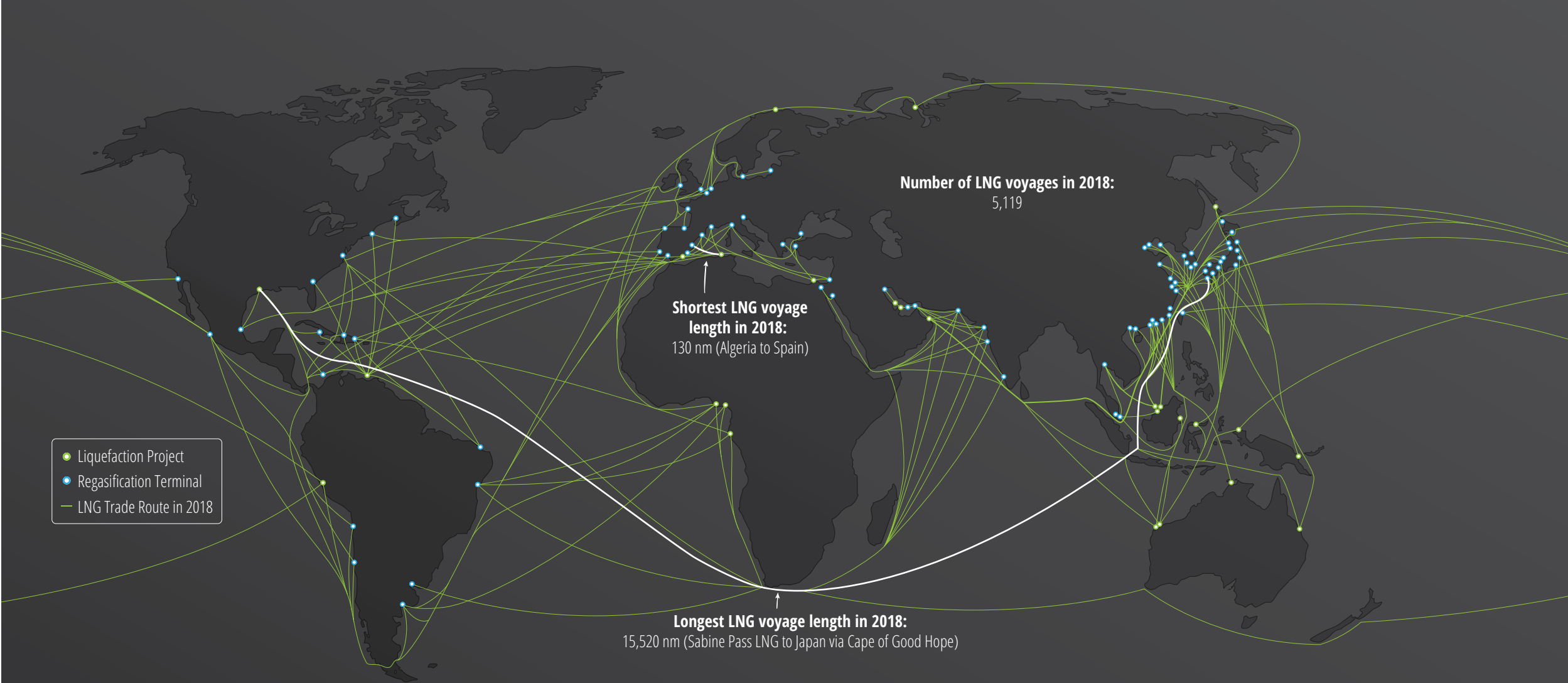
The LNG market will continue to flourish with increasing dynamism, and a growing number, diversity, and size of players.



Key Trends from 2018



LNG is Opening Access to Clean and Reliable Energy Wherever It is Needed



Floating LNG Technologies

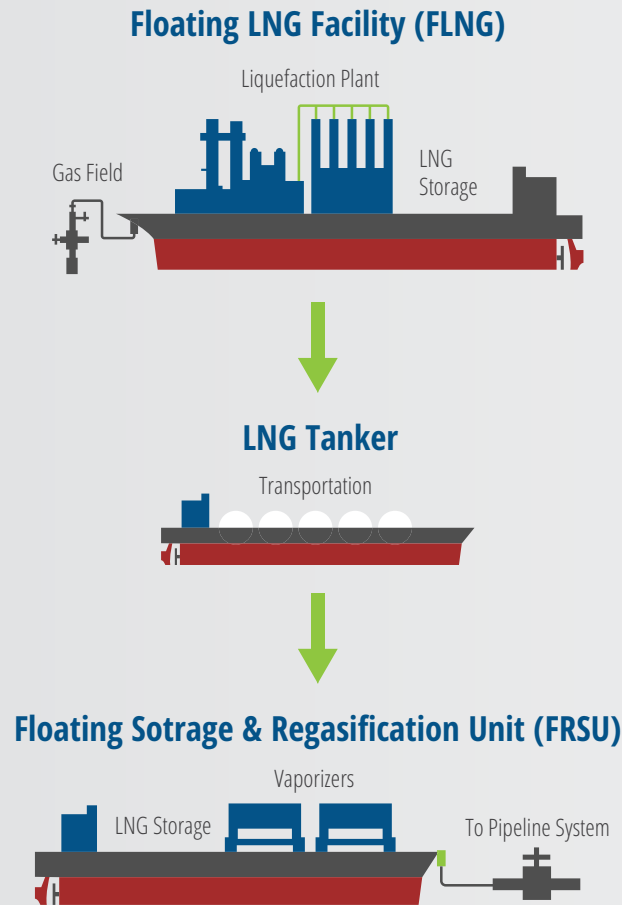
Floating Storage and Regasification (FSRU) are proving to be an energy access and security breakthrough technology.

These vessels act as a mobile regasification service.

They can be moored at sea, or docked in a port, to re-gasify LNG and feed it into a transmission or distribution network, or deliver it directly to an end-user.

Out of 37 LNG importing markets in 2018, 11 gained access via floating capacity alone, and 5 had relied on both, on- and off-shore terminals. Over the coming years, many more new markets will gain access to LNG via new FSRU projects.

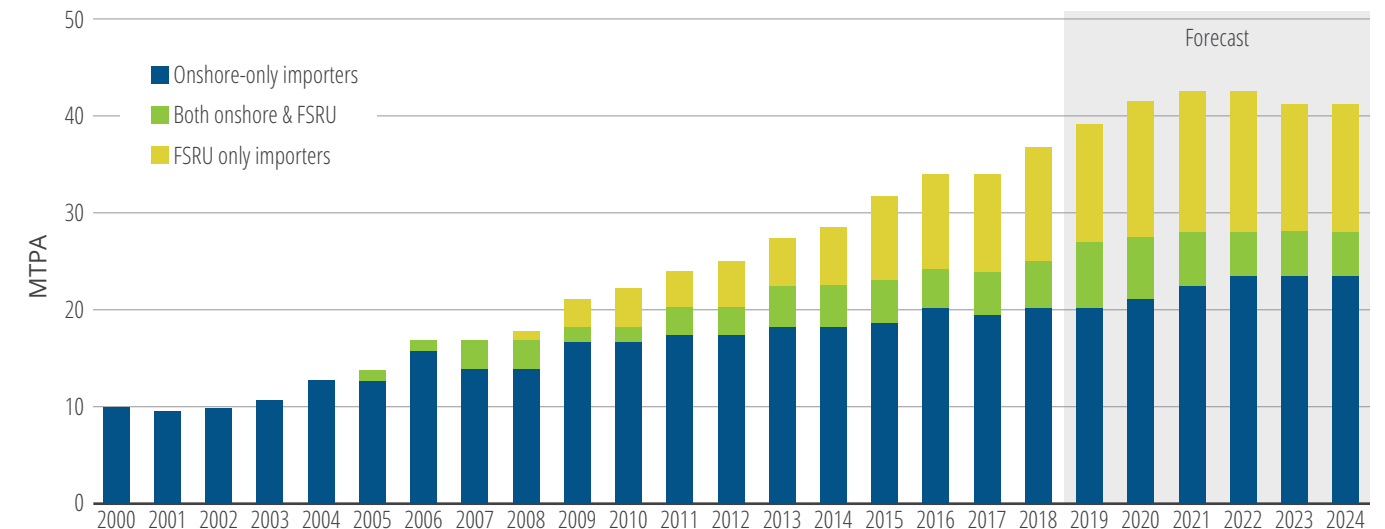
Ghana, El Salvador, Croatia, Côte D'Ivoire, Cyprus, Ireland, Lebanon, Myanmar, Namibia, Nigeria, South Africa, and Sudan are among new entrants expected to gain access to LNG via FSRU.



Floating LNG (FLNG) is a novel technology that allows a vessel with liquefaction capability to tap directly into remote offshore fields and load it onto an LNG carrier, avoiding the need for expensive underwater pipelines.

As this technology gains commercial deployment experience, costs will come down, and it will unlock gas deposits that are currently too small or far away to be economic.

At the end of 2018, there were already two operational FLNG projects, successfully producing and exporting LNG off the shores of Malaysia (Satu, 1.2 MTPA), and most recently Cameroon (Kribi, 2.4 MTPA). An additional 11.5 MTPA in floating liquefaction capacity has reached FID and is anticipated to come online by 2022. There are also over 160 MTPA of proposed projects.



Affordable Option for New Flexible Capacity

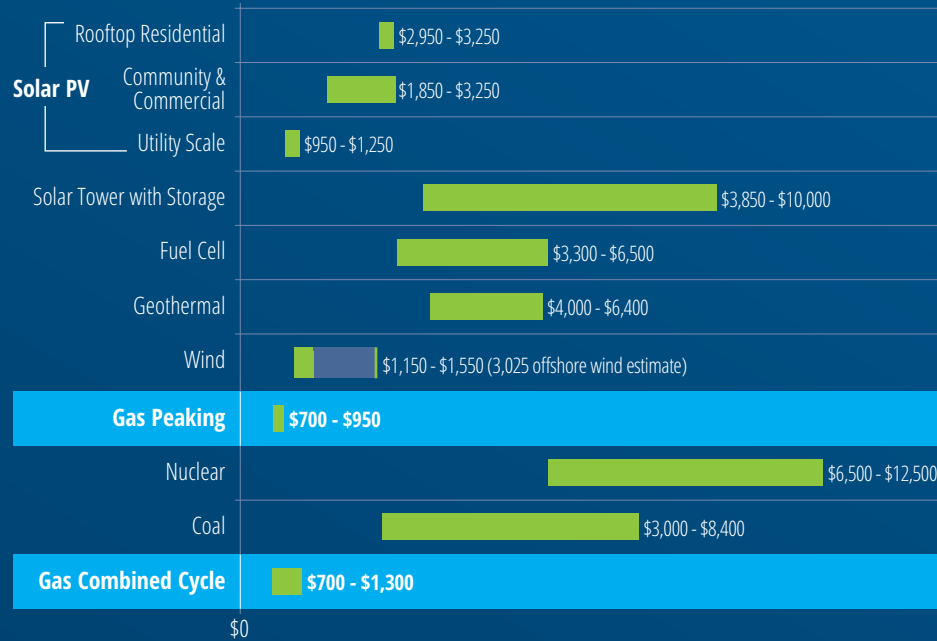
Natural gas provides an economic, efficient, and stable option to generate electricity. It is particularly suitable for developing economies, which require significant new capacity investments.

The high pollution costs make coal a more expensive option, despite its lower marginal cost.

For example, in non-OECD countries, the welfare costs of pollution exceeded USD 500 per capita in 2015, and are projected to rise to between USD 2,000 and USD 3,000 per capita by 2060.

In addition to the clean air benefits, natural gas provides high system capacity and reliability, helping to mitigate integration costs of variable renewables.

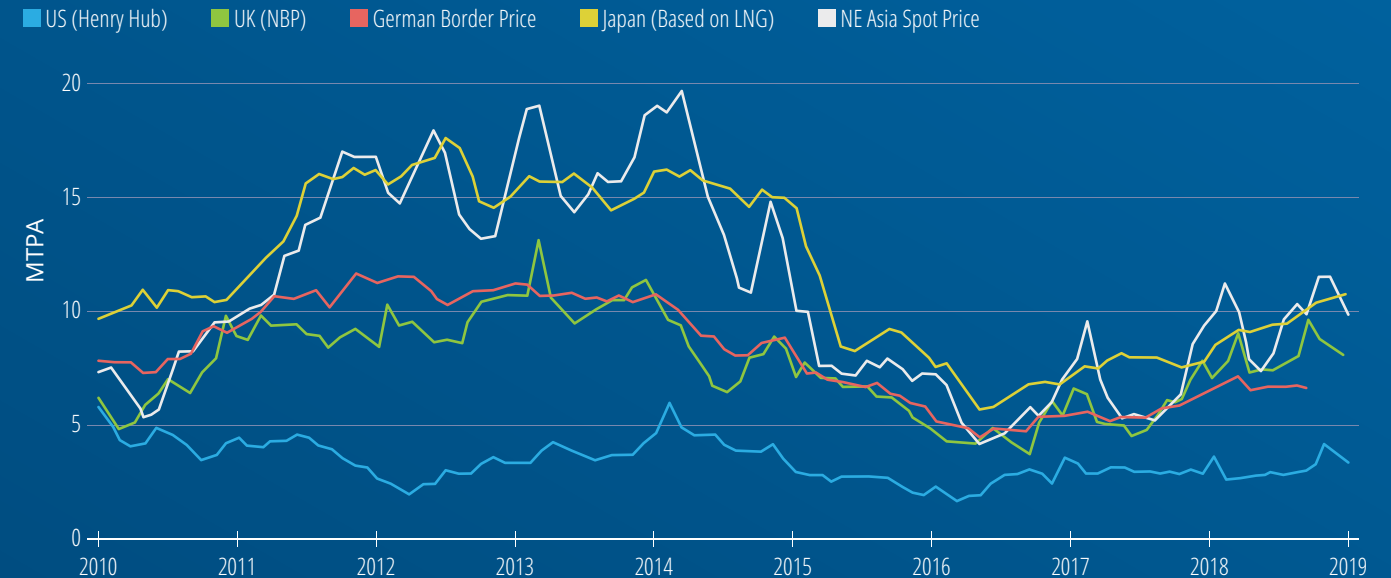
Capital Cost Comparison (\$/kW)



Global Price Convergence in LNG

With increasing globalization of the LNG market, there is a clear trend of convergence between the main global price indices, helping to lower costs further through competitive pressure

Monthly Average Regional Gas Prices (\$/mmBtu)

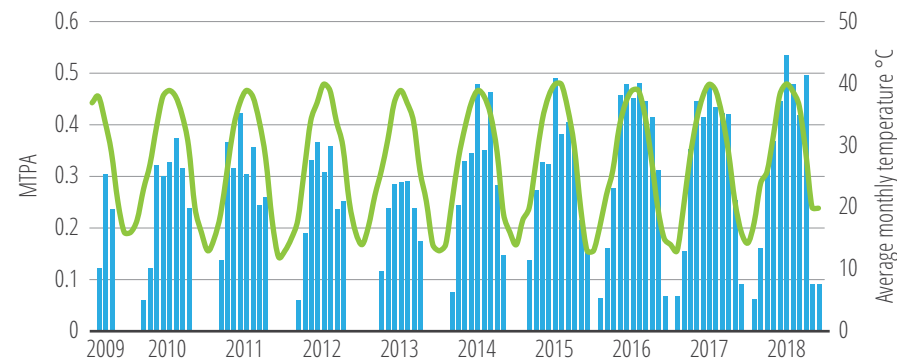


Flexible Reliability Resource for Power and Comfort

Natural gas is the most flexible, multi-purpose, source of energy for all basic needs of the modern society.

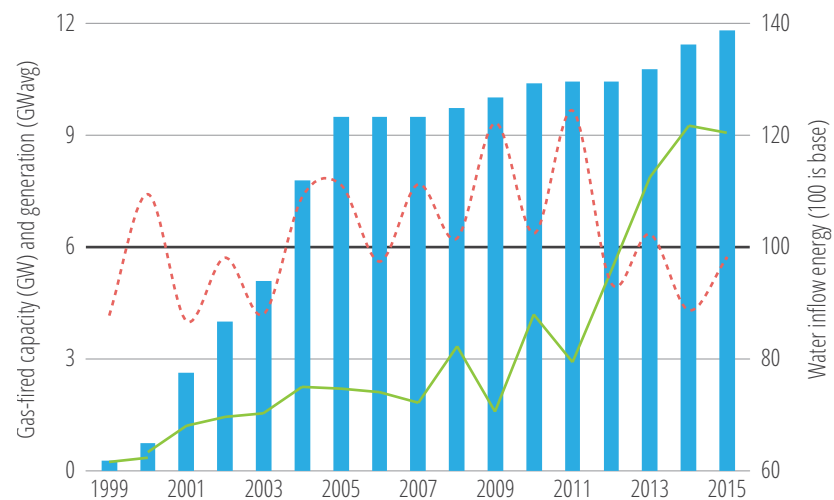
Meeting seasonal cooling demand in Kuwait

■ LNG Imports ■ Temperature °C



Meeting Seasonal Power Needs in Brazil

■ Gas Variable Capacity (GW) ■ Gas generation (GWavg) ■ Water inflow versus long-term average



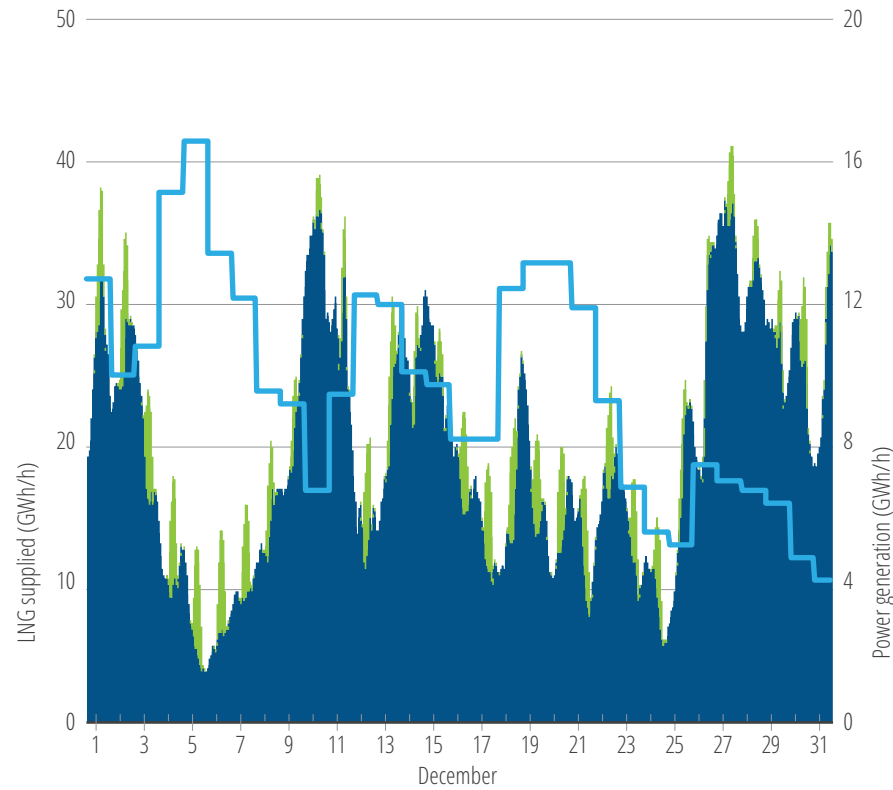
An increasing share of variable renewable energy is making it more challenging for governments and utilities to develop electricity systems that match supply and demand efficiently.

In Brazil, hydropower provides around 90% of electricity when there is sufficient rainfall. In years when there is not enough rain, gas-fired power plants make up the shortfall. Many of the gas-fired power plants in Brazil today were built in response to severe water shortages in 2001 and 2002. In 2015, a severe drought saw hydropower's share of electricity supply drop to around 70%.



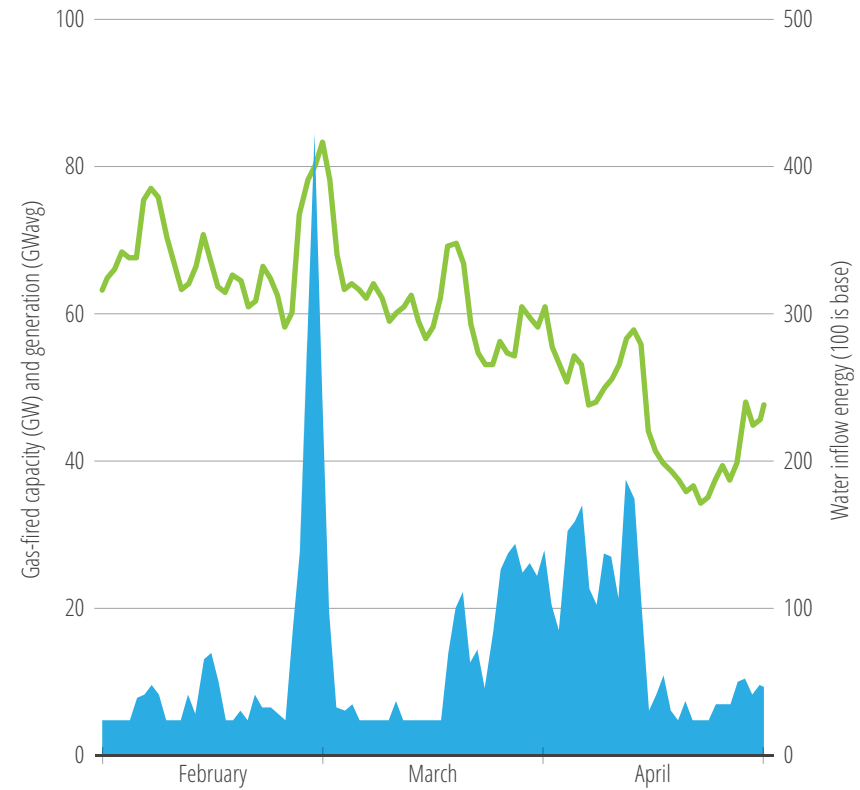
LNG Complements wind and solar in Spain (Dec 2017)

■ Wind ■ Solar ■ LNG Supply (GWh/h)



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■ LNG Supply ■ Total Gas Demand (RHS)



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The International Gas Union (IGU) was founded in 1931. It is a worldwide non-profit organisation registered in Vevey, Switzerland with the Secretariat currently located in Barcelona, Spain.

The mission of the IGU is to promote the political, technical and economic progress of the global gas industry. The IGU seeks to improve the competitiveness of gas in the world energy markets by promoting transparency, public acceptance efforts, and the removal of supply and market access barriers.

The IGU also seeks to collaborate with governmental agencies and multilateral organizations to demonstrate the economic, social, and environmental benefits of gas in the global energy mix.

More than 150 IGU members are associations and corporations representing over 95% of the global natural gas market. IGU covers the entire natural gas value chain, from exploration and production, to transmission via pipelines and liquefied natural gas (LNG), through to distribution and combustion at the point of use.

[igu.org](https://www.igu.org)