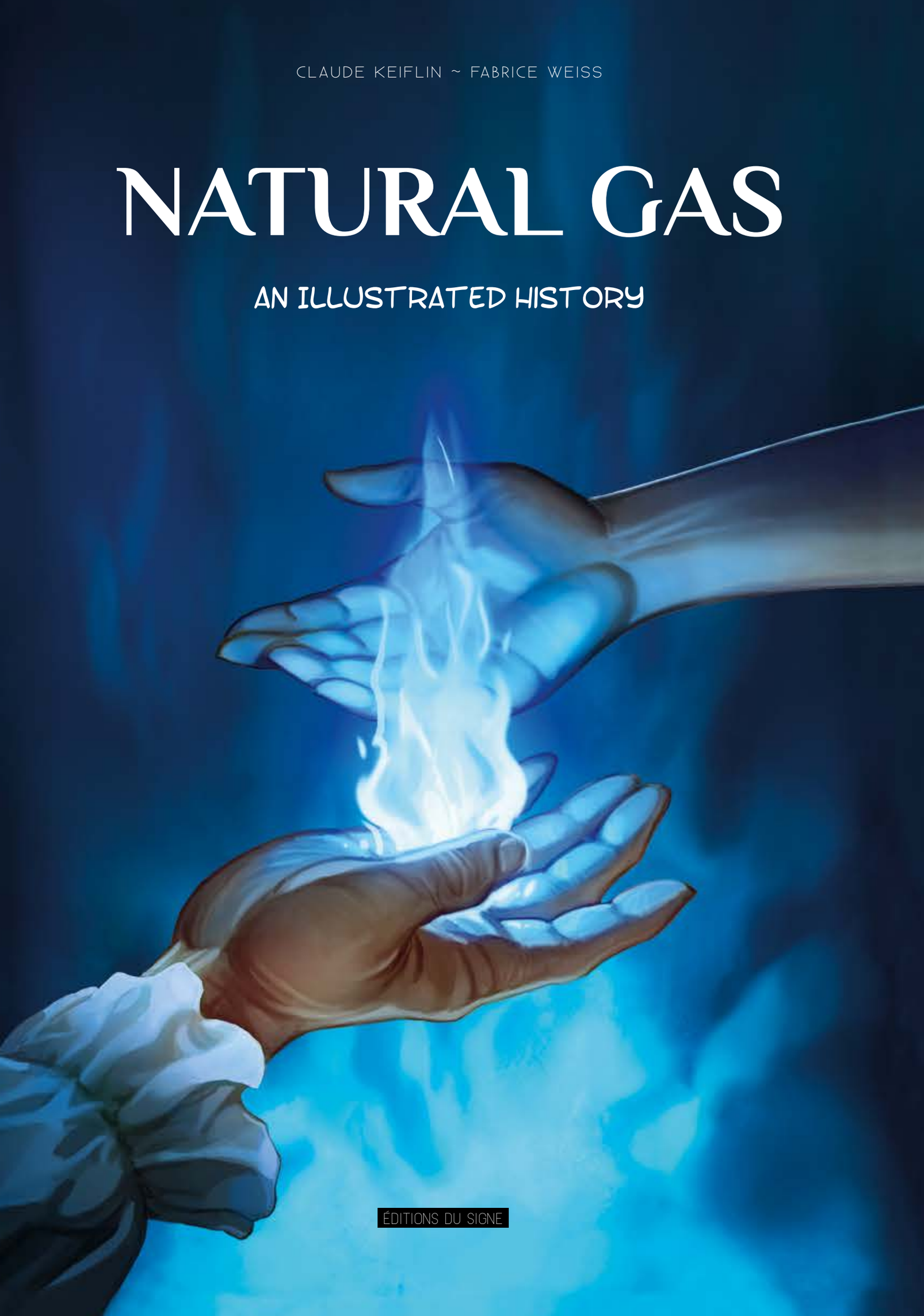
CLAUDE KEIFLIN ~ FABRICE WEISS

NATURAL GAS

AN ILLUSTRATED HISTORY



ÉDITIONS DU SIGNE

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SCRIPT:
CLAUDE KEIFLIN

ILLUSTRATIONS & COLORS:
FABRICE WEISS

EDITIONS DU SIGNE

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Mesopotamia (present-day Iraq), three thousand years ago. In the southern delta of the Tigris and Euphrates rivers, the people of the kingdom of Sumeria venerate the "eternal fires": gas, emitted from subterranean pockets, which ignites upon reaching the air. The king himself conducts the religious ceremonies.

O great Enki, god of the abyss, may you be praised, for you have given your servant knowledge of the secrets of the earth and magical power.

Many centuries before our time, east of the Caucasus mountains, lay the "Land of Fire" in present-day Azerbaijan. The Zoroastrians, adorers of fire, worshiped there.

In ancient times, a "flaming fountain" appeared in a ravine in what is now southeastern France. It gave rise to a cult of Vulcan, the Greek god of fire and forges.

In Hippo, in North Africa, St. Augustine (354-430) mentioned this phenomenon in his book "The City of God."

This flaming fountain reveals the power of God.

Centuries later, in 1885, an engineer by the name of Piret investigated the site.

There is an enormous reserve of petroleum under there, I'm certain of it.

This man Piret has spent a lot of money on this dream of his.

You're not the only investor who has almost been ruined in this business!

In China, under the Han Dynasty (206 BC to 220 AD), an advanced civilization developed, employing technologies which would not be discovered in the west until centuries later.

The Chinese built wells to extract seawater.

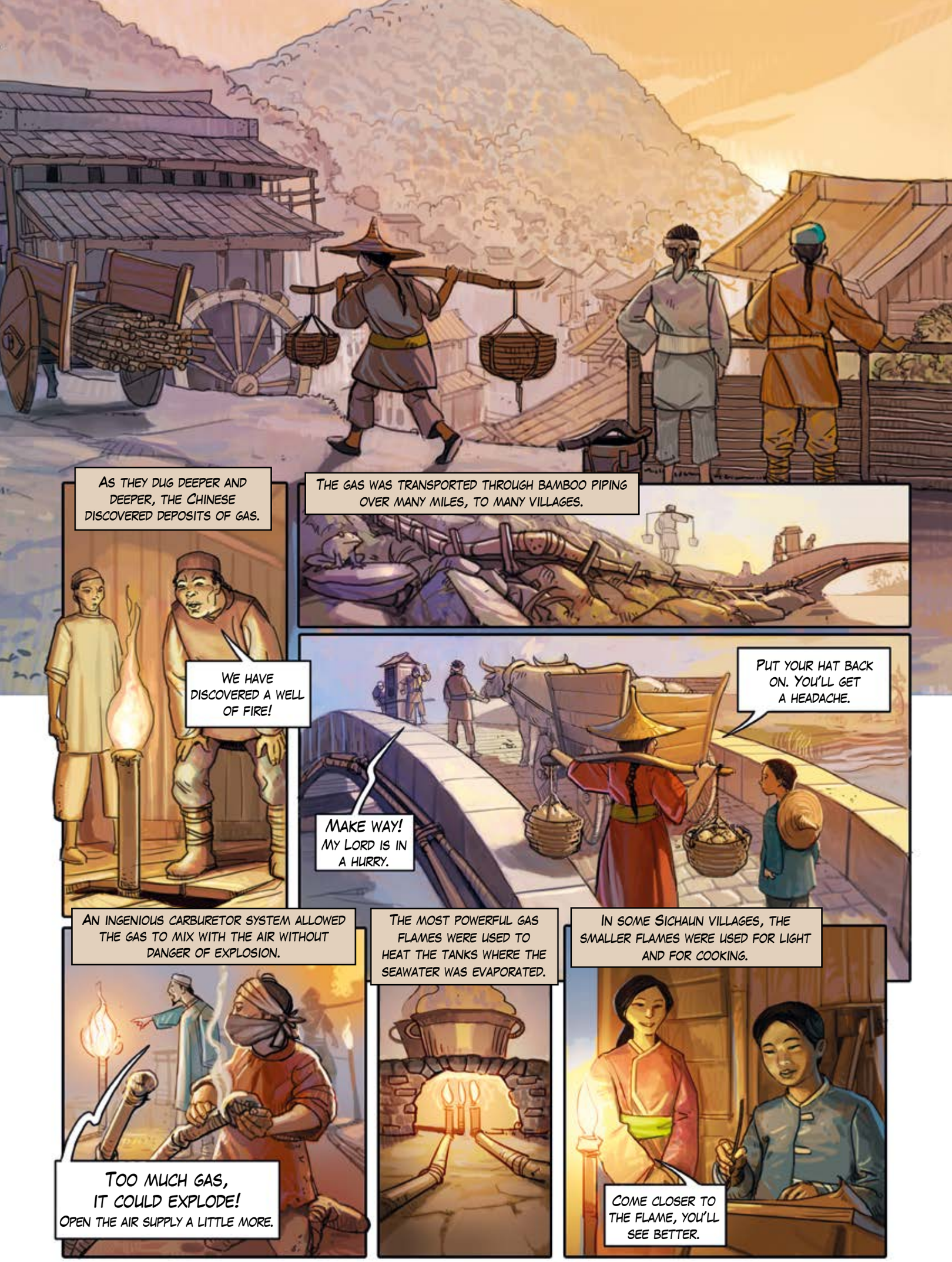
Come on! Faster!

Put your back into it!

From the well came pipes made of bamboo which carried the seawater.

Do you see that leak? Seal it up.

As the sea water evaporated, the salt was collected.


As they dug deeper and deeper, the Chinese discovered deposits of gas.
We have discovered a well of fire!
The gas was transported through bamboo piping over many miles, to many villages.
Put your hat back on. You'll get a headache.
Make way! My lord is in a hurry.
An ingenious carburetor system allowed the gas to mix with the air without danger of explosion.
Too much gas, it could explode!
Open the air supply a little more.
The most powerful gas flames were used to heat the tanks where the seawater was evaporated.
In some Sichaun villages, the smaller flames were used for light and for cooking.
Come closer to the flame, you'll see better.


In the West, the discovery of the uses of gas would have to wait until the 18th century and the Industrial Revolution. English coal miners were among the first to recognize the presence of gases deep in the earth, which they called "coal damp" and "choke damp."
In 1764, in New Jersey, Benjamin Franklin investigated the phenomenon of "swamp gas."
Strange, the air above this swamp is flammable!
"London. April 10, 1774. Dear Monsieur Lavoisier, I write to you on the subject of the flame that can be produced from certain waters..."
At Como, Alessandro Volta carried Franklin's researches even farther.
Let's see if the gas of Italian swamps is as flammable as in America.
In 1777, he recreated his experiment in Strasbourg in the presence of Baron Dietrich.
The flammable air, Baron, is a gas, which emerges from plants as they decompose.
In my observations, I have noted that this gas will detonate when it meets the common air while enclosed in a vessel.
It is remarkable that this air burns with a blue flame.
In Paris, the Baron presented the discovery of Volta to the great French scientist Antoine Lavoisier and the members of the Academy of Sciences.


In 1786, a young French aristocrat, the 19-year-old Philippe Lebon d'Humbersin, heated sawdust in a glass retort.
It looks like St. Elmo's fire.
It's gas, father. I am going to call it "hydrogen gas."
1797. Having completed his studies in Paris, Philippe Lebon continued to carry out experiments with gas lighting in his family home.
This flame does not give much light.
There are still too many impurities in the gas.
In 1799, Philippe Lebon obtained a patent for his invention, which he called a "thermolamp." Two years later, he was commissioned to light the Hotel Seignelay in Paris. It would be years before his extraordinary invention would find practical applications.
It's beautiful!
It certainly is, my dear.
Wanting to associate his name with some great invention, King Louis XVIII of France decided to finance a gas company.
We will begin by lighting the Hospital of St. Louis.
I beg your pardon, your Majesty, but won't the lighting keep the sick people awake at night?
Why are you here at the hospital?
For a skin disease.
Ah yes, this hospital specializes in that.


In the 1820's there was a lively debate between advocates and opponents of coal gas.
Gas allows us to save the wood of our forests...
...and to free up agricultural land we are now using to produce lighting oil for other crops.
Not to mention that the gas lighting in the streets is very helpful to the police...
If all the streets of London were lit, there would not be so much crime.
WHEEEEE
Due to hydrogen sulfur, manufactured gas had a strong odor.
Can you smell the gas? It's disgusting!
Another leak. The gas often starts fires in restaurants and cafés.
People living near gasometers larger and larger structures used to store gas worried about the danger of explosion.
That huge thing full of gas terrifies me.
In England, one of them exploded, and many people died.
Faulty connection of pipes resulted in leaks and explosions, as in 1864 at the Austerlitz Bridge in Paris.
Nevertheless, by the middle of the 19th century, hundreds of miles of gas pipe ran below the streets in Paris and other large cities.

In 1821, in the State of New York, a gunsmith by the name of William Hart noticed bubbles forming on the surface of Lake Erie.

Could it be gas?

He began digging as well with a simple shovel! About eight yards down, the workers released methane, trapped in the shale.

Be careful not to make any sparks with your tools!

The gas was funneled to the town of Fredonia in hollow logs sealed with rags and tar.

By 1825, William Hart's well provided light to four shops, the post office, and the fire department.

When will you be able to install the gas in my house?

As soon as all the businesses and public buildings are provided for.

DRUGSTORE

In 1858, entrepreneurs carrying on the work of William Hart created the Fredonia Gas Light Company, the first American gas company.

In 1826, Fredonia built its first public school. It welcomed 8 students the first year, 136 the second year - 81 boys and 55 girls.

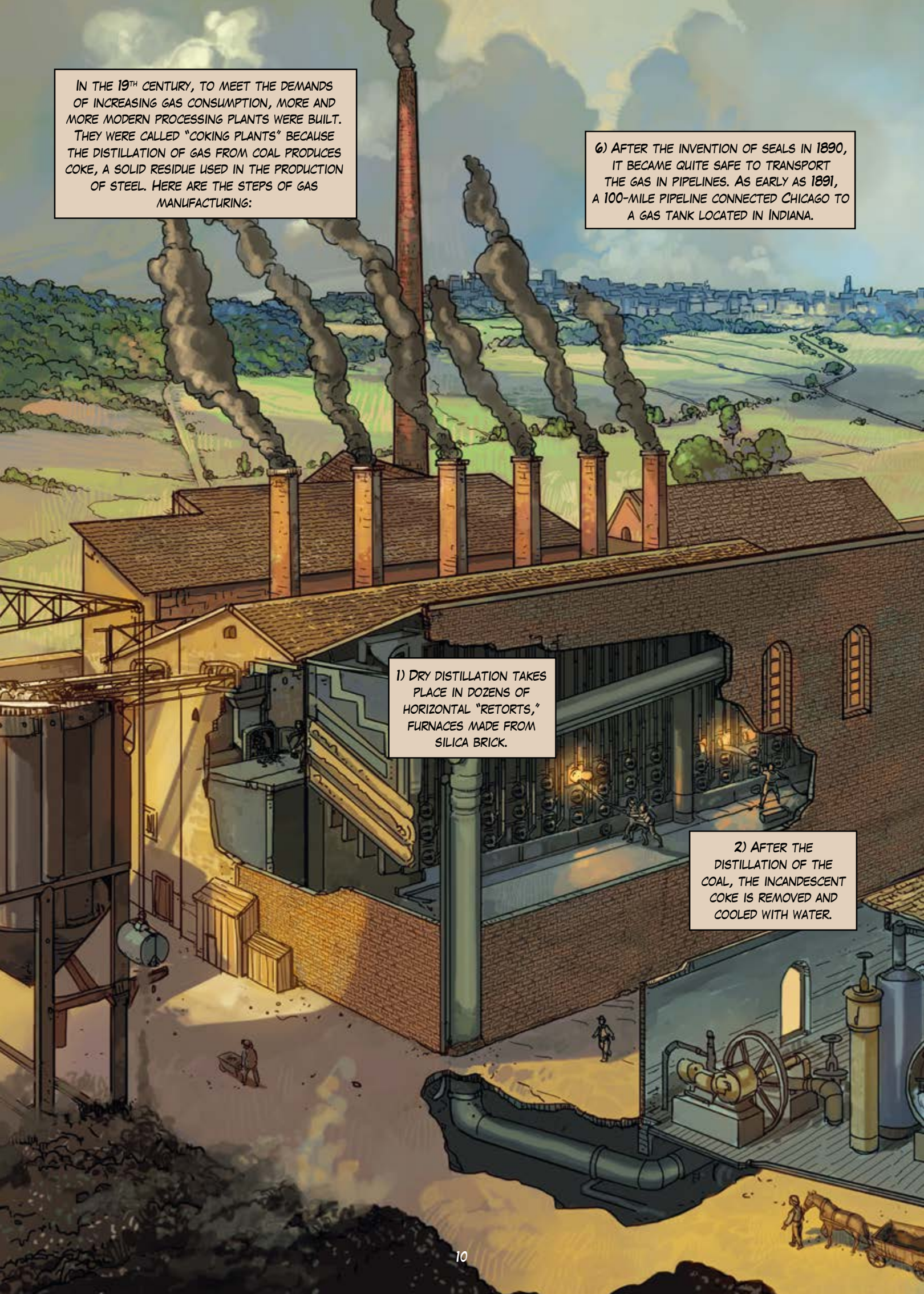
PRIMARY SCHOOL

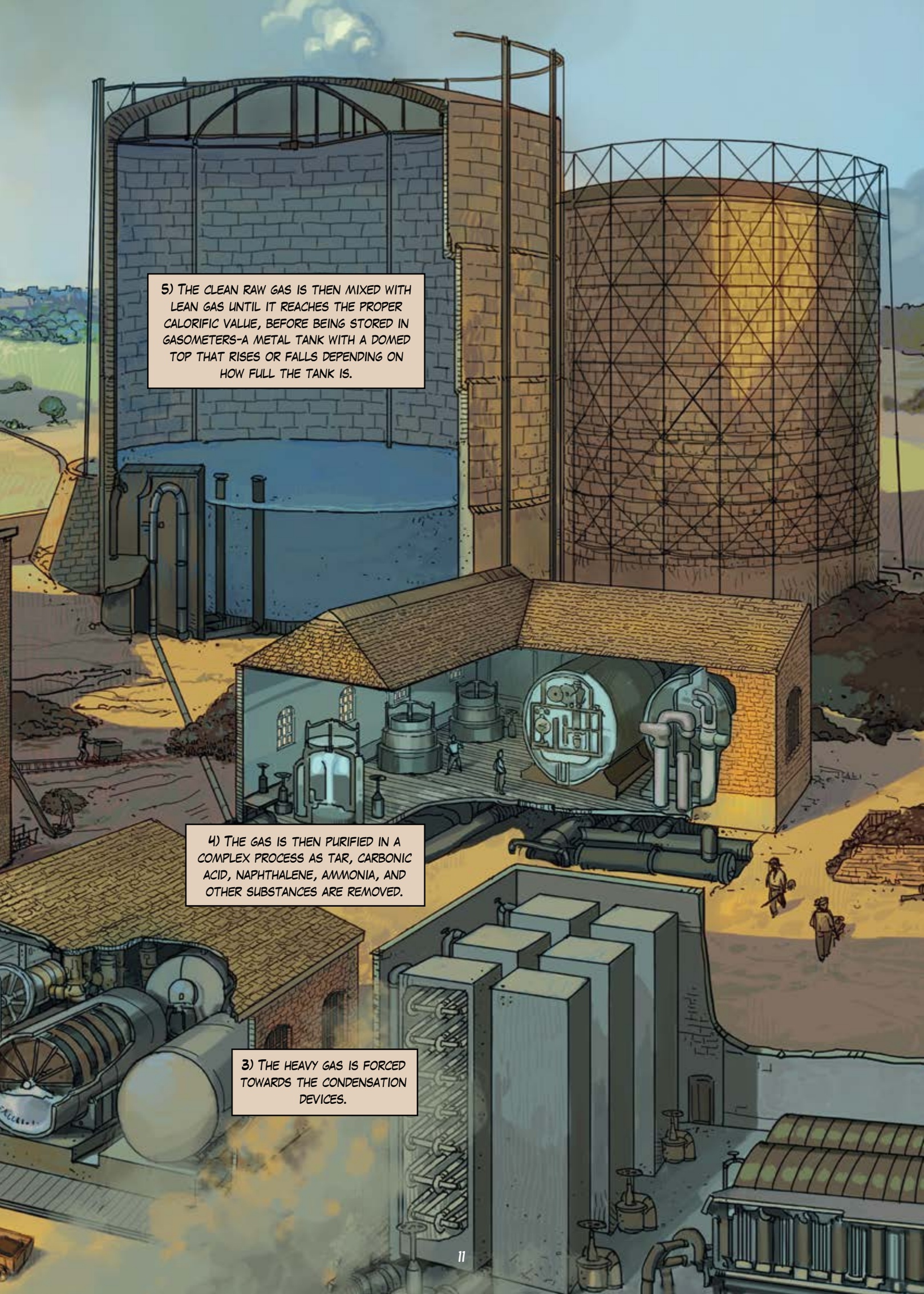
We should have a portrait of William Hart here!

You're right. He's the father of American natural gas.

FREDONIA
GAS LIGHT CO

Today, Fredonia forms part of the State University of New York.


In the 19th century, to meet the demands of increasing gas consumption, more and more modern processing plants were built. They were called "coking plants" because the distillation of gas from coal produces coke, a solid residue used in the production of steel. Here are the steps of gas manufacturing:
1) Dry distillation takes place in dozens of horizontal "retorts," furnaces made from silica brick.
2) After the distillation of the coal, the incandescent coke is removed and cooled with water.
6) After the invention of seals in 1890, it became quite safe to transport the gas in pipelines. As early as 1891, a 100-mile pipeline connected Chicago to a gas tank located in Indiana.


5) The clean raw gas is then mixed with lean gas until it reaches the proper calorific value, before being stored in gasometers-a metal tank with a domed top that rises or falls depending on how full the tank is.
4) The gas is then purified in a complex process as tar, carbonic acid, naphthalene, ammonia, and other substances are removed.
3) The heavy gas is forced towards the condensation devices.

In the United States, an artist and entrepreneur by the name of Rembrandt Peale was fascinated by gas technology.

The clear, steady light allows me to work by night as well as by day!

In 1814, he opened one of the first public museums in the city of Baltimore.

I want the museum to be a place where people not only see art, but the latest advances in science as well!

Such marvelous paintings!

The lightning is marvelous, too!

The museum became the first public building to be lit entirely by gas.

The museum showcased both Peale's paintings and scientific discoveries, like the mastodon fossils his father had unearthed.

There is so much we don't know about the world. So much yet to be discovered!

Thanks to the company Peale established, Baltimore became the first American city to be lit by gas.

Peale was only the first of many artists to be fascinated by gaslight....

Gaslight would later be used in the burgeoning film industry to provide light as well as atmospheric effects.

It even inspired a famous film!

The workers who monitored the ovens - "cokemen"- had an extremely dangerous job. They worked in hellish temperatures and constantly breathed an atmosphere of hot dust.

COUGH
COUGH
COUGH

Go get a drink, I'll put someone in your place.

In a group photo, cokemen pose with their tools.

The coke removed from the retorts would ignite in the air. Water was required to cool it.

Cokemen were well paid, but more than in other jobs, they were subject to many illnesses, especially lung disease.

Your lungs are heavily congested, young man.

Long and continuous strikes paralyzed European factories at the end of the 19th century.

WORKERS ON STRIKE
THERE IS WATER IN THE GAS

They need to give us days off!

And a higher salary!

Coke, the by-product of the distillation of coal, was sold to businesses and individuals.

With that, you'll be able to heat what you need for quite a while, ma'am.

Lamplighters existed long before gas lighting began to be used.

When we no longer have to tend to the candles, what will become of our jobs?

At dusk, the brigades of lamplighters had only a limited time to light all the street lamps, according to a precise table drawn up by city authorities.

It's time, don't dawdle. If you're late it will be taken out of your pay!

The use of gas simplified the work of the lamplighters, who could now use a long pole instead of a ladder to light the lamps.

To avoid switching crews between lighting and extinguishing the lamps, dormitories were provided for the lamplighters.

Other professions linked to gas began to develop. The first gas meter was developed by Samuel Clegg in 1815, and the role of meter-reader grew rapidly in the 19th century. Later, coin-operated meters came into use.

Let's see! Ten cents should be enough to cook my potatoes...

I'm here to collect for the gas, ma'am.

GAS

During World War I, as men were drafted into the armed forces, women replaced men in gas-related jobs as well as many other professions on the home front.

I'm not just going back home when the war is over!

Neither am I. This is a great job and the money is good.

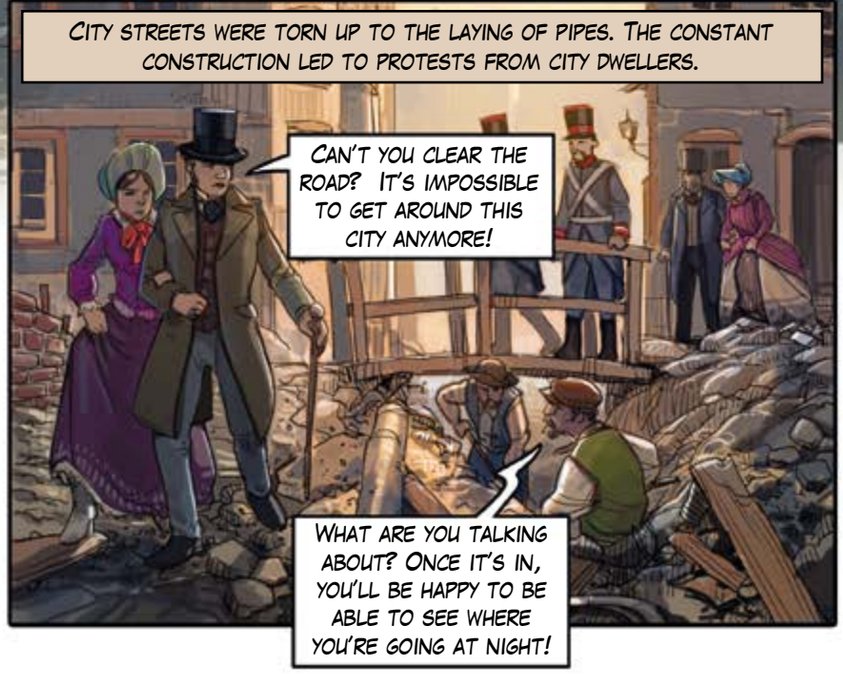
The Chinese used bamboo to carry gas, while the Americans and Europeans used hollowed-out trunks of trees. Improvements in metals, welding techniques, and pipe making during World War II made pipeline construction more economically attractive and the U.S. began building its pipeline network.

By the middle of the 19th century, thousands of miles of cast iron, lead and iron pipes were constructed throughout the U.S.

Over time, cast iron pipes become porous.

People blamed gas for polluting wells and causing epidemic diseases.

City streets were torn up to the laying of pipes. The constant construction led to protests from city dwellers.



The rapid expansion of gas networks in cities leads to increasingly stringent regulations.

In the second half of the 19th century, several innovations came by way of Eastern Europe. In the Austro-Hungarian Empire (present-day Poland), Ignacy Lukasiewicz dug one of the world's first oil wells in 1854.

Lukasiewicz also developed a portable gas lamp. He advised the Rockefellers, but did not want any pay for his services.

I work for the good of humanity, not to make myself rich.

On this site, a Museum of the Oil and Gas Industry would later be built.

At about the same time, the German chemist Robert Wilhelm Bunsen and his team perfected a new laboratory apparatus which would produce an intense gas flame to heat preparations or sterilize equipment.

Professor, I think scientists of the future will call this device the "Bunsen burner."

In 1882, at the University of Heidelberg, an Austrian by the name of Auer von Welsbach completed a PhD thesis under the supervision of Robert Bunsen.

Auer, who studied rare-earth elements, added a bec to the Bunsen burner. In 1885, he invented the incandescent gas mantle to increase the brightness of the flame.

It is the effect of magnesium which soaks into the cotton.

Ugh, this greenish light...

Auer replaced the magnesium with a solution of thorium salts and cerium, producing a white light. The effect was not always pleasant.

You are very pale! Are you sure you're not ill?

Not at all, it's this new light that gives everyone such as sickly look!

Nevertheless, the Auer bec would have a "bright" future. It is still used today!

Throughout the nineteenth century, gas-powered engines were replacing steam engines in factories. In 1804, a Swiss inventor and politician by the name of François Isaac de Rivaz built the first coal gas engine.

In this cylinder, the piston is forced up by combustion. When it falls back, it operates a rope which turns the front wheel.

Very clever!

On January 24, 1860, Franco-Belgian Jean-Joseph Etienne Lenoir filed a patent for a spark ignition engine. He manufactured four hundred of these engines, some of which powered the riverboats of the Seine in Paris!

...this new engine runs on gas and pressurized air.

In 1872, American George Brayton invented the first commercial liquid-fueled internal combustion engine, one of the first engines to be used for motive power. In 1881 a Brayton engine was used by John Philip Holland to power the Fienian Ram, the world's first successful self-propelled submarine.

In 1872, with Gottlieb Daimler, Otto started the "Gasmotoren-Fabrik Deutz AG" from which the Daimler, Mercedes-Benz and BMW companies were born.

This new 4-cylinder engine is truly revolutionary for the automobile.

We will present it to the whole world at the Universal Exhibition in Paris!

In 1884, the Frenchman Edouard Delamarre Debouteville, with his chief mechanic Léon Malandin, perfected the first car equipped with a 4-cylinder combustion engine. It had a front seat and a rear platform.

The gas fuel is admitted here and drawn by valves.

In 1920, Georges Imbert invented the wood gasifier which had a hard time competing with diesel. During World War II, however, this type of fuel got a new lease on life when the shortage of gasoline made alternate fuels more attractive. The Peugeot company produced more than 2,500 charcoal gasifiers between 1940 and 1944.


By the end of the 19th century, gas was an integral part of daily life.
Gas was used in workshops and laundries and powered night shifts in factories...
Restaurant
GAS ON ALL FLOORS


In family homes, gas provided light and heat and was used in the kitchen and the bath...
Hairdressing
And gas was used in shops, restaurants, hair salons, bakeries, and more!

At the end of the 19th century, Carl von Linde, a German engineer, used the studies of several scientists to develop the technology to liquefy gas cryogenically.

In 1873, he invented the refrigerating compression engine.

By using ammonia as a refrigerant, I am able to get much lower temperatures.

His invention would transform breweries, allowing for fermentation at low temperatures and the storage of beer.

To think that in my father's time, the only way to keep beer fresh was to plant chestnut trees above the cellar!

Gabriel Sedlmayer, Jr., installed the new system at Spaten, the most important brewery in Munich.

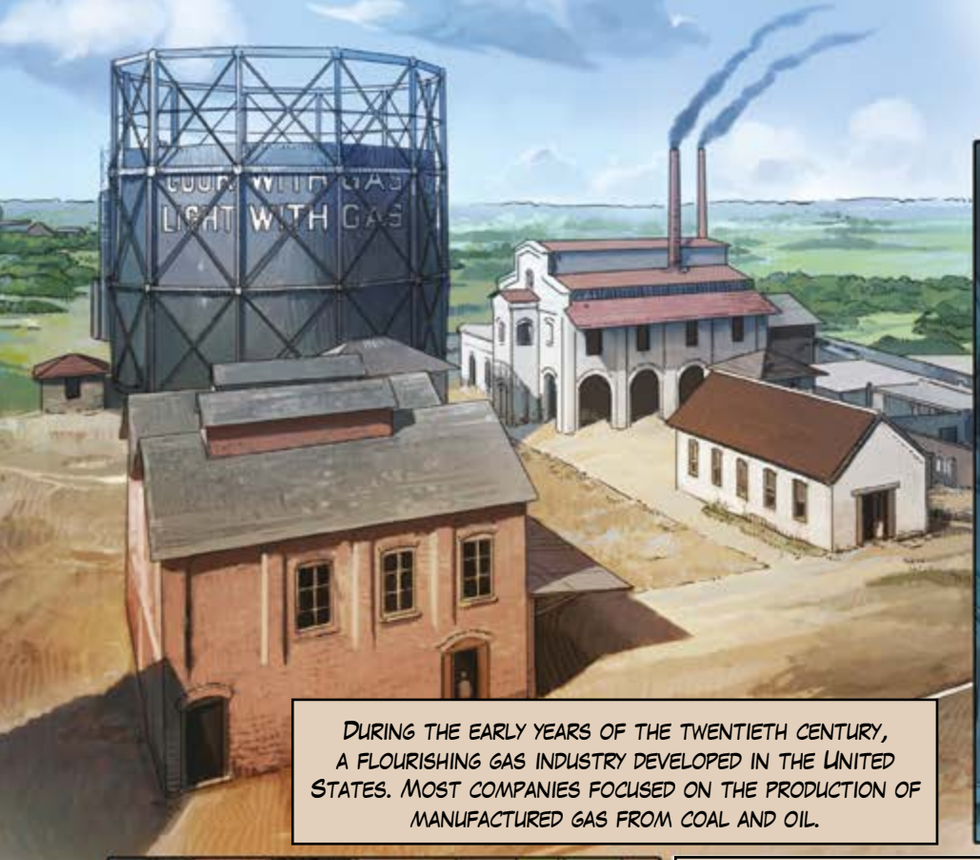
After 1884, Linde continued to explore the world of very low temperatures. His machine to liquefy air received the Grand Prize at the Universal Exposition in Paris in 1900.

A contemporary of Linde by the name of Kastner invented the Pyrophone in 1876 an organ run on coke gas. Today only two examples survive, one in New York and one in Kastner's native Strasbourg.

Linde's work was also the starting-point for the first domestic refrigerator, which appeared in the United States in 1913. Among the many applications of cryogenics is the possibility of transporting liquid natural gas over long distances.

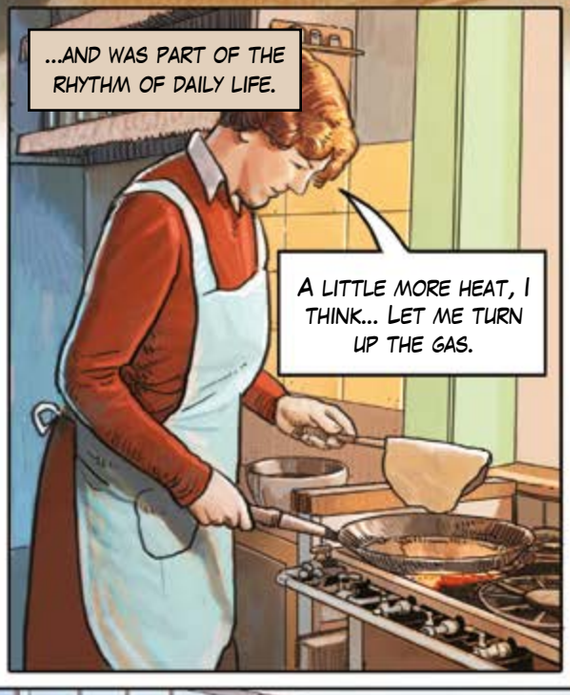
Thank goodness, I no longer have to get blocks of ice to keep things fresh!

The flame heats the air in the tubes, causing them to sound. By adjusting the flow of each nozzle, we can get two octaves.



During the early years of the twentieth century, a flourishing gas industry developed in the United States. Most companies focused on the production of manufactured gas from coal and oil.

Manufactured gas lit great cities...

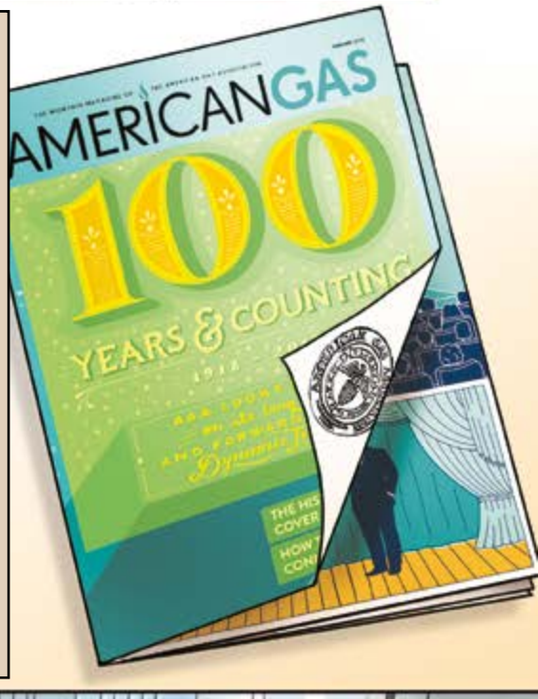


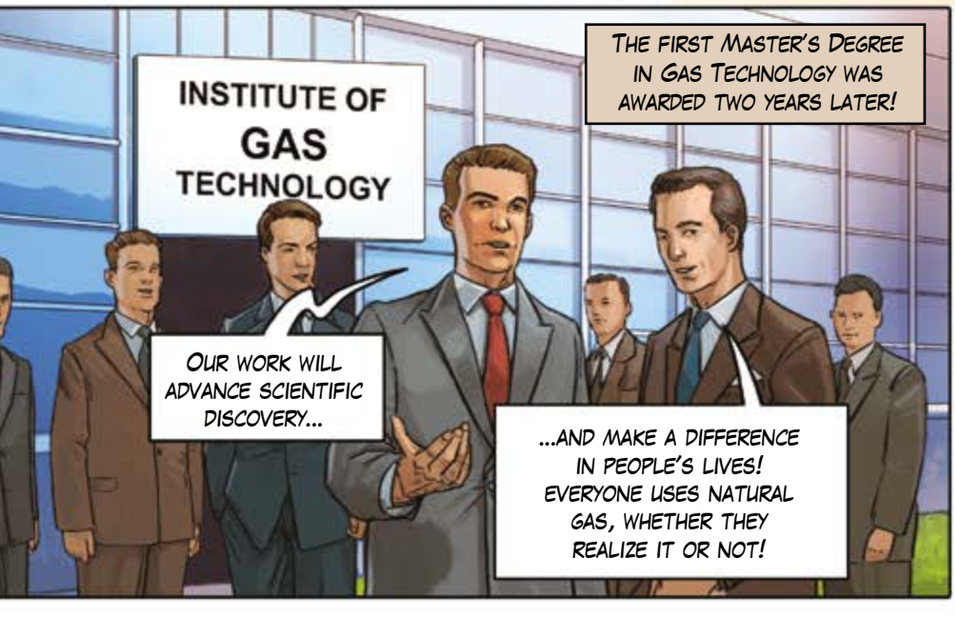
...and was part of the rhythm of daily life.

A little more heat, I think... Let me turn up the gas.

The American Gas Association was formed in June 1918 to improve safety and provide information on trends, activities, and strategies on how to improve gas companies. Today it represents local energy companies that deliver clean natural gas to 95% of residential, commercial and industrial natural gas customers in the U.S.

In 1941, just before the U.S. entered World War II, many American gas companies came together to form the Institute of Gas Technology (IGT), predecessor to Gas Technology Institute (GTI). Based in Chicago, it was focused on education and research into gas technology.



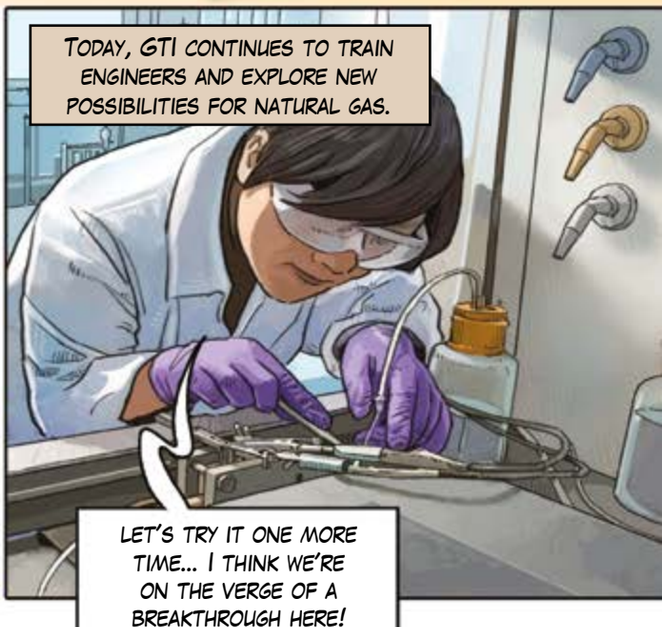


The first Master's Degree in Gas Technology was awarded two years later!

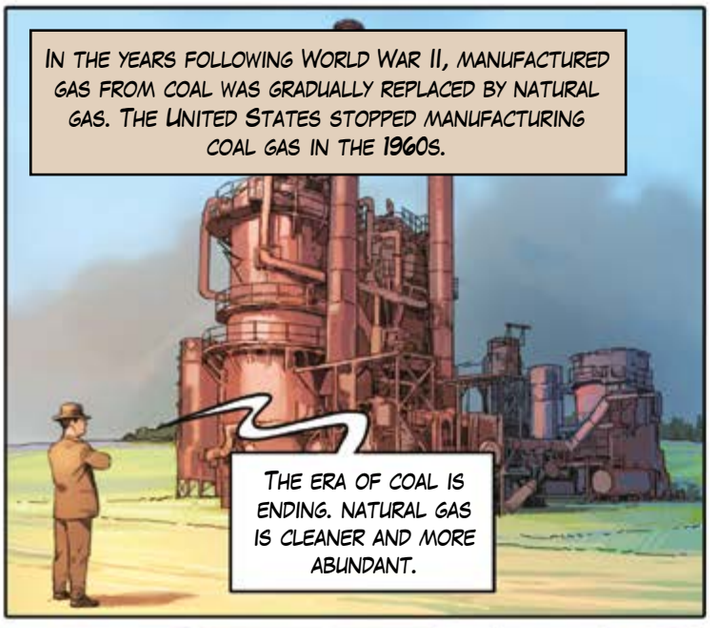
Our work will advance scientific discovery...

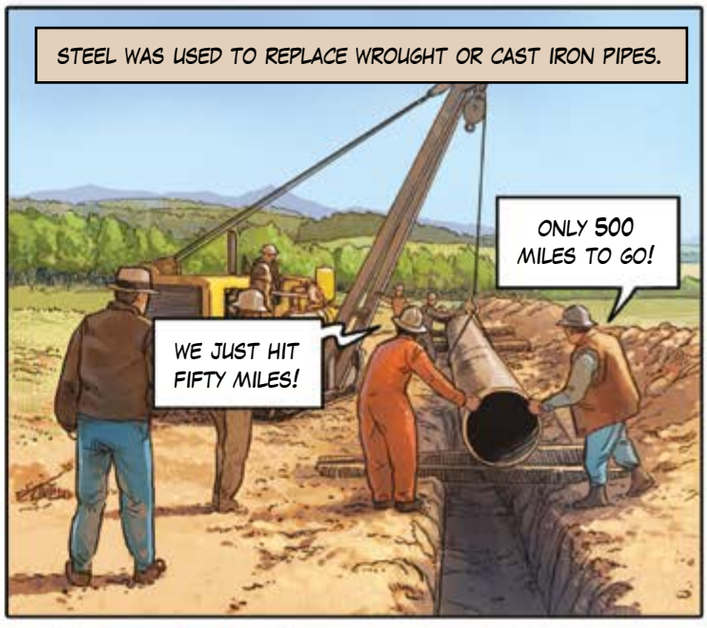
...and make a difference in people's lives! Everyone uses natural gas, whether they realize it or not!

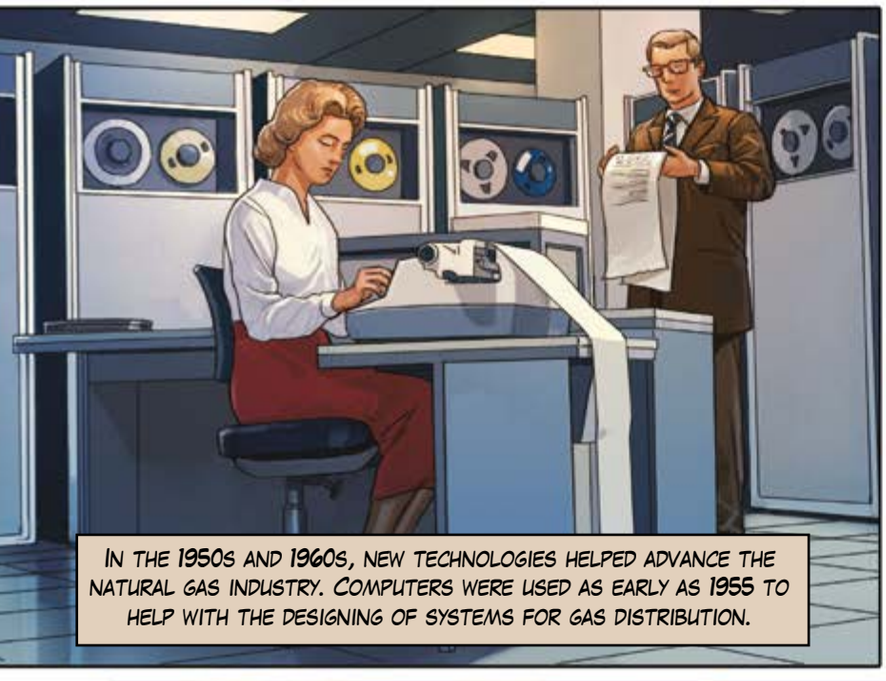
Today, GTI continues to train engineers and explore new possibilities for natural gas.

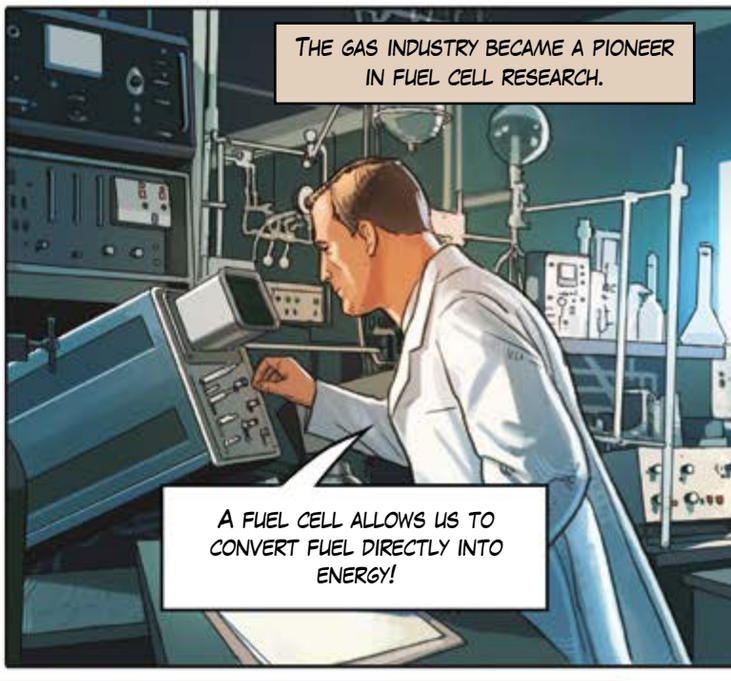


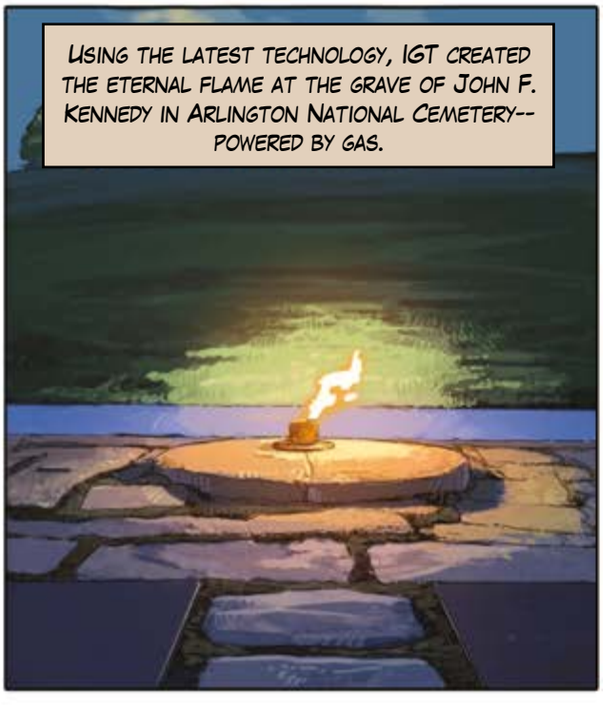
Let's try it one more time... I think we're on the verge of a breakthrough here!

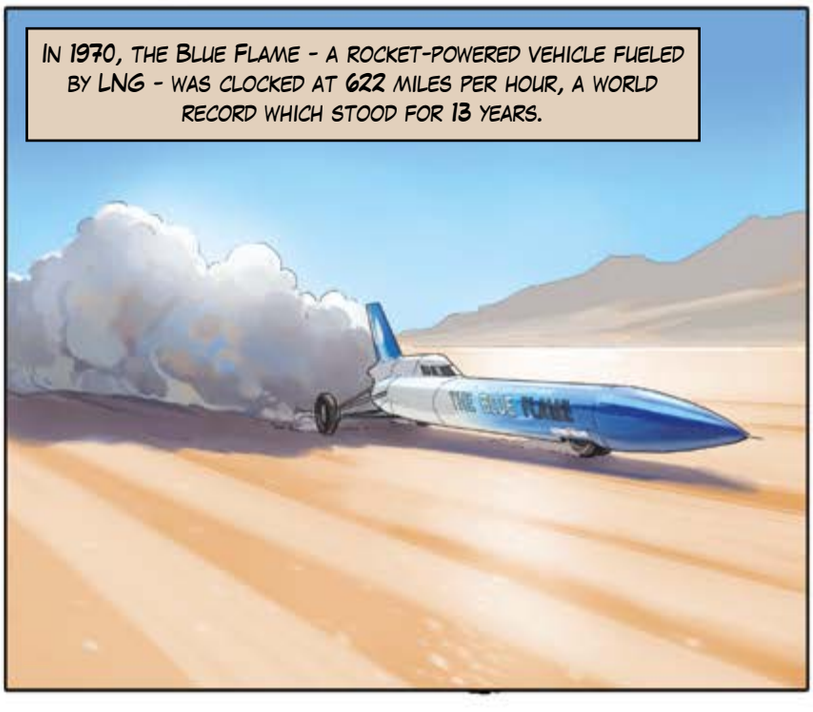

In the years following World War II, manufactured gas from coal was gradually replaced by natural gas. The United States stopped manufacturing coal gas in the 1960s.
The era of coal is ending. Natural gas is cleaner and more abundant.


Steel was used to replace wrought or cast iron pipes.
Only 500 miles to go!
We just hit fifty miles!


In the 1950s and 1960s, new technologies helped advance the natural gas industry. Computers were used as early as 1955 to help with the designing of systems for gas distribution.


The gas industry became a pioneer in fuel cell research.
A fuel cell allows us to convert fuel directly into energy!


Using the latest technology, IGT created the eternal flame at the grave of John F. Kennedy in Arlington National Cemetery--powered by gas.


In 1970, the Blue Flame - a rocket-powered vehicle fueled by LNG - was clocked at 622 miles per hour, a world record which stood for 13 years.

In the 1970s, the global energy crisis focused attention on U.S. dependence on foreign energy sources.

Temporarily CLOSED
OUT OF GAS

Sorry, we are out of gasoline!

Energy independence became public policy, and mid-decade, various federal government agencies were consolidated into the U.S. Department of Energy.

DEPARTMENT OF ENERGY

Gas Research Institute (GRI) was created to manage natural gas R&D for the entire industry.

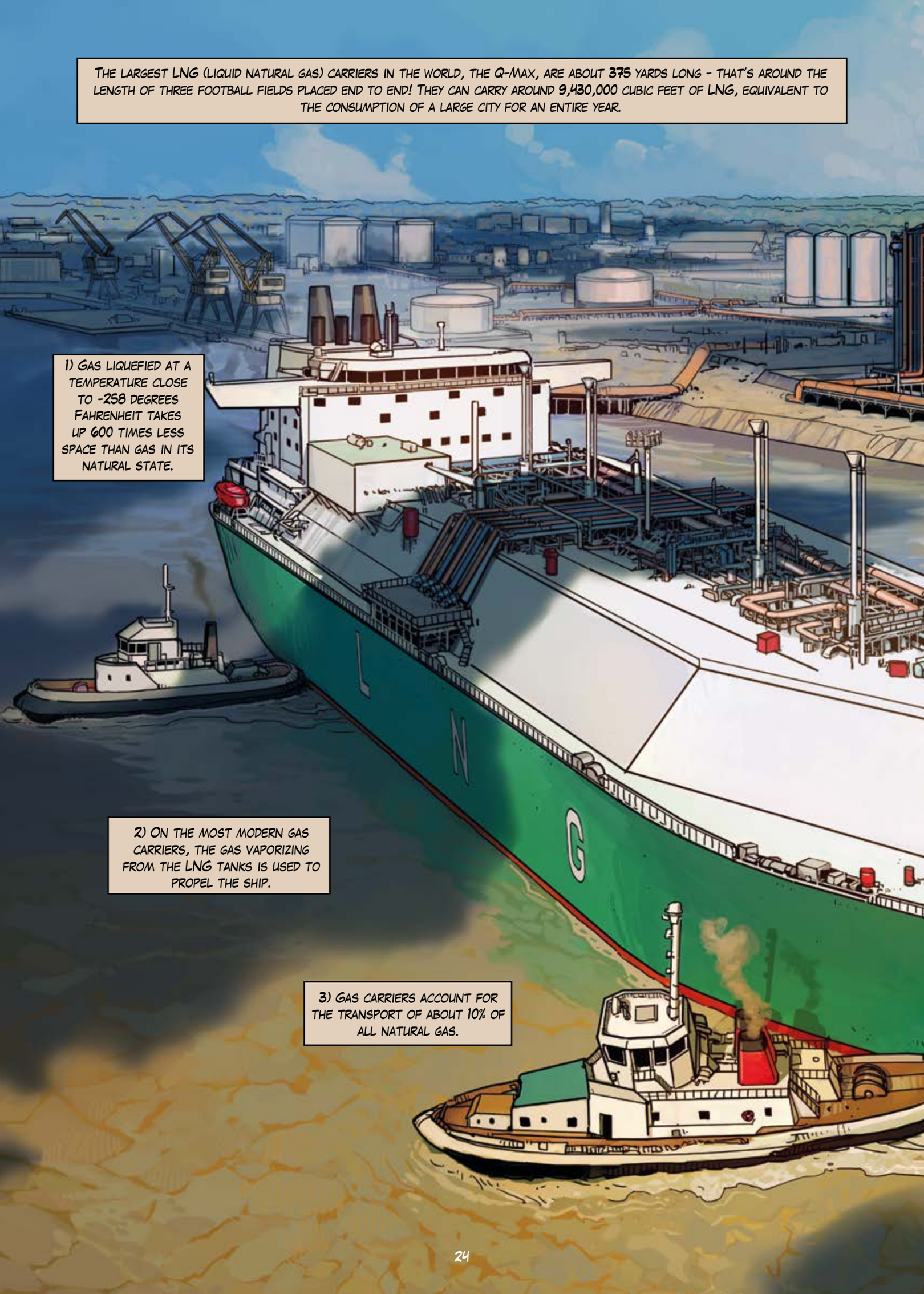
GRI 5-Year R&D plan

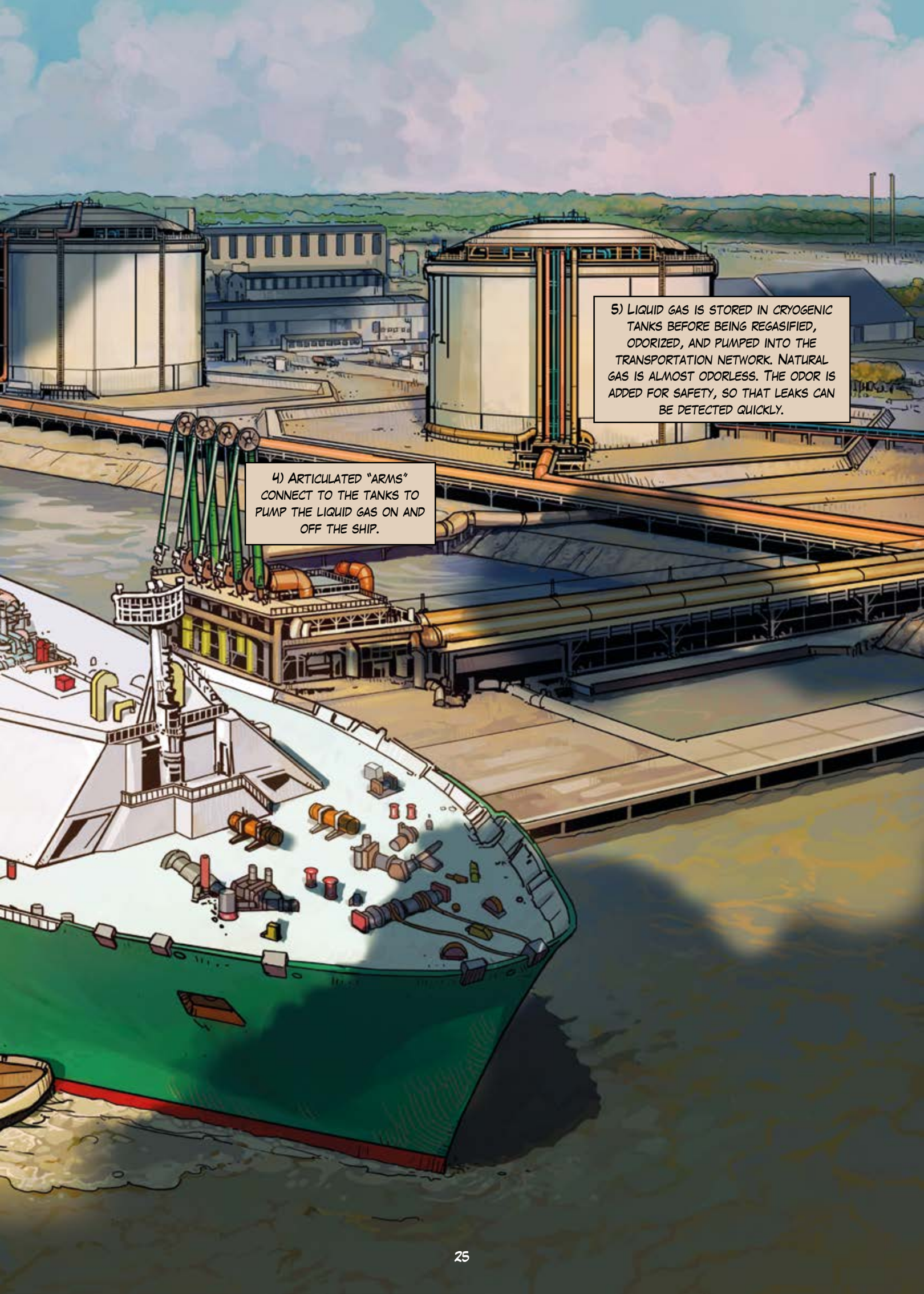
Some of GRI's research focused on new supplies of natural gas from unconventional resources.

Protection of the environment was of utmost importance, and in 1987, President Reagan signed the National Appliance Energy Conservation Act, which required manufacturers to improve the energy efficiency of appliances.

The result was a burst of creativity, as companies worked to improve their products, including the first major innovations in home furnaces in more than two decades.

That spirit of innovation also informs an extraordinary program at the Altamont Landfill in California, where biogas from the landfill is captured, purified, and used to power a fleet of trash haulers, saving 2.5 million gallons of diesel fuel and 30,000 tons of GHG emissions - every year.


The largest LNG (liquid natural gas) carriers in the world, the Q-Max, are about 375 yards long - that's around the length of three football fields placed end to end! They can carry around 9,430,000 cubic feet of LNG, equivalent to the consumption of a large city for an entire year.
1) Gas liquefied at a temperature close to -258 degrees Fahrenheit takes up 600 times less space than gas in its natural state.
2) On the most modern gas carriers, the gas vaporizing from the LNG tanks is used to propel the ship.
3) Gas carriers account for the transport of about 10% of all natural gas.
L
N
G


5) Liquid gas is stored in cryogenic tanks before being regasified, odorized, and pumped into the transportation network. Natural gas is almost odorless. The odor is added for safety, so that leaks can be detected quickly.
4) Articulated "arms" connect to the tanks to pump the liquid gas on and off the ship.

Just as research was about to be abandoned in 1969, Phillips Petroleum discovered one of the largest oil and gas deposits in Ekofisk in the North Sea, 186 miles off the coast of Norway. These underwater reserves are estimated at more than 5800 billion cubic feet.

The offshore environment is rough and dangerous: violent winds, powerful waves and currents, low temperatures, and frequent storms.

It looks like the next crew won't be arriving today. They're already three days late.

The engineers and crew spend several weeks at a time on the platform.

There are three types of offshore drilling platforms: The fixed platforms rest directly on the ocean floor. Semi-fixed platforms have retractable feet and can be moved to different locations. Semi-submersible platforms rest on ballasts and are held in place by anchors.

Semi-fixed Platform
(up to 1640 ft deep)

Semi-submersible Platform
(up to 3280 ft deep)

330ft

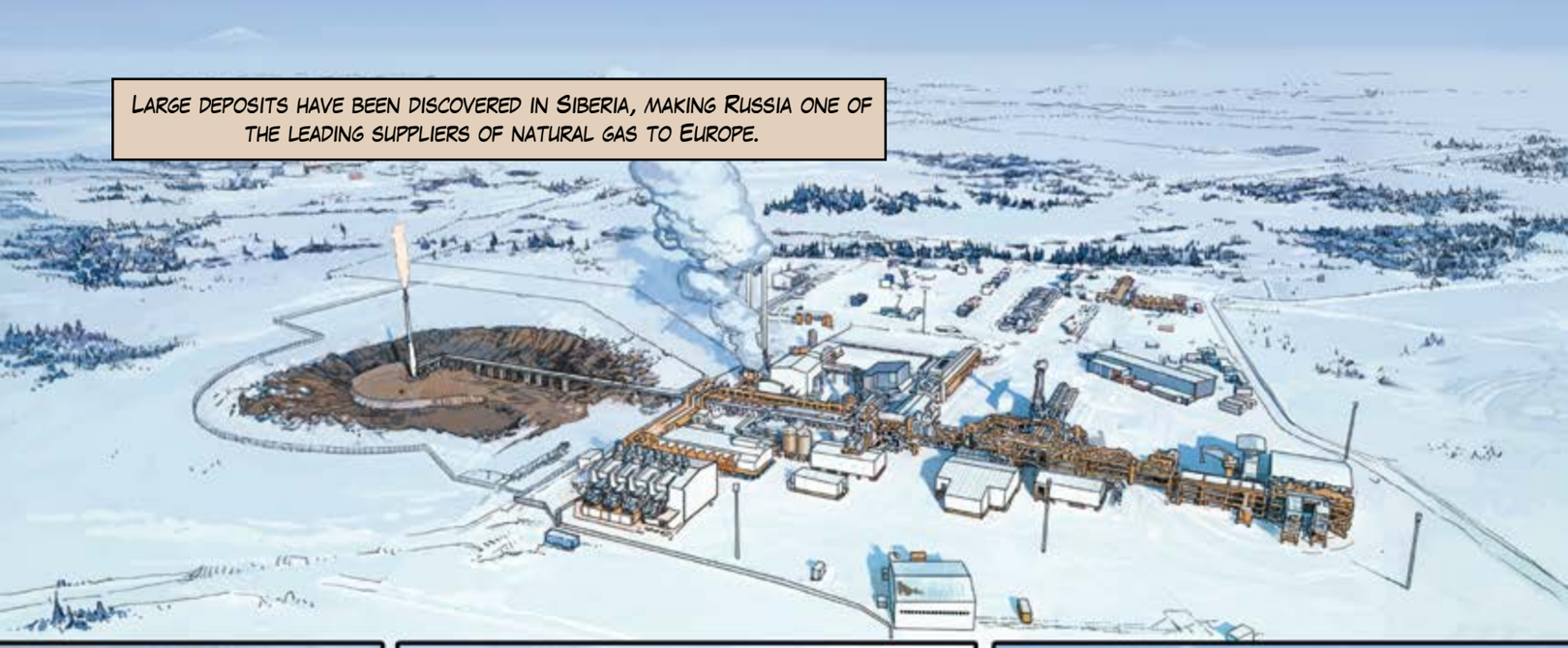
1640ft

3280ft

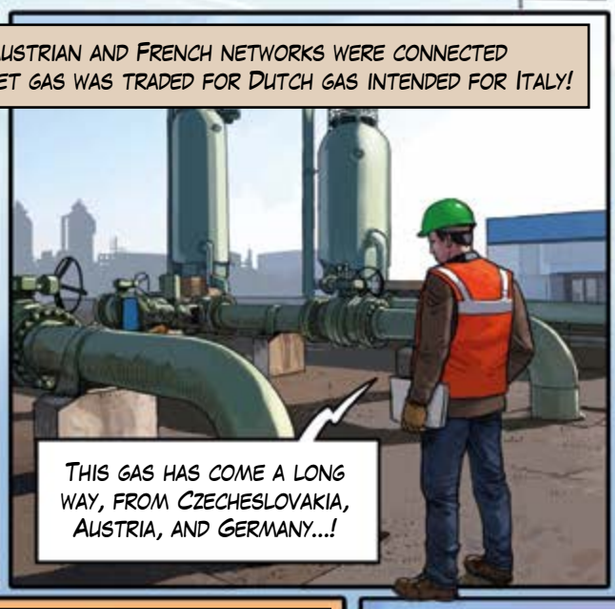
Fixed Platform
(up to 330 ft deep)

Today, gas from Ekofisk is pumped towards the coast of Germany by a 248-miles underwater pipeline connected to the European grid.

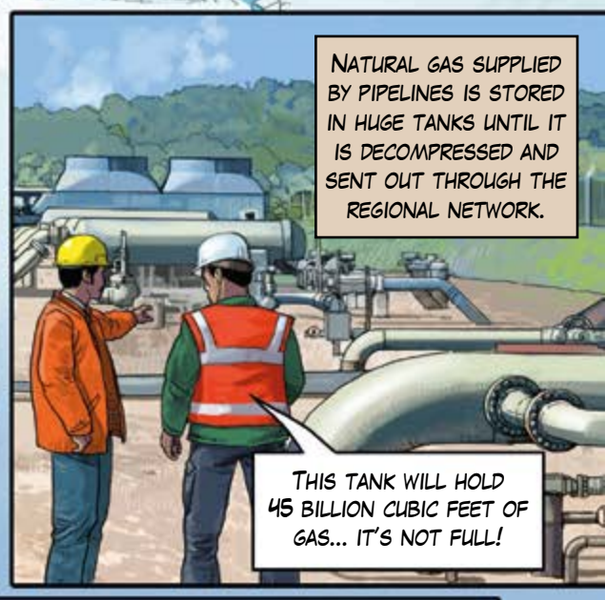
Large deposits have been discovered in Siberia, making Russia one of the leading suppliers of natural gas to Europe.



Until the Austrian and French networks were connected in 1979, this Soviet gas was traded for Dutch gas intended for Italy!



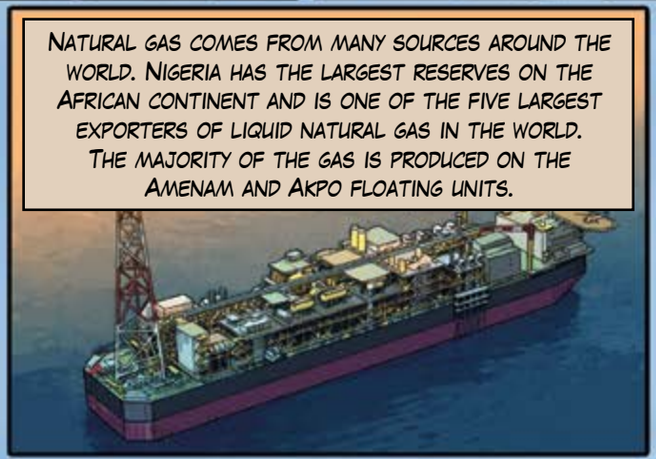
This gas has come a long way, from Czechoslovakia, Austria, and Germany...!

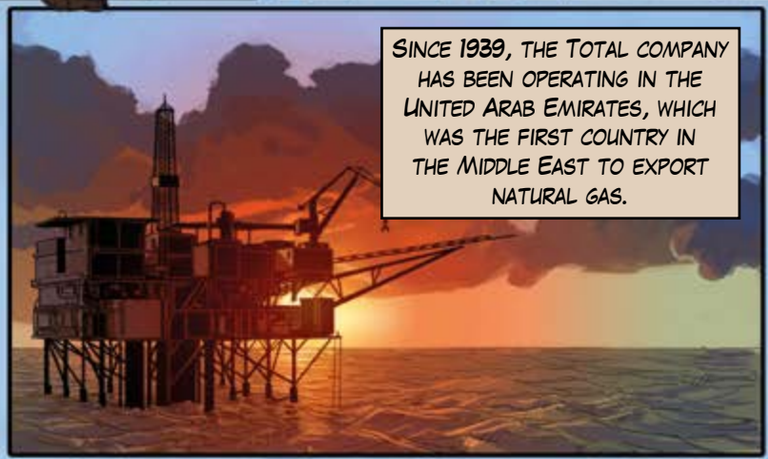


Natural gas supplied by pipelines is stored in huge tanks until it is decompressed and sent out through the regional network.

This tank will hold 45 billion cubic feet of gas... It's not full!

Natural gas comes from many sources around the world. Nigeria has the largest reserves on the African continent and is one of the five largest exporters of liquid natural gas in the world. The majority of the gas is produced on the Amenam and Akpo floating units.





Since 1939, the Total company has been operating in the United Arab Emirates, which was the first country in the Middle East to export natural gas.

Qatar is another major natural gas producer. In fact, the port of Ras Laffan, 50 miles north of Doha, is the world's largest center for the export of natural gas.

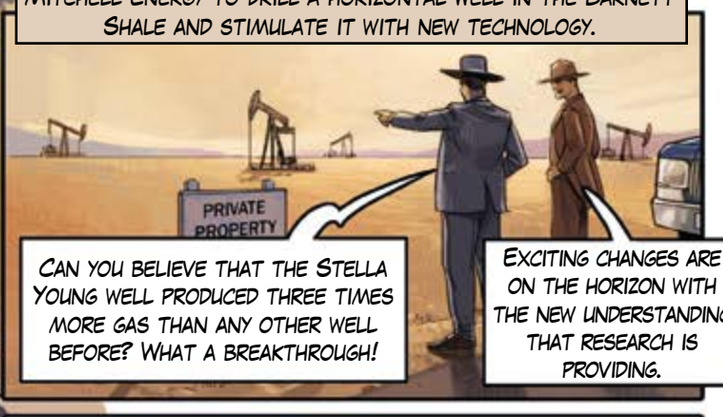
Australia continues to move towards a leadership position in the world LNG production and export industries.

The U.S. is currently the world's largest producer and consumer of natural gas.

It was in 1821 in Fredonia, New York, that William Hart discovered what would later be called shale gas, in a layer of shale about 30 yards underground.

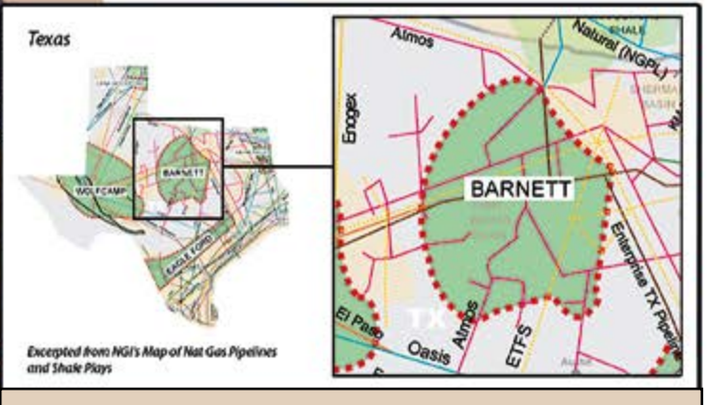
Because it was so much easier to collect conventional natural gas, shale gas was largely forgotten for quite some time. But in the early 1980s, collaborative research brought together industry and academics to develop new tools and technologies to make production of unconventional shale gas, coalbed methane, and tight gas sands more cost effective.

In 1991, GRI researchers worked with George Mitchell and Mitchell Energy to drill a horizontal well in the Barnett Shale and stimulate it with new technology.

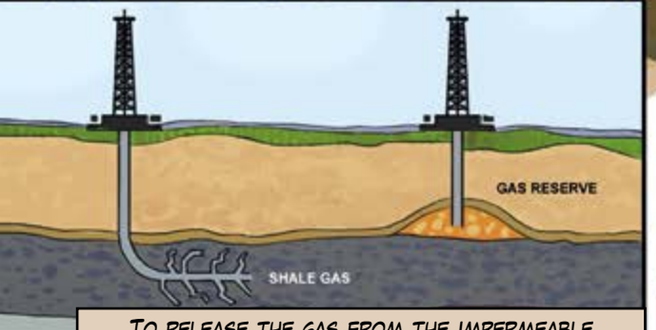


Can you believe that the Stella Young well produced three times more gas than any other well before? What a breakthrough!

Exciting changes are on the horizon with the new understanding that research is providing.

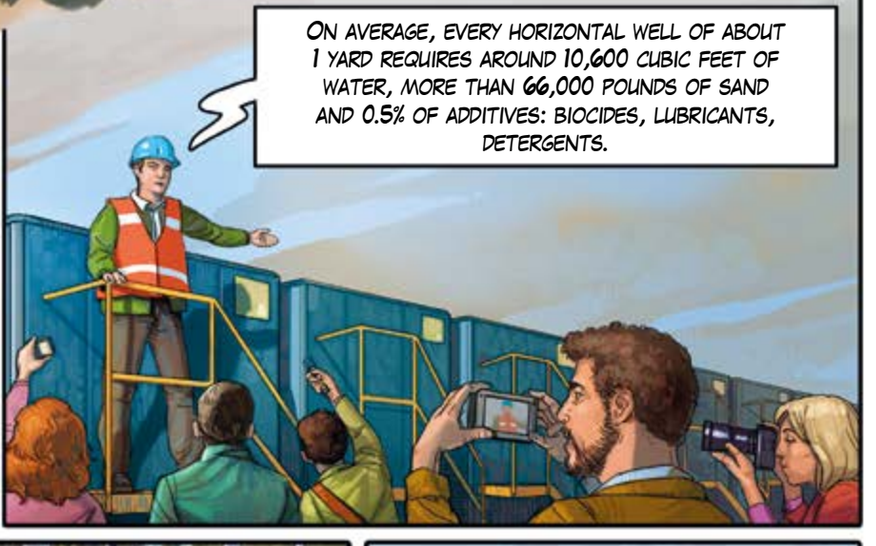


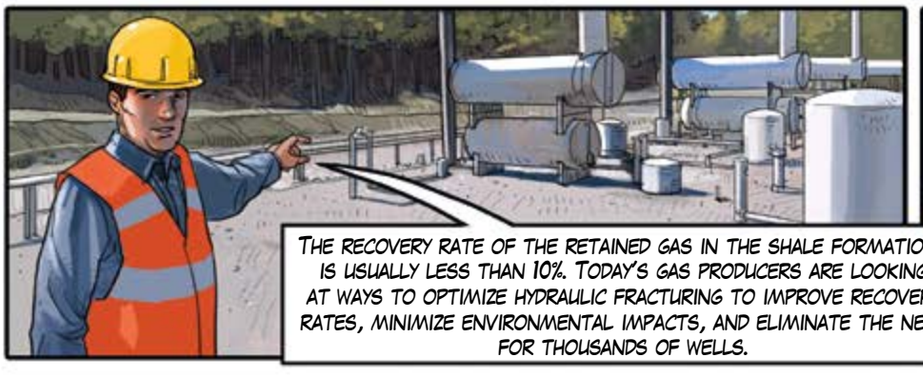
A decade later, hydraulic fracturing was combined with horizontal drilling to further improve productivity. This pivotal point in the U.S. shale gas evolution truly kicked off shale production and transformed the energy industry.



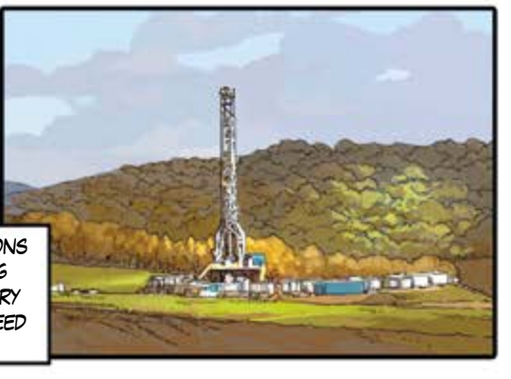
To release the gas from the impermeable bedrock, it is necessary to drill vertically down to the shale layers, which are located 1795 to 3500 yards and deeper underground. Then drilling is done horizontally. The rock is fractured by a high pressure injection of a mixture of water and sand. This hydraulic fracking technique has been used extensively in North America since the beginning of the 21st century.

On average, every horizontal well of about 1 yard requires around 10,600 cubic feet of water, more than 66,000 pounds of sand and 0.5% of additives: biocides, lubricants, detergents.





The recovery rate of the retained gas in the shale formations is usually less than 10%. Today's gas producers are looking at ways to optimize hydraulic fracturing to improve recovery rates, minimize environmental impacts, and eliminate the need for thousands of wells.



Shale gas, composed mainly of methane, accounts for one-third of the earth's total reserves of natural gas. China, Argentina, Algeria and the United States have the largest deposits of shale gas.

The exploitation of shale gas has provoked strong opposition, around the world.

It uses too much water! It can pollute our groundwater!

END FRACKING NOW

No more fracking!

End our dependence on gas!

In 2013, the French government prohibited fracking on French soil.

Significant research has been performed in the U.S. to assess hydraulic fracturing safety. An in-depth study by the EPA on the impact of fracturing relative to groundwater and the environment in general concluded that while there is some environmental impact, hydraulic fracturing is effective and safe.

In a 2015 project on a Hydraulic Fracturing Test Site (HFTS), GTI completed air and groundwater quality evaluations. Results indicate the HFTS well pads had minimal impact on local air emissions concentrations, and analysis of water quality did not find any trace of hydrocarbon-related compounds over the life of the project.

Alternative techniques, such as dry fracking with hot helium, are not yet operational. The United States continues to export LNG produced, in part, with shale gas.

Huge gas reserves are regularly discovered, but with increasingly difficult operating conditions. In 1988, a reserve of 1,377,000 billion cubic feet of natural gas was discovered at Stockman in the Arctic Circle, about 375 miles from Murmansk. In this hostile environment with many icebergs, efforts to access the gas have been temporarily abandoned.

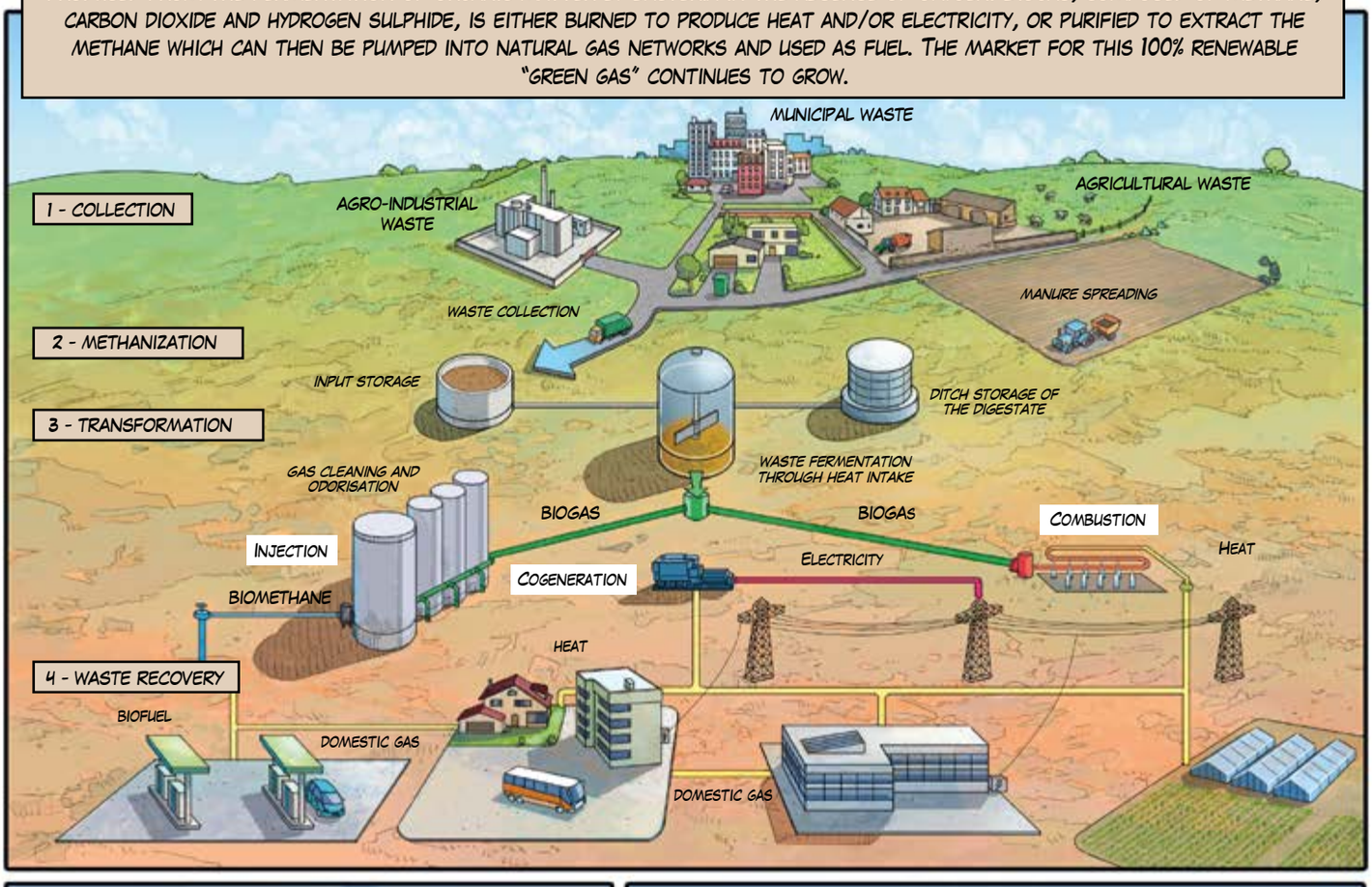
In the Yamal peninsula, about 1550 miles from Moscow and 370 miles north of the Arctic Circle, Russian, French, and Chinese companies began working together in late 2013. They have drilled 250 wells and built a liquefaction plant that will supply more than 18 million tons of LNG per year to Europe and Asia. The gas will be transported by 15 ice-breaking LNG carriers.

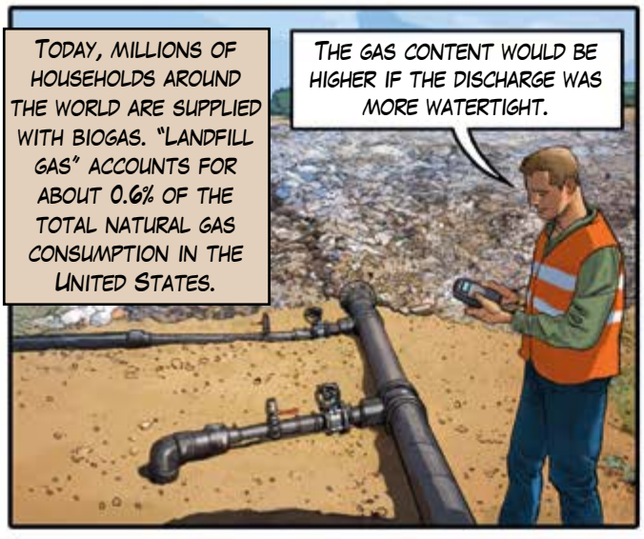
It's crazy! The plant where we work is built on 80,000 pilings embedded in permafrost. In winter, it is dark for three months and we work under a spotlight, in minus 40 degree temperatures. But do not worry, darling, everything is fine...

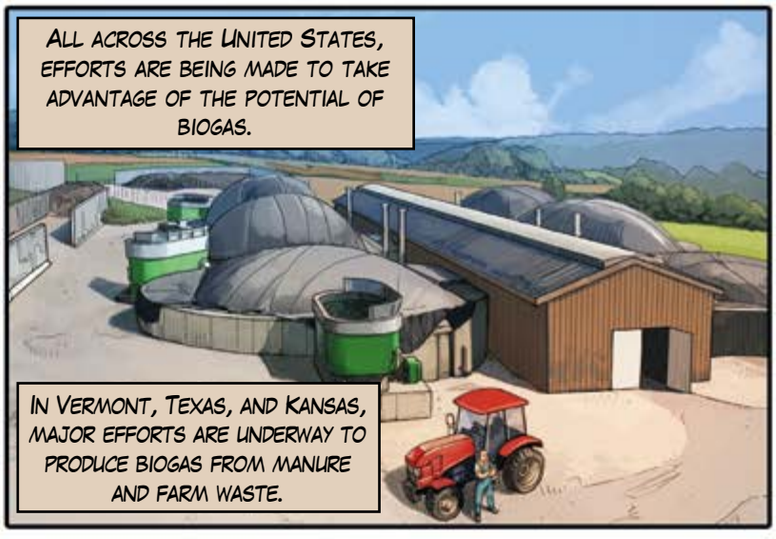
The deep seabed holds 8% of the world's gas resources and it is estimated that two-thirds of deep offshore reserves are yet to be discovered. Giant fields are located off West Africa, several hundred miles from the coast and at depths of up to 3,280 yards and more.

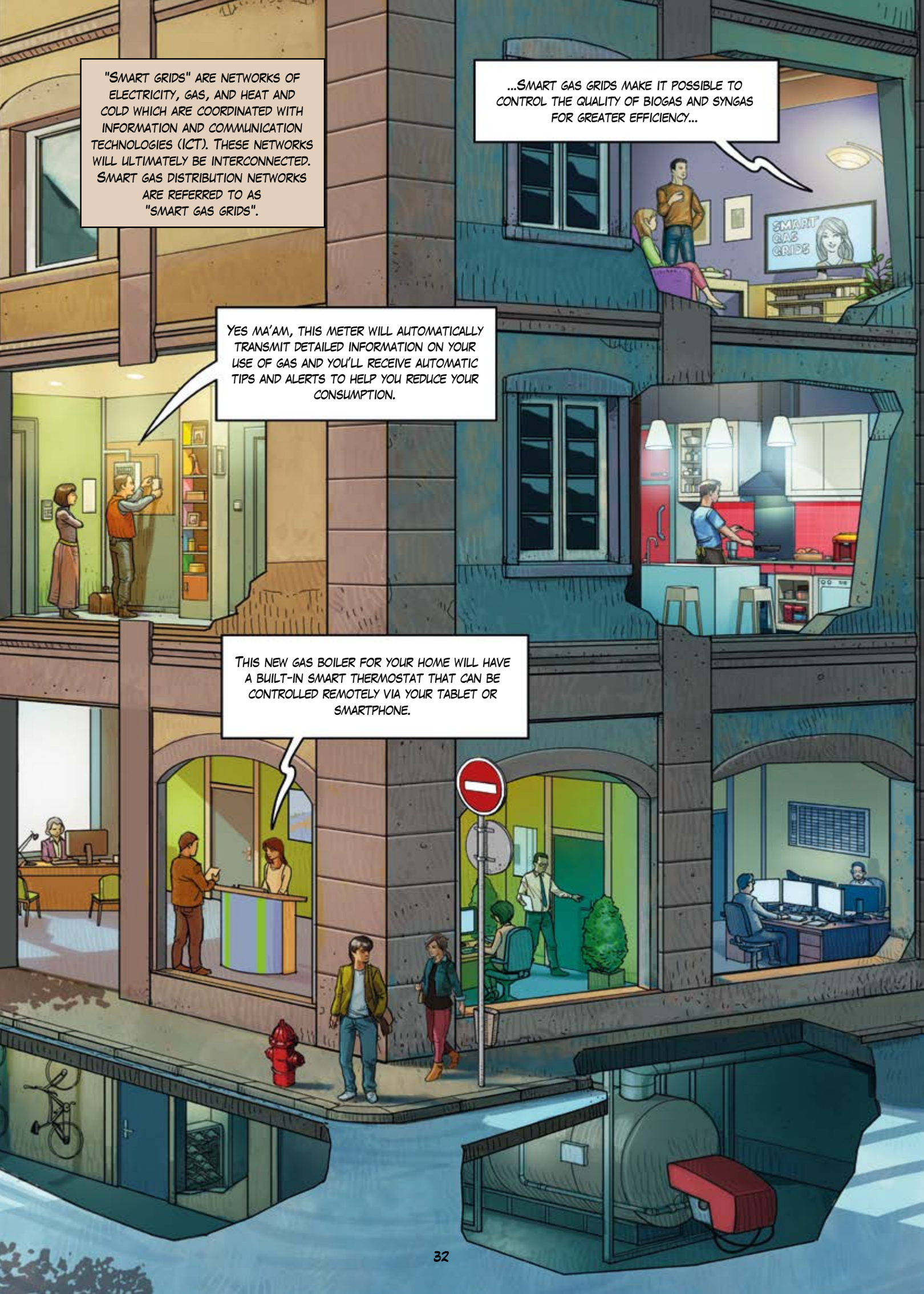
Subsea pumping installations are under intense pressure and the pumped hydrocarbons are corrosive. Gas companies have become world specialists in deepwater exploration and exploitation.

There is a constant search for new forms of energy, especially renewable energy. Biogas is one such energy. It is produced from the fermentation of organic matter by bacteria in the absence of oxygen. Biogas, composed of methane, carbon dioxide and hydrogen sulphide, is either burned to produce heat and/or electricity, or purified to extract the methane which can then be pumped into natural gas networks and used as fuel. The market for this 100% renewable "green gas" continues to grow.



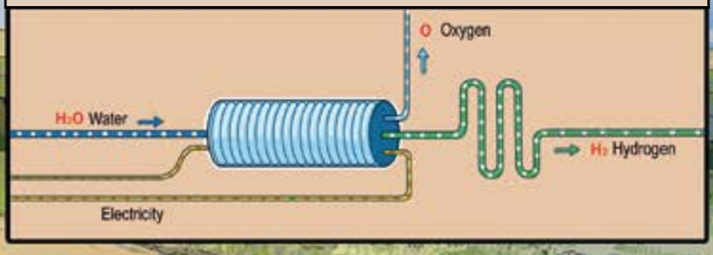





"Smart grids" are networks of electricity, gas, and heat and cold which are coordinated with information and communication technologies (ICT). These networks will ultimately be interconnected. Smart gas distribution networks are referred to as "smart gas grids".
...Smart gas grids make it possible to control the quality of biogas and syngas for greater efficiency...
SMART GAS GRIDS
Yes ma'am, this meter will automatically transmit detailed information on your use of gas and you'll receive automatic tips and alerts to help you reduce your consumption.
This new gas boiler for your home will have a built-in smart thermostat that can be controlled remotely via your tablet or smartphone.

Wind energy is another renewable energy source. Because the storage capacity of electricity is limited, it is necessary to stop wind turbines at times to prevent overproduction.

"Power to Gas" is an innovative solution for transforming and storing renewable energies. Surplus electricity is used to produce hydrogen by electrolysis of water. Stored or transformed, hydrogen can then be used in different ways:



1) Fuel cells converting hydrogen to electricity can be connected to the electrical grid.

But why do you turn electricity into hydrogen just so it can turn into electricity again? It's silly!

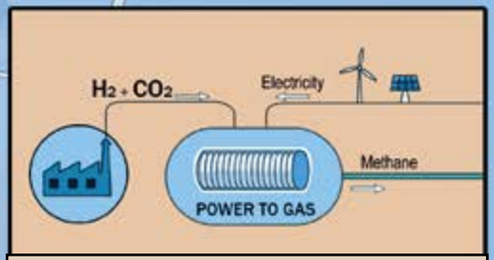
Not really. This is one way to store electricity when it produces too much.

2) Other places are experimenting with the direct injection of hydrogen into the natural gas network, in order to increase its heating potential for domestic uses and city buses.

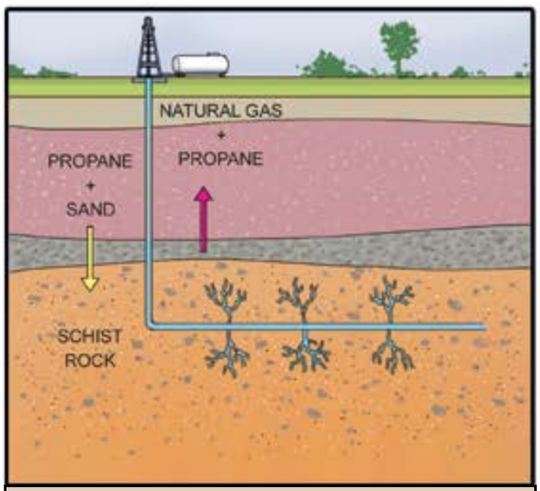
What's in that white cube, mom?

That's where they make the gas for our stove and water heater.

3) In the future, Power to Gas projects connected to the natural gas network will open up new horizons for natural gas by 2030.



Hydrogen combined with the carbon dioxide recovered from the discharges of a neighboring factory becomes synthetic methane, the properties of which are identical to natural gas: this is called methanation.

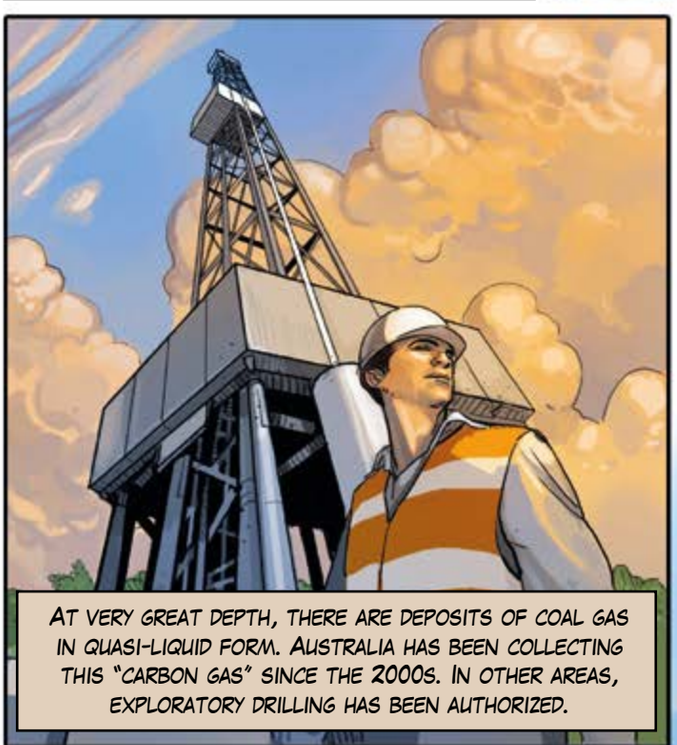


During the last decade, identified reserves of natural gas have increased 30% worldwide. In addition to the reserves of the deep seabed (see page 32), other deposits are being explored or developed. The alternative technique of propane fracking be a way to collect shale gas without resorting to the highly controversial hydraulic fracking.

In Canada, GasFrac is already using frozen propane fracking in several hundred wells. Propane has a better yield than water but is highly flammable and must be handled with great caution.

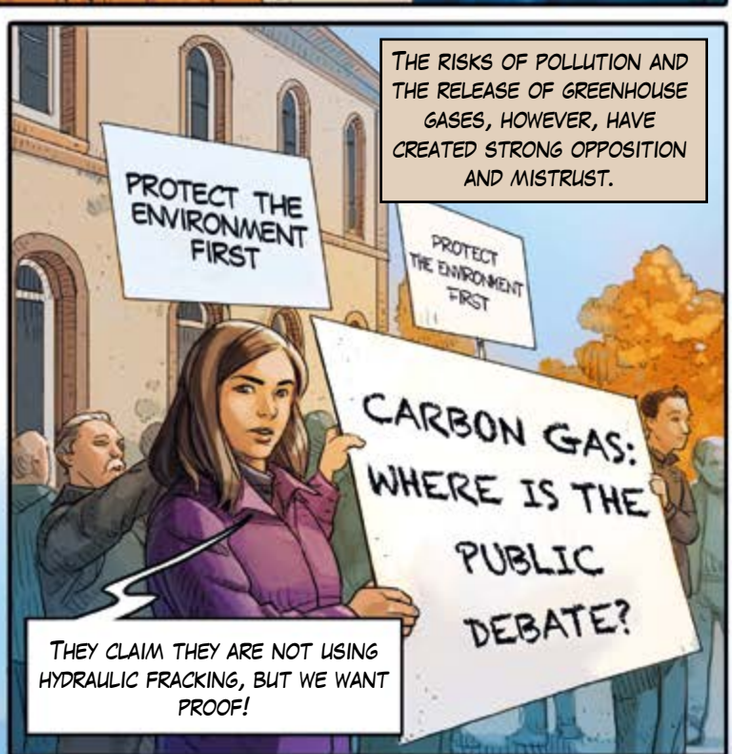
The cost of production is too high at this point, but we are continuing research in this area.

We should use fluoropropane, which is non-flammable and 100% renewable.



At very great depth, there are deposits of coal gas in quasi-liquid form. Australia has been collecting this "carbon gas" since the 2000s. In other areas, exploratory drilling has been authorized.

The risks of pollution and the release of greenhouse gases, however, have created strong opposition and mistrust.

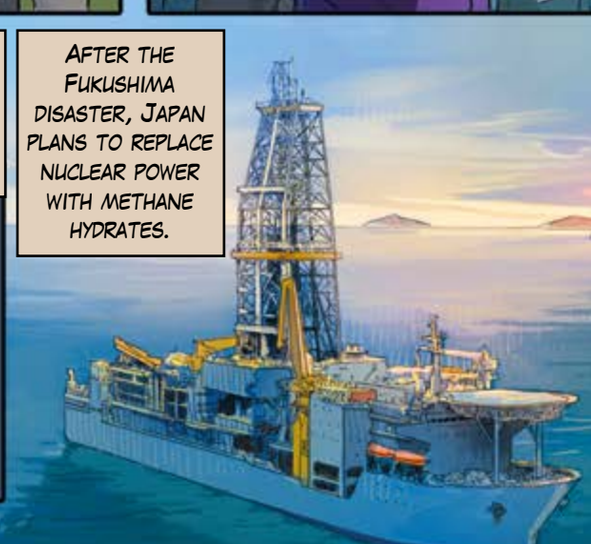


They claim they are not using hydraulic fracking, but we want proof!

The seabeds, frozen Arctic soils, and some other locations contain considerable reserves of methane hydrate, which becomes very unstable when it is not subjected to high pressure at very low temperatures.

It has the consistency of ice. Some call it "burning ice."

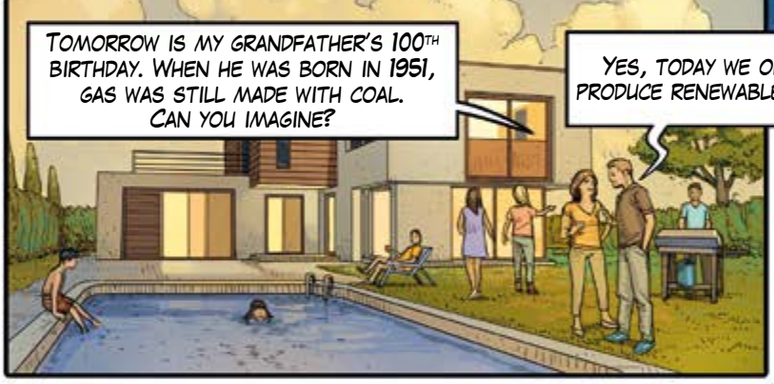
After the Fukushima disaster, Japan plans to replace nuclear power with methane hydrates.



Fifty miles off the Atsumi peninsula, the drill ship Chikyu managed to extract methane from these hydrates, without removing them from the seabed.

Global energy needs will grow by 30 to 50 percent by 2030, according to the International Energy Agency. By that time, natural gas will represent 25% of the total energy mix.

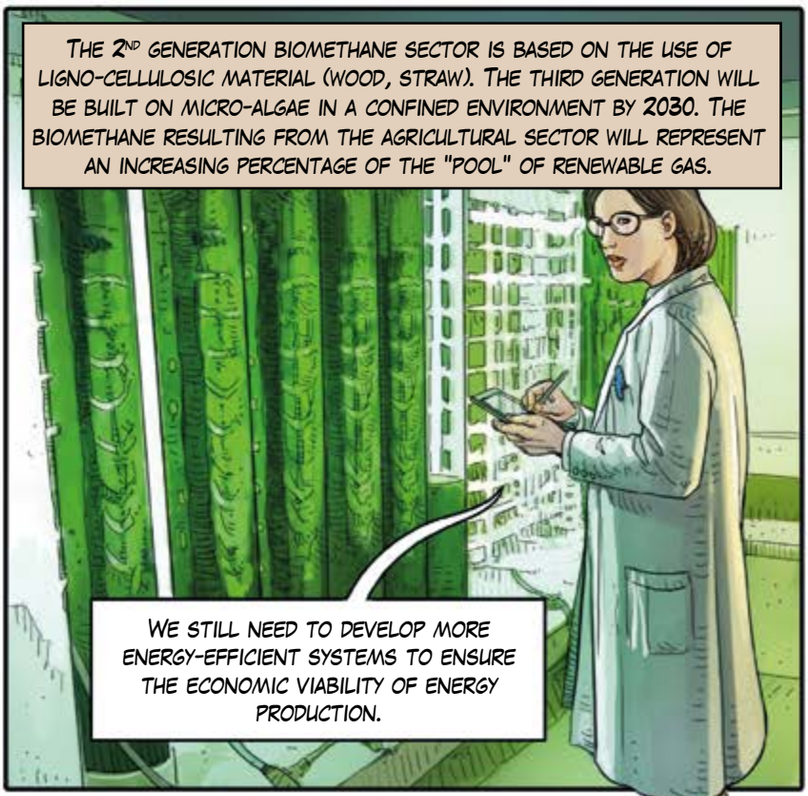
Resources are also increasing: in 2030, 10% of the gas consumed will be from renewable sources. By 2050, some countries hope to rely exclusively on renewable energy.



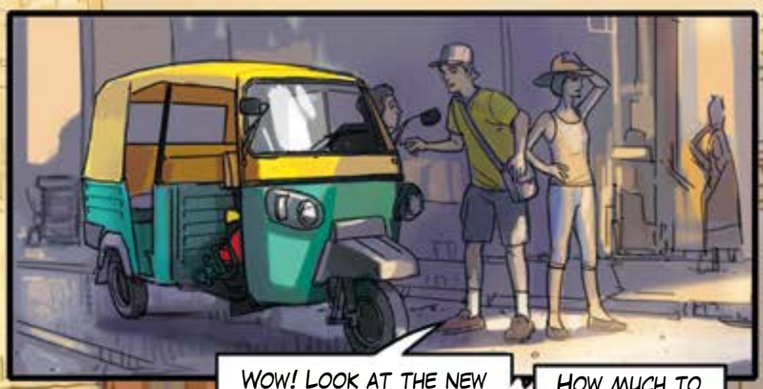
Biomethane production sites continue to increase.

Biomethane will eventually be able to fuel millions more vehicles, including trucks, buses, utility vehicles and passenger cars. California is a U.S. leader in reducing greenhouse gas emissions. There, more than 50% of all natural gas vehicles (NGVs) are using biomethane.

The 2nd generation biomethane sector is based on the use of ligno-cellulosic material (wood, straw). The third generation will be built on micro-algae in a confined environment by 2030. The biomethane resulting from the agricultural sector will represent an increasing percentage of the "pool" of renewable gas.



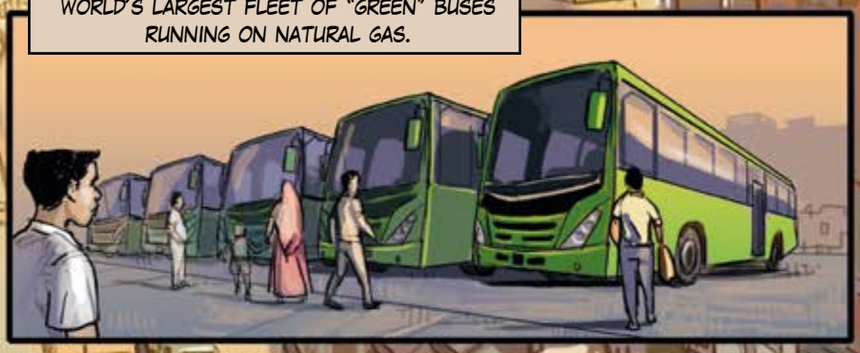
New Delhi, the capital of India, with a population of 16 million, is one of the most polluted cities in the world. The Indian government is counting on natural gas to limit pollution. In 1998, the Supreme Court of India ruled that all public transit vehicles - buses, taxis, rickshaws - had to run on compressed natural gas (CNG).



Wow! Look at the new rickshaw unveiled at the latest auto show.

How much to go to Old Delhi?

The Delhi Transport Corporation has the world's largest fleet of "green" buses running on natural gas.



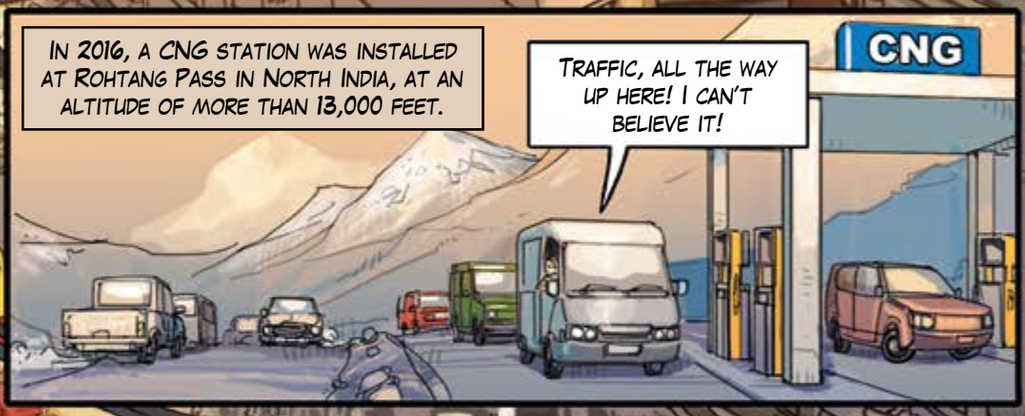
REUH!

BEEEEP!

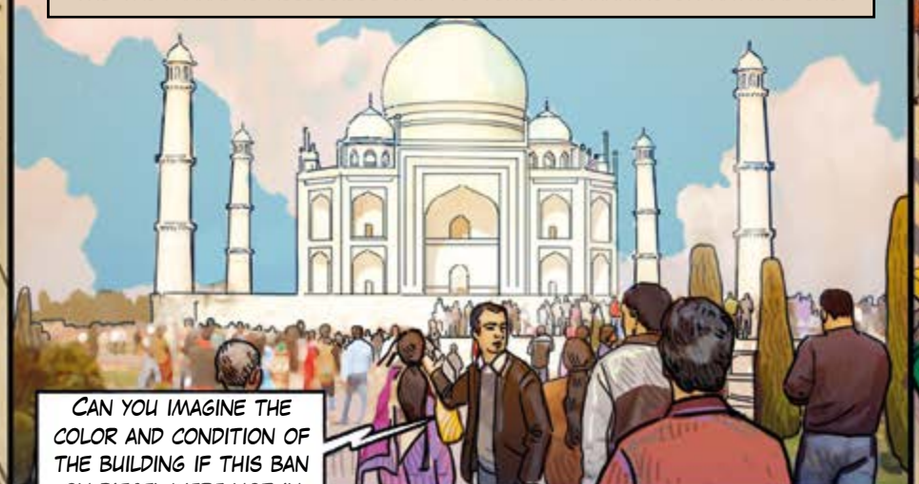
HONK HONK!

In 2016, a CNG station was installed at Rohtang Pass in North India, at an altitude of more than 13,000 feet.

Traffic, all the way up here! I can't believe it!



Car traffic and industrial emissions are limited in a 12,000 square yard area around the city of Agram, about 125 miles from Delhi. The Taj Mahal is accessible only to vehicles running on natural gas.



BEEEP!

Can you imagine the color and condition of the building if this ban on diesel were not in place?


Natural gas, liquefied or compressed, is the most ecological solution for mobility by land, sea and air. The American Carnival Corporation, the world's leading line of cruise ships, has already ordered seven ocean liners fully powered by LNG.
We are going to have to develop special LNG loading stations at the ports in order to supply these behemoths with gas.
Just one of these new ships will be able to carry 6,600 passengers!
In the world of air transportation, experiments have already shown the feasibility of commercial flights using LNG as fuel. In the future, it may replace kerosene on airplanes.
GNL
In the United States, gas-powered trucks can travel more than 930 miles without having to refill the tank.
U.S. engine manufacturers are developing ultra-low NOx emissions engines for medium and heavy-duty trucks that are 90% cleaner than the latest diesel engine.
More and more companies are switching to trucks and buses powered by natural gas. These vehicles of the future produce 30% less carbon dioxide emissions and reduce fine particles by 95%.
GEODIS
Keolis
It is 4 PM and you're listening to News Radio... Government officials announced today that by 2050, 75% of natural gas will be green gas, resulting from the methanisation of organic waste, with an almost neutral impact on the environment...
Wow. Next time we buy a car, let's get one that runs on natural gas.

Abundant resources are still available. However, it is still essential to monitor gas consumption and work to prevent energy losses...

These experimental drones are equipped with a thermography device to detect places where heat is being wasted.

...everyone can help wherever they are. Buildings, both industrial and residential, are responsible for 50% of the world's energy waste.

Companies are working to improve their energy efficiency.

Good insulation not only reduces CO_2 emissions, but also lowers energy consumption.

Your state-of-the-art boiler captures the fumes produced by the combustion of the gas. It then releases heat by condensing the water vapor in the fumes.

High-efficiency, low-NO_x burners and systems in restaurants control emissions, saving energy and improving food quality.

Mom, mom, if you put a lid on the pan it will heat up faster!

You're right! We must all be careful not to waste energy.

...After all, even though there are many resources available, we still have the responsibility to ensure reserves for future generations.

F.W.

THE END

THE STORY OF GAS STRETCHES ACROSS MILLENNIA.

IT BEGINS WITH ANCIENT CIVILIZATIONS WHICH OFFERED WORSHIP TO MYSTERIOUS, SPONTANEOUS FIRES EMANATING FROM GAS DEPOSITS IN THE EARTH.

IN THE GLORIOUS HAN DYNASTY, THE CHINESE WERE ALREADY USING GAS AS A SOURCE OF ENERGY.

THE INVENTION OF MANUFACTURED GAS IN THE 1700S CONTRIBUTED TO THE GROWTH OF INDUSTRY AND TO THE URBANIZATION OF MODERN SOCIETY.

THE DISCOVERY OF NATURAL GAS MADE IT EASIER FOR BUSINESSES AND INDIVIDUALS TO ACCESS ONE OF THE MOST-USED ENERGIES IN THE WORLD.

EVERY TECHNOLOGICAL LEAP FORWARD HAS LED TO A MORE EFFECTIVE USE OF THIS RESOURCE IN THE SERVICE OF HUMANITY.

THE REGULAR DISCOVERY OF NEW DEPOSITS, THE EASE OF STORAGE, THE POTENTIAL FOR THE TRANSFORMATION OF RENEWABLE ENERGY, AND ITS USES FOR TRANSPORTATION MAKE GAS THE ENERGY OF THE PRESENT AND OF THE FUTURE, ENERGY EFFICIENT AND RESPECTFUL OF THE ENVIRONMENT.

THIS BOOK TELLS THE STORY OF A FANTASTIC ADVENTURE, WHICH REACHES DEEP INTO HISTORY—AND IS FAR FROM OVER! IN THESE PAGES, YOU WILL MEET THE STUDENTS, THE SCIENTISTS, THE ENGINEERS AND THE WORKERS WHO, OVER THE COURSE OF CENTURIES, HAVE WRITTEN THE STORY OF GAS.

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