



# Separate Ways

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In order to meet the increasing demand for natural gas, more and more gas fields with a high CO<sub>2</sub> content are being tapped. This is an ideal area of application for the new high-tech membranes from Austria

Natural gas extraction in Canada: Many gas fields have high concentrations of CO<sub>2</sub>, which must be separated from methane

**A**lthough natural gas is a clean energy carrier, it streams out of the earth in a mixture that is fairly dirty. The hot, crude natural gas that is extracted at the southern tip of the Americas contains methane, which is used as a fuel for stoves, heating systems, power plants, and engines. It also contains lots of CO<sub>2</sub>, which has a negative property: It reacts with water to form an aggressive substance, carbonic acid. Stoves, heating systems, power plants, and engines would probably break down fairly fast if they were operated with crude natural gas. That also applies to the pipes through which it flows from the producer to the user.

Acid gas is well known in the energy sector. That's why every extraction system includes separation systems that process the crude natural gas and separate out carbon dioxide and other undesirable substances such as water and heavy hydrocarbons. However, for some time now the volume of acidic natural gas has been increasing. "The demand for natural gas is so high that more and more deposits with very high proportions of CO<sub>2</sub> are being opened up," says Patrick Schiffmann, a process engineer at the plant construction company Linde Engineering. "We're seeing increasing proportions of CO<sub>2</sub> because the carbon dioxide that has been separated from extracted natural gas has been forced back into the soil for a number of years now." As a result, natural gas extraction and purification are becoming increasingly complex.

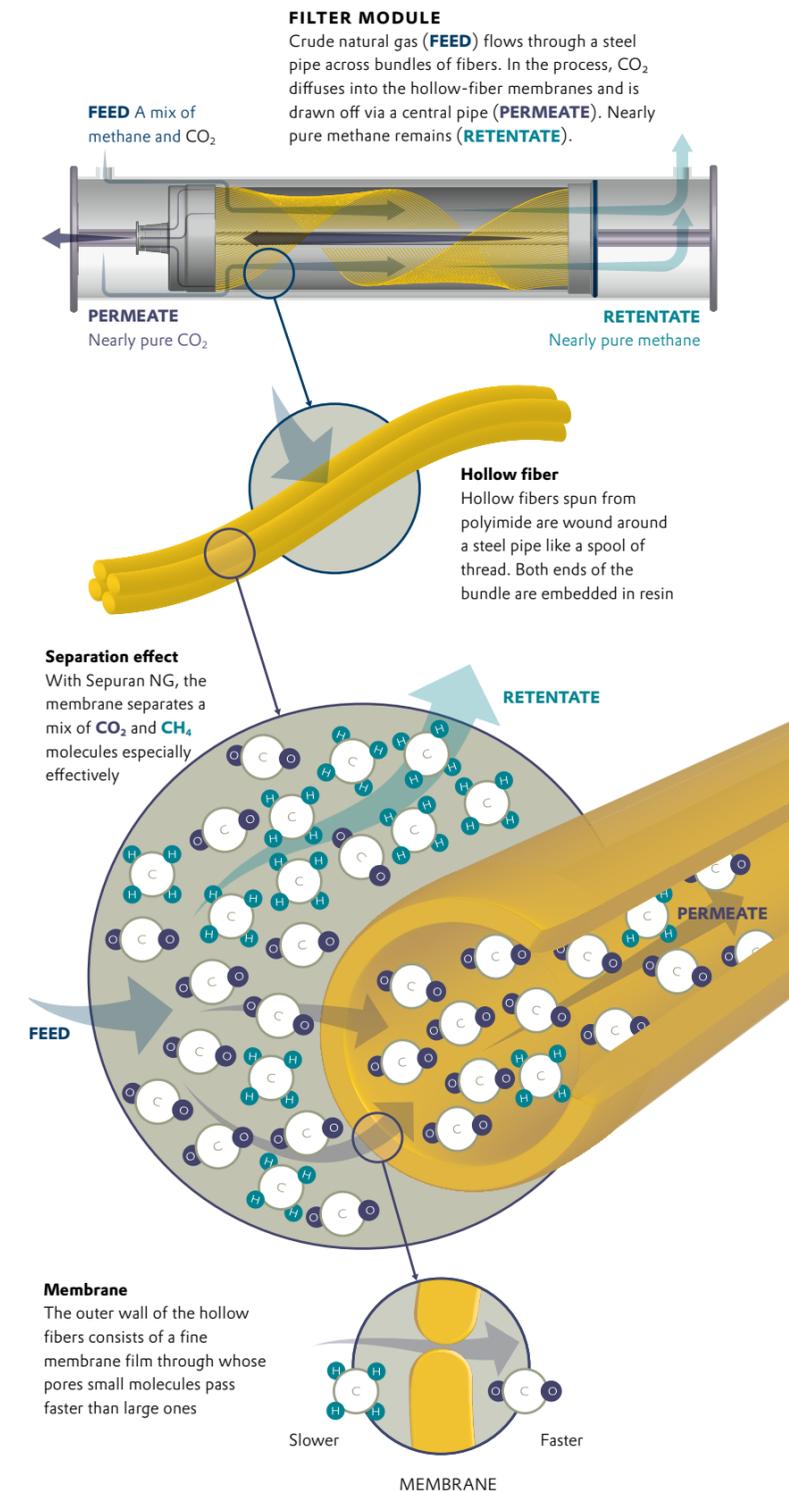
For over a year, the plant construction company has been operating a new separation technology in a natural gas field in southern Argentina. This technology, which is known as "gas sweetening" in the international natural gas sector, has the potential to basically transform natural gas processing. The technology is based on a product from Evonik that has already proved its worth in other natural gas markets: Sepuran, a plastic membrane that functions differently from all the other competing products. As a result, Sepuran can play a key role in efforts to meet the growing demand for natural gas.

## POLYIMIDE INSTEAD OF CELLULOSE ACETATE

In the region where Linde is using the membranes from Evonik to optimize its customer's processes, the natural gas has a CO<sub>2</sub> content of up to 50 percent. However, the threshold value for the CO<sub>2</sub> in the natural gas to be fed into pipelines is only two percent. According to Schiffmann, until now the operator only managed to produce natural gas with ten percent CO<sub>2</sub>. The →

## REMOVING THE CO<sub>2</sub>

The latest generation of the Sepuran modules has been designed to purify natural gas by removing aggressive carbon dioxide



sensitive core element of the extraction plant is the conventional membranes made of cellulose acetate, a type of wood-based plastic fiber. “It’s actually a wonderful material,” says Götz Baumgarten, who is responsible for the Membrane market segment at Evonik. “However, it has two problems. Firstly, the membranes don’t last very long, and every time they are changed the production must come to a halt. Secondly, this type of membrane is not particularly selective.”

Selectivity is an important factor in the cost-effectiveness of a membrane’s operation. Ideally, it lets only one kind of molecule through and keeps other molecules out. In the case of crude natural gas, pure methane would accumulate on one side of the membrane and (undesirable) CO<sub>2</sub> on the other. Unfortunately, things are not so simple under real conditions. The membrane doesn’t “recognize” which molecules are about to pass through it, and as a result some of the valuable methane always diffuses through the membrane and escapes.

The separation effect occurs because different kinds of molecule pass through the membrane at different speeds. The greater the difference between the speeds of two types of molecule, the more thoroughly the gas can be separated out. “When our customer used traditional products, ten percent of the methane was lost,” says Schiffmann, the expert from Linde. “Through the Evonik technology, we’re reducing the loss to two percent. At an output of 25 metric tons of natural gas per hour, that’s a lot of money that is no longer being wasted, and a lot of greenhouse gas that is no longer escaping into the atmosphere. This makes it possible to utilize our limited natural gas deposits much more responsibly.”

Unlike conventional membranes, Sepuran consists of polyimide, a high-performance plastic that Evonik has developed in-house and is now producing and processing into fibers. The last two steps of the processing take place in the town of Schörföling in Austria (see the report starting on page 34). Baumgarten believes that the intense vertical integration of the manufacturing process is a huge advantage compared to the competition. “We control the entire process ourselves, from the design of the molecules and polymers to the way we wind the fibers and insert them into a membrane module,” he says.

The complex structure of the membrane can be seen by means of an electron microscope (see the graphic on page 31). Each fiber is hollow, like a straw, and inside it is material that is as porous as a sponge. “This structure makes the fiber robust,” Baumgarten explains. “By contrast, its surface is formed by a smooth film that creates the separation effect.” Inside the membrane cartridges, the fibers are wound around a steel pipe. The result looks like a gigantic spool of thread. As the crude natural gas flows alongside the fibers, CO<sub>2</sub> molecules diffuse through the surface of the membrane into the interior of the hollow fibers. As the natural gas makes its way through the cartridge, its CO<sub>2</sub> content continues to decrease.

**TOUGH STUFF**

Sepuran has been on the market for the past eight years. During this time it has established itself—for example, in biogas plants, where it helps to purify methane. It’s also used to extract nitrogen

from ambient air and to concentrate valuable gases such as helium and hydrogen. All of these applications have one thing in common: In all of them, the feed gas is channeled into the interior of the hollow fibers. The gas that diffuses through the membrane, which is known as the permeate, is separated from the other gases, which are known as the retentate. In other words, the separation process goes from the inside to the outside of the fibers.

For the new application, Evonik has reversed the direction of the separation and changed the design. “When the membrane is used to purify natural gas, it’s subjected to greater stress, because the pressure and the temperatures are higher,” Baumgarten explains. “That’s why we came up with a structure that involves wound fibers. That gives us the durability we need.”

The membrane is in fact so tough that Linde could not detect any loss of performance even after several months of continuous operation. “For cellulose acetate membranes, there’s already a noticeable drop in performance after one month, and after three months you need to replace some of the cartridges,” says Schiffmann. “With Sepuran, we had the same separation performance after six months as we had in the beginning.” For plant operators, this means they less frequently need to partially or fully stop the facility in order to change the membranes. A further benefit is that if liquid hydrocarbons temporarily form inside the plant, the Sepuran membranes regenerate themselves. “If that happens to a cellulose acetate membrane, the membrane is destroyed,” says Schiffmann.

**ONE LESS SEPARATION STEP**

In a test, the separation effect was so good that it affected the entire design of the natural gas processing plant. “You often need two separation stages,” says Schiffmann. “After the first stage, the permeate still contains so much methane that we have to compress it with a compressor and send it through a second membrane stage. That way we can separate out most of the methane.” This calls for an immense amount of energy and capital, he adds. “But with the hollow-fiber membranes, the retentate is already so pure after the first stage that we can sometimes switch these machines off or operate them at half power. All of this saves money and increases availability.”

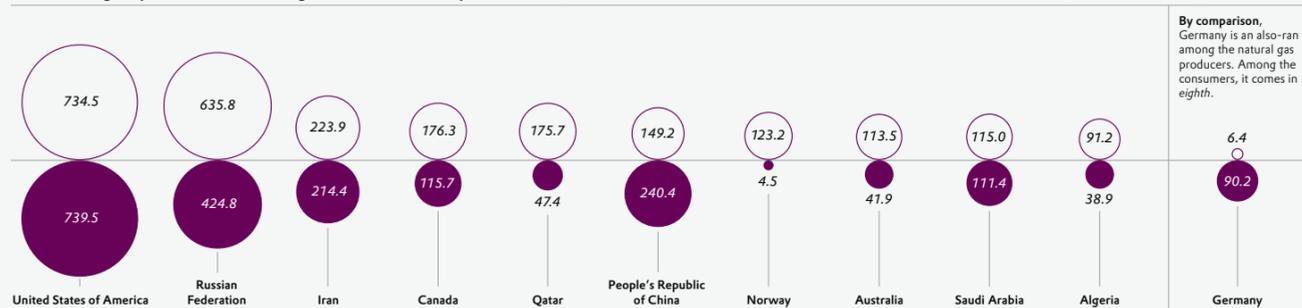
Schiffmann’s team uses the operating data from the plant and from their own lab to plan new plants and retrofit existing ones. But that’s not all: “We also transmit our data, information, and knowledge back to Evonik so that the construction can be refined.” It’s a win-win situation for both partners.

According to Götz Baumgarten, even if one starts with pessimistic assumptions, the new technology has tremendous market potential. The higher the CO<sub>2</sub> content of a natural gas deposit, the more likely it is that membranes will be used rather than the still widespread chemical purification processes such as amine scrubbing. “In the market for natural gas sweetening, membranes have a market share of just eight percent, and until now 80 percent of these membranes have been made of cellulose acetate,” says Baumgarten. He estimates that a market worth several hundred million euros is waiting for the sector to catch on—and Evonik aims to secure a large part of that market for itself.

# Natural Gas

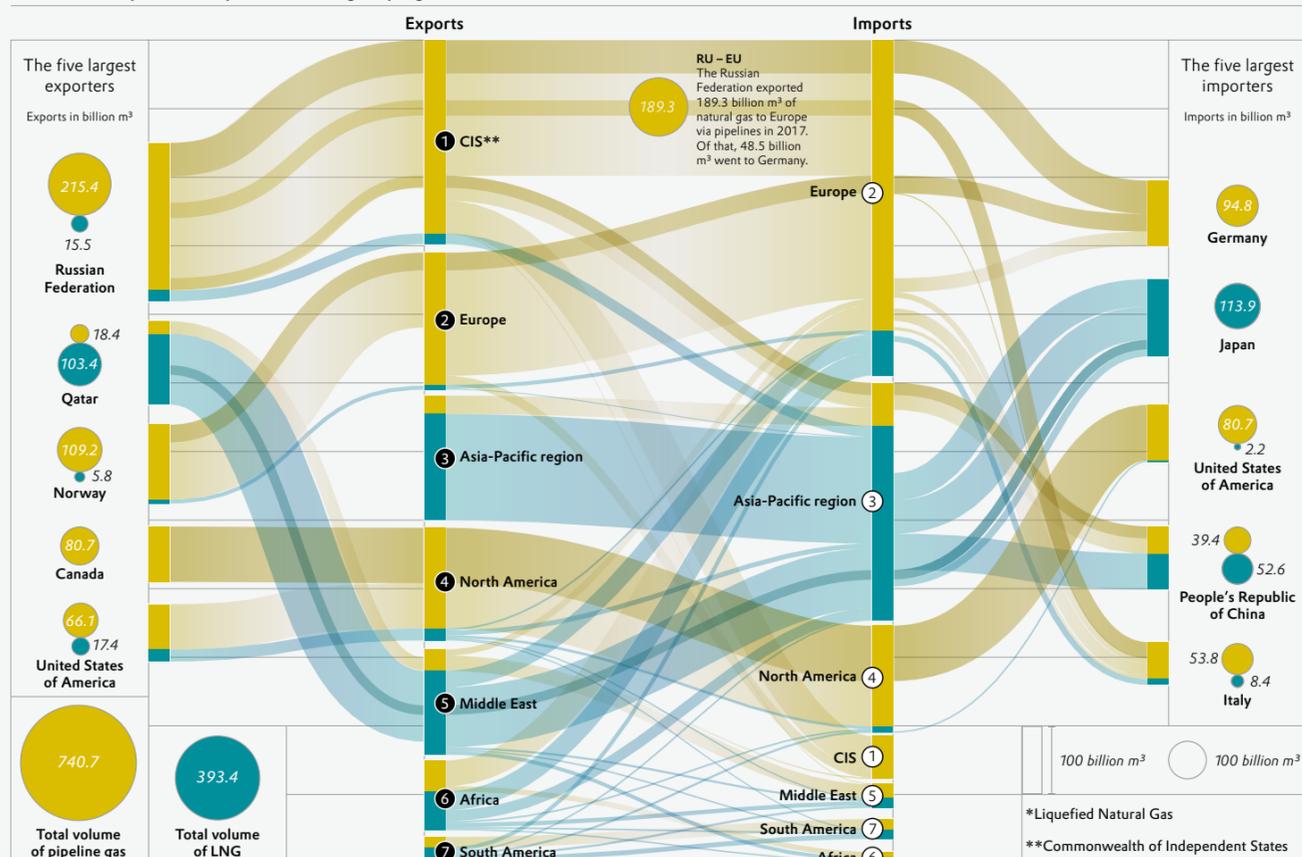
Natural gas is used to heat homes and generate electricity. It also produces heat for industrial processes and serves as a fuel. However, its deposits are generally not in the places where the demand is greatest. Here’s an overview of the reserves and transportation routes of one of the most important fuels.

The 10 largest producers of natural gas and their consumption in 2017, in billion m<sup>3</sup>



By comparison, Germany is an also-ran among the natural gas producers. Among the consumers, it comes in eighth.

Worldwide exports and imports of natural gas by region, 2017, in billion m<sup>3</sup>



in billion m <sup>3</sup>	CIS**	Europe	Asia-Pacific region	North America	Middle East	Africa	South America
Pipeline gas exports	282.9	192.8	26.8	146.4	30.9	45.0	15.4
LNG exports	15.5	8.3	155.0	17.4	122.5	55.4	19.1
Pipeline gas imports	62.3	423.4	62.9	146.8	22.2	7.6	115.4
LNG imports	-	65.7	283.5	9.2	13.0	8.2	13.8

Source: BP Statistical Review of World Energy 2018