UNDERGROUND STORAGE OF NATURAL GAS

SoCalGas

A Sempra Energy utility®

STORING NATURAL GAS THE SAME WAY NATURE ALWAYS HAS...

DEEP UNDERGROUND

Most of the natural gas used in Southern California travels from supply sources as far away as Texas and Canada. So, in order to maintain a balance between supply and demand, storage is a necessity. Without it, we might not always be able to meet our customers' needs.

Customer needs change by the season, by the day, and even by the hour. On a cold winter day, for example, residential customers can use seven times the amount of natural gas used on an average summer day.

Five decades ago, balancing customer demand meant relying on natural gas holding structures, which stood several stories high and resembled oil storage tanks.

In 1941 we introduced a new system to the Southwest: underground storage of natural gas. This system is based on the simple premise that if an underground rock formation held oil and natural gas securely for millions of years, it could continue to do so under controlled circumstances.

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Extensive research and our experience have proven that this concept is sound. Depleted oil and natural gas fields offer ideal storage conditions because they are comprised of natural underground traps. Care is taken that the original formation pressure of the field is not exceeded. These subterranean rock formations can be repeatedly refilled and drawn from to meet the fluctuating needs of our customers.

When out of state pipelines can't deliver enough natural gas to meet heavy demand, which might occur on a cold winter day, we withdraw natural gas stored underground to supplement pipeline supplies. When customer needs for natural gas drop below the available pipeline supply, which can happen during the summer, we inject the surplus natural gas into the underground reservoirs. We also sell storage capacity to other large companies so they will have natural gas (which they purchase on the open market) available to them when they need it.

Geologic traps are rock formations which trap and hold natural gas, oil and water.

WHERE IS THE GAS STORED?

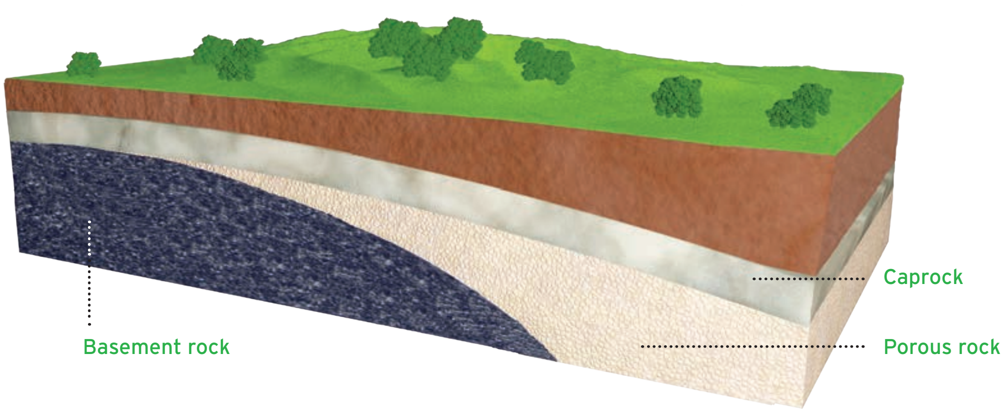
Surplus natural gas is forced down through wells drilled into porous rock formations thousands of feet below the earth's surface, where oil and natural gas originated. The formations appear solid but are actually sandstone made up of sand, with spaces between the grains.

The rock formations are called "geologic traps" because they are shaped by nature, and trap and hold natural gas, oil and water within a specific area. Like a sandwich, the basic trap contains porous reservoir rock between layers of nonporous rock. The top layer is commonly called "caprock," while the bottom most layer is often called "basement rock."

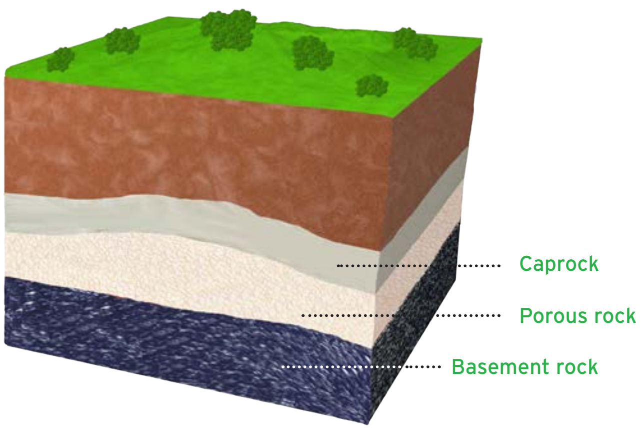
There are several different kinds of geologic traps. One is a pinch-out trap (left, below), in which the caprock meets the basement rock at one end, effectively sealing the porous storage area. The most common geologic trap is the anticlinal trap (right, below) which resembles a buried hill. This is because the caprock arches over the top of the porous rock "reservoir" to stop natural gas from traveling upward. Another type of trap is formed by shifts in the ancient earth strata that moved one section of rock against another, so that it abuts the caprock, creating a fault-bounded trap.

We can depend upon the force of gravity to separate the natural gas, oil and water that may already be in any trap. As the lightest component, natural gas will always rise to the top.

PINCH-OUT TRAP



ANTICLINAL TRAP



WHAT DETERMINES A GOOD STORAGE FIELD

CORE SAMPLES

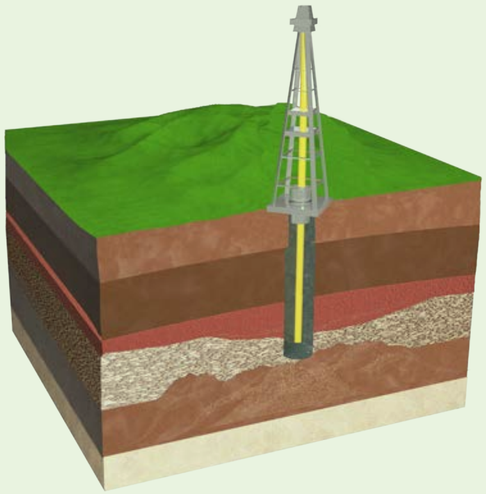
Before using any former oil or natural gas field for our storage, extensive geologic data of each of the field's rock layers are carefully examined. This usually is accomplished by studying "core samples," which are taken by drilling with a hollow core diamond cutting edge deep down through the earth's sedimentary layers.

Numerous core samples and other geologic surveys help us profile a specific field. Measuring anywhere from 10 to 60 feet (3 to 20 meters) long, the core samples tell us the location, depth and condition of the caprock, the storage reservoir and the basement rock. They also determine the present concentration of any natural gas, oil or water deposits.

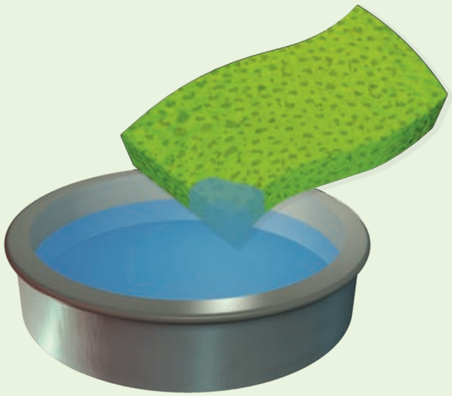
POROSITY

The first characteristic we look for when examining the core sample is porosity. Porosity refers to the volume percentage of rock pore space available for natural gas or liquid retention between the rock or sand grains. It is essential that the reservoir of rock have high porosity, because that indicates a high storage capacity.

The ability of porous rock to absorb natural gas and liquids can be demonstrated with a sponge. Take the sponge and barely touch one corner to the surface of a liquid. Watch it soak up the liquid until saturated, without altering the shape or size of the sponge. The fluid simply fills the small pores of the sponge. Underground storage is based on the same principle.



Core samples are taken by drilling with a hollow core deep into the earth.



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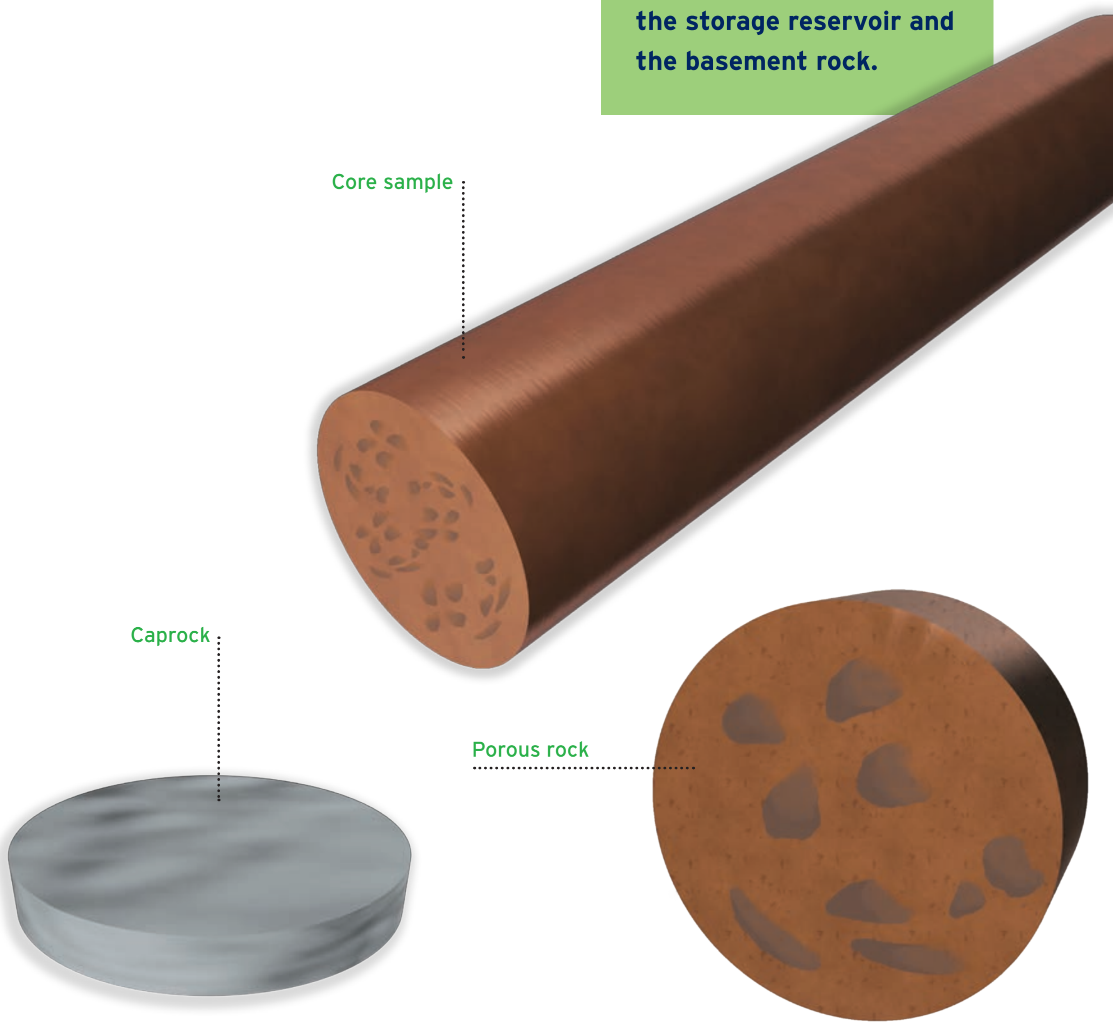
PERMEABILITY

Permeability, closely related to porosity, is another characteristic we look for when evaluating core samples. Permeability is important for efficient natural gas storage because it measures how well the pore spaces are interconnected.

It is essential that the reservoir rock be highly permeable because the natural gas must be able to move freely through the storage zone during injection and withdrawal. If the rock isn't very permeable, meaning most of the pore spaces are isolated, then the natural gas injection and withdrawal rates will be low.

In caprock, we look for just the opposite. A rock such as shale is an ideal caprock since its impermeability prevents natural gas from traveling upwards and being lost.

Below the caprock, we need a porous, permeable layer of rock that will permit natural gas to flow in and out of the reservoir. The underlying water-saturated rock and dense basement rock trap the lighter natural gas in place above.



A TYPICAL UNDERGROUND GAS STORAGE FIELD

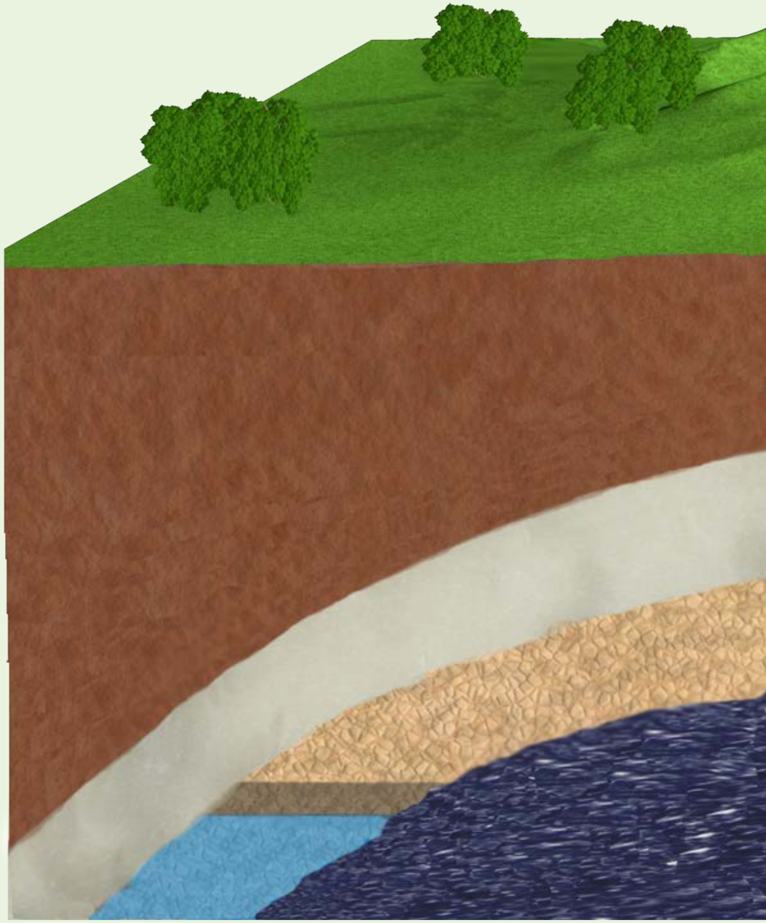
As shown at right, we operate two basic types of wells in our natural gas storage fields.

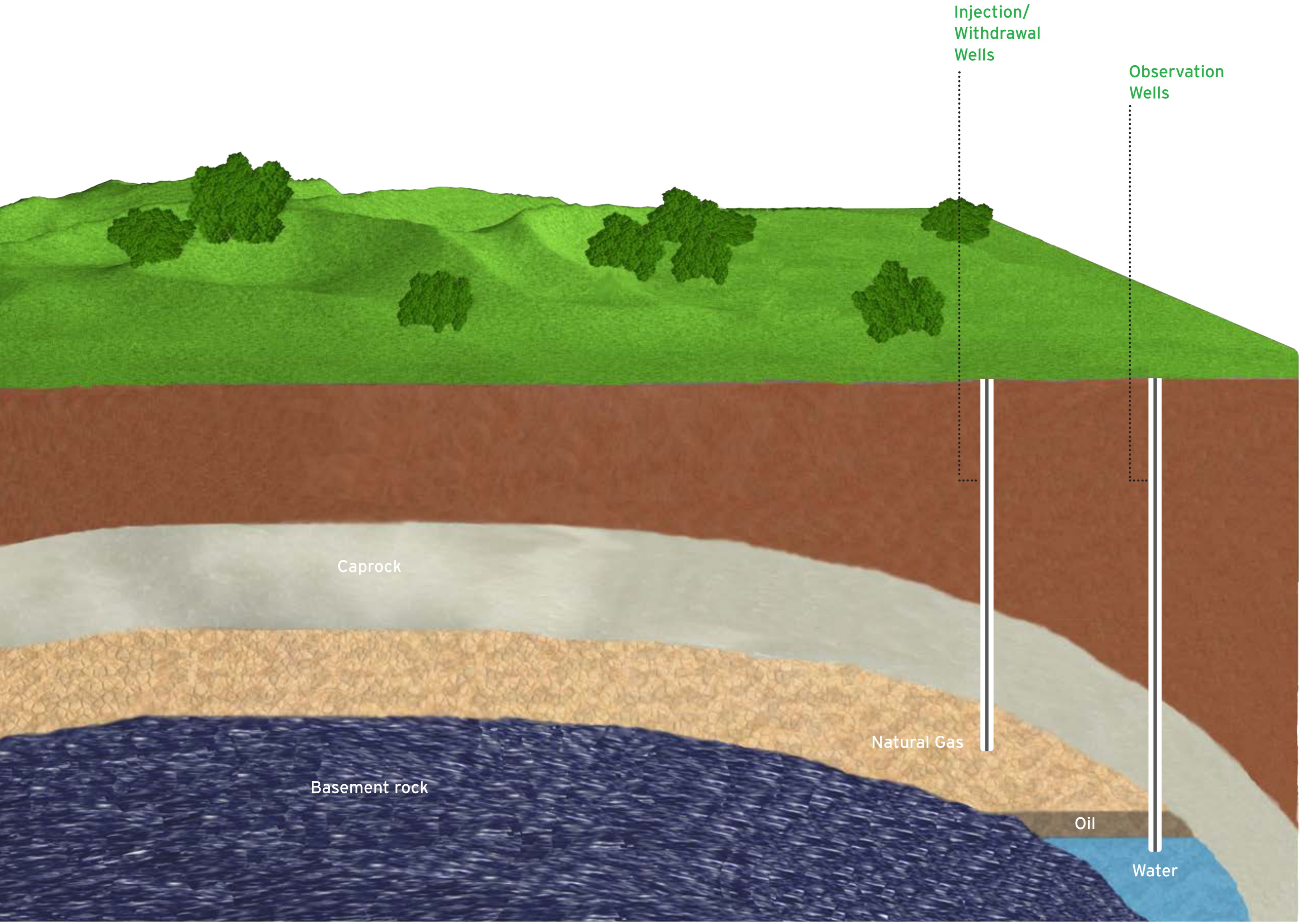
1 INJECTION/WITHDRAWAL WELLS

Functioning in the upper level of the reservoir and at shorter depths, these wells are used for withdrawing natural gas from storage. Many of these wells are also used to inject natural gas into the storage zone.

2 OBSERVATION WELLS

Observation wells are used for monitoring reservoir pressures and the integrity of the caprock.




Injection/
Withdrawal
Wells
Observation
Wells
Caprock
Natural Gas
Basement rock
Oil
Water

OPERATING THE UNDERGROUND STORAGE FACILITY

Storage operations are activated on orders from our gas control center to specific storage fields. Customarily, storage is required for seasonal load balancing: injecting summer supplies of gas underground to be held in reserve for winter withdrawal.

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SCRUBBING

As natural gas comes from the pipeline, it is run through intake scrubbers to remove any liquids that may have accumulated in the pipeline and might damage the compressors. Only natural gas that meets set specifications is brought into our pipeline system and injected into our fields.

COMPRESSION

Gas supplied in transmission pipelines flows under pressures often ranging from 250 pounds to 1,030 pounds per square inch (psi). The pressure in the underground storage reservoir, however, can be up to three or four times higher. To force the natural gas a mile or more down into the porous rock, it must be compressed to 1,500 psi (103 bars) or higher. This function is handled in two stages. Initially, high horsepower engines boost the pressure up to 800 to 1,500 psi (55 to 103 bars), significantly raising the temperature of the natural gas, since compression generates heat. To increase compression efficiency, the natural gas is next sent through cooling equipment before the second compression stage boosts it to 1,500 to 3,900 psi (103 to 270 bars), completing the process.

Before injection, the compressed natural gas will again be cooled to protect pipelines and other equipment in the storage field.

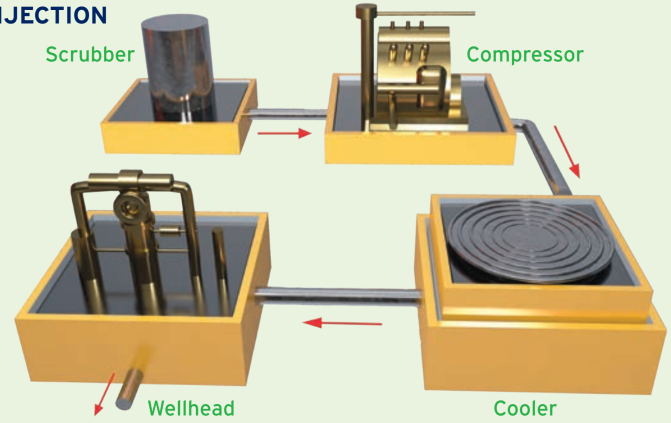
COOLING

Most of our storage facilities use the unique cooling system known as a "fin-fan." Appropriately named, each cooler contains a set of giant fan blades, whose rapid rotation pulls cool air across a system of tubes containing the natural gas. The tubes are wrapped with thin aluminum "fins" that assist in the cooling.

THE WELLHEAD

Generally referred to as a "Christmas tree," this collection of piping and valves controls all natural gas movement in and out of the storage wells. The Christmas tree controls are easily accessible to the crews which operate them during injection and withdrawal of natural gas.

INJECTION



WITHDRAWAL

Just as in storage injection, the signal to commence withdrawal of natural gas from storage is relayed to the field from our main natural gas control center. Withdrawal is usually ordered to meet heavy customer demand (1) throughout the cold, rainy winter season; (2) on air pollution episode days; or (3) during peak-load conditions when natural gas from storage augments the volumes constantly flowing in from out-of-state suppliers.

THE WELLHEAD

To start withdrawal, valves at the well site must be opened. Both injection/withdrawal wells and oil wells can be used to withdraw natural gas supplies, although the percentage of natural gas produced by the oil wells is limited.

SEPARATORS

When natural gas is withdrawn from the field, it generally flows under its own pressure directly into special vessels which separate most of the oil and water from the natural gas coming out of storage. Since natural gas is lighter than the accompanying fluids, it rises in the vessels, where it is collected for cooling. The oil and water left behind are separated, with the oil stored in tanks to be sold and the water stored for disposal or reinjected in the ground.

COOLING AND DEHYDRATION

When natural gas is removed from underground storage, it brings along petroleum liquids, water vapor and the hot temperatures from the earth a mile or two below. The natural gas is cooled by running it through a cooling system, and any free liquids are removed by another scrubber. Next, triethylene glycol, a substance similar to the ethylene glycol used as antifreeze in automobile cooling systems, is used to remove water vapor from the natural gas via a process known as dehydration.

ODORIZING

Natural gas is normally odorless. Its characteristic aroma is man-made for safety reasons and after its stay underground, the natural gas loses some of its manufactured scent. To give it that characteristic odor so important in detecting leaks, we add a drop of chemicals (as much as (1) 8-ounce cup per million cubic feet) just before delivering the natural gas into our distribution lines.

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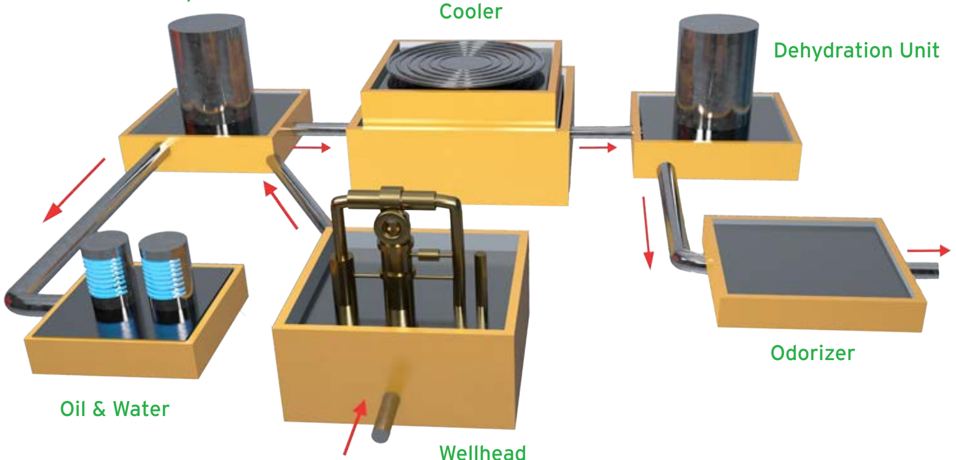
WITHDRAWAL



SOCALGAS UNDERGROUND STORAGE SITES

SoCalGas, operates four underground storage fields. Each facility has been developed due to unique geological characteristics, which makes it ideal for natural gas storage. The work done at these sites performs an essential function for all of our natural gas customers in the Southern California area. We work to meet our customers' needs in a safe and environmentally sound manner, thereby assuring the continuance of good neighbor relations with surrounding residents.

FACTS ABOUT NATURAL GAS

NATURAL GAS HAS SOME IMPORTANT PROPERTIES:

- It is colorless and odorless. We add the distinctive smell to natural gas as a safety precaution.
- It is lighter than air, which is an important built-in safety feature. If natural gas should escape outside, it will rise and dissipate harmlessly into the atmosphere.
- It is the cleanest burning of all hydrocarbon fuels.
- It will burn only when specific concentrations come in contact with an ignition source.

A TRADITION OF SERVICE

SoCalGas has a long tradition of providing dependable service to homes, business and industries in over 530 communities in a twelve-county area.

As the largest natural natural gas distribution company in the nation, we serve most of Central and Southern California. Providing safe, reliable and efficient natural gas service to meet this vast and fluctuating energy demand requires a highly responsive distribution system of more than 45,000 miles (83,000 kilometers) of natural gas main. The underground storage of natural gas plays a vital role in balancing the region's energy supply and demand.

SAFETY FIRST

Safety has always been a top priority with us. The technology to monitor and operate an underground natural gas storage field has developed steadily through the years. In addition, all of our operations are closely monitored for compliance with the safety standards of the California Public Utilities Commission, the Division of Oil, Gas, & Geothermal Resources, the Occupational Safety and Health Administration, and local fire departments.

This map shows the major pipelines which supply SoCalGas' service territory, as well as their strategic location relative to the storage fields.

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