Early retailers stored gasoline in drums or barrels. Then, as larger volumes were sold, the storage tanks were moved underground, both to save space and for safety. But burying the tank didn't necessarily bury the problem. Steel tanks would eventually corrode and begin leaking. For a long time, minor leaks were not considered a serious issue. The only cost of a leak was the lost gasoline. Now, an undetected underground leak is the gas station owner's worst nightmare. Hundreds of tons of contaminated soil have to be dug out and carted off to be treated as hazardous waste.

To deal with the leak hazard, steel tanks have been replaced by corrosion-free fiberglass ones. Monitoring wells are drilled all around the tanks for early detection of any hydrocarbons entering the soil or groundwater. Sometimes electronic leak-detection systems are installed. And in some parts of the United States, aboveground storage tanks have come back into favor, especially for kerosene and diesel fuel, which don't present quite as much risk of fire and explosion as gasoline does.

A typical tank at a large gas station holds 12,000 gallons, and there are three or four such tanks to accommodate the various grades of fuel. The tanks are filled through fittings recessed into the concrete apron that surrounds the pumps. A standard color code is developing for the various hatches and access caps. White marks regular unleaded gasoline, blue is the "plus" grade, and red is premium gas. Yellow and green are for diesel fuel—the yellow for low sulfur and the green for high sulfur. Finally, brown is for kerosene. Monitoring wells are danger orange: you wouldn't want the delivery truck to pump 10,000 gallons of high test into the well.

In heavy-smog areas, gas stations have had to make another change: installation of vapor-recovery systems. As noted earlier, gasoline is rich in butane, a very restless molecule that takes any opportunity to escape confinement. The gas-pump nozzle is fitted with a plastic hood, and an interlock switch allows the pump to run only when the hood is seated to the filler pipe. Suction draws the butane vapor through the hood and into a separate hose, eventually to be returned to the storage tank.

The storage of gasoline and other fuels at retail outlets has also undergone significant change. Originally stored in elevated tanks, gasoline was later put underground for safety reasons. But in many jurisdictions, tanks are now being installed above ground again because of the risk of underground leaks. The tanks below are at a gas station in western Missouri.

NATURAL GAS

The petroleum and natural gas industries are twins separated at birth. They have a great deal in common; indeed, the raw materials for both industries often come out of the same hole in the ground. And yet they have grown apart, developing different cultures, practices, and technologies.

The word *gas* is a variation on *chaos*. The name was suggested by Jan Baptista van Helmont, a seventeenth-century Flemish chemist, who thought of gases as unruly spirits given off when solids or liquids are heated. (Or maybe he was just being whimsical.) The stuff we burn today is called natural gas to distinguish it from manufactured gas, which came first historically. All through the nineteenth century and up until about 1950, gas was made by roasting coal or heavy oil residue to drive off a mixture of combustible gases—mostly carbon monoxide but also some hydrogen and methane and traces of much else. The gas was a poor fuel, not to mention a deadly poison. The residue left behind at the gas works, called coal tar, was even nastier. Efforts to find a use for the stuff or somehow get rid of it were so assiduous and enduring that they pretty much created the discipline of organic chemistry, and then the dyestuff and pharmaceutical industries.

Manufactured gas hasn't been manufactured for decades, but many of the companies that once made it live on as distributors of natural gas. Companies such as Brooklyn Union Gas and Public Service of New Jersey converted their old gas works to storage facilities for the new fuel flowing in from Texas and Oklahoma. The most difficult part of the conversion was readjusting millions of stove burners and furnaces.

Natural gas is a simpler fuel than manufactured gas. It is mostly methane, the smallest of the hydrocarbon molecules, with few impurities except water. The only major products of combustion are carbon dioxide and water. One impurity is deliberately

Rigid-walled gasholders loom over a residential neighborhood in Genoa, Italy. Most tanks of this kind were built in the years before 1950 and originally held manufactured gas. Often they are the tallest structures in the area and therefore serve as important landmarks. Inside the tanks, a floating piston separates a layer of natural gas below from air above.

Telescoping gasholders in Elizabeth, New Jersey, were designed to rise and fall inside their skeletal framework as gas was stored and withdrawn. In this photograph the gasholders are fully deflated. They had probably been emptied in preparation for demolition; since the photograph was made in 1998, the gasholders have disappeared, like many others of their kind.

added to the gas before it enters the distribution pipelines: methyl mercaptan, the sulfur compound that gives gas its characteristic smell. (The methane itself is odorless.)

Natural gas became a practical fuel only with the construction of long-distance pipelines. Other forms of transport are simply too expensive, which means that gas fields not served by a pipeline can't be developed. The gas in the Alaskan North Slope, for example, has no way of getting to market, and so it is reinjected into the wells, where it helps push oil to the surface. A few oceangoing tankers carry natural gas as a cryogenic liquid (temperature –259 degrees Fahrenheit), but commerce in liquefied natural gas (LNG) has not taken off the way the world petroleum market has.

Gas received through the pipeline system is stored in the equivalent of tank farms. The traditional storage facility is a gigantic, collapsible canister, or holder, that rises and falls with changes in the supply and demand for gas. In New York City, generations of commuters came to know two such gas tanks near the Long Island Expressway in Elmhurst, Queens. The Elmhurst tanks have been demolished, like many others around the country.

The holders are essentially inflatable structures, but made of telescoping sections instead of elastic fabric. The walls are concentric rings called cups, linked together by flanges. As the empty tank starts to fill with gas, the innermost cup (which supports the slightly domed roof) starts to rise. A flange at the base of the innermost cup engages a matching flange at the top of the next cup, which is therefore pulled up as the filling continues. The joint between sections is sealed with water, which is steam-heated in winter to keep it from freezing. At full extension a typical holder stands more than 200 feet high and holds roughly 10 million cubic feet of gas. The sections are held in

High-pressure cylinders store natural gas in a smaller volume than the low-pressure rigid and telescoping gasholders. The cylinders are in Ljubljana, Slovenia.

Liquefied natural gas (LNG) is stored at even greater density than high-pressure gas. The LNG depot at right, shrouded in foggy vapors on a winter afternoon, is in Everett, Massachusetts.

A vent stack on a city sidewalk serves as a pressure-relief valve for the gas distribution system. Ordinarily the valve is closed and nothing escapes through the vent; if a malfunction causes higher-than-normal pressure in the mains, it is better to release the gas through a vent like this one than through leaks in underground pipes or inside buildings.

alignment and braced against wind loads by a cylindrical exoskeleton of steel trusses.

Because of the immense volume, the pressure needed to inflate the holder and lift the cups is very slight—only about one-half pound per square inch above atmospheric pressure. You could blow up the holder with your breath, like inflating a giant beach toy, but it would take a while—perhaps 300 million lungsful.

There are also rigid gas holders, which look from the outside like plain steel tanks without moving parts, but inside they have a floating piston that separates gas in the lower part of the holder from air above. (Keeping air and gas apart is the point of all the storage arrangements. Gas is reasonably safe as long as there's no oxygen present.)

The big low-pressure gas holders are being replaced by high-pressure tanks and by insulated tanks for liquefied gas. The typical facility for high-pressure storage is a bank of cylindrical tanks with hemispherical end caps. Each tank is about the size of a house trailer. A dozen of these tanks have as much capacity as one of the giant old telescoping holders. That's about a day's supply for a major city.

Larger stocks are stored in liquid form. Six hundred cubic feet of natural gas condenses into a single cubic foot of LNG. Tanks for LNG don't have to withstand pressure, but they have to be insulated to keep the fuel cold and be built of materials that retain their strength in the deep freeze. In addition to the storage tanks, an LNG depot will have a refrigeration plant, and an evaporator, which accomplishes the opposite task—making the gas a gas again.

Although storage technology has changed, the gas-distribution system remains much as it has been for the past century. The gas moves through underground pipes at very low pressures—roughly 0.2 pound per square inch over atmospheric pressure. This is less than the change in barometric pressure when the weather turns from fair to stormy. Thus, the gas is very gently wafted through the pipes. The low pressure entails much larger pipes than a high-pressure system would need. Some of the gas mains in New York are six feet in diameter. Low pressure is a safety feature; it reduces the leakage rate when a pipe fails or a pilot light goes out.

FUELING THE FUTURE

In the fall of 1973, the idea that oil is a finite resource became more than an abstraction for many Americans. After a cutback in production by members of the Organization of Petroleum Exporting Countries (OPEC), gas pumps ran dry and prices soared. Filling the tank in the family station wagon—a chore that had been so routine it slipped below the level of conscious attention—became an obsessive quest. If you wanted gas, you got up before dawn, and found cars already lined up for blocks.

The 1973 shortage lasted only a few months, but it made a powerful impression on those who lived through it. For a while, American automobiles became smaller, lighter, and less thirsty. A 55-mile-per-hour national speed limit was imposed as a fuel-saving measure, and it remained the rule of the road for more than 20 years. "Energy independence" became a potent political slogan.

Oil wasn't running out in 1973, but that possibility was on everyone's mind. Back in the 1950s, the geologist M. King Hubbert had predicted that U.S. petroleum production would reach a peak in the early 1970s and decline thereafter. Events proved him correct. In 2001 Kenneth S. Deffeyes, another geologist and Hubbert's protégé, predicted that *global* oil production would peak in 2005 or 2006 and then begin a long, painful slide to depletion. This time the turning point failed to appear on cue, and indeed the subsequent boom in "tight oil" has led to a reassessment of Hubbert's earlier analysis. Current trends suggest that U.S. gas and oil output could regain the 1970 peak within a few years, and the worldwide oil supply has had no trouble keeping up with demand, so far.

However, even if the date of oil's last gasp is highly uncertain, the principle is surely sound. We are burning petroleum much, much faster than the earth is making it. Accumulating the stockpile took a few billion years; we've consumed a significant fraction of it in a little over a century. And even if we could find enough oil and other fossil fuels to burn for centuries to come, it's probably not a good idea to do so. Atmospheric carbon dioxide has already increased by 60 percent, with perceptible effects on climate.

If a world without gasoline seems unimaginable, look back to the 1850s, when a world without whale oil must have seemed equally unlikely and forbidding. Finding a replacement for petroleum is a huge scientific and engineering challenge, but there's time yet to address that challenge. It will be fascinating to see what the new energy source is, what features it adds to the technological landscape, and how society and the economy reorganize themselves.

The politics of "peak oil" is played on bumper stickers and vanity license plates.