Underground gas storage

Geology, technology, planning and regulation

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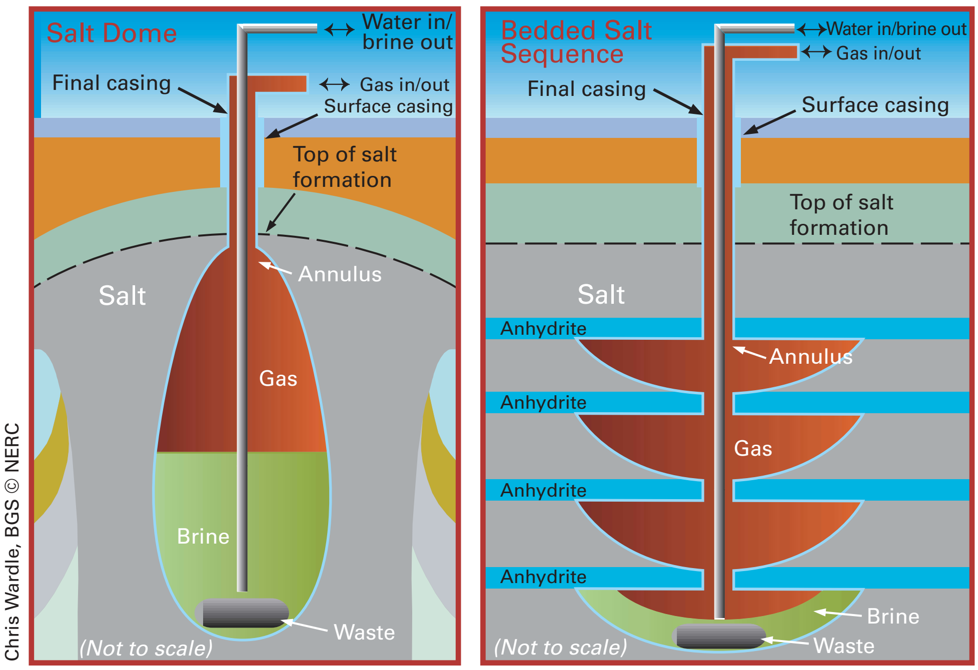
Underground storage of compressed natural gas (CNG) is a widely used technology with a track record going back more than 80 years. According to the Institut Français du Petrol, there are currently 554 storage sites worldwide, with a total working capacity of 243 billion cubic metres and a total volume of 502 billion cubic metres. The amount stored is equivalent to 11% of world consumption. In Western Europe there has been a general expansion in underground gas storage capacity in recent years, with the current total capacity of the 66 underground storage facilities standing at 86 billion cubic metres. Storage capacity is highly variable from one country to another, ranging from France, with the equivalent of 110 days of average consumption, to the UK with only 17 days of stored reserves. Transco has recently stated in its consultative document to the regulator, the Office of Gas and Electricity Marketing (Ofgem): 'The ability of the UK gas market to survive a severe winter within the next five to ten years is currently inhibited by the limited development of new storage facilities'.

Gas storage has four main functions: (a) provision of a strategic reserve in the event of supply difficulties, (b) smoothing out of fluctuations in demand, (c) optimizing the capacity of gas transmission pipelines, and (d) as a financial hedge against changes in the price of gas on the open market. When gas is pumped into storage in the summer months, to meet higher demands later in the year, the process is known as 'seasonal load balancing'. The smoothing out of short-term fluctuations in demand caused by, for example, very cold weather, is known as 'peak-shaving'.



Schematic of underground gas storage in salt caverns constructed in both salt domes and bedded salt sequences (normally the brine is displaced by gas before the cavern is brought into operation).

Storage in porous rock

Two basic forms of CNG storage in porous rock are used: the conversion of a depleted oil or gas field into a storage facility, or the injection of gas into an aquifer containing non-potable water. The main requirement in both situations is that there should be no leakage of gas into adjoining formations. The storage horizon must therefore be overlain by rocks that are virtually impermeable, forming a gas-tight seal (*left*). There are several examples of gas storage in depleted hydrocarbon reservoirs around the UK, but we have yet to exploit aquifers for this purpose.

The most important gas storage facility in the UK gas system is Rough Field operated by Dynegy Storage (formerly BG Storage). Rough is a partially depleted gas field in Lower Permian Rotliegend sandstone at a depth of around 3000 metres beneath the southern North Sea. With a maximum operating pressure of 205 bar, the field is able to store around 30 terawatt-hours (UK figures are usually quoted in energy terms), equivalent to the amount of gas needed to supply the UK market for 13 days. It also has a high deliverability rate of 455 gigawatt-hours (GWh) per day. The operator sells capacity to the gas shippers.

The Hatfield Moors gasfield is located east of Doncaster and operated by Edinburgh Oil and Gas. The depleted gas reservoir is in Upper Carboniferous sandstone at a depth of around 440 metres and was converted for use as a gas storage facility in September 1999. The field has 1260 GWh of space and deliverability of

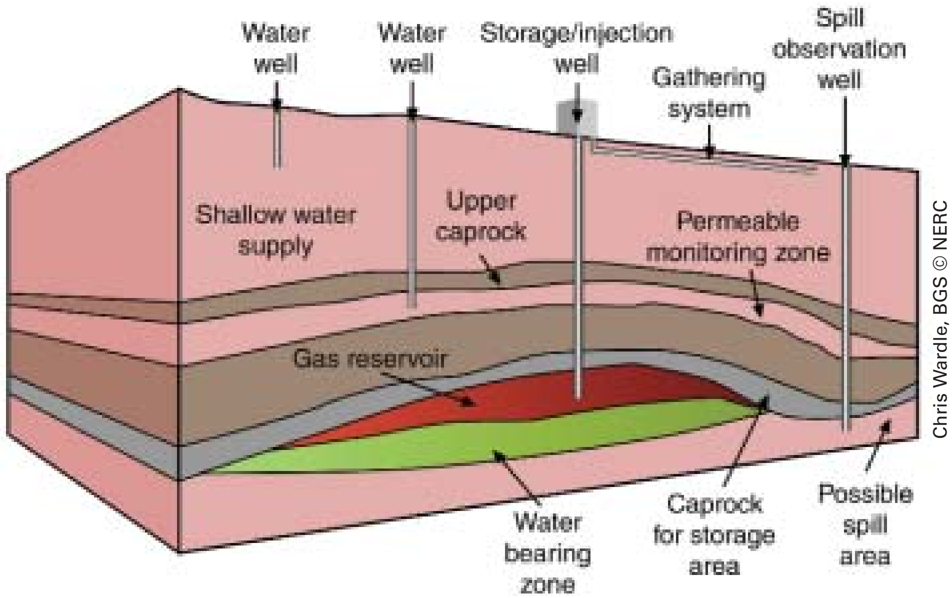
54.7 GWh per day. The company signed a 25 year agreement with ScottishPower giving them exclusive rights to inject, store and withdraw gas. Revenue is based on storage capacity and the provision of reservoir management services.

The Humbly Grove project in Hampshire is a proposal by Scottish Power to develop a 160 megawatt, open-cycle gas turbine electricity power station at the Holybourne Oil Terminal site. The gas would be taken from the regional transmission system near Binstead, piped to the Humbly Grove Oilfield and stored underground in the gas cap above the oil-bearing Great Oolite limestone (Jurassic). The gas would then be returned to Holybourne when electricity generation was required. The existing infrastructure at Humbly Grove is well-suited to storage and Star Energy, the operator of the field, is perfecting techniques to reinject the gas. The field has 1080 GWh of space and 36 GWh per day of deliverability. According to Star Energy, there is further potential for storage at Albury, Singleton, Storrington, Bletchingley, and the large Eskdale field in North Yorkshire.

Storage in salt caverns

The caverns are created in thick rock salt formations by controlled leaching of the soluble salt using water circulated through pipes installed in a borehole. The roof of the cavern is usually protected from dissolution using a blanket of oil. Development takes around three years. High flow capability makes salt caverns ideal for peak-shaving and daily balancing needs. A prime concern is preserving the integrity of the cavern. Creep, or time-dependent rock deformation, is an important factor in the design and operation of deep storage caverns. Although some shallow caverns can be fully depressurised, it is necessary to maintain a minimum pressure (known as cushion gas pressure) in deeper cavities in order to control creep closure and ensure long-term stability. Disposal of the brine from cavern development is an important planning consideration. Options include use of the brine in salt production and direct disposal into the sea.

Dynegy Storage operates the Hornsea salt cavern storage facility in East Yorkshire, where development at the site near Atwick started in the mid-1970s. The gas is stored in nine teardrop-shaped cavities in Permian Zechstein II salt at a depth of around 1800 metres.



Schematic representation of subsurface gas storage in depleted oil and gas reservoir.

The cavities were leached using sea water, with the resulting brine dispersed offshore through a sub-sea pipeline. The total usable space is 3495 GWh and the caverns can deliver gas at the rate of 195 GWh per day. The US-based energy group Aquila also operates a salt cavern storage facility in Triassic salt at Hole House Farm, near Minshull Vernon in Cheshire. By the autumn of 2002, two out of a total of four caverns at the site were in use for gas storage, providing 821GWh of space and a deliverability of 59 GWh per day. British Salt benefits by receiving the brine and gets an annual fee for cavern development and a rental for storage.

ScottishPower failed to obtain planning permission from Cheshire County Council for a £70M project to develop up to eight gas storage caverns in Triassic bedded salt at a site near Byley. The brine would have been taken by the Salt Union. Public concerns about pollution were cited as a main reason for refusal. InterGen and BG Storage also ran into planning difficulties with their £120M scheme to develop six salt caverns at Aldborough in East Yorkshire.

Moving forward

The underground storage of CNG is a mature technology with an excellent general safety record. With Britain likely to become dependent on foreign gas imports as early as 2004/05, there is a pressing need for the development of additional capacity. Ofgem has called on the gas industry to respond. However, the experience of the past few years has underlined the fact that planning permission is the single biggest obstacle to the development of additional storage capacity in the UK. Many would agree that our present planning system, with its emphasis on local needs and priorities, is not well-suited to the task of determining the fate of these key components of our national energy supply infrastructure.

Whilst it will always be difficult to convince people of the need for specific kinds of development in their immediate neighbourhoods, genuine public fears and misunderstandings relating to environmental impact, pollution and safety have often arisen because of poor communication between developers, regulators and the community. These are essentially matters that should be addressed by dialogue with skilled engineers, geologists and environmental scientists. Public confidence in the wisdom and technical competence of the regulatory authorities is also vital in the effort to win over public support for this technology. We need to take a look at the way in which other countries, with more experience than ourselves, plan and regulate underground storage and to put in place measures that provide a guarantee of best practice in all matters relating to planning, design, operation and monitoring. Acceptability is largely based on public confidence.