The Value of Underground Gas Storage ("UGS")
By Glen Gill

Contents

1. General

Storage serves as both a sink for surplus gas production and a source of gas readily available to the market. This dual role performs a unique function in the market. "In fact, in the view of the many natural gas industry participants and observers, it would be difficult to overstate the importance of storage and information about storage levels and stock builds and draw downs in influencing prices in both cash and futures markets."[1] Storage is essentially cost effective "line pack". While pipelines can temporarily store gas, their ability to do so pales in comparison to underground storage facilities.

In its injection mode of operation, UGS is essentially a demand sink for surplus gas production, processing and transmission capacity that allows efficient utilisation of infrastructure when gas demand wanes. In Australia the absence of a vibrant short term trading gas market and open access underground gas storage facilities forces gas producers to curtail gas production during low gas demand periods. Producers attempt to manage the degree of swing gas capacity and operations by entering into long term onerous take-or-pay gas supply contracts but a much better solution is a market model that embraces a short term trading market and open access non-discriminatory UGS facilities and services. The role of underground gas storage in facilitating a competitive and vibrant gas market in Australia where all market participants enjoy the benefits of this important commodity and resource is an important and unique one. In addition to this important role in the physical gas market of any region or continent, UGS also has a commmercial role in the provision of liquidity to support physical and financial gas trading activity associated with a short term trading market and in the balancing of pipeline and gas hub operations in such a market. UGS facilities become such a sink for gas when market conditions dictate – i.e. when the net request for storage services by UGS customers results in a physical injection of gas into the facility from the connecting pipeline(s).

[1] Energy Information Administration, *Natural Gas Monthly December 1997,* page ix.

Major gas demand sinks that contribute to gas demand volatility in any market include the following:

- Cold weather driving demand in the space heating segment of the market;
- Hot weather driving demand in the gas fired power generation segment of the market;
- Ancillary services provided by gas fired power generation in the electricity market;
- Fuel switching to gas from other fuels due to price fluctuations or operational considerations;
- Temporary shut-ins of gas feed stock operations due to maintenance, market conditions, etc;
- Fluctuations in gas exports – export pipeline and/or LNG liquefaction facilities.

These are the major factors that contribute to fluctuating gas demand in most regional gas markets such as Eastern Australia, served by an onshore gas transmission grid and multiple gas production facitlities.

In its withdrawal mode of operation, gas storage is essentially a source of gas supply. This source of gas supply mitigates price volatility in the short term trading market and facilitates the efficient supply of the volatile gas demand sinks previously listed. Eastern Australia has coped with its volatile gas demand in the past by operating production facilities with some upstream gas storage facilities embedded in those upstream facilities at variable operational levels (commonly referred to overseas as swing production). This model is very inefficient and is not sustainable with growing gas fired power generation, introduction of exports from onshore gas supplies and the introduction of a short term trading market in gas. Eastern Australia has had a few very large gas supply disruptions in the past that also reveal that the past model is not acceptable in terms of adequate security of supply.

Alternative gas sources to UGS that may supply voaltile gas demand sinks and/or provide security of supply include the following:

- Utilisation of excess gas processing capacity;
- Utilisation of excess gas pipeline capacity connecting gas supplies to demand centers;
- LNG, propane air, or other gas peaking facilities;
- Fuel switching from gas to an alternate energy source and then selling such gas in the market;
- Packing gas in purpose built gas pipelines associated with peaking gas demand facilities such as exists at the Braemar and Colongra power stations in Qld and NSW respectively.

These solutions have a much higher cost per unit of gas delivery capacity than does UGS. Australia also has relied on the re-direction of gas by Government loosely defined intervention procedures and protocols away from the large end users to the small end users (voters) in times of supply disrutpions.

In Australia the use of UGS to date has been very limited and controlled by the incumbent upstream joint ventures who also have, until recently, dominated the gas supply. Market participants have not embraced as yet the role that UGS could provide to liberate the gas market in Eastern Australia. Producers have elected to build excess offshore and onshore gas production and processing plant capacity and gas reticulation companies have elected not to use conventional load leveling tools and peak gas supply facilities with the exception of a 12,000 tonne LNG peak shaving facility in Victoria and UGS facilities in Victoria and W.A. operated by TRUenergy and APA respectively. Gas is stored in various depleted reservoirs by producers primarily for the load leveling of gas processing plants and to mitigate unplanned and planned outages in their production facilities. This has historically been done in the following fields:

Basin	Field	Year Developed	Operator
Cooper	Lower Daralingie	Early 1970's	Santos
Surat	Newstead	1998	Boral
Ballera	Chookoo	1985	Santos
Carnarvon	Tubridgi	?	BHP Billiton

The development and operation of UGS by gas utilities and pipeline companies in Australia is limited to the two facilities listed below:

Basin	Field	Year Developed	Operator
Perth	Mondarra	1996	APA
Otway	Waare, North Paaratte & Wallaby Creek	1999	TRUenergy (CLP)

TRUenergy's UGS facility located at Iona, Victoria is the only open access non-discriinatory facility in operation in Australia.

For various reasons, not the least of which is the relatively young age of the Australian gas industry, the benefits of utilising load balancing devices such as storage have not been pursued to date. Very little fuel switching capability exists and few interruptible and short term gas supply contracts. Such an industry structure is indicative of economic inefficiency, particularly given the high capital costs associated with large production facilities.

The above ground storage of town gas and of liquids has constituted the bulk of petroleum product storage in Australia. The storage of petroleum product underground first occurred in the onshore Cooper Eromangna basin of S.A., as producers were forced to store ethane until such time as the S.A. government decided whether or not to encourage the development of a petrochemical industry. This storage of ethane occurred until the construction of a 1500 km ethane pipeline connecting the gas fields with ICI's petrochemical complex in Botnay Bay, NSW. A large cavern was mined out of cemented sandstone at Botnay Bay to store 65,000 tonnes of LPG's underground by Elgas .

Unlike North America and Europe, gas pipeline companies and gas reticulation companies in Australia did not initiate the development of downstream underground gas storage for load leveling and emergency gas back-up services. Santos initiated upstream gas storage as an operational procedure simply because it was forced into the storage of ethane by the S.A. Government. As a result, Santos has installed substantially less reserve processing plant margin than any other producer. Santos and the other members of the S.A.

Cooper Basin production unit have become by far the most sophisticated of the gas producers in Australia regarding such operational matters as the spiking of the calorific value of pipeline gas and the use of UGS to supplement installed plant capacity.

2. Commercial Background of Gas Storage

Underground gas storage has long been recognised as the most cost-effective way to meet fluctuating gas demands. Gas storage was first developed by gas utilities and gas pipeline companies around the world to manage uncertain gas demand profiles that are largely weather dependent and therefore relatively unpredictable. Such storage was developed in or in close proximity to large gas demand centers and is generally referred to as Market Region Storage. Market region storage in North America and Europe was historically economically regulated based on the traditional cost of service model similar to gas pipelines and retuculation systems.

As the gas market was liberalised in North America and independent UGS developers and a few gas producers developed additional UGS for the upstream sector of the gas industry in the dominant supply regions in order to improve capital utilisation and lower gas production costs. Such storage is commonly referred to as Production Region Storage. Production region UGS remains largely unregulated and operators charge storage rates that are market based. Production region UGS facilities tend to be high deliverability multiple cyce facilities utilising either salt caverns or depleted reservoirs with exceptional containment and flow qualities.

As gas became a commodity in North America, a third category of UGS was introduced: Hub Storage. The development of hub storage has been the rage in North America since gas de-regulation in the mid 1980's. This storage was developed primarily by gas marketing companies and pure storage operators. The commercial driver behind the development of these facilities is primarily the creation of hubs or nodal points across North America to support the vibrant wholesale gas market. Gas hubs are basically trading points supported by access to multiple gas pipelines and an underground gas storage reservoir. The blending of these two tools allows for the creation of many innovative service offerings by hub operators.

These categories are not based on the different technical aspects of UGS, but reflect the commercial aspects of UGS. From a commercial perspective, UGS facilities doe not create gas supplies or markets in the longer term, but can dramatically influence the overall market and the gas industry value chain by temporarily reshaping the macro supply / demand equation and by facilitating a deepening of the overall market. Gas storage provides a sink (market) or a source (supply) at the discretion of the storage operator. Such a facility can dramatically impact on the price of gas in the regional short term trading market, and in fact the spot price of gas or index in North America has historically been driven as much, if not more, by storage operations and fill levels as by weather patterns and influences.

Because the gas industry is capital intensive, second only to the electricity industry, the use of UGS to load level facilities throughout the value chain leads to a substantial overall cost reduction in the cost of gas and economic efficiency. Gas from many sources may be stored at a UGS facility by third-parties under fee-for-

service, buy-sell, or other contractual arrangements. Although a menu of traditional UGS services exists in North America and Europe, it is imperative, especially in an evolving market place such as Australia, to tailor make services in order to best meet the needs created primarily by idiosyncrasies in the market. These idiosyncrasies tend to disappear as a market matures or deepens.

3. Storage Services

3.1. Market Region Storage

The origination of UGS services commenced with market region storage. Traditionally, the services offered include the following:

- Seasonal base load storage or the injection and delivery of gas on a single cycle per year basis;
- While needle peaking needs are customarily done by LNG facilities, multiple cycle storage is offered for shoulder peaking requirements;
- Security of supply

The value of gas storage is highest when located at the end of long distance pipelines and in gas markets where gas demand is volatile. The volatility of gas demand is primarily driven by weather: hot weather if demand fluctuations are predominantly driven by gas fired power generation, as is the case in South Australia and increasingly so in other states, and by cold weather if demand is predominantly driven by gas heating, as is the case in Victoria. For example, Canadian reticulator, Union Gas, uses UGS for up to 33% of its peak day deliverability requirements in the province of Ontario, Canada. However, gas utilities located in the heart of predominantly gas producing areas often develop UGS as an integral part of their gas supply portfolio. An example of this is ATCO's Carbon UGS salt cavern facility developed in Alberta in 1967. The benefits to gas pipelines, gas distribution companies, and gas retailers of market storage include the following:

- Insurance against volatile or abnormal weather since gas distributors are often the supplier of last resort in a highly political industry
- Lower gas supply costs as poor load factor gas supply contracts are expensive due to the capital-intensive nature of the entire gas supply chain.
- Minimise the over-building of gas pipelines, especially long distance ones
- Provide security of supply in event of temporary pipeline outages, gas supply failure, etc
- Avoid an over reliance on the short term trading market for emergency supplies

While market region UGS used to dominate the gas storage activity in North America, it now accounts for only approximately 68% of the total UGS market.

3.2. Production Region Storage

The development of production region UGS occurred in the Western Canadian Sedimentary Basin from 1988 to 1993. It is also common in the Gulf Coast states in the USA. The region surrounding production region UGS is a net exporter of gas. Traditionally the storage services offered are similar to that of market region UGS but the commercial drivers are quite different and include the following:

- Production of gas that would otherwise be drained by a competitor's well;
- Extend the life of low productivity reservoirs and wells, i.e. coal seam gas, shale gas and tight gas;
- Disposal site for solution gas, blow down gas, and other *must produce* gas due to reservoir management practices or the recovery of associated liquids;
- Load level capital intensive gas production and processing facilities;
- Insurance against widespread production outages due to tropical storms in offshore areas such as the Gulf Coast, large gas plant outages such as in British Columbia, Canada, and transportation outages or bottlenecks as in Alberta, Canada;
- Optimise freight costs and service levels on complicated gas pipeline systems such as the Nova system in Alberta, Canada;
- Aggregate gas taken in kind from interest in various gas fields or gas basins;
- Balance gas taken in kind with market arrangements;
- Enhance producer's gas prices by providing reliability to high value export gas markets;
- Grants producers the decision to either sell gas at prevailing market prices or to temporarily store gas in UGS facilities.

The use of production regin UGS is often a good alternative for gas producers over placing the gas into the market at a time that is inconsistent with market requirements. Deterioration in the overall spot or short term trading market price by such practice costs the upstream industry dearly, for the last molecule of gas tends to set the price for the entire domestic market. While some wells can be shut-in and produced at higher rates later as demand rises, there is a large cost associated with the shut in of certain wells and reservoirs. In terms of insurance against supply default, the use of storage is more cost effective than exposure to liquidated damages at a time of major or significant supply loss and increasing short term prices.

3.3. Hub Storage

The trend in North America since gas de-regulation leading to the commoditisation of gas has been less working gas inventory and higher UGS delivery capacity. This trend has clearly been associated with the development of hubs, storage hubs, and market centers. Multiple cycling of working gas creates the most profitable UGS projects and hub storage allows for greater cycling.

> About two-thirds of the storage deliverability brought on line in 1995 was high-deliverability storage. In addition, storage operators cycled salt cavern storage about 1.14 times in the past heating season, up from 0.53 in 1991-92. At sites associated with market centers, cycling of storage was at a much higher average of 1.45 during the past heating season, reflecting the strategic value of

storage sites, particularly salt cavern, associated with hubs and market centers. Before 1993, this type of storage was often marketed like conventional storage and used primarily as seasonal backup supply rather than as peaking or short-term swing supply … 47 percent of working gas storage capacity in North America is directly or indirectly accessible by market centers.[2]

4. The Value of Gas Storage

The difference between gas prices in the spot or short term trading market is a major factor in determining the value of UGS in a liquid market. At present, due to the concentration of gas supply contracts and associated pricing in Victoria, there is little to no seasonal, monthly, daily, or hourly swings in the price of gas. The lack of price signals to the Eastern Australia gas market at this time is not conducive to UGS projects but that environment is changing with the introduction of the short term trading market, the increasing supply of gas to gas fired power generation facilities, the increase in upstream competition and the plans to export csg in the form of LNG from Queensland. These are all major drivers for UGS development in Eastern Australia.

The following table was generated by U.S. based Gas Research Institute based on market research done by International Gas Consulting and gives indicative values for some of the applications for UGS facilities and services:

Peaking	$0.10 - $0.50/Mcf
Swing	$0.05 - $0.25/Mcf
Gas Inventory Charge (GIC)	$0.15/Mcf
Contract Warranty	2 - 10%
Emergency Supply	$0.10 - $0.20/Mcf
Daily Balancing	$0.03 - $0.12/Mcf
OFO Balancing at city gate	$7-$10/Mcf

Source: *GRI*, 1995, $US.

The initial value for these services in Australia will differ dramatically from this table due to the many distortions and idiosyncrasies found in the market at this time. A similar situation existed in Canada in the mid 1980's. Furthermore, this table gives an indication of how the gas market in Australia may evolve as competition increases.

Just as price changes affect the value of gas in storage, storage activity can affect gas prices. Storage levels of working gas and storage activity exhibit the strongest influence on the gas market when the entire industry can be expected to experience the greatest stress in terms of matching supply and demand. .

The load leveling of capital intensive infrastructure is the major efficiency gain provided by underground gas storage. Storage is used to load level gas pipelines and upstream facilities such as processing plants and gathering lines. Market participants who use storage for this purpose are mainly producers and distribution companies.

[2] Energy Information Administration, "Natural Gas 1996: Issues and Trends", pages x and xi.

The dominance of a single gas supply to each of the three regional gas markets in Australia has led to the installation of redundant upstream capacity or reserve plant margin. Excess productive capacity in the U.S. in the early 1980's was as high as 30%.; prior to large inter-state trade flows. Interstate and inter-country trade growth has essentially eliminated this surplus. In the 1970's and early 1980's Canada's excess gas production capacity was as high as 50% and this too was eliminated by a freeing up of export restrictions and by developing and utilising production area UGS. As interstate gas trade increases in Eastern Australia, one would expect that the current high level of excess production capacity will disappear.