Petroleum storage

Peter Roberts
Andrews Kurth LLP

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1. Introduction

This chapter considers the essential legal and commercial aspects of the business of storing petroleum in its various forms. The principal focus of the chapter is upon arrangements for the underground storage of natural gas, but the storage of other forms of petroleum is also considered for completeness.

A number of introductory points will be helpful to note:

- Petroleum – except where specific references are made, this chapter relates generally to petroleum, which is used as a generic term for crude oil, refined oil products, natural gas, associated gas liquids and processed gas forms such as LNG and LPG.
- Fungibility – petroleum, in whatever form it takes, has one specific characteristic which makes it very different to truly solid and readily divisible goods: once one quantity of petroleum of a particular grade has been mixed with another quantity of petroleum of the same grade then the respective quantities can no longer readily be distinguished. They are rendered molecularly indistinct by the process of commingling. Petroleum is therefore a truly fungible product. 'Fungible' is defined by the *Oxford English Dictionary* as "a thing which precisely or acceptably replaces or is replaced by another".
- The fungibility of petroleum presents certain challenges when it comes to the storage of commingled stock. It becomes difficult to apply conventional rules relating to the identification of discrete property interests to which title can be held where individual petroleum quantities have become unascertainable through commingling.
- Segregation – petroleum of a particular grade could be held in segregated storage, with specific identification. Segregated petroleum is intended not to suffer the problems associated with being a part of commingled stock.
- Segregation is not always an operational possibility however. In an onshore tankfarm certain tanks could be set aside for the storage of segregated petroleum quantities. In a tank, a pipeline or a ship which is designed for the common transportation of petroleum belonging to different shippers, segregation is physically and conceptually impossible.
- Facility ownership and access – a distinction can be made between petroleum storage facilities which are owned, operated and used by a person solely to meet that person's own petroleum storage needs and facilities which are owned by persons who rent out capacity in those facilities to petroleum

owners under a form of services agreement, in exchange for a fee. It is also necessary to consider the rights at law which non-facility owners might have to compulsorily acquire access to such facilities.

2. Crude and refined oil products strorage

An onshore tankfarm could be constructed for the storage of crude oil or refined oil products. Such a tankfarm could be directly owned and operated by an upstream oil production company or (which is more likely) could be owned and operated by an affiliated company, where the upstream company is part of a vertically integrated undertaking. In the tankfarm crude oil and/or refined oil products interests would be stored in commingled or in segregated tankage.

As an alternative to the notion of the equity ownership of a tankfarm (whether directly by an upstream company or through an affiliated entity), a party requiring the storage of its crude oil or refined oil products could contract with a third party which owns a tankfarm for the provision of storage capacity at that tankfarm (in exchange for the payment of an agreed tariff by the storing party). The resultant storage services agreement which applies between the tankfarm owner and the storing party could go beyond the provision of bare storage, and could also provide for certain processing and/or transportation services to be supplied by the tankfarm owner to the storing party. All of these arrangements would be recited within a combined storage, transportation and processing agreement between the two parties.

As an extension to the conventional business of tankfarm storage of crude oil and refined oil products, where a company will store oil or oil products with a view to immediate physical delivery and sale at the prevailing market price, in storage trading the company will enter contracts for the future sale and delivery of the stored oil or oil products at a price which is higher than the price which would be realised by an immediate physical delivery. As the intended future date for physical delivery approaches the existing contracts are closed out, with new contracts entered into for the sale and future delivery of the same oil or oil products. This process is repeated, often with the consequence that the oil or oil products never actually move out of storage.

Trading in this fashion is only properly successful in a contango market – where the price of oil or oil products in the future (the forward price) is higher than the current market prices. Alternatively the contract could be left in place, with a physical delivery of oil or oil products on the intended delivery date.

The term ‘strategic storage’ is used to describe a crude oil inventory which is stockpiled by the government of a particular country, providing economic security in the event of an energy crisis. The US Strategic Petroleum Reserve is one of the largest such reserves, with a capacity of 727 million barrels owned by the US federal government and held in underground salt caverns along the coastline of the Gulf of Mexico. A typical target for governments is the retention of a crude oil inventory equivalent to 90 days of net oil imports.

3. LNG, LPG and gas storage

LNG which is unloaded from an LNG ship at an unloading port can go into a purpose-built refrigerated storage tank as LNG, rather than proceed straight to the process of regasification, and can be later released from that storage and regasified when needed. The residence time for such LNG storage is typically relatively short, however, which in part reflects the operational necessity of keeping LNG flowing through an import terminal.

Gas can also be offtaken from a pipeline, liquefied to give LNG and stored as such (with the attendant volume reduction from the gas liquefaction process which allows greater volumetric storage capacity) and then regasified and released back into the pipeline as gas when needed.

LNG storage facilities could be owned and operated directly by the person requiring access to them, or could be owned by a third party and the capacity made available to an LNG owner as a storage customer through a form of storage services agreement.

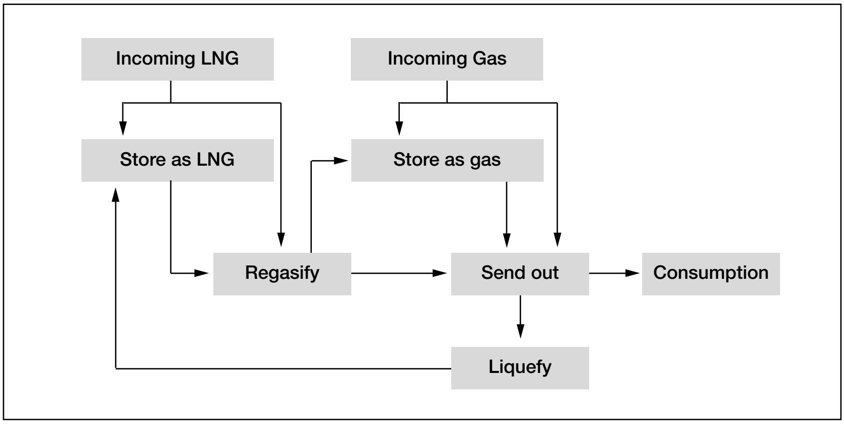
Natural gas can be stored against future use requirements in specifically constructed steel or concrete surface gas storage tanks (sometimes called gasometers or gas holders). The gas is stored at atmospheric pressure and ambient temperature, and the volume of the storage tank is directly related to the quantity of stored gas since the storage tank typically has a moveable cap which goes up and down according to the quantity of gas in store. Natural gas held in a pipeline as linepack is also, essentially, gas in storage, although the principal purpose of a pipeline in the transportation of gas, rather than its storage.

LPG is also stored in specifically manufactured cylindrical surface storage tanks, known variously as pressure tanks or bullets.

Such storage tanks could be owned and operated directly by the person requiring access to them, or could be owned by a third party and the capacity made available to a gas owner as a storage customer through a form of storage services agreement.

The conventional view of natural gas sales and transportation arrangements is that gas will be produced, sold, transported and consumed according to the immediacy of the prevailing market demands.

It may be, however, that natural gas (which could be raw gas produced direct from a reservoir or regas delivered from regasified LNG) is not consumed, but instead



is injected into a special underground natural gas storage facility (onshore or offshore), to be redelivered at a later date when market demands dictate. This is the essence of gas storage, which is a means of holding a gas inventory for release into an energy market when it is most needed.

The options for storing natural gas and LNG can be expressed by the schematic shown on the previous page.

4. Underground gas storage

Underground gas storage is a form of flexible gas supply which supports the ability of a gas supplier to meet gas demand on a daily, weekly, monthly or seasonal basis and can be invaluable in response to the challenges posed by supply constraints, adverse weather conditions, operational problems or geopolitical issues which might otherwise interrupt the free flow of gas into a market.

Any underground gas storage facility (whether onshore or offshore, and of whatever structure (see below)) is founded on the principle of putting gas in, storing gas and taking gas out when needed, according to the demands of the market. Any such facility will be based on a common set of features:

- Cushion gas and working gas – the facility will contain a permanent gas inventory (cushion gas, also called base gas) which remains in the facility at all times, as an essential operational buffer between the hardware of the facility and those volumes of gas (working gas) which are put (or injected) into and taken out (or redelivered) from the facility according to the needs of the gas supplier. Cushion gas could be owned or leased by the storage facility owner.

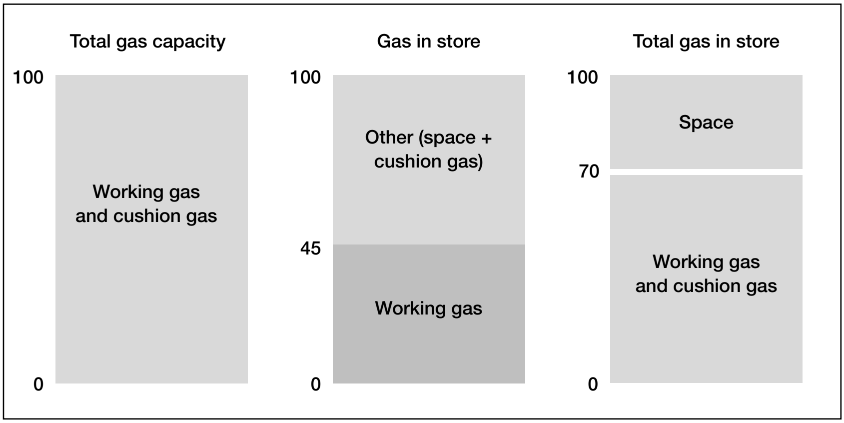
The term total gas capacity is used to describe the notional cushion gas and working gas capacity in a facility, the term 'gas in store' accounts for actual working gas (but not cushion gas) in store and 'total gas in store' describes how much cushion gas and working gas actually resides within the facility at any one time, all as illustrated within the schematic[1] shown on the following page.

- Cycling, deliverability and duration – working gas will be injected into and redelivered from the facility through the process of cycling (also called turnover). The cycle rate represents the number of times in a given period of time that the entirety of a facility's working gas capacity can be so cycled.

  The term 'deliverability' is used to describe the volume of gas which can be redelivered from the facility in a given period of time – this measure of deliverability will vary according to the particular facility, since the rate of deliverability will be at its greatest when the total gas in store is at its highest, and will drop off as the facility depletes.

  The term duration is used to describe the time which it takes to redeliver the total working gas capacity from the facility.

1 The schematic is merely illustrative. The practical reality is that within any gas storage facility gas molecules will be commingled and the gas will always expand to fill the available storage space. Cushion gas and working gas interests will only be so segregated as a matter of notional accounting and a gas-free void is an operational impossibility.



A larger volume gas storage project will inevitably have a longer duration, but this is not an absolute measure of performance – as a rule of thumb, doubling the rate of deliverability will halve the duration, and halving the rate of redelivery will double the duration.

- Shape – this term is used to define each facility's often unique combination of cushion gas and working gas capacities, cycle rates, rates of deliverability, proximity to market, operating costs and available infrastructure, to give an overall picture of that facility's inherent flexibility and capability. Different gas storage facilities have different shapes, making them suited for different roles, and a gas storage sector participant could have interests in multiple facilities in the interests of building a wide and flexible gas storage portfolio.
- Values – the economic profile of a facility is often defined according to extrinsic values (ie, by reference to the cycle rate of a facility which is able to access and arbitrage short-term gas supply and demand variations and price volatility for a profit) and intrinsic values (ie, by reference to the ability of a facility to take advantage of seasonality (see below) and forward gas price differentials over longer term spreads, without taking extrinsic values into account). Intrinsic values, at least notionally, have greater external price visibility than extrinsic values.
- Seasonality and range – a facility might be used to meet seasonal gas demand variations, where gas will be sourced and injected during summer months (where there will be the expectation of lower demand and lower prices) and redelivered during winter months (where there will be the expectation of greater demand and higher prices), on a single, annual cycle. This is seasonality. This principle of seasonality applies where gas is consumed as a fuel for heating in winter months. The opposite cycle of seasonality would apply where gas is consumed as a fuel for air-conditioning and district cooling during summer months. It may also be that a particular market demonstrates both seasonal cycles within a single year.

  Gas storage facilities are also sometimes classified as long-range storage (LRS), medium-range storage (MRS) or short-range storage (SRS). What constitutes LRS, MRS and SRS is somewhat opaque, and these definitions are relative rather than absolute. The UK gas regulator, Ofgem, uses the following definitions, based on the length of time taken by a facility to deliver all of its working gas volume at full capacity:

- SRS – up to five days;
- MRS – between five and 70 days;
- LRS – more than two months.

The only safe thing to say in defining the range of a particular facility is that medium is longer than short, and long is longer than medium. LRS, MRS and SRS each operate on the same curve; it is only the amplitude which is different. Typically, LRS facilities are operated to take advantage of seasonality. SRS facilities benefit from much faster cycle times, even including the possibility of within-day flexibility. It is also possible for a single facility to combine LRS, MRS and SRS range characteristics.

Three types of structure can be considered for use as an underground gas storage facility – depleted gas reservoirs, salt caverns and aquifer reservoirs. Each type of facility possesses distinct physical and economic characteristics which determine the suitability of a particular type of facility for a given gas storage application:

- Depleted gas reservoirs – these are onshore or offshore reservoirs from which economically recoverable reserves of gas have been produced (subject to the remainder of any residual native gas). The reservoir is readily capable of storing injected gas and using such a facility is economically attractive because it allows the re-use, with suitable modification, of the extraction and distribution infrastructure remaining from the productive life of the original gas field, which reduces project start-up costs. Depleted gas reservoirs are attractive because of their known porosity and permeability; their geological and physical characteristics have benefited from previous study and so are already understood. Consequently, depleted gas reservoirs are generally the cheapest and easiest to develop, operate and maintain of the various types of underground gas storage facility. In a depleted gas reservoir the native gas originally in the reservoir could also be kept as cushion gas and the further injection of gas might not be needed, unless gas from the reservoir has been produced beyond the level of the required cushion gas volume.
- Salt caverns – these onshore or offshore facilities are developed from discovered underground salt deposits. Once a suitable salt deposit is discovered and found to be suitable for the development of a gas storage facility a cavern is created within the salt deposit. This is done by the process of salt leaching, whereby fresh water is pumped down a borehole into the salt deposit. The inherent salt is dissolved, leaving a void, and the salinated water is pumped back to the surface. This resultant void is a cavity which will be used for the storage of gas. Salt caverns are usually smaller than depleted gas reservoirs and consequently salt caverns cannot ordinarily hold the volumes of gas necessary to meet large volume and/or long duration gas storage requirements.

- Aquifer reservoirs – these are underground porous and permeable rock formations that act as natural water reservoirs and which, in some cases, can be used for gas storage. The geological and physical characteristics of an aquifer reservoir are not generally known ahead of time and significant investment has to go into investigating these and evaluating the aquifer reservoir's suitability for gas storage, and into developing topsides gas infrastructure, which can make for an expensive and uncertain project.

With salt caverns and aquifer reservoirs all of the associated sub-surface and surface infrastructure typically has to be developed from scratch, increasing the development costs of the project compared to a depleted gas reservoir project. This includes the drilling of wells and the installation of gas injection and redelivery equipment and takeaway pipelines.

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