Underground Gas Storage Terminology

Annual Cycling Capability: The ability of an UGS facility to cycle its rated Working Gas Capacity over one year. The Annual Cycling Capability ranges from 1 (180 day service) to 18 (10 day service).

Areal Extent of the Storage Structure: Subsurface area of the depleted reservoir formation or pool. This area is usually defined by 3D seismic, structural mapping, well log information, and volumetric calculations. In a water drive reservoir the Areal Extent of the Storage Stucture is very large compared to that portion of the structure containing the gas. Note that the areal extent of the Gas In Place when the gas is pressured up to the Maximum Allowable Storage Pressure will usually be smaller than the Areal Extent of the Storage Structure.

Aquifer Storage Field: The underground storage of natural gas in a porous and permeable rock formation topped by an impermeable cap rock, the pore space of which was originally filled with water. Acquifer storage by definition involves delta-pressuring above the hydrostatic pressure gradient in order to displace the formation water and it involves the injection of significant cushion gas relative to the working gas capacity, of which most is not recoverable. This is the least preferable method of gas storage for both the risks and the costs are high relative to other methods. An aquifer is suitable for gas storage if the water bearing sedimentary rock formation is overlaid with an impermeable cap rock. While the geology of aquifers is similar to depleted production fields, their use in gas storage usually requires more base (cushion) gas and greater monitoring of withdrawal and injection performance. Deliverability rates may be enhanced by the presence of an active water drive

Backhaul: Notional flow of gas accomplished by exchanging gas that is nominated to flow in the opposite direction of the physical flow (usually in a gas pipeline but also in a gas storage facility). Backhauls essentially create additional capacity in any facility and should be charged accordingly or failing that the secondary market will arbitrage this activity.

Balancing Storage Service: Storage service used to equalize receipt and delivery quantities of gas on an hourly, daily, weekly, monthly, or seasonal basis. Hourly and daily balancing is generally used to equalize receipts and deliveries on a pipeline system while longer term balancing services pertain to customer specific load patterns or supply outages

Base Gas: (see Cushion Gas**)**

Baseload (Seasonal) Storage Service: Primarily seasonal storage service where gas is injected and stored over a 7 month period and then withdrawn over a 5 month period. This service utilizes one cycle or turnover of working gas

capacity per year and is typical of gas reticulation companies serving a residential heating load. This type of storage is ofen referred to as 1 cycle or 180 day storage.

Bedded Salt: Bedded Salt refers to either a relatively thin layer or a combination of stacked thin layers of underground salt. Bedded Salt is not nearly as attractive as Salt Domes for the creation of caverns for the purposes of gas storage. Caverns created in Bedded Salt tend to be smaller and of irregular shapes and sizes, thereby costing more on a per working gas capacity basis and resulting in a less stable pressure vessel.

Brining: See Solution Mining

Buffer Zone: A subsurface zone that extends beyond the mapped reservoir pool boundary or at least beyond the Gas Cap Boundary acquired by an UGS operator to ensure adequate protection against exploration and production activity that might conflict in the future with the actual reservoir boundaries or a surface zone that extends beyond the surface area required for storage related surface facilities acquired by an UGS operator in order to prevent future conflict over incompatible uses of the land, noise complaints, odour complaints, etc. The difficulty of recovering escaped gas, physically or financially argues for ample buffer zones around the estimated boundaries of the UGS pool or formations.

Caprock: Sealing formation overlying a Porous Storage Pool that prevents gas migration. While the porosity and permeability of the Caprock is very low, it does exist and consequently a small and often negligible amount of Injected Gas may be absorbed in the Caprock under Delta-Pressuring conditions.

Cavern Convergence: Reduction in geometrical cavern volume caused by e.g. salt creeping. The annual reduction of the geometrical cavern volume is expressed by the convergence rate.

Cavern Creep: The phenomena whereby the salt walls of a salt cavern slowly flow due to stresses associated with either the cycling of natural gas or due to tectonic activity. Also refers to the natural self-sealing characteristic of salt whereby fissures or fractures created by drilling and dissolution processes will heal and a sound permeability seal will be reestablished in a relatively short time frame.

Cavern Fill Rate: The time it would take to fill the cavern based on the working gas capacity and the injection capacity – usually 20 days.

Cavern Spacing: The spacing between any two salt caverns should be sufficient to prevent any risk of the caverns communicating over time. The minimum Cavern Spacing for salt caverns used for cycling natural gas is

Closure: Vertical distance between the top of the structure and the Spill Point.

Commercial (open access) Gas Storage Facility: An underground gas storage facility that is essentially open for customers to generally use, subject to agreed upon services and contracts. Gas storage facilities that are owned by gas producers for strictly their own proprietary gas production are not considered to be commercial gas storage facilities and may not enjoy all of the economic benefits afforded to other facilities.

Coning: Coning refers to the phenomena of pulling liquids (oil or water) into I/W Wells; thereby hindering gas storage operations. Coning occurs when drawdown pressures around the wellbore when withdrawing gas from a gas storage reservoir are excessive. Horizontal wells can mitigate or reduce this issue as does the location of I/W Wells at sufficiently structural high points in the reservoir away from liquid contacts if possible.

Containment (Hydraulic Integrity): Ability of the storage reservoir or cavern and the storage well(s) to contain all Injected Gas and Native Gas over the life of an UGS project to an acceptable degree. While there are a number of variables that determine the degree of Containment, gas losses in UGS projects are often negligible over an extended life of cycling and storing gas, even under delta-pressuring conditions. It is important to verify Containment initially and to monitor any and all deterioration to Containment over the storage project's life and operating conditions. Containment should not be confused with bypassed gas losses inherent with gas cycled in strong water drive reservoirs.

Cost of Service Storage Rates: Gas storage service rates charged by the storage owner/operator to its customers based on the actual costs of providing the service (including a fair return on capital) generally set by a regulator. Capacity related costs are usually derived from book asset values and commodity related costs are as incurred.

Commodity Charge: see Variable Charge

Condemnation of Property Rights: Some states in the USA have statutory provisions that allow utilities and in some cases non-utilities, the right to acquire the necessary rights for the development of UGS facilities through a condemnation process. Such rights exist due to the fact that storage developers must acquire rights from all surface owners, mineral owners, lessees, and royalty owners usually in numerous tracts of land prior to developing an UGS project and therefore can easily be frustrated. Since the development of UGS generally serves the overall public interest, condemnation rigthts exist to assist in the process. During the operation of UGS facilities, again some but not all states in the USA permit the storage operator to condemn any property rights reasonably

necessary to operate and protect the storage project, including producing wells in a buffer zone around the project.

Cushion gas: The quantity of natual gas held within the confines of the underground gas storage container intended as permanent inventory required for reservoir management purposes and to maintain an adequate Minimum Storage Pressure. Cushion Gas is rarely, if ever, produced and the amount of Cushion gas required is dependent upon the reservoir quality, number of injection/withdrawal wells, gas withdrawn schedule, amount of compression, and field operating parameters. The Cushion Gas volume may consist of recoverable and non-recoverable in-situ gas volumes and injected gas volumes. One of the largest cost components for an UGS project is the purchase of Cushion Gas prior to placing the facility into service. UGS facilities tend to have a long operating life thereby destroying the present value of the ultimate recovery and sale of Cushion Gas. One of the ongoing optimizations of any UGS project is to balance the Cushion Gas requirements and costs related thereto with the costs of additional installed compression that would be required to lower the Cushion Gas requirement. The ratio of Cushion Gas to Working Gas Capacity or to Total Gas Capacity has a significant impact on the economics of storage operations due to the upfront capital and carrying cost of this gas inventory. Typically Aquifer gas storage has a very high Cushion Gas requirement (80% of the Total Gas Capacity), Depleted reservoir gas storage has the next highest requirement (30% to 70% of the Total Gas Capacity) and salt cavern gas storage has the lowest Cushion Gas requirement (typically 20% to 30%).

Cycle: One storage cycle is the theoretical time required to completely inject and withdraw the working gas quantity for any given underground gas storage facility or the turnover time for the working gas capacity rating of the facility. The cycle rate of any storage facility is usually expressed in cycles per year and is the number of times the working gas volumes can theoretically be turned over each storage year. The cycle rating for Porous Storage varies from 1 to 6 per year while that for Salt Cavern Storage are as high as 12 per year.

Days Service: The Days Service is another manner in which to describe the capability of an UGS facility or the rights of a storage customer pursuant to a Firm Gas Storage Service contract to cycle working gas capacity. The Days Service refers to the number of days required to completely withdraw the Maximum Working Gas Inventory associated with a facility or a storage contract. The following table matches Days Service with Annual Cycling Capability:

# Days Service	Annual Cycling Capability
10	18
30	9
60	4
90	2
150	1

Deliverability: see Withdrawal Rate

Delta-Pressuring: The practice of operating an underground gas storage reservoir at a maximum pressure greater than the discovery pressure associate with that reservoir, for the purposes of increasing both the Working Gas Capacity and Withdrawal Rate. While not applicable to every gas storage reservoir, generally accepted Delta-Pressuring in the gas storage industry is up to 160% of the hydrostatic pressure gradient. The fracture pressure for the region, the integrity of the sealing formations, spill points, containment properties, etc have to be considered and quantified in order to obtain regulatory approval to Delta-Pressure a storage reservoir. As discussed under Hydrocarbon Pool, the best candidates for Delta-Pressuring are Hydrocarbon Pools formed by stratigraphic traps, particularly those with a Discovery Pressure Gradient that is much lower than the Hydrostatic Pressure Gradient

Depleted Reservoir Storage Field: A sub-surface natural geological reservoir, usually a depleted gas or oil field, used for the primarily for the storing and cycling of natural gas. The economically recoverable reserves have usually been nearly or completely produced prior to the conversion of the reservoir to gas storage operations. The integrity of the reservoir has been demonstrated throughout the primary production stage of operations and then verified by extensive gas injection/withdrawal testing.

Depth Top of Structure/Cavern Roof Depth: The true vertical depth from the surface down to the top of the storage formation or salt cavern roof.

Discovery Pressure Gradient: The pressure gradient of the original pressure in a given reservoir at the time of its discovery. The Discovery Pressure Gradient of a reservoir is commonly equal to the Hydrostatic Pressure Gradient; a reservoir is classified as over-pressured if it was discovered at a Discovery Pressure Gradient that exceeds the Hydrostatic Pressure Gradient and a reservoir is classified as under-pressured if it was discovered at a Discovery Pressure Gradient that is less than the Hydrostatic Pressure Gradient. For the purposes of UGS operations, it is important to note that an under-pressured reservoir is by definition well sealed, depletion drive, and the Delta-Pressuring of the reservoir has a more pronounced effect on the amount of Gas In Place that the reservoir can hold relative to the original gas in place.

Displacement or Backhaul: Describes the notional transaction of gas flows into or out of a gas storage facility, as the case may be, due to offsetting coincidental injection and withdrawal requests or nominations by two storage customers at any time.

Dual Flow Meter Station: A gas meter station connecting an UGS facility to each and every interconnecting gas pipeline. This meter station is the custody transfer point for the storage facility and therefore must be acceptably accurate in terms of both energy content and volumes.

Easements: Right-of-ways must be acquired and maintained by UGS operators in order to accommodate the construction and operation of all Storage Subsurface Facilities.

Efficiency Ratio: One of many indicators used for rating and comparing UGS facilities and is the ratio of the Working Gas Capacity to the Total Gas Capacity. The average Efficiency Ratio in the US is approximately 50:50 but may be as high as 80:20 for best in class storage operations.

Firm Storage Services: Entitles the holder of a firm storage contract to store a specific contract quantity of working gas in a storage facility with a guarantee for delivery to and re-delivery from the storage facility on terms specified in the contract (the ratchets) in consideration for the payment of the demand and commodity rates stipulated in the contract.

Flow Lines: Large diameter pipelines (often 24" O.D.) that are used to both collect previously stored gas from the I/W wells during the withdrawal or production stage of the storage cycle and to distribute gas sourced from gas pipelines and/or production facilities to the I/W wells during the injection stage of the storage cycle. The flow lines essentially connect the I/W wells to the compression and gas processing facilities. In the event of multiple reservoirs or caverns on any given UGS site, it is a common practice to be able to isolate the flow lines to enable the compression to be dedicated to any one underground reservoir or cavern. Such a configuration has a higher capital cost but significantly lowers operating costs and allows a higher performance of the overall storage facility.

Fracture Gradient: The pressure gradient for any given region determined by rock mechanics at which the overburden fractures thereby causing fissures and cracks that temporarily and possibly permanently destroy the integrity of the reservoir or salt cavern. The Fracture Gradient is usually around 1.0 psi/ft.

Gas Cap Boundary: The estimated and mapped outer edge of the space in a reservoir occupied by the Maximum Gas In Place. It is important for a gas storage operator to ensure that there is adequate confidence in the Gas Cap Boundary.

Gas Hub (Market Centre): A transfer site or system where several gas pipelines interconnect and where pipeline customers may obtain various services to manage and facilitate the routing of gas supplies from production areas to markets. One of the services typically available at a Gas Hub is underground

gas storage. The greater the liquidity of any particular Gas Hub (unconstrained access of stored gas and storage capacity to pipeline takeaway and delivery capacity respectively and to multiple counterparties) the greater the value for storage services at that Gas Hub. Gas Hubs may be located in predominantly gas producing regions or in predominantly gas market regions. Hubs are characterized by the free inter-change of gas between market participants (price transparency and liquidity) and usually have both physical and financial services. The availability of a material UGS facility at a Gas Hub greatly facilitates trading and marketing of natural gas services. Canada has 9 well established Gas Hubs and the USA has 28. The development of Gas Hubs has been promoted and encouraged in the North America since 1993 as a necessary tool that creates greater efficiency in the gas industry. Gas Hubs offer three major functions: physical deliver; information and services; and paper trading.

Gas In Place (Gas Inventory): At any time the total quantity of gas contained in any underground gas storage facility is the Gas In Place and is equal to the sum of the Net Injected Gas and the Remaining Native Gas.

Gas Migration: The movement of Injected Gas either into sections of the reservoir that did not previously contain gas (i.e. over Spill Points or coning behaviour through liquid contacts which may result in a permanent loss of gas) or into other formations due to either fracturing of the Caprock or lack of hydraulic isolation behind well casing which will definitely result in a permanent loss of gas.

Gas Storage Year: Defined in North America as the consecutive 12 month period from April 1 to March 31. The Gas Storage Year is defined by the continental gas market wherein the UGS facility is located and usually begins with the predominantly Injection Season.

Header Pipeline (Storage Manifold): The gas pipeline connecting the UGS facility with one or more connecting gas transmission pipelines. The Header Pipeline is usually owned and operated by the storage owner/operator and is commonly 42” OD and often 10 to 30 miles in length. The cost of a Header Pipeline can be material and minimized by the location of UGS projects vis-à-vis gas pipeline systems and Gas Hub related infrastructure.

Heat Content: The heat content is usually expressed as Btu/Scf and tends to vary over time in UGS depleted reservoir storage operations due to the commingling of Injected Gas with Native Gas.

Hydrocarbon Pool: A Hydrocarbon Pool is essentially an underground trap that is filled with gas or oil or both. Hydrocarbons migrate from a source or “kitchen” and are trapped underground in a container formed of porous rock. The trapping mechanism can be classified into two types: structural and stratigraphic traps. All traps consist of a porous rock sealed overhead by an impermeable rock layer

called a Caprock and sealed laterally either by impermeable rocks (stratigraphic trap) or by structural closure (structural trap). Furthermore most structural traps do not have a bottom seal, a particular concern when Delta-Pressuring such a reservoir for the Injected Gas under such conditions may push down the gas/water or gas/oil contact, as the case may be, and leak out of the trap at the Spill Point. Conversely, in a stratigraphic trap the container for the hydrocarbon is formed by lateral and vertical changes in rock type, within the same formation. In most stratigraphic traps the porous reservoir is completely surrounded by non-porous material and therefore makes excellent underground gas storage containers (low Cushion Gas requirement, good Delta-Pressuring potential and excellent Containment features).

High Deliverability Multiple Cycle (HDMC) Storage: A depleted reservoir storage facility whose design allows a relatively quick turnover of the working gas capacity and therefore multiple cycles per year or a Salt Cavern Storage.

Hydrostatic Pressure Gradient: The hydrostatic pressure gradient is 0.433 psi/ft.

Injection Capacity (or rate) is the complement of the deliverability or withdrawal rate - it is the amount of gas that can be injected into a storage facility on a daily basis. Injection capacity is usually expressed in MMcf/d, Bcf/d, TJ/d or PJ/d and typically stated as the maximum or peak daily injection capacity available when the storage container is at the minimum operating pressure. The injection capacity of a storage facility is also variable, and is dependent on factors comparable to those that determine deliverability. By contrast, the injection rate varies inversely with the total amount of gas in storage: it is at its lowest when the reservoir is most full and increases as working gas is withdrawn. When benchmarking storage facilities the injection capacity is usually stated as a percent (%) of the working gas capacity.

Injection/Withdrawal (I/W) Wells: Large diameter and often horizontal Infill wells associated with UGS facilities required to quickly cycle large volumes of gas into and out of the reservoir or cavern. In high quality reservoirs (i.e. high permeability and good radial flow characteristics), each I/W well can be capable of maximum rates in excess of 100 MMcf/d. Horizontal I/W wells are often 11 5/8’ in O.D. and have a horizontal interval exceeding 500’. One vertical well (usually 13 5/8” to 20” OD) per cavern is required for gas storage operations utilizing a salt caverns.

I/W Well Damage: The deterioration of performance of I/W Wells due to a number of possible causes including: fines migration, scale build-up, water coning, etc. This can be identified by history matching of actual performance to that expected from modelling.

Injected Cushion Gas: The portion of the Cushion Gas requirements supplied by Injected Gas as opposed to Native Gas.

Injected Gas: Natural gas that is injected into a storage reservoir, aquifer, or salt cavern from extraneous sources in order to bring the reservoir or cavern pressure and volume of Gas In Place up to the desired level. It is important to note that Injected Gas had a pipeline gas market value at the time of injection and that Injected Gas may or may not remain the personal property of the UGS operator if it strays or migrates to another formation (uphole or downhole communication) or to sections of the storage formation that are not covered by the subsurface storage rights. Whether or not there is protection in this regard for the storage operator is specific to the jurisdiction where the facility is located.

Injection Season: The continuous period in any given Gas Storage Year that is characterized by a general surplus of gas production capacity to gas demand requirements (i.e. a lower than average gas price or contango forward price environment). The Injection Season extends from April 1 to Oct 31 in North America.

Interruptible Gas Storage: Storage services which are superseded by firm storage services (i.e. available on an as available basis)

Last Day Withdrawal Rate: Withdrawal rate which can be delivered based on the installed subsurface and surface facilities and technical limitations when the storage reservoir or cavern is at or close to its cushion gas volume.

Load Factor: The load factor pertaining to UGS operations is the physical turnover of working gas volume over any period divided by the theoretical capacity to turnover the maximum amount of working gas volume in that same period. The load factor tends to decrease as the ability to cycle gas increases (i.e. seasonal storage or 1 cycle storage has the highest load factor).

Market Area (Downstream) Storage: UGS facilites located in regions of a continental gas market which are in relative close proximity to the major markets (predominantly a gas demand region). UGS facilities originated in North America in the 1930's and as Market Area Storage facilities developed and operated by gas distribution and gas pipeline companies. Currently Market Area Storage comprises less than 50% of the total gas storage capacity in Canada and approximately 70% of the total gas storage capacity in the US. These storage facilities are located generally downstream of the major gas pipeline network and therefore have access to Backhaul pipeline capacity throughout the year.

Market Based Storage Rates: Rates for storage services charged by a storage owner/operator to storage customers from time to time based on market conditions and what customers are prepared to pay for those services (what the market will bear). In the US gas storage is highly recognized as a tool that

serves the public interest and therefore a market power test must be met prior to the granting of the right to charge customers market based storage rates. The FERC and various state jurisdictions may approve market-based rates where the market is sufficiently competitive to preclude the exercise of market power and to ensure just and reasonable rates. The US is relaxing the rules associated with this test as the market matures and regional inter-connections improve. Canada is much more liberal than the US in the permission of charging market-based storage rates. Storage operators in both Canada and the US of Supply Area Storage tend to be able to charge market-based rates without attracting the attention of regulators.

Maximum Allowable Storage Pressure: The maximum operating pressure permitted in the reservoir or cavern, as the case may be, as stipulated from time to time in the storage licence or permit. The Maximum Allowable Storage Pressure ensures that the integrity of the reservoir or cavern is maintained and this pressure is reached at the end of the injection cycle or when the Working Gas Inventory equals the Working Gas Capacity and the Total Gas Inventory equals the Maximum Gas In Place. The Maximum Allowable Storage Pressure for a Salt Cavern is often equal to 80% of the Fracture Gradient times the vertical depth from surface to the top of the Salt Cavern.

Maximum Gas In Place: The quantity of natural gas in a salt cavern or a reservoir when at the Maximum Allowable Storage Pressure.

Maximum Wellhead Injection Pressure: The maximum allowable wellhead pressure under gas injection mode in order to not exceeed the Maximum Allowable Storage Pressure.

Monthly Capacity Demand Charge: The amount a gas storage operator (Lessor) charges on a monthly basis to each storage customer (Lessee) for their contracted firm storage capacity over the term of any storage leasing agreement. Usually expressed in $/Mcf working gas capacity/month when charges based on the contracted working gas space. This space or working gas capacity charge is payable regardless of the utilization of that space by the Lessee for it reflects the fixed costs associated with making storage services available.

Monthly Deliverability Demand Charge: The amount a gas storage operator (Lessor) charges on a monthly basis to each storage customer (Lessee) for their contracted firm storage deliverability capacity over the term of any storage leasing agreement. Usually expressed in $/Mcf maximum deliverability capacity/month when charges based on the contracted maximum daily withdrawal rate. This demand charge is payable regardless of the utilization of the right to withdraw gas by the lessee for it reflects the fixed costs associated with making storage services available.

Monthly Injection Demand (Charge: The amount a gas storage operator (Lessor) charges on a monthly basis to each storage customer (Lessee) for their contracted firm storage injection capacity over the term of any storage leasing agreement. Usually expressed in $/Mcf maximum injection capacity/month when charges based on the contracted maximum daily injection rate. This demand charge is payable regardless of the utilization of the right to inject gas by the Lessee for it reflects the fixed costs associated with making storage services available.

Minimum Storage Pressure: Minimum pressure of the storage reservoir or cavern, normally reached at the end of the decline phase of the withdrawal profile. The minimum pressure is related to a reference/datum depth. The minimum pressure of salt caverns has to be engineered and approved in order to ensure stability. The Minimum Storage Pressure is also determined by the required delivery and injection rates over throughout the storage season given the performance of the installed surface and sub-surface equipment.

Native Cushion Gas: Natural gas originally present in the reservoir and remaining after initial depletion of the reservoir to the stage of its conversion to gas storage purposes. Native Cushion Gas is comprised of both recoverable and non-recoverable native gas. The presence of Native Cushion Gas helps minimize the requirement for Injected Cushion Gas. Native Cushion Gas is only applicable to depleted reservoir storage and the recoverable portion of the native cushion gas is recoverable when the storage facility is taken out of service.

Native Gas: All remaining indigenous gas in place at the time that a reservoir is converted into an UGS facility. This amount may be simply the original unrecoverable gas in place as would be the case of converting a reservoir that has been fully depleted or it may be a combination of unrecoverable and yet to be recovered gas as is the case when the reservoir of converting a partially depleted reservoir. It is important to note that the interests of all royalty owners and lessees of any remaining recoverable hydrocarbons must be compensated for the impact of suspending hydrocarbon production operations for a long period of time in order to convert the reservoir into an UGS operation. If the storage developer is not the lessee of the petroleum rights then the developer must acquire the reservoir from the parties who have the P&NG rights. Furthermore, the royalty owners of any remaining recoverable hydrocarbons typically continue to be compensated as if the production operations were not suspended and until all of the remaining recoverable hydrocarbons have been notionally produced.

Net Injected Gas: The net amount of injected gas at any given time in the underground gas storage facility. It is important to monitor this quantity over numerous storage cycles in order to ensure the integrity of the underground gas storage container. The Net Injected Gas is usually plotted over time from the commencement of gas storage operations until the retirement of the facility. Net

Injected Gas is commonly comprised of Injected Cushion Gas and Injected Working Gas.

Nominal Withdrawal Rate: Withdrawal rate representing the deliverability of the subsurface and surface facilities available over an extended period of withdrawal (plateau period). This rate corresponds to the constant rate period of the withdrawal profile.

Offsetting Coincident Storage Service Requests: Requests for gas storage services (gas withdrawal or injection) by a number of gas storage customers at a given UGS facility that result in notional transactions rather than physical flow to meet some or all of the service requests. Offsetting Coincident Storage Service Requests offer many cost saving and other profit enhancement advantages to an UGS operator.

Operating Pressure Gradient: The pressure gradient expressed in psi/ft that is selected upon which to base the Maximum Allowable Storage Pressure upon.

Open Season: The process whereby the developer of a greenfield UGS facility or the owner/operator of an existing UGS facility solicits the interest of customers regarding a commitment to and pricing of various gas storage services. Minimum acceptable rates are established and maximim rates and maximim contract trems are also specified. The beginning and ending dates for the open season must be established and capcity must be awarded based on the discounted present value (price, term) of the rates bid by interested parties. Some regulatory bodies, such as the FERC in the US, require that an open season be used for allocating storage capacity in the marketplace for it limits the potential for discriminatory rate and service preferences. Also used by operating UGS facilities whereby a period of time is alloted wherby all parites are given equal opportunity to contrct for storage services.

Peak Withdrawal Rate: Maximum flow rate which can be delivered based on the installed subsurface and surface facilities and technical limitations. This flow rate is normally reached when the storage is at its maximum working gas volume, i.e. maximum allowable storage pressure. Also known as ‘maximum design deliverability’ this rate is often expressed as a % of the Maximum Working Gas Capacity in order to compare the ablility of a gas storage facility to cycle gas (ranges from less than 2% for depleted gas storage facilities to 9% for salt caverns).

Peaking Storage Service: Storage used to meet sudden spikes in demand or to monetize daily gas price volatility. Peaking service is generally 30 to 50 day high deliverability service.

Porous Storage: An UGS facility that utilizes a porous reservoir for an underground container as opposed to a cavern. Porous Storage involves the

flow of gas into and out of a porous medium that is often have heterogeneous flow characteristics (permeability and porosity) as well as numerous other pressure drawdown and buildup implications. Porous Storage utilizes either an aquifer or a Hydrocarbon Pool. Porous Storage facilities are characterized by many I/W Wells and a much lower gas cycling ability than that of Salt Caverns Storage. Porous Storage has a development capital cost advantage over Salt Cavern Storage, lower operating costs, and the ability to store a higher Working Gas Inventory.

Porous Storage Drive Mechanism: The energy drive mechanism that exists and enables the withdrawal of Injected Gas in a Porous Storage configuration is either depletion drive or water drive. By far the most preferable is a depletion drive mechanism that is well demonstrated by material balance techniques (P/z Vs cumulative production graphs). A depletion drive will result in predictable gas storage behaviour and performance over the life of the storage facility as long as the Hydraulic Integrity of the reservoir is not compromised. The advantage of a water drive is less Cushion Gas requirement but the loss of Injected Gas can be material.

Pressure Datum Level: Reference depth at the porous storage level, normally related to the sea level, used for pressure normalisation and correlation throughout the reservoir. In caverns the depth below surface of the last cemented casing shoe is normally used as the reference level for pressures.

Pressure Observation Wells: Wells that either periodically or continuously monitor the bottom hole pressure in the underground storage reservoir. It is important to monitor pressures in order to maintain proper gas inventory accounting and to ensure that no material gas losses exist.

Ratchets: Some, but not all, storage contracts contain contractual provisions that change the rights to inject or withdraw gas depending on the inventory in the storage account. This contracting practice reflects the changing physical capabiltiy of the storage facility to inject or withdraw gas as it nears the lower and upper Working Gas limits. For example, many storage contracts contain a clause that reduces the withdrawal rights once the customer inventory is below a certain threshold quantity.

Remaining Native Gas: The amount of remaining indigenous gas reserves in place in any depleted hydrocarbon reservoir upon its conversion to a gas storage operation. The Remaining Native Gas is usually a portion of the Cushion or base gas inventory but may exceed the Cushion Gas requirement.

Recoverable Cushion Gas: The volume of gas that is predicted to be recovered if and when the UGS operations are terminated and the underground container depleted to the abandonment pressure.

Salt Cavern Storage: A storage facility that cycles gas in and out of underground caverns leached, brined or mined in either Bedded Salt or a Salt Dome. Salt Cavern Storage is used to store a number of different liquids or gases but natural gas Salt Cavern Storage is used throughout Canada, the USA and Europe. Salt caverns tend to be of varying sizes and shapes depending on the salt thickness, depth and purity. For example, a conical salt cavern in New York located at a depth of 4000' and a size that is 76' tall, 280' across at the base and 200' across at the top will hold approximately 3 Bcf of gas. Since pure salt is essentially impermeable, a salt cavern has much less risk of gas migration than does a depleted reservoir that is used for storage purposes. In the case of salt cavern storage only the wellbore and the possibility of roof rock fracturing are possible leakage paths from the cavern. Salt Cavern Storage is by definition high deliverability storage or Peaking Storage as opposed to Baseload Storage. **Salt caverns** provide very high withdrawal and injection rates relative to their working gas capacity. Base gas requirements are relatively low. The large majority of salt cavern storage facilities in North America have been developed in salt dome formations located in the Gulf Coast states. Salt caverns have also been leached from bedded salt formations in Northeastern, Midwestern, and Southwestern states of the US as well as in the provinces of Alberta, Saskatchewan and Ontario in Canada.

Salt Domes: Salt domes are diapiric intrusives, more or less cylindrical in form. They can be very thick, relatively pure and quick extensive in areal extent; thereby creating rather ideal conditions for Salt Cavern Storage development.

Seasonal Storage Services: See Baseload Storage Services

Solution Mining (Leaching or Brining): The process whereby fresh water is circulated into a salt deposit in such a manner as to create essentially a pressure vessel or cavern of suitable design to enable the storage and cycling of natural gas in that cavern. The size and dimensions of the cavern are important as well as are adequate distances of undisturbed salt between each cavern and between the cavern floor and cavern ceiling and the neighbouring rock formations. Often diesel or oil is used during the brining process to ensure adequate salt remains above the cavern ceiling. The final cavern capacity is dewatered for operation as a gas storage facility.

Spill Point: Structural point within a reservoir, where hydrocarbons could leak and migrate out of the storage structure. These exist when the gas pool has been formed by a structural trap as opposed to a stratigraphic trap.

Storage Additions: The total volume and energy of gas injected or otherwise added to underground natural gas storage during the applicable reporting period.

Storage Capacity: The present developed maximum operating capacity.

Storage Integrity: The hydraulic integrity of all of the facilities associated with UGS facilities (wells, caverns, reservoirs, flow lines, etc) are of paramount importance on an ongoing basis to ensure safety and loss prevention. Salt Caverns are less likely to have Storage Integrity issues than depleted reservoirs but a single point failure of the well associated with a large salt cavern can result in a major issue due to the infinite permeability of a salt cavern.

Storage Inventory: An amount of working gas held within the underground gas storage reservoir or salt cavern, as the case may be at any given time. This gas may relate to third-party customer volumes or to owner/operator volumes of working gas or both

Storage Withdrawal Capacity: The amount of gas that is or can be removed from a natural gas storage facility – usually expressed in MMcf/d, Bcf/d, TJ/d or PJ/d and typically stated as the maximum or peak daily withdrawal capacity available when the storage container is at the maximum operating pressure. When benchmarking storage facilities the withdrawal capacity is usually stated as a percent (%) of the working gas capacity. Storage Withdrawal Capacity or rate declines as the inventory or Gas in Place declines.

Storage Ratchet: A term commonly used in North America to describe how the right to withdraw and inject gas for a gas storage customer varies with the actual working gas inventory level for that customer. In essence the storage owner/operator obligation to perform (i.e. inject or withdraw gas for a storage customer) varies with the actual performance of the gas storage facility. Storage Ratchets are storage facility specific and they also vary with the cycle rate associated with the storage service (i.e. 1 cycle storage service has a different ratchet than a 2 cycle storage service).

Storage Rights: Special subsurface rights are required in order to either convert a depleted reservoir into an UGS operation or to create a salt cavern or a series of salt caverns for the purposes of an UGS operation.

Storage Surface Facilities: UGS projects require compressor stations for the injection and withdrawal of natural gas, gas treatment facilities, communication facilities for remote operation, a control center and a Dual Flow Meter Station or custody transfer point. Storage Surface Facilities are sized much larger than is typical for gas production operations and their working condition must be maintained at an excellent level in order to mitigate exposure to non-performance risk and costs. One of the largest cost components for an UGS project is compression (installed compression is typically in the order of from 25,000 to 50,000 HP). The longevity and scale of UGS projects is rather unique compared to typical gas production operations.

Storage Subsurface Facilities: UGS projects require injection/withdrawal wells, monitoring wells, water injection wells, Flow Lines, and one or more Header

Pipeline. Storage Subsurface Facilities are sized much larger than is typical for gas production operations and their working condition must be maintained at an excellent level in order to mitigate exposure to non-performance risk and costs.

Storage Withdrawals: Total volume of gas withdrawn from underground storage during the applicable reporting period.

Storage Value: Comprised of Intrinsic & Extrinsic Value components in North America derived by option models that evaluate ones ability to monetize both short term and seasonal gas price volatility using time-spread options. The value of leasing storage capacity to third parties is typically the sum of 100% of the Intrinsic Value and 50% of the Extrinsic Value determined for any given cycle rate, forward price curves, volatility projections, and relevant market hub pertaining to the storage faciltiy.

Stored Gas: All gas physically injected into an UGS facility and part of the gas inventory. Stored Gas excludes all Native Gas.

Subsurface Rights: Storage developers must acquire adequate licences, permits and rights in order to eiter evaluate a depleted reservoir or acquifer for the purposes of building a gas storage or to evaluate the quality of a targeted salt deposit for the purposes of building a gas storage facility. In the case of reservoir or aquifer gas storage the tenure legislation typically is dealt with in the Petroleum Act while in the case of a salt formation the tenure legislation typically is dealt with in the Mining & Minerals Act in the relevant jurisdiction. For numerous reasons subsurface rights pertaining to UGS operations are distinct from those pertaining to either petroleum or mining exploration and production activities. UGS activities do not focus on the recovery of petroleum or minerals but rather on the use of the pore space in the case of reservoirs or the void created by a salt cavern to cycle and store natural gas in. This activity is typically considered to be of higher value to the general public interest than the most efficient recovery of the relevant resources (hydrocarbons or salt) from the relevant footprint. The mineral owner receives an annual payment for the use of subsurface pore space or cavern space as the case may be. It is important to note that most current oil and gas leases and mining leases do not contain storage provisions.

Surface Rights: Storage operators must acquire sufficient long term surface rights to accommodate the construction and operation of Storage Surface Facilities.

Supply Area (Upstream) Storage: UGS facilites located in regions of a continental gas market which are in relative close proximity to the major gas producing operations (predominantly a gas supply region). The development of Supply Area Storage lagged that of Market Area Storage due primarily to the extensive economic regulation of the natural gas industries of both Canada and the US until the 1980's. Since that time extensive Supply Area Storage has been

and continues to be developed by gas producers and independent gas storage operators in primarily Alberta, Texas and Louisiana. Currently Supply Area Storage comprises more than 50% of the total gas storage capacity in Canada and approximately 30% of the total gas storage capacity in the US. These facilities are located upstream of major gas pipelines and their value is linked to the availability of generally excess capacity on those gas pipelines.

Synthetic Storage: The creation of storage like services from

Third Party Storage Capacity: Storage capacity that is leased out to third parties and therefore is not available for the storage owner/operator except on an interruptible basis.

Total gas storage capacity is the maximum volume of gas that can be stored in an underground storage facility in accordance with its design, which comprises the physical characteristics of the reservoir, installed equipment, and operating procedures particular to the site. The Total Gas Storage Capacity equals the sum of the Cushion Gas and the Working Gas Capacity.

Total Gas in Storage: the volume of storage in the underground facility at a particular time.

Total Gas Capacity: The Total Gas Capacity of any underground gas storage facility is equal to the Maximum Gas In Place that can exist in the UGS facility at the maximum downhole operating pressure. The Total Gas Capacity is equal to the Working Gas Capacity plus the Cushion or Base Gas Requirement. The Total Gas Capacity in a depleted reservoir gas storage facility that is delta-pressured can be as high as 200% of the OGIP found in that reservoir at its discovery pressure. The Total Gas Capacity of any UGS facility is determined by the physical characteristics of the reservoir or salt cavern and the Maximum Allowable Storage Pressure. Thus the Total Gas Capacity of an UGS facility can change over time.

Type of Storage: There are several types of underground gas storage facilities, which differ by storage formation and storage mechanism:

Porous rocks
- Storage in aquifers
- Storage in former gas fields
- Storage in former oil fields

Caverns
- Storage in salt caverns
- Storage in rock caverns (including lined rock caverns)
- Storage in abandoned mines

Underground Gas Storage (UGS): All subsurface and surface facilities required for the storage and for the withdrawal and injection of natural gas. Naturally or artificially developed containments in subsurface geological strata are used for the storage of natural gas. Several subsurface storage horizons or caverns may be connected to one common surface facility, which is referred to as the underground gas storage location

Upstream Storage: see Supply Area Storage

Variable (Commodity) Charge: Generally a charge per unit of gas injected and/or withdrawn from storage as per the rights and obligations pertaining to a gas storage lease that is payable each month to the lessor by the lessee. This charge may be a combination of gas shrinkage and $/Mcf and is usually not based on actual costs since whether or not compression is required or notional flows are part of the transaction are irrelevant. Analogous to commodity charges for gas pipeline service.

Withdrawal Profile: Dependency between the withdrawal rate and the withdrawn working gas volume. The withdrawal profile and the time (utilization hours) required for withdrawal are indicative of the layout of an underground gas storage facility. The withdrawal profile usually consists of a constant rate (plateau) period (see 'Nominal Withdrawal Rate') followed by a period of declining rates.

Withdrawal Rate: M**o**st often expressed as a measure of the amount of gas that can be delivered (withdrawn) from a storage facility on a daily basis. Withdrawal Rate may also referred to as the deliverability rate, delivery capacity, or withdrawal capacity and is usually expressed in terms of millions of cubic feet per day (MMcf/day). The Withdrawal Rate of a given storage facility is variable, and depends on factors such as the amount of gas in the reservoir at any particular time (Gas In Place), the pressure within the reservoir, compression capability available to the reservoir, the configuration and capabilities of surface facilities associated with the reservoir, and other factors. In general, a facility's Withdrawal Rate varies directly with the Gas In Place: it is at its highest when the reservoir or salt cavern is most full and declines as Working Gas is withdrawn.

Withdrawal Season: The continuous period in any given Gas Storage Year that is characterized by a general tightening of gas production capacity to gas demand requirements (i.e. a higher than average gas price or backwardation in the forward price curve). The Withdrawal Season extends from November 1 to March 31 in North America.

Working Gas: Natural Gas that has been injected into an UGS facility and stored therein temporarily with the intention of withdrawing it.

Working Gas Capacity: Also referred to as the Stated Capacity and the Top Gas Capacity of a gas storage facility and it refers to the maximum theoretical volume of natural gas that can be cycled in any given gas storage facility under normal operating conditions (minimum to maximum pressure and then back to minimum pressure). This round trip volume may change over time due to facility configuration changes and approved operational pressure ranges and is equal to the Total Gas Storage Capacity minus the Cushion Gas.

Working Gas Inventory: The actual quantity of Working Gas that exists in a storage facility at any particular time, usually expressed in Bcf. This inventory level is frequently reported to the regulator as required. Any gas storage customer specific working gas inventory is also reported frequently to them on an individual basis throughout the term of their storage service contract.