Underground Gas Storage in the European Gas Infrastructure

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Introduction

The underground storage of compressed natural gas (CNG) is an efficient proven common technology in use since 1915.

Underground gas storage (UGS) became an essential indispensable link in the gas supply chain for adjusting gas supply to meet short-term and seasonal changes in gas demand.

Natural gas produced from oil and gas fields is increasingly being used to supply energy requirements. The mainly inflexible gas production from these fields does not match with the variable market demand.

Natural gas is injected into subsurface storage reservoirs when market demand falls below the level of gas delivery or if there is an economic incentive for injection. Gas is withdrawn from storage facilities to supplement the steady supply if demand exceeds that supply or withdrawal is economically attractive.

UGS are designed for long operational lifetime. The construction requires long lead times and is highly capital intensive.

Purpose of Underground Gas Storage

The primary function of underground gas storages is to ensure that supply is adjusted for peak and seasonal demand. Apart from this, the storage facilities can provide stand-by reserves in case of interruption of the planned supply. Increasingly, UGS is applied for trading purpose and new types of commercial storage services are offered to the market.

In summary, underground gas storage facilities are used for:

- security of supply
- providing flexibilities
- balancing of seasonal demand variations
- structuring of gas demand and supply
- provision of balancing energy for the optimisation of transport grids
- trading and arbitrage purpose
- stand-by/reserve provisions
- structuring renewable energy sources – power to gas
- storage of associated gas as service for production optimisation and resultant environmental conservation.

In connection with increasing energy contributions from renewables which are delivered either continuously (biogas) or erratically (wind, solar) an extended application of gas storages for structuring and for power to gas conversion will be required.

New business opportunities may develop for the storage of hydrogen, compressed air energy (CAES), helium, etc.

Types of Underground Gas Storage

For storage of natural gas the following different types of storage facilities, which differ by storage formation and storage mechanism, are applied:

Pore storage

- storage in aquifers
- storage in former gas fields
- storage in former oil fields

Caverns

- storage in salt caverns
- storage in lined rock caverns
- storage in abandoned mines.

The applied UGS type is dependent on geological conditions and prerequisites as well on the demand structure and requested capacity layout.

Characterisation of UGS Types

Underground gas storage facilities are naturally or artificially developed reservoirs in subsurface geological strata used for the storage of natural gas. An UGS consists of all subsurface and surface facilities required for the storage and for the withdrawal and injection of natural gas (reservoir/cavern, wells, dehydration units, compressors, etc.) providing the storage capacities - working gas volume, withdrawal rates and injection rates.

Storage in oil and gas fields and aquifers

UGS in pore storages are developed by building up a reservoir of compressed natural gas in the pores of a subsurface structure, which was either originally hydrocarbon bearing as in oil and gas fields or originally water bearing as in aquifer structures. Storage of gas in oil and gas fields and aquifers is a proven technology mainly used for the storage of large gas volumes at medium/low withdrawal/injection rates.

Storage in salt caverns

Underground storages of compressed natural gas (CNG) in solution-mined salt caverns are artificially developed containments in salt rock to provide small working gas volume, high cycling capabilities and high withdrawal capacities but may in some cases as well be used for the storage of large gas volumes in a cavern storage facility with numerous caverns.

Storage in lined rock caverns

Underground gas storage in lined rock caverns comprises subsurface facilities of a gallery, excavated in hard rock and subsequently covered internally by a welded steel liner, and related surface facilities for treatment of the stored product.

Underground storage in lined rock caverns is more costly than conventional storages but can be an alternative to underground storage in salt leached caverns especially where the local geological conditions do not provide salt or where the salt does not offer suitable characteristics for solution mining.

Underground Gas Storage in the World and in Europe

The installed storage capacities in the world increased continuously. According to reports of the WOC 2 of IGU some 630 UGS facilities are in operation providing some 350 G m³ of working gas volume (incl. strategic reserves). The majority of storage facilities and of the related working gas volume in the world is installed in UGS facilities developed in former gas fields (78 %), followed by storage

facilities in aquifer structures (12%), former oil fields (5%) and caverns (5%). Abandoned mines and rock caverns are of no great relevance on a world scale.

This distribution of storage types differs from region to region. In Europe for example, with a working gas capacity of some 85 G m³ (Vn), more storage capacities are installed in aquifers (18%) and caverns (12%) and less in UGS in oil/gas fields (68%).

Dependent on the expected gas demand and changes in the gas supply sources/origin additional storage capacities are required in the future. In Europe, the flexible indigenous production is declining and the gas import from remote areas is increasing. The expected storage demand range was assessed based on different demand scenarios.

For Europe, the expected storage demand will be compared with significant additional reported potential storage capacities of some 75 G m³.

In general, the importance of UGS is expected to increase in the future.

Requirements for UGS / Technology Improvement

Underground storage technology historically was a follower to E&P-technologies usually adapted for storage use. Successively separate storage technologies were developed for specific requirements of storage facilities – fast pressure and temperature fluctuations, high integrity/containment requirements, high productivity and high availability requirements.

Some of these technologies are: integrated subsurface/surface storage management/simulation models, 3 D / 4 D seismic, techniques for increasing the max. storage pressure respectively the operating pressure range, thermodynamic modelling, rockmechanic models, drilling/completion technology (horizontal/multilaterals, expandable tubular, cement), welded casing/tubing, development of mega caverns, online subsurface pressure monitoring by fibre optical temperature/pressure sensors, solution mining under gas while operating, replacement of natural gas cushion gas by inert gases, sealed high speed compressors/motors.

Special attention has to be dedicated to the safety of UGS operation and the analysis of the influence of UGS on the environment. The communication process with involved parties and neighbours is of special importance in the construction and operation period.

Most attractive UGS locations were developed already. New UGS will be developed in more complex and challenging structures, such as multi-layered and fractured aquifer structures, and in complex salt structures including significant amounts of insoluble components.

Technology improvements have to be applied as new storage developments are more complex and costly and many of the old storage facilities require costly retrofitting but as well to prepare for further increasing economic pressure on storage operators.

In case initiatives for economic improvements are not successful shut in and abandonment of marginal storage facilities have to be considered.