



## Natural Gas

# Safe and cost-effective pipe storage facility in Bocholt (Germany)

By U. Kühn

*The deregulation of natural gas markets in Europe and the growing share of natural gas on the energy supply market have made pipe storage facilities increasingly important for energy distributors. Flexible gas supply realised with the help of underground pipe storage facilities smooths out the volatility of peak prices and supports independent pricing. On behalf of Germany-based Bocholter Energie- und Wasserversorgung GmbH, TÜV SÜD Industrie Service accompanied the construction of the energy distributor's gas pipe storage facility from design to implementation.*

The construction of a new gas pipe storage facility spanning a total length of over 3,000 m in Bocholt-Mussum (Germany) and the upgrading of the Bocholt delivery station into Energy Supply Centre West will increase the flexibility of gas supply in future. The new pipe storage facility of Bocholter Energie- und Wasserversorgung GmbH (BEW) can transport and store up to 350,000 m<sup>3</sup> of natural gas. In peak times up to 12,000 m<sup>3</sup> of natural gas can be withdrawn per hour, which supports peak shaving and enables distributors to negotiate lower purchasing prices on the deregulated gas market.

The pipe storage facility was constructed in only five and a half months, between April and September 2007, and now enables BEW to purchase low-price natural gas from various suppliers and all gas shippers. Previously, BEW's grid was connected exclusively to a

transport network. Since it was impossible to control the amount of gas stored, direct purchasing from alternative sources or injection from other networks had been possible only to a limited extent or not at all. Plans now provide for the BEW site above the underground high-pressure gas pipes, which covers an area of approx. 11,000 m<sup>2</sup>, to be released for agricultural use.

### Trend towards underground pipe storage facilities

Natural gas pipe storage facilities are constructed exclusively underground and used to balance gas demand variations in day-to-day business. Gas can be withdrawn from the pipe storage and fed into the distribution network at any time. Pipe storage facilities offer technical and economic advantages over gasometers. Design concepts for their construction

have existed for roughly 20 years. In addition to underground pipe storage, Germany operates a host of other large-scale underground gas storage facilities, such as gas storage in caverns and aquifers, which store gas in artificial cavities or porous rock formations. While pipe storage facilities are used exclusively to smooth hourly or daily fluctuations in demand, these large underground storage areas are used to even out variations in seasonal demands (summer/winter).

Underground pipe storage offers many advantages over pressure vessels installed above ground. Pipe storage facilities are protected from adverse weather conditions, such as temperature fluctuations or precipitation. Underground installation also offers a high level of protection against external mechanical impacts. All large-diameter pipes are manufactured and delivered with high-quality PE insulation, and integrity of insulation is checked repeatedly throughout pipeline construction. Additionally, a cathodic protection system is provided for the gas pipe storage facility. On the basis of this combination of passive and active protection systems, corrosion is virtually eliminated. By measuring pipe current, any defects in the insulation can also be detected when the facility is already in operation. The facility is relatively low maintenance. Shaft structures are unnecessary and, depending on the design, structures above

ground may not be needed at all. As no point loads occur during operation, foundations are also unnecessary. The entire facility is based on simple geometries (pipelines), so that for the most part standard components can be used. This reduces construction costs, facilitates licensing approval and offers cost benefits during both operation and maintenance.

### The benefits of optimised supply/demand balance for gas distribution companies

At gas distribution companies (GDC) which supply a high percentage of heating gas, gas consumption rises eight to tenfold during peak times. According to experience, peak times generally include morning hours and noon-time. In winter, the demand for natural gas is also significantly higher than in summer. Regular billing with the upstream network operator and energy supplier(s) considers both an energy rate for the total amount of gas supplied and – similar to the electricity market – a demand rate for the maximum volume per hour delivered. Consequently, a few extremely cold winter days can influence gas prices for the whole year. Generally, there is only one local gas transporter. On the now-deregulated gas market, the gas distribution company can freely choose its energy suppliers and use the storage volume now available to benefit from alternative purchasing channels.

In peak times, the pipe storage facility delivers additional volumes of gas into the GDC's grid, thus reducing the maximum volume of gas ordered from the upstream supplier. The pipe storage facility balances supply and demand, thus resulting in balanced purchase quantities and stable prices. Supply and delivery volumes and pressures are balanced, which increases the security of supply in the distribution grid – also with respect to supply failure in the upstream network (e.g. due to maintenance work).

### Licensing

Construction of a natural gas pipe storage system requires a licence in line with the German Energy Industry Act (EnWG). Completed licensing procedures demonstrate that no (!) environmental impact assessment (EIA) as per Article 3, paragraph 1 (1) in conjunction with Annex 1, Section 19.2, Environmental Impact Assessment Act (EIAA), is needed when a natural gas pipe storage system is installed on a privately owned site or the operating premises of a local distribution company. This means that planning permission as set forth in Art. 43b EnWG is mandatory, which, however, in line with paragraph 2, may be waived if the criteria for projects of "minor significance" outlined in Art. 74 of the German Administrative Procedures Act (VwVfG) are fulfilled.



Fig. 2: Welding work on the small-bore piping

A project may be classified as of minor significance as defined in Art. 74 VwVfG if it has no negative impacts on public interests or if the required official decisions are available and not in conflict with planning and no rights of third parties infringed upon. As the last criterion is a given when a project is realized on a privately owned site, only approval by the competent bodies representing the interests of the general public must be obtained. Competent bodies in this case are the authorities in charge of building permits, fire safety, nature conservation, groundwater and soil protection plus the competent State Mining Authority named in the Ordinance Governing High Pressure Gas Pipelines (Verordnung über Gashochdruckleitungen, GasHDrLtgV) and other bodies affected by the construction project. If approval by these bodies – possibly including some requirements to be satisfied – is obtained, mandatory planning permission as set forth in Art. 74 VwVfG may be waived.

### Technical Data of the Bocholt gas pipe storage system

Technically speaking, the Bocholt-based storage system is a DN 1200 high-pressure natural gas pipeline with a maximum operating pressure of 90 bar licensed under EnWG and GasHDrLtgV. The pipe storage system, which was installed next to a gas delivery station and connected to the RWE gas grid with a maximum operating pressure of 70 bar, has a total length of 3,072.5 m. Spirally welded steel pipes 1219 x 18 mm in grade L485MB steel as specified in the EN 10208-2 standard were used for the system.

The entire pipe storage facility consists of 17 individual pipes just under 181 m long, laid in parallel and interconnected by DN 150 steel tubing. A vent and a drain port consisting of DN 50 steel tubes were realised at the highest and lowest points of each pipe. The drain port discharges into a DN 100 collector pipe with immersed tube. All vent ports are equipped with double block valve sets. Both storage and inlet pipes are buried and covered by over one

Fig. 3: Work on the venting sockets





**Fig. 4:** Small-bore piping on the new gas-pressure regulation system

meter of soil. The individual pipe runs are installed at a clearance of 80 cm to each other and 0.3 per cent downhill gradient. The collector pipe is also installed at a slight downhill gradient.

### Compressor station and expansion system

Maximum operating pressure (MOP) of the RWE gas inlet pipeline is 70 bar. The pipeline is normally operated between approx. 30 and 40 bar. Within the scope of construction, the pipe connecting the system to the gas pressure regulator had to be extended by 30 m. For this purpose, DN 150 steel pipes with a maximum operating pressure of 70 bar were used. A gas pressure regulator and measuring unit and a compressor station were built parallel to the pipe storage system. A gas expansion system already operated at the site was accommodated in the building of the new Energy Supply Centre. The Energy Supply Centre West supplies gas to BEW's medium and low-pressure distribution systems. Important control and monitoring signals are transmitted to BEW's centralized grid control centre.

In its Energy Supply Centre West, BEW produces electricity by operating a natural gas expansion system. The system is based on large pressure differences. Gas with a pressure of 33 bar is injected into the expansion system and its pressure reduced there to roughly 3 to 4 bar, the pressure needed in the local distribution network. In the course of this process, gas preheated to 50 °C drives a high pressure or expansion turbine which in turn is connected to a power generator. After passing

through the high-pressure turbine, the gas still has a pressure of approx. 12 bar and therefore passes a second expansion level coupled with a low pressure turbine. With its two turbo-generators with magnetic bearings, BEW generates approx. 1.6 million kilowatt hours (kWh) of electricity at an estimated 7,000 hours of operation annually, which corresponds to the annual demand of approximately 500 households. The heat required to pre-heat the gas is delivered by a biogas plant nearby.

### Reliable profitability analysis

Critical factors for cost effectiveness are considerations related to operational strategy, such as: Is it advisable to use a compressor station? How do higher construction costs incurred by the compressor system correlate with savings realized by a smaller pipe field? At this stage, the actual conditions at the construction site must also be considered in the various implementation concepts: How can the gas pipe storage system be integrated into supply and distribution networks? What mode of operation and what frequency of operation is planned? Are there any special soil-related features, e.g. due to specific contamination caused by previous use or provisions related to groundwater or nature conservation zones? The framework conditions are also important. For the Bocholt project, for example, the model computations by Düsseldorf-based Rechenzentrum für Versorgungsnetze Wehr GmbH and TÜV SÜD experts included steel prices as a critical and, at present, rapidly changing cost factor from an early stage.

To calculate the cost-effectiveness of gas pipe storage systems, the experts first analyse

available data and the system's actual state of repair. The decisive factor in this context is the structure of gas delivery: analysis is based on the time-variation curves of purchased gas volumes (on an hourly basis) of different winter periods. Also considered are the available grid and the contractual situation. Based on these data, the experts prepare various models in which they simulate future gas purchases as a portfolio of various contracts over several 'climate years'. Important parameters in this context include regression curve, storage volume, purchase limits and supply and delivery pressures. A complete parameter study should also include sensitivity analysis by temperature, volume, increase, purchase limits, pressure control, recording of volumes purchased, etc.

Finally, the strategy that makes most technical and economic sense is implemented in close cooperation with the client. Planned investment should not only comply with budget and other limits, but also be realized to schedule.

### Integrated on-site support

In Germany, gas pipe storage systems are governed by the Ordinance Governing High-Pressure Gas Pipelines (GasHDrLtgV). Questions addressing factors such as applicable building code or planning jurisdiction of the competent regional authority (e.g. for compressor and gas pressure regulator stations) are clarified individually with the competent authorities. To ensure cost-effective compliance with requirements, the experts from TÜV SÜD Industrie Service cooperate closely, also during the planning of details and realization of the project. Exact specifications of materials, wall thicknesses, dimensioning and construction were available before the material was delivered to Bocholt. The plans of the gas pressure regulator, compressor station and expansion system were reviewed and discussed in expert opinions before the start of construction. An experienced engineer from TÜV SÜD Industrie Service monitored all complex construction activities on site. This integrated approach enabled key issues to be solved and agreed with the client quickly and unbureaucratically.

### Testing and optimisation of the system using stress tests

On the construction site, specialist engineers inspected incoming goods and tested the quality of welds. Welds were examined visually and subjected to ultrasonic and X-ray testing. After installation had been completed, stress pressure testing in line with VdTÜV Code 1060 was carried out on the storage system. This stress test is a water pressure test carried out on pipelines which enables critical defects which may impair pipeline strength to be detected and eliminated. The

test increases the reliability, life and safety of new and existing pipeline systems. The gas pipeline and storage system to be tested is exposed to at least 1.6 times the maximum operating pressure. The test imposes a load approximating to the actual yield point of the pipes. Similar to stress relief annealing, the high pressure imposed during the stress test reduces residual stresses in the pipe. As an integral approach, the test thus permits both evaluation of a pipeline's actual state of repair and improvement of its stress properties, thus increasing pipeline availability and cost-effectiveness. TÜV SÜD experience shows that gas pipelines subjected to stress testing can reach residual lives of over 100 years.

## Conclusion

Changes on the gas market have increased the demand for pipe storage systems. In Bocholt, the installed pipe storage system assists the local distribution company in balancing its purchasing quantities and thus achieving stable prices. Early integration of third-party experts has led to safe and cost-effective project realization along the entire value chain. Success is ensured thanks to profitability analysis, material specifications defined in the run-up to the project, quality assurance during construction, expert opinions and professional licensing management. These third-party services ensure that gas

pipe storage systems comply with safe, environmentally-compatible and cost-effective energy supply as required in Articles 1 and 11 of the Energy Industry Act.

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