

## Development and Utilization of Underground Gas Storage in Indiana

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The financial and operational benefits of underground gas storage are so substantial that gas utilities in Indiana and other states are diligently pursuing a plan of action to discover and develop underground storage facilities. Generally speaking, a gas utility with one or more underground gas reservoirs can solve the major problem of meeting its peak demands for gas, increase the number of customers who can be served, reduce the costs of purchasing gas, and improve the operating efficiency of its equipment and pipe lines.

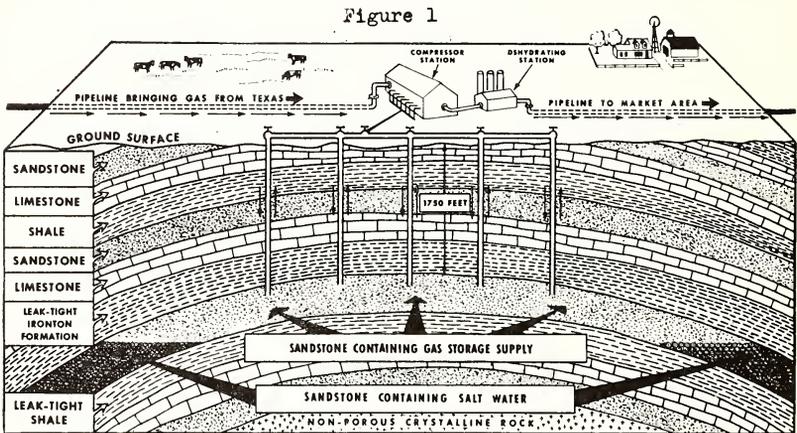
In order to understand the fundamental economic and operational advantage of underground storage, one must be aware of the general supply situation in the gas business as it relates to the extensive use of natural gas as a fuel for space heating, i.e., heating residential, commercial, and institutional buildings. At the present time, a utility obtains its gas supply for space heating and other purposes from pipe line corporations who transport the gas from the vast gas deposits located in the southwest section of the United States. When space heating requirements reach their peak on extremely cold winter days, these transmission pipe lines operate at maximum capacity. Consequently, they have no additional volumes of gas to deliver to local gas utilities. Therefore, a utility must limit its service to the number of customers it can adequately serve on the coldest day of the year, considering the supply of gas allocated to it from the interstate supplier. During the warmer months of the year when the need for space heating gas is absent, however, the supply situation is reversed. The interstate pipe lines have the capacity to deliver large quantities of gas but now the utility has no suitable market for it. Underground storage makes it possible for a gas utility to take substantial volumes of this available gas and store it for use during the winter heating season (November through March). With this additional supply of gas, a utility's capacity to meet peak loads will be so improved that it can now serve many more customers and increase its revenues accordingly.

At the present time, there are over two hundred underground storage fields in operation in this country with an estimated deliverable volume of almost two trillion cubic feet. These reservoirs represent a capital investment of \$456,000,000—approximately \$350,000,000 of this total has been invested since 1949 (1).

Most underground storage installations are constructed from subterranean stone formations that formerly held natural gas. In other words, depleted and exhausted gas fields are reconditioned to again hold gas. Gas utilities, with the assistance of geologists, have been quite successful in utilizing these local fields for storage purposes. Understandably, such fields are not available to all gas utilities—various

areas and regions of the United States contained no natural gas deposits. Nevertheless, gas companies in such areas do have a chance to develop underground reservoirs, provided they can discover and utilize non-gas bearing rock structures capable of holding gas. In attempting to construct this type of reservoir, the element of risk is definitely greater because there is no assurance that a particular geological formation has the ability to retain natural gas. In developing a storage facility from an old gas field, on the other hand, it is known that the formation at one time was, and probably still is, capable of storing gas. The biggest problem in making these abandoned fields usable or gas-tight once more is to find and seal all the open well holes previously drilled into the formation.

In both the gas bearing and non-gas bearing structures, the gas is reintroduced or stored in stone formations characterized by a high degree of porosity and permeability—a porous formation which lacked permeability would not be suitable for storage purposes. The cross section diagram (Fig. 1) illustrates the geological requirements of



the most common type of gas reservoir, a domal gas pool. Notice that the several layers of rock strata conform to the shape of a large dome. The porous and permeable layer or bed of rock which is to hold the gas is, in this case, sandstone—limestone is another common storage agent. The gas, under pressure, is forced into and stored in the billions of tiny pores and crevices of the sandstone. In some formations, these openings are so minute that they are not visible to the naked eye. From this description, then, it is apparent that underground storage does not involve the discovery and use of large caverns or underground cavities. Of course, the layer of sandstone has to be bracketed by impervious formations to prevent the gas from escaping. The cross section view shows a cap of leak-tight Iron-ton and a floor of leak-tight shale. The necessary gastight seal is completed by the back pressure which develops when the gas injected into the storage formation displaces and pushes the salt water to the sides of the dome—salt water or brine is normally found in such formations. The gas is pumped

into and out of the storage field through the five wells shown in the sketch.

The other type of formation utilized in underground gas storage is the porosity lens type. Although this formation does not have a domal shape, it still involves the use of a porous and permeable layer of rock surrounded by impermeable formations. These two types of storage formation may be anywhere from a few hundred feet beneath the earth's surface to four or five thousand feet down. The gas is stored under pressures varying from one hundred to one thousand pounds per square inch. In most instances, the storage pressure is less than the original rock pressure of the formation—a few fields have been successfully operated at pressures above the original rock pressure. The higher the compression, the greater the storage capacity of a given formation.

Unfortunately, the advantages of underground storage are not available to every gas utility. Many utilities are not located near any abandoned gas fields or suitable non-gas bearing formations. Principally because of exhausted gas fields, the states of West Virginia, Pennsylvania, New York, Ohio, and Kansas contain the greatest number of storage projects. Pennsylvania and West Virginia have the highest number of underground storage facilities, sixty and thirty-seven, respectively.

Although not as fortunate as some states with respect to storage strata, Indiana possesses limited opportunities for the construction of underground gas reservoirs. Currently, five gas companies, including an interstate pipe line supplier, have developed, or are in the process of developing, such reservoirs in this state. Only two of these reservoirs will be constructed from geological formations which have not previously held natural gas. The locations of these storage fields are indicated by the circles shown on the map of Indiana (Fig. 2). The map also shows, by dashed lines, the interstate pipe lines which serve Indiana. Observe the proximity of the storage fields to these supply lines. Because of the high costs of constructing connecting pipe lines from the storage site to the pipe lines of the utility and the transmission corporation, a gas utility must limit itself to explorations for underground storage in the vicinity of its general service area and the supplier's pipe lines.

The Texas Gas Transmission Corporation, one of four interstate pipe lines in Indiana, has four of the ten storage projects in this state. The interstate supplier's interest in underground storage is not unlike that of the local distributing gas utility. This corporation developed the first operating storage reservoir in the state of Indiana in 1944. The Oaktown Field, located three miles west of the town of Oaktown in Knox County, was developed by merely converting a natural gas field, which was still producing small quantities of gas, into a storage facility. Since this field was still in production when the conversion took place, its ability to hold natural gas was conclusively established. The usual search for possible openings or leaks in the formation was not necessary. Furthermore, the pipe lines and equipment already in-

stalled to take gas out of the field were used to deliver and pump gas into the formation. The storage potential of this field is rated slightly over one billion cubic feet.

The corporation's second project is known as the Alford Field and is situated two miles east of the town of Alford in Pike County. This storage pool of four billion cubic feet capacity was constructed from a depleted and abandoned gas and oil field. The problems encountered in making this old field usable again are indicative of the general construction situation. All the old unplugged or improperly plugged well holes had to be located and sealed to make the formation gastight. To do this, hundreds of acres of land had to be carefully searched. For the most part, there were no written records of these wells to aid the searchers. Before the Alford Field was satisfactorily sealed, eighty well holes had to be plugged. It took two years of searching to finally find one of these abandoned wells which was leaking gas.

Texas Gas Transmission Corporation is currently developing a third storage facility near the town of Leesville in Lawrence County. Begun in 1955, this project is still in the experimental stage. Here, the corporation plans to use a non-gas bearing stratum as a reservoir. Geological analysis of this formation indicates the possibility of a water bearing rock structure with a good seal. Numerous test or core holes have been drilled to determine the suitability of this formation for storage purposes. The storage process at the Leesville Field will begin when the introduction of gas, under high pressure, displaces and holds back the water. The huge "gas bubble" which forms at the point of injection constitutes the storage volume.

The initial development of this corporation's most recent project occurred in 1957 in the area just north of the town of Wilfred in Sullivan County. This area contains an abandoned gas field.

The Southern Indiana Gas and Electric Company, serving the Mt. Vernon-Evansville-Newburg area along the Ohio River, operates an underground storage field near the town of Oliver in Posey County. The Oliver Field was created in 1954 by reconditioning a gas bearing formation to again hold natural gas. Representing a \$1,100,000 investment, the project has a rated storage capacity of 2,300,000,000 cubic feet. In order to improve the field's daily deliverability or ability to supply more gas for peak day demands, additional wells have been drilled into the storage formation. This allows more gas to be pumped out of storage on any given winter day. It also reduces the time required to recharge or refill the reservoir. Increasing the number of wells to boost a storage field's daily deliverability is a common practice.

The Central Indiana Gas Company which serves the Muncie-Marion-Anderson area began construction on its storage field in 1957 after several years of investigation and exploration. The project is located in Randolph County between the towns of Modoc and Unionport. Costing a minimum of two million dollars, the reservoir is estimated to have a storage capacity of no less than two billion cubic feet. A limestone formation which once held natural gas is being used to develop this reservoir—it formed a segment of the famous Trenton Field which



in Daviess County. Construction was started in the spring of 1955, and the first input of storage gas occurred in the summer months of the following year. Utilizing an exhausted gas field, a reservoir with a capacity of 500,000,000 cubic feet was created.

Indiana Gas and Water Company completes the list of gas utilities in Indiana that have made use of the technique of underground storage of gas. This utility, serving central and southern Indiana, has two installations in operation and a third project under construction. The company's first project was started, completed, and placed in service during 1950. Located five miles south of the city of Greensburg in Decatur County, a producing gas field was simply converted into a storage reservoir. The reservoir serves the area around the city of Greensburg with a storage capacity of one billion cubic feet. The second project was constructed from an old, depleted gas field located just west of the town of Unionville in Monroe County. The Unionville Field, representing a \$500,000 expenditure, has a capacity of 1,700,000,000 cubic feet. This project was initiated in the winter of 1953; the first year of input began in the fall of 1954.

At the present time, the Indiana Gas and Water Company is working on a third storage site adjacent to the town of Westpoint in Tippecanoe County. Started early in 1956, experimentation is still being carried on to ascertain the suitability and storage potential of a non-gas bearing structure, water-bearing limestone. When completed the reservoir will serve such cities as Lafayette, West Lafayette, and Crawfordsville.

It is safe to say that the utilities already named, as well as the other Indiana gas companies, are interested in finding additional storage sites. Some are currently engaged in preliminary investigations and explorations with this objective in mind. The greatest potential for underground storage development lies in the central and southern sections of Indiana where the state's natural gas fields, now depleted, are located and where geological formations of a non-gas bearing nature are most favorable for holding gas. It is here that gas utilities, including interstate pipe line corporations, are centering their attention.

With both interstate and intrastate gas utilities seeking appropriate storage sites in the state, further underground storage developments are a certainty. Indiana residents and businesses are thus assured a greater natural gas supply to meet the ever-increasing demand for this premium heating fuel.

#### Literature Cited

1. SPRINGBORN, H. W. 1956. Underground Storage Exceeds Two Trillion. Gas Age 117:29.