Underground Natural Gas Storage Reservoir Management

Authors:

I. Ortiz
R. Anthony

Contractor:

United Energy Development Consultants, Inc.
2301 Duss Avenue, Suite 12
Ambridge, Pennsylvania 15003

Contract Number:

DE-AC21-94MC31113

Conference Title:

Natural Gas RD&D Contractor's Review Meeting

Conference Location:

Baton Rouge, Louisiana

Conference Dates:

April 4 - 6, 1995

Conference Sponsor:

Co-Hosted by Department of Energy (DOE)
Morgantown Energy Technology Center
Morgantown, West Virginia
and
Southern University and
Agricultural and Mechanical College
Baton Rouge, Louisiana

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UNDERGROUND NATURAL GAS STORAGE RESERVOIR MANAGEMENT

CONTRACT INFORMATION

Contract Number DE-AC21-94MC31113
Contractor UEDC United Energy Development Consultants, Inc.
2301 Duss Ave. Suite 12
Ambridge, PA 15003
1-412-266-8833
1-412-266-9002 fax
Other Funding Sources ----
Contractor Project Manager Isaias Ortiz
Principal Investigators Isaias Ortiz
Robin V. Anthony
METC Project Manager Anthony M. Zammerilli
Period of Performance Phase I -- Sept. 23, 1994 -- April 30, 1995
Schedule and Milestone

	FY95	Program Schedule											
Phase I		S	O	N	D	J	F	M	A	M	J	J	A
Electronic Data		_____											
Research Storage Losses			_____										
Summarize Losses				_____									
Evaluate Financial Impact						_____							
Write Report								_____					

OBJECTIVES

The objective of this study is to research technologies and methodologies that will reduce the costs associated with the operation and maintenance of underground natural gas storage. This effort will include a survey of public information to determine the amount of natural gas lost from underground storage fields, determine the causes of this lost gas, and develop strategies and remedial designs to reduce or stop the gas loss from selected fields.

Phase I includes a detailed survey of US natural gas storage reservoirs to determine the actual amount of natural gas annually lost from underground storage fields. These reservoirs will be ranked, the resultant will include the amount of gas and revenue annually lost. The results will be analyzed in conjunction with the type (geologic) of storage reservoirs to determine the significance and impact of the gas loss. A report of the work accomplished will be prepared. The report will include; 1) a summary list by geologic type of US gas storage reservoirs and their annual underground gas storage losses in ft³; 2) a rank

by geologic classifications as to the amount of gas lost and the resultant lost revenue; and 3) show the level of significance and impact of the losses by geologic type.

Phase II includes a determination of the mechanisms and causes of lost gas due to migration and related causes shall be summarized. Correlation's among storage reservoir types, locations, characteristics such as trap type, and gas loss mechanisms that are common to all U. S. storage reservoirs surveyed will also be included. For each type of storage field identified, screen, rank, and evaluate the source causes of gas migration. Strategies for prevention of gas loss as a result of the analysis, strategies and remedial designs to reduce or stop the gas loss from the highest ranked fields identified will be evaluated.

BACKGROUND

Gas storage operators are facing increased and more complex responsibilities for managing storage operations under Order 636 that requires that storage be unbundled from other pipeline services. Low cost methods that improve the accuracy of inventory verification are needed to optimally manage stored natural gas. Gas loss is costly to the operator as well as to the consumer.

Migration of injected gas out of the storage reservoir is a problem that has not been well documented by industry. The two types of gas losses that occur are those due to mechanical communication with adjacent formations or migration of gas out of the storage reservoir due to unknown faults or poor reservoir traps. The goal of this investigation is to estimate the amounts of natural gas annually lost from underground storage fields and determine the significance and impact of the lost gas, and resultant revenue loss.

Storage reservoir types, regional locations, characteristics such as depth, pressure, trap types, and vintage of U. S. storage reservoirs

are discussed. Correlation's between certain types of storage fields and commonly found mechanisms of gas leakage are elaborated. The impact of this gas loss is assessed from available databases, which, due to the sensitive nature of the information, is reported on an aggregate basis. Once this impact is quantified, the source causes of gas migration and gas loss mechanisms can then be evaluated in order to develop strategies to mitigate these losses.

For northern climates' storage gas represent some 20% of the annual sales; while on a cold day, storage gas may reach some 50-70% of gas sold. By providing continuous fuel service to residences, hospitals, and commercial buildings, underground gas storage has been a vital part of natural gas distribution systems.

Historically, underground storage, which was first practiced in 1915, experienced a remarkable growth starting in 1950 resulting in nearly 7.5 trillion cubic feet in storage in more than 400 pools in 25 states by 1979. Currently, gas storage operators are facing increased responsibilities for managing these storage operations under Order 636 that requires that storage be unbundled from other pipeline services.

Energy supply and demand over the last twenty years are shown on Figure No. 1. As shown, the net amount of energy imported has increased steadily, while the relative contribution of US production to domestic supply requirements has steadily declined. Figure No. 2 shows only US gas consumption and production; similarly, consumption has exceeded supply.

Concurrently, the amount of storage activity has increased in conjunction with the net increase of natural gas imports as shown on Figure No. 3. Storage is playing an ever increasing importance in supplying the domestic energy requirements.

Natural gas was first stored underground successfully in 1915 in Canada, where a depleted gas reservoir was developed for peak requirements. In 1916 the first successful underground storage project in the United States was developed by Iroquois Gas Company (a National Fuel affiliate). That project, the depleted Zoar Field, is still in use today.

The first depleted oil and gas field developed for natural gas storage was Fink Field in Lewis County, West Virginia, in 1941 by Hope Natural Gas Company (Consolidated Gas Supply Corporation). Historic records show that gas storage began by allowing depleted gas reservoirs produced in the winter to be recharged in summer by pipeline gas. As the intercontinental pipeline systems spread rapidly in the post war period, reservoirs were selected and refurbished for full utilization as underground storage reservoirs. Figure No. 4 shows the development of storage in the US since 1916.

The first depleted oil reservoir used for natural gas storage was started by Lone Star Gas Company, which developed the New York City Field in Clay County, Texas, in 1954. Eventually a number of depleted oil fields were converted to gas storage. Oil recovery was part of the objective in the early years of operation. Oil in reservoirs however, added complications over dry gas storage fields due to liquids in the well bore, possible enrichment of the gas, and condense formation in pipelines. Also, gas could go into solution in crude oil in amounts that made it difficult to assess the volume of stored gas in the reservoir.

In the 1950's, aquifer storage was developed by injecting gas into structures filled with water. Here water movement and caprock quality became focal points of interest for research and technical development. Louisville Gas and Electric Company first started experimenting with the storage of natural gas in a water-bearing sand aquifer in 1931 and developed the Doe Run Field in 1946. This

Meade County, Kentucky, project is the oldest aquifer storage field operating in the United States, although it no longer exhibits the water-drive characteristics of an aquifer.

Porous and permeable rock provided by nature was the only storage host of natural gas until 1961, when cavities in bedded salt were developed by Southeastern Michigan Gas Company in St. Clair County, Michigan. Leached cavern storage in salt dome intrusions was developed by Transcontinental Gas Pipe Line Corporation in 1970 in Covington County, Mississippi. Currently, salt domes, which occur principally in the Gulf Coast region of the United States, account for 1% of gas stored underground.

In 1959 mined cavern storage of natural gas was introduced by the Public Service Company of Colorado, which converted an abandoned coal mine in Jefferson County, Colorado, into a storage reservoir. No mine has yet been excavated solely for natural gas storage, although extensive studies have been conducted.

The relative contribution of these types of storage reservoirs as shown on Figure No. 6. Regional storage capacity is summarized on Figure No. 5. The largest amount of storage is located in the Northeast and Mid-west.

Low cost methods that improve the accuracy of inventory verification are needed to optimally manage stored natural gas. Gas loss is costly to the operator as well as to the consumer. Migration of injected gas out of the storage reservoir is a problem that has not been well documented by industry.

The types of gas losses that occur are those due to mechanical communication with adjacent formations or migration of gas out of the storage reservoir due to unknown faults or poor reservoir traps. This study was undertaken to address the problem of this gas loss. The source causes of gas migration (Table No. 1) and gas loss mechanisms need

to be identified and evaluated in order to develop strategies to mitigate these losses.

PROJECT DESCRIPTION

Sources of information used in this report include textbooks, journal articles, American Gas Association (AGA) and Gas Research Institute (GRI) reports, and Federal Energy Regulatory Commission (FERC) and Energy Information Administration (EIA) databases. Underground storage fields, operators and geologic formations were identified and categorized and the available databases were analyzed. A summary of the sources of information is tabled below: (Table No. 2)

A database search was conducted in order to identify sources of detailed and comprehensive information on the storage field reservoirs in the United States. Databases and reports are available from a number of public sources, including both private and government institutions. Non-government sources include the Gas Research Institute (GRI) and the American Gas Association (AGA). The Federal Regulatory Commission (FERC) public databases were also accessed. In addition, certain restricted information was also made available through the Energy Information Administration (EIA). Results from the analysis of the EIA data are reported in a manner consistent with the regulations regarding the use of this information. The types of information contained in the databases used for analysis are summarized below.

FERC

Public reports on underground gas storage are available through the Federal Energy Regulatory Commission (FERC). Data from 1988 onward has been submitted to the FERC by companies under the FERC's jurisdiction, via electronic media and has been incorporated into computer databases. The following FERC reports were initially examined:

- Form 2: Annual Report of Major Natural Gas Companies, filed by about 45 interstate and natural gas pipeline companies with combined gas sold for resale and gas transported or stored for a fee exceeding 50 billion cubic feet. The 132-page report contains general corporate information, financial statements and supporting schedules, and engineering statistics.
- Form 2-A: Annual Report of Non-major Natural Gas Companies, filed by about 86 interstate natural gas pipeline companies, with annual sales or volume transactions of more than 200 million cubic feet but less than 50 billion cubic feet. The 19-page report contains corporate information, financial statements and supporting schedules, and engineering statistics.
- Form 8: Underground Gas Storage Report, five-page report filed monthly by about 40 natural gas companies that operate natural gas storage fields in the United States.
- Form 11: Natural Gas Pipeline Company Monthly Statement, filed by about 35 natural gas pipeline companies that sold and/or transported, for a fee, more than 50 billion cubic feet of gas during the previous calendar year. The 7-page report contains data on revenues, income, operating and maintenance expenses, and gas supplies.

Three-quarters of the volume of gas stored underground are in fields operated by companies reporting in FERC Form 2. Therefore, a detailed analysis was conducted on FERC Form 2 data. Data from this form was sorted and comparisons between data sets were graphed in order to identify potentially useful relationships.

An in-house FERC report, "The Semi-Annual Report on Jurisdictional Underground Natural Gas Storage Fields in the United States" was also obtained, along with the supporting electronic database and graphs covering a ten-year period. Monthly injection

and withdrawal cycles of gas from underground storage are reported by each pipeline company subject to the jurisdiction of the FERC. (Figure No. 7) The gas volumes represent around 70% of the volume of gas stored underground in the United States. Reported as an aggregate of all active storage fields operated per company, this database does not discern individual storage field volumes. The report is based on the compilation of present and past information, technical interpretation and analysis by the Supply Analysis Branch staff (currently reorganized under the FERC's Office of Pipeline Regulation).

AGA

The 1992 AGA Operating Section Report-Survey of Underground Gas Storage Facilities in the United States and Canada was also used for this study. The information in this report contains individual storage field summaries, including: the company, reservoir name, formation, type of trap, reservoir characteristics, base and working gas, etc. Once again, however, monthly volumes per field are not available. A total of 425 reservoirs is listed in the AGA report, with cumulative gas volumes, wells, acreage and horsepower, and average thickness, depth and pressure, are summarized below. The US has around 400 storage reservoirs. Figure No. 8 shows the number of storage operators versus the total capacity as a percentage. Only 20% of the storage operators operate about 80% of the total underground storage capacity. Two major operators operate nearly 25% of the underground storage capacity in the US.

EIA

The Energy Information Administration (EIA) collects monthly individual storage field data on working and base gas volumes, total gas in storage and injections and withdrawals that they report on their Form 191. This detailed information allows for a more thorough examination of changes in storage field conditions. Gas losses that may be concealed

through aggregate reporting methods may become more apparent when viewed on a monthly basis by field. Access to this report is necessarily restricted due to the confidential nature of the material reported. This information was used, in conjunction with the publicly available data, to better determine actual gas loss, define general field characteristics that may be indicative of gas loss and quantify overall trends concerning gas migration.

All of these databases were imported into a spreadsheet format. This format allows for manipulation of the databases and sorting by category, such as company or geologic formation, that will allow for rapid characterization of, and correlation among, the various storage fields. For example, a preponderous amount of lost gas among a particular geologic formation or type of trap may indicate a geologic cause of migration (such as natural fracturing or incomplete seal) as opposed to a correlation with date of storage conversion, which may indicate a mechanical mechanism, especially in older vintage wells. Mechanical problems, such as pipe corrosion, can cause leakage, while repeated injection and withdrawal (perhaps with prior repeated hydraulic stimulation to improve deliverability), could result in eventual damage to the formation.

RESULTS

Current Status Of Underground Storage

The AGA database lists a total of 83 operators in the United States who maintain active storage fields with a total capacity of around 7 trillion cubic feet (TCF) of gas. Roughly 72% of this gas are under the jurisdiction of the Federal Energy Regulatory Commission (FERC). Approximately 45% of gas stored underground is working gas, with the remaining 55% forming the base gas.

The number of storage operators that represent a large percentage of the total

storage capacity is relatively small. One quarter of storage field operators maintains three quarters of the US underground storage capacity. Half of the storage capacity is operated by ten percent of the active storage operators. Nearly one-quarter of the storage capacity in the US is operated by only two companies.

Underground natural gas storage facilities in the United States are located in only 25 of the lower 48 states. Even there, almost half the total storage capacity is concentrated in only three of these states as illustrated by the chart below. (See Figure No. 9.)

The majority of underground natural gas storage capacity, facilities and deliverability in United States is located primarily in the Eastern and Midwestern geographical areas.

Types Of Storage

Storage reservoirs can be classified by several parameters. Common classification schemes include: drive mechanism, type of geologic trap, lithology, permeability and initial fluid content. In working with available databases and reports, an attempt was made to determine the common parameters addressed in each of the databases. Three types of underground storage recognized by the FERC, EIA, GRI and AGA are

- 1) Depleted reservoir,
- 2) Aquifer, and
- 3) Cavern or mine.

The three storage classifications are defined by drive mechanism, type of geologic trap, lithology, and initial fluid content. (Permeability is another important parameter that strongly influences well deliverability; however, the value of field permeability is often uncertain or unknown.) Drive mechanism can usually be described as one of two readily determinable states: water drive or pressure drive. Drive mechanism has an important effect on the productivity of a well. All of the caverns and most (around 85%) of the depleted reservoirs

are classified as pressure drive. Pressure drive has also been referred to as pressure depletion or volumetric expansion. All aquifers have water drive mechanisms. The term aquifer refers to a water-bearing zone. Thus, the initial fluid content of all aquifers is water. Figure No. 6 shows the total number of US storage reservoirs in each of these classifications:

Depleted reservoirs are the only type of storage field found in the Northeast. Aquifers are most common in the Midwest, while most salt caverns are found along the Gulf Coast. Half of the salt caverns are located in Texas. The one storage reservoir in an abandoned coal mine is located in Colorado.

Another parameter known to have a significant influence on the production and maintenance of a gas well is the trap type. Many geologic trap descriptions are given in Table No. 3, below. Lithology is another important and easily determined categorization parameter. All known underground gas storage reservoirs consist of porous formations of sandstone (or carbonate) or are salt dome associated. Although a variety of geological terms are used by the operators, four descriptions can be used to generically specify any of the geologies listed below. These are:

- 1) salt cavern
- 2) stratigraphic
- 3) structural
- 4) combination of stratigraphic/structural

Gas Loss -- Comparative Database Analysis

The FERC, EIA, and AGA databases contain gas volume information. This gas volume information was analyzed for evidence of gas loss.

Gas losses are reported directly in the FERC Form 2 report and indirectly through the accounting and financial data of this report.

The indirect and reported gas losses were summarized, compared and added in order to

arrive at an estimate of the magnitude of total gas loss occurring. Gas-in-Place for storage fields is calculated by the following equation. Losses are reported directly in the FERC Form 2 report and indirectly through the accounting and financial data of this report.

$$\text{GIP} = \text{NATIVE} + \text{BASE} + \text{WORK} + \text{ADD} - \text{LOSS}$$

Where GIP = (gas-in-place)

NATIVE = native gas originally in place

WORK = working gas

ADD = additions to storage and

LOSS = gas losses

The EIA reports end of year (EOY) and beginning of year (BOY) GIP volumes. The amount of GIP and associated storage losses can be calculated by the following:

$$\text{EOY(GIP)} = \text{BOY(GIP)} + \text{INJ} - \text{WITH} + \text{ADD} - \text{LOSS}$$

Where INJ = injected volumes during the year

WITH = withdrawals during the year

Gas Loss Reporting

Gas losses from storage reservoirs can be reported in several ways by virtue of the reporting method. FERC Form 2 gas losses are reported as transportation losses' 98% of the time, vs. other forms of gas loss, such as reservoir.

Gas storage losses are often reported as an increase in cushion gas, particularly for gas storage in aquifers (FERC-personal communication). Migration of gas, into tighter areas of the formation, or solution of gas in the water or the creation of isolated non-recoverable pockets of gas are the primary mechanisms of gas loss in these instances. Aquifers are used for gas storage exclusively in the Midwest. Approximately 25%, or one-

quarter of the storage fields have an active water drive. Of these, half are aquifers.

The largest gas losses appear, from FERC Form 2 data, to be from conventional depleted gas reservoir storage fields in the Northeast. These fields are primarily sandstone with either structural or stratigraphic trapping mechanisms. In certain instances, these apparent losses are reported in FERC Form 2 as gas removed from storage or as a negative addition to gas storage. This type of loss tends to be reported over one or two months in one calendar year, although the loss may actually be cumulative ongoing. Pressure depletion (gas expansion) reservoirs account for 72%, or almost three-quarters, of active storage fields. Two-thirds of these reservoirs are in sandstone. Therefore, depleted sandstone reservoirs account for half of all storage reservoirs.

Table No. 4 (and Figure No. 10) Summarize the gas-in-place volumes from EIA data. The end-of-year, injected and withdrawn gas volumes are reported. Also, shown on this table are the net gas losses and additions associated with storage. The total gas loss/additions to storage from 1989 to 1994 is 530 BCF. This number also includes additions to storage during that time period.

It appears that, except for salt cavern storage, most fields, for various mechanical and geological reasons, will experience a certain amount of ongoing gas loss. Certain cases have demonstrated that a leak from the reservoir does not necessarily prevent it from serving a market very effectively.

The impact of this loss may be offset by other factors, such as geographical location and proximity to market, the size of the company and the number of fields it operates, the size of the storage field, the availability, or lack, of a suitable replacement field, the costs of maintaining vs. developing a storage field, the cost of various mitigation measures, and whether these measures will prove effective in eliminating or containing the problem.

While the economics may vary, in general, some of the smaller fields that experience a large percentage of inventory decline due to gas loss may be effectively abandoned. Conversely, mitigate measures may be sought for larger, more critically important fields, before a decision to abandon the field is sought.

The effectiveness of mitigation measures and the types of fields to which they apply along with new technologies and the use of new reservoir types (such as salt caverns) need to be compared for an effective overall storage strategy to be implemented in the wake of Order 636.

FUTURE WORK

The work presented here in Phase I incorporates information obtained solely from public sources. A detailed analysis of EIA Form 191 data, which tabulates individual reservoir data also has to be incorporated into this analysis along with the Form 2 financial information to arrive at the impact of losses categorized by storage type.

Remaining work includes:

- detailed loss estimate for 400 reservoirs
- categorization of these losses by geologic type
- categorization of losses by drive mechanism
- Estimation of the financial losses for each reservoir

The results of Phase I will be reviewed and incorporated in Phase II of this study.

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Figure 1. US Total Production and Net Imports as Percent of Consumption (1973-94)
source: Table 1.2 Energy Overview EIA

Figure 2. US Total Gas Consumption and Production (1973-94)

Figure 3. US Underground Natural Gas Storage Activity and Net Imports Gas (1973-94)

Figure 4. Underground Natural Gas Storage Development (1916-92)

source: AGA 1992 database

Figure 5. Total US Regional Storage Distribution -1994

source: FERC 1994 semi-annual report

Figure 6. Distribution of Storage Reservoir Types

source: AGA 1992 database

Figure 8. Storage Capacity in the US Vs Number of Operators
source: AGA 1992 database

Figure 7. US Underground Natural Gas Storage Capacity (1983-94)
source: FERC 1994 database Form 2.

Figure 9. US Storage Capacity % of Total 1992

source: AGA 1992 database

Figure 10. Underground Natural Gas Bar Chart (1988-94)

source: Energy Information Administration, Natural Gas Monthly, Table 13.

WELLHEADS	WELLBORES	RESERVOIRS
Christmas Tree	Casing Collars (mechanical)	Fractures
Gathering System	Corrosion (internal and/or external)	Faults
Surface Equipment	Cement Bond	Areas of Minimum Structural Closure
Compressor	Leaks	Caprock Thresholds
Pipeline	Blowouts	Down Structure
		Gas Fingering (in aquifers)
		Areas of Lower Permeability

Table 1. Causes and Areas for Unmetered Loss of Inventory

(after Tek, M.R., Underground Storage of Natural Gas, Gulf Publishing Co., Houston, TX, 1987.)

TEXTBOOKS & PAPERS	JOURNAL ARTICLES	GRI	AGA	FERC	EIA
Textbooks: Katz Tek Papers from: SPE AGA GRI AAPG	Journal of Petroleum Technology Oil & Gas J.	topical report	Annual Survey of Underground Storage (US/Canada)	Jurisdictional Report & Database Form 2 Form 2A Form 8 Form 11	Form 191

Table 2 Information Sources

STRUCTURAL	STRATIGRAPHIC	STRATIGRAPHIC/STRUCTURAL	SALT
faulted structural	sand lens	faulted stratigraphic	salt intrusion
faulted anticline	terrace lens	reef-anticline	salt caverns
structural lens	porosity lens	anticlinal pinch-out	
anticline	permeability trap		
dome	permeability pinch-out		
domal anticline	stratigraphic draping		
anticlinal dome	bioherm		
closed anticline	reef		
elongated anticline	pinnacle reef		
plunging anticline			
truncated anticline			

Table 3. Underground Natural Gas Reservoir Geologic Types

(from GRI report)

	(TCF) EOY GIP =	BOY GIP +	INJ -	WITH	+ ADD - LOSS
	EOY GIP -	BOY GIP -	INJ	+ WITH	= ADD /LOSS
1988	6.7	-	2.17	2.24	
1989	6.3	6.7	2.49	2.80	(0.01)
1990	6.9	6.3	2.43	1.93	0.11
1991	6.8	6.9	2.61	2.69	(0.08)
1992	6.4	6.8	2.56	2.72	(0.20)
1993	6.3	6.4	2.76	2.72	(0.16)
1994	6.4	6.3	2.72	2.41	(0.20)
					Total (0.53)

Table 4. Underground Natural Gas Storage Operation Summary (1988-1994)

source: Energy Information Administration, Natural Gas Monthly, Table 13.

Underground Natural Gas Storage Reservoir Management

Isalas Ortiz
Robin V. Anthony
United Energy Development Consultants, Inc.
Pittsburgh, PA

Contract DE-AC21-94MC31113
METC Project Manager: Anthony M. Zammerilli

Natural Gas RD&D Contractors Review Meeting
April 4-6-1995
Baton Rouge, LA

UEDC

Project Objectives

- **Phase I**
 - » summarize gas loss
 - volume and dollar impact
- **Phase II**
 - » evaluate gas loss mechanisms
 - » develop gas strategies for prevention

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Total U.S. - Production/Consumption

UEDC

Total U.S. - Storage Inj/With & Net Imports (BCF)

UEDC

Overview

- **Underground Storage Background**
- **Project Status**
- **Key Issues**
- **Summary**

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Underground Storage Background

- **Cavern (salt / coal mine)**
- **Matrix porosity**
 - depleted gas, oil fields, aquifers

UEDC

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Terminology

- *GIP (Gas in Place)*
- *Native Gas*
- *Cushion Gas / Base Gas*
- *Working Gas*
- *Operating Capacity*

UEDC

Geologic formation matrix porosity

- *Geologic trap types (carbonates/sandstones)*
 - » *structural*
 - » *stratigraphic*
- *Pressure Mechanisms*
 - » *volumetric depletion*
 - » *aquifer/waterdrive*

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Storage Mechanisms

UEDC

Pressure Response

UEDC

Storage Calculations

$$GIP = NATIVE + BASE + WORK$$

$$EOY\ GIP = BOY\ GIP + INJ - WITH + ADD - LOSS$$

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Storage Loss Reported As:

- *Storage Loss*
- *Transportation Loss*
- *Revision to base gas (addition)*
- *Not reported*

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Storage Operators

- 92 Operators
- 388 Storage Fields

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No. of Storage Fields

Depleted	332
Aquifer	43
Cavern	13
Total	388

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Storage Types

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Ratio Working/ Base Gas

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Average Working Gas - Mcf/well

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Location of Storage Fields

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-20-

Regional Storage Capacity

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US STORAGE CAPACITY 1983 - 94 (BCF) FERC

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Data Sources

- FERC (U.S. jurisdictional)
- EIA (U.S. jurisdictional & LDC's)
- AGA (U.S. & Canadian Members Co.)

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Data Sources

- Data Collection
 - » FERC
 - Form 8 & 11
 - Form 2
 - Staff Data
 - Rate Cases
 - » EIA
 - F 191
 - » AGA
 - Computer Diskette

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FERC - AGA DATA

	TOTAL WELLS	TOTAL BASE GAS (Tcf)	TOTAL WORKING GAS (Tcf)	GRAND TOTAL (Tcf)
TOTAL - AGA	18,485	4.57	2.87	7.24
TOTAL - US	19,035	4.35	2.41	6.76
TOTAL - FERC	12,888	3.21	1.76	4.97
% FERC OF AGA - US	72%	74%	73%	73%

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Storage Loss Reported As:

- Storage Loss
- Transportation
- Revision to base gas (addition)
- Not reported

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U.S. Storage Activity 1988 - 94

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AGA Data

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EIA - Year End Summary (TCF)

Year	GIP	INJ	WITH
1988	6.65	2.17	2.24
1989	6.33	2.49	2.80
1990	6.94	2.43	1.93
1991	6.78	2.61	2.69
1992	6.41	2.56	2.72
1993	6.30	2.76	2.72
1994	6.41	2.72	2.41

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EIA - Storage Changes

(TCF)					
EOY GIP = BOY GIP + INJ - WITH + ADD - LOSS					
	EOY GIP	BOY GIP	INJ	+WITH	= ADD / LOSS
1988	6.65	-	2.17	2.24	
1989	6.33	6.65	2.49	2.80	(0.01)
1990	6.94	6.33	2.43	1.93	0.11
1991	6.78	6.94	2.61	2.69	(0.08)
1992	6.41	6.78	2.56	2.72	(0.20)
1993	6.30	6.41	2.76	2.72	(0.16)
1994	6.41	6.30	2.72	2.41	(0.20)
					TOTAL= (0.53)

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System Gas Losses F-2 (BCF)

	PROD	STORAGE	TRANS	DISTRIB	OTHER	UNACCOUNTED	TOTAL
1990	0	2.64	51	5	20	78	
1991	0	(5.39)	125	6	24	149	
1992	0	1.00	109	2	16	129	
1993	0	0.13	120	(0)	32	152	
		(1.63)	406	14	91	510	

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Status

- Accomplishments
 - » AGA & FERC data
- Issues
 - » Classification of losses
- What was learned during period of report
 - » losses greater than reported

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FERC DATA

UEDG

**METC Meeting
Speaker Checklist**

Natural Gas RD&D Contractors Review Meeting

April 4-6, 1995

2/23/95

TASK

DUE DATE

SEND TO:

- 24-
- ☒ Author Data Sheet
 - ☐ Preprint Abstract (camera-ready original and 2 copies)
and/or (electronically)
 - ☐ Patent Clearance Form 1332.1 (original and 2 copies)
 - ☐ Paper Copy of Slides

February 27, 1995

Conference Services
Morgantown Energy Technology Center
P.O. Box 880, MS K07
3610 Collins Ferry Rd.
Morgantown, WV 26507-0880

- or electronically:
DKULLM@METC.DOE.GOV

- ☐ Advanced Registration Form

March 17, 1995

Conference Services

- ☐ Paper (camera-ready original and one copy)
and/or (electronically)

March 22, 1995

Conference Services

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DKULLM@METC.DOE.GOV