U.S. Underground Natural Gas Storage Developments: 1998-2005

This special report examines the current status of the underground natural gas storage sector in the United States and how it has changed since 1998, particularly in regards to deliverability from storage, working gas capacity, ownership, and operational capabilities. In addition, it includes a discussion and an analysis of underground natural gas storage expansions in 2005 and an examination of the level of proposed additional storage expansions over the next several years. Questions or comments on the contents of this article should be directed to James Tobin at james.tobin@eia.doe.gov or (202) 586-4835.

Access to efficient and dependable underground natural gas storage operations is crucial in today's competitive natural gas transportation marketplace. The approximately 400 underground natural gas storage facilities located strategically throughout the United States are key to maintaining the reliability, integrity, and capability of the Nation's natural gas transmission and distribution network (Figure 1).

At the close of 2005, 394 underground natural gas storage facilities were operational in the Lower 48 States although 37 were marginal operations that reported little or no activity during the year (Table 1).[1] This compares with 410 underground natural gas storage facilities in operation in 1998[2] and a peak figure of 418 operational sites in 2001. Between 1998 and 2005, 42 facilities were abandoned as uneconomic or defective,[3] representing a loss of 223 billion cubic feet (Bcf) in total capacity,[4] while 26 new sites, accounting for 212 Bcf of new capacity, were placed in operation.[5]

Consequently, the total level of U.S underground natural gas storage capacity, including base gas and working gas capacity, fluctuated within a relatively narrow range during the period (8.18 trillion cubic feet (Tcf) in 1998, 8.42 Tcf in 2001, and 8.26 Tcf in 2005), finishing with about a 1-percent overall net increase. Yet, as abandoned capacity was compensated for with new storage field development and the completion of more than 87 storage expansion projects over the period, working gas capacity and design-day withdrawal capability (deliverability), the two prime measures of storage utility in today's natural gas storage market, grew steadily and substantially (see Box, "Storage Inventory Definitions").

Total U.S. working gas capacity and daily deliverability by 2005 reached record levels of 4.01 Tcf and 83.7 Bcf per day, respectively. However, there are several ways that total working gas capacity may be measured. The Energy Information Administration (EIA) recently estimated that, after adjustment for operational considerations that hinder the attainment of full storage at all fields simultaneously, a likely practical estimate for maximum working gas capacity is roughly 3.6 Tcf.[6] Working gas capacity estimates compiled for this article are based upon working gas design capacity for individual sites calculated by and reported by the 123 companies that operate the 394 underground natural gas storage facilities currently in operation in the United States.

Overview

While much of available underground natural gas storage is used as a seasonal supply source and as backup for meeting peak-day natural gas demands, it is also used for several other

Notes:

All data related to specific underground natural gas storage facilities identified in this article were compiled from publicly available sources such as filings with the Federal Energy Regulatory Commission (FERC), company press releases, Internet web sites, and/or industry trade press articles. Data from the EIA Form 191A "Annual Underground Storage Report," such as working gas capacity and daily deliverability, on the other hand, were used in the compilation of the several summary tables and figures featured in this report including historical comparisons of these data.

The six U.S. regions referenced throughout this article are based upon the 10 Federal regions defined by the U.S. Department of Labor's Bureau of Labor Statistics. These combined regional breakouts were chosen because their geographic areas include, to a very high degree, the market areas served by the underground natural gas storage facilities located within their boundaries.

[1]Energy Information Administration (EIA) considers any underground natural gas storage site to be operational and subject to its reporting requirements, regardless of the level of operational activity, until it has been officially designated as abandoned by its jurisdictional agency.

[2]Energy Information Administration, *Natural Gas Annual(s)*, 1998- 2004, DOE/EIA-0131 (Washington, DC), http://www.eia.doe.gov/oil_gas/natural_gas/data_publications/natural_gas_annual/nga_historical.html

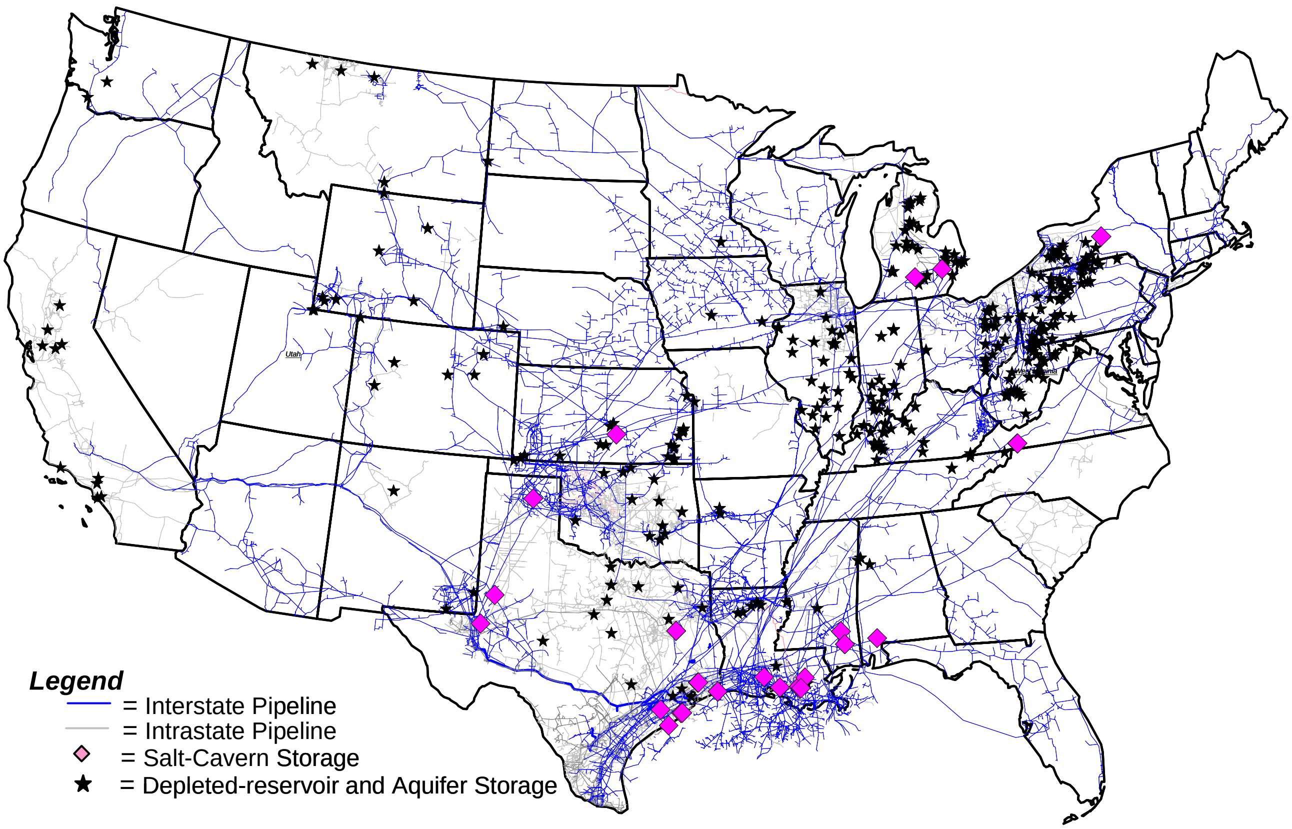
[3]An underground natural gas storage facility may be physically abandoned, that is, all wells are plugged with concrete and aboveground facilities such as compressors and dehydration equipment removed from the site, or it may be sold to another party, i.e., abandoned by sale. In the latter case it may be returned to service at a future date.

[4]"Total capacity" represents the combined base gas and working gas capacity that was available in the individual underground natural gas storage facilities prior to abandonment.

[5]Two additional underground natural gas storage fields, which were placed in operation during the period but were subsequently abandoned because of operational problems, are not included.

[6]Energy Information Administration, *Estimates of Maximum Underground Working Gas Storage Capacity in the United States*, September 2006 (Washington D.C.). http://www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publications/ ngcapacity/ ngcapacity.pdf

Figure 1. U.S. Underground Natural Gas Storage Facilities in Relationship to the National Natural Gas Transportation Grid, 2005



Note: EIA has determined that publication of this figure does not raise security concerns, based on the application of Federal Geographic Data Committee's Guidelines for Providing Appropriate Access to Geospatial Data in Response to Security Concerns.
Source: Energy Information Administration, GasTran Natural Gas Transportation Information System.

purposes as well.[7] Mainline transmission pipeline companies, for instance, also use their storage facilities for balancing the flow on their systems in order to keep pipeline pressures within design parameters and thereby maintain operational integrity. These pipeline companies also use storage to support deliveries to no-notice service (NNS) customers who have contracted for firm transportation or storage services.[8] In some cases, pipeline companies may reserve one or more storage facilities on their system strictly for these purposes.

In today's natural gas transportation market, it is the pipeline customer/shipper's responsibility to maintain a contractual balance between the natural gas volumes it delivers into a pipeline system and the volume it takes off, paying a penalty for any protracted imbalance situations. To meet these requirements and avoid penalties, shippers use underground natural gas storage services to withdraw or inject supplies as needed. Indeed, the increasing importance and need for more immediate access to stored working gas by shippers has resulted in a greater emphasis on the development of higher-deliverability storage facilities in recent years.

Another user group, natural gas producers, also use underground storage as a way to level their production over periods of fluctuating market demand. Natural gas that is not immediately marketable is stored until it is. Producers and other parties may also use storage as a marketing or price hedging tool, storing natural gas if they believe the price will increase in the future, and selling their stocks when a desired market price is reached.

Expansion Activities

Compared with 2004, underground natural gas storage development activity fell significantly in 2005. Additions to storage deliverability were 38 percent less than in 2004, and

[7]Seasonal supply sites are configured to be filled during the 214-day non-heating season (April through October) and drawn down during the 151-day heating season (November through March). Most are depleted-reservoir and aquifer storage sites.

[8]No-notice service is a contractual obligation to provide firm transportation and/or storage services, permitting customers to withdraw natural gas from storage with little or no notice to the pipeline and reserving a specified amount of storage capacity for their support. No-notice service may also provide for the short-term loaning of gas from storage to the customer, who is required to repay the gas in-kind.

Table 1. Underground Natural Gas Storage, by Region, State and Reservoir Type, 2005

Region/ State	Depleted-Reservoir Storage			Aquifer Storage			Salt-Cavern Storage			Total		
	Sites	Working Gas Capacity (Bcf)	Daily Withdrawal Capability (MMcf)	Sites	Working Gas Capacity (Bcf)	Daily Withdrawal Capability (MMcf)	Sites	Working Gas Capacity (Bcf)	Daily Withdrawal Capability (MMcf)	Sites	Working Gas Capacity (Bcf)	Daily Withdrawal Capability (MMcf)
Central Region												
Colorado	8	42	1,088	0	0	0	0	0	0	8	42	1,088
Iowa	0	0	0	4	75	1,025	0	0	0	4	75	1,025
Kansas	18	117	2,348	0	0	0	1	1	0 [1]	19	118	2,348
Missouri	0	0	0	1	11	350	0	0	0	1	11	350
Montana	5	196	300	0	0	0	0	0	0	5	196	300
Nebraska	1	16	169	0	0	0	0	0	0	1	16	169
Utah	1	51	427	2	1	100	0	0	0	3	52	527
Wyoming	7	42	227	1	4	75	0	0	0	8	46	302
Subtotal	**40**	**464**	**4,559**	**8**	**91**	**1,550**	**1**	**1**	**0**	**49**	556	**6,109**
Midwest Region												
Illinois	11	51	835	18	256	5,294	0	0	0	29	307	6,129
Indiana	10	14	261	12	20	501	0	0	0	22	34	762
Michigan	43	631	14,636	0	0	0	2	2	85	45	633	14,721
Minnesota	0	0	0	1	2	60	0	0	0	1	2	60
Ohio	24	220	4,692	0	0	0	0	0	0	24	220	4,692
Subtotal	**88**	**916**	**20,424**	**31**	**278**	**5,855**	**2**	**2**	**85**	**121**	**1,196**	**26,364**
Northeast Region												
Maryland	1	15	400	0	0	0	0	0	0	1	15	400
New York	22	99	1,640	0	0	0	1	2	145	23	101	1,785
Pennsylvania	49	402	8,518	0	0	0	0	0	0	49	402	8,518
Virginia	1	1	22	0	0	0	2	4	325	3	5	347
West Virginia	31	244	3,701	0	0	0	0	0	0	31	244	3,701
Subtotal	**104**	**761**	**14,281**	**0**	**0**	**0**	**3**	**6**	**470**	**107**	**767**	**14,751**
Southeast Region												
Alabama	1	1	14	0	0	0	1	7	600	2	8	614
Kentucky	20	80	1,753	3	7	68	0	0	0	23	87	1,821
Mississippi	4	39	1,070	0	0	0	3	31	3,022	7	70	4,092
Tennessee	1	1	20	0	0	0	0	0	0	1	1	20
Subtotal	**26**	**121**	**2,857**	**3**	**7**	**68**	**4**	**38**	**3,622**	**33**	**166**	**6,547**
Southwest Region												
Arkansas	2	15	231	0	0	0	0	0	0	2	15	231
Louisiana	8	286	3,999	0	0	0	6	42	2,853	14	328	6,852
New Mexico	2	54	310	1	2	3	0	0	0	3	56	313
Oklahoma	13	185	3,626	0	0	0	0	0	0	13	185	3,626
Texas	20	355	4,840	0	0	0	14	85	6,346	34	440	11,186
Subtotal	**45**	**895**	**13,006**	**1**	**2**	**3**	**20**	**127**	**9,199**	**66**	**1,024**	**22,208**
Western Region												
California	11	266	6,330	0	0	0	0	0	0	11	266	6,330
Oregon	6	14	493	0	0	0	0	0	0	6	14	493
Washington	0	0	0	1	21	850	0	0	0	1	21	850
Subtotal	**17**	**280**	**6,823**	**1**	**21**	**850**	**0**	**0**	**0**	**18**	**301**	**7,673**
Total	**320**	**3,437**	**61,950**	**44**	**399**	**8,326**	**30**	**174**	**13,376**	**394**	**4,010**	**83,652**
(Marginal Sites) [2]	(34)	(63)	(569)	(1)	(2)	(43)	(2)	(5)	(0)	(37)	(70)	(612)

[1] Less than 0.5 MMcf per day.

[2] An underground natural gas storage site was categorized as "marginal" if during the year; (1) no injections or withdraws at all were reported; or (2) no working gas was present, but withdrawals were made from base or native gas; or (3) no injections were reported although some withdrawal activity occurred. These marginal sites are included in the above Total and State-by-State summary lines.

Note: Bcf = Billion cubic feet. MMcf = Million cubic feet. Totals may not sum due to independent rounding.

Source: Energy Information Administration, GasTran Natural Gas Transportation Information System, Underground Natural Gas Storage Database.

Table 2. Regional Underground Natural Gas Pipeline Storage Project Summary, 2004-2008

Region	Actual [1]						Potential [2]								
	Completed in 2004			Completed in 2005			Scheduled for 2006			Scheduled for 2007			Scheduled for 2008		
	Number of Projects	Added Working Gas Capacity (MMcf)	Added Deliverability (MMcf/d)	Number of Projects	Added Working Gas Capacity (MMcf)	Added Deliverability (MMcf/d)	Number of Projects	Added Working Gas Capacity (MMcf)	Added Deliverability (MMcf/d)	Number of Projects	Added Working Gas Capacity (MMcf)	Added Deliverability (MMcf/d)	Number of Projects	Added Working Gas Capacity (MMcf)	Added Deliverability (MMcf/d)
Central	1	3,500	68	0	0	0	2	2,000	105	0	0	0	1	3,000	400
Midwest	2	23,340	800	1	500	18	1	3,000	20	0	0	0	0	0	0
Northeast	2	1,000	175	1	1,520	36	4	12,500	512	3	25,500	176	1	585	50
Southeast	1	2,400	0	2	10,460	706	1	5,060	150	4	27,102	1,780	1	3,000	300
Southwest	4	21,552	439	2	6,620	350	7	45,236	2,151	5	23,900	1,400	4	37,400	2,400
Western	3	9,165	370	3	5,780	30	2	6,200	50	1	1,200	0	1	1,436	0
U.S. Total	**13**	**60,957**	**1,852**	**9**	**24,880**	**1,140**	**17**	**73,996**	**2,988**	**13**	**77,702**	**3,356**	**8**	**45,421**	**3,150**

[1] Does not include any adjustments to total U.S. working gas capacity and deliverability due to abandonments, shifts of base gas capacity to working gas capacity, or the reassessment of capabilities made as a result of updated field testing. Therefore, the total added volumes shown in these columns may not correspond to the year-to-year changes shown in Figures 1 and 2.
[2] Includes only projects that are under review by jurisdictional agencies, or have already been approved, or are under construction, as of July 2006.
Note: MMcf = million cubic feet. MMcf/d = million cubic feet per day.
Source: Energy Information Administration: GasTran Natural Gas Transportation Information System, Underground Natural Gas Storage Projects Database.

Storage Inventory Definitions

Working gas capacity is the difference between total design capacity and the in-place base gas level reported at the end of the calendar year. The maximum amount of working gas capacity that may be actually used at a particular site is a function of economics, the type of reservoir, and its geology.

Base (cushion) gas is the volume of gas stored as semi-permanent inventory in a reservoir and is used to maintain adequate drive pressures and deliverability rates throughout the withdrawal season.

Working gas is the volume of natural gas stored in a reservoir that is not base gas. It is natural gas that is stored with the intention of being withdrawn in the near future as market conditions change, system imbalances occur, or to meet seasonal peaking demand.

Deliverability is the measure of natural gas that can be delivered (withdrawn) from a storage facility in a given length of time, usually per day. The actual deliverability of a given storage facility varies, depending on factors such as the amount of gas in the reservoir at a particular time (which dictates the pressure within the reservoir), compression capabilities available to the site, the configuration of surface facilities associated with the reservoir, (e.g., the design capacity of the connecting pipeline laterals), and other factors. In general, a facility's deliverability rate varies directly with the amount of working and base gas in the reservoir: it is at its highest when the reservoir is full and declines as working gas is withdrawn.

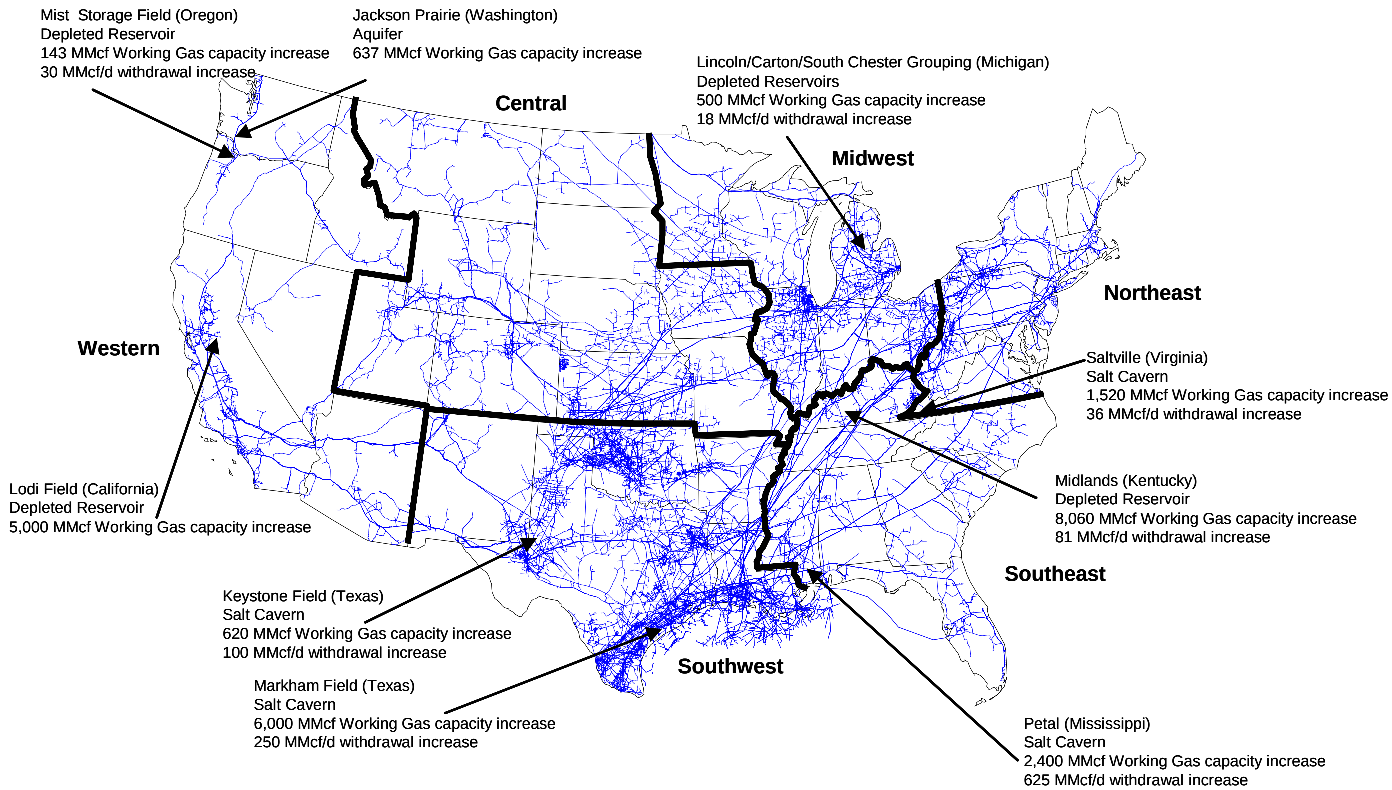
Injection rate is the measure of natural gas that can be moved into a reservoir over a specific period of time, usually daily. The injection rate depends upon several factors including the porosity of the reservoir, available compression, and the current level of working gas.

additions to working gas capacity were 59 percent less than year-earlier levels (Table 2). Added daily withdrawal capability was only 1.1 Bcf per day (Bcf/d) compared with 1.9 Bcf/d in 2004, while added working gas capacity was 24.9 Bcf compared with 61.0 Bcf in 2004. All of the nine underground natural gas storage projects completed during 2005 were expansions or upgrades to existing facilities rather than new facilities (Figure 2). These included four salt cavern facilities, four depleted-reservoir type storage operations, and one aquifer storage facility.

Nevertheless, between 1998 and 2005 estimated working gas capacity increased by 6 percent, rising from 3.79 Tcf in 1998 to 4.01 Tcf in 2005 (Figure 3). During the same timeframe the estimated overall natural gas storage deliverability (withdrawal) rate rose from 73.9 Bcf per day in 1998 to 83.6 Bcf/d in 2005, a 13-percent increase (Figure 4). Among the key reasons for the sizable increase in working gas capacity and, in particular, daily deliverability has been the incorporation of more efficient operational techniques, such as horizontally drilled wells at existing depleted-reservoir storage facilities, and the ongoing expansions of existing salt-formation facilities through the addition of new caverns.

Depleted-reservoir storage, which accounts for the vast majority (320) of underground natural gas storage sites, between 1998 and 2005 also experienced the largest increase in new site installations (21) and the largest increase in the installation of new working gas capacity (136.6 Bcf) among the three types of underground natural gas storage facilities (see Box, "Principal Types of Underground Natural Gas Storage Facilities"). However, while the average working gas capacity addition for new depleted-reservoir storage sites was a significant 5.7 Bcf per site, the average increase in working gas capacity at existing depleted-reservoirs was the lowest within any category (Figure 5). Less than one-third of depleted-reservoir expansions of working gas capacity represented large-scale upgrades to site operations. Instead,

Figure 2. Underground Natural Gas Storage Expansion Projects, 2005



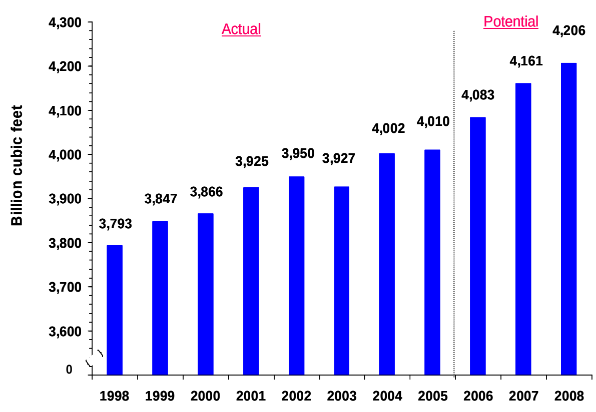
MMcf/d = million cubic feet per day.
Notes: **Security:** EIA has determined that publication of this figure does not raise security concerns, based on the application of Federal Geographic Data Committee's Guidelines for Providing Appropriate Access to Geospatial Data in Response to Security Concerns; **Regions:** The six U.S. regions shown in this figure are based in whole or in part upon the 10 Federal regions as defined by the U.S. Department of Labor's Bureau of Labor Statistics.
Source: Energy Information Administration, Office of Oil and Gas, Gas Tran Natural Gas Transportation Information System, Natural Gas Storage Projects Database.

most were primarily the result of minor upgrades to operations and equipment, accounting changes in base gas versus working gas capacity, and periodic field re-evaluations and testing.[9]

Deliverability levels at depleted-reservoir sites expanded at only 45 depleted-reservoir facilities, including 20 of 80 sites where working gas capacity was increased as well. Much of the increase in depleted-reservoir deliverability was accomplished by increasing the number of input/output wells, horizontally drilling more of these new wells, and upgrading the compression units at the facility. Expansions to depleted-reservoir storage during the period resulted in an increase in both average deliverability and average working gas capacity in this group of about 14 percent.

Additions to working gas capacity and deliverability through expansions to existing sites were larger for salt-cavern natural gas storage than for depleted-reservoir or aquifer storage (Figures 5 and 6). As the demand for high-deliverability salt-

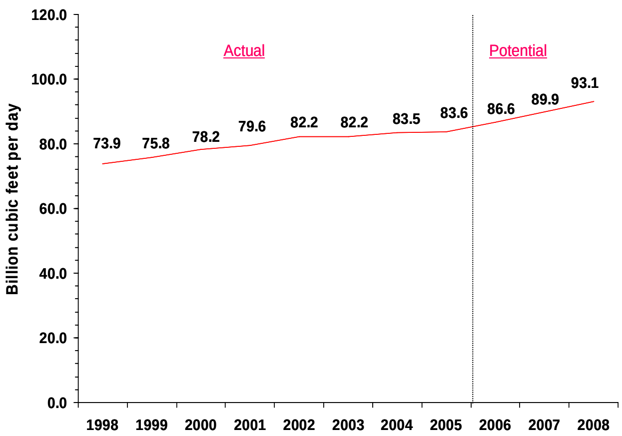
Figure 3. Underground Natural Gas Storage Working Gas Capacity, 1998-2008



Note: The working gas capacity level of all Lower-48 underground natural gas storage fields that reported to EIA during the particular year is reflected in the total, regardless of activity level. "Potential" capacity is based on projects that are under review by jurisdictional agencies, or have been already been approved, or are under construction, as of July 2006.
Source: Energy Information Administration, Office of Oil and Gas, GasTran Natural Gas Transportation Information System, Underground Natural Gas Storage and Natural Gas Storage Projects Databases.

[9]Based on data for the years 1998 through 2005. Energy Information Administration, Office of Oil and Gas, Underground Natural Gas Storage Database.

Figure 4. Underground Natural Gas Storage Daily Deliverability, 1998-2008



Note: The deliverablity (daily withdrawal rate) level of all Lower-48 underground natural gas storage fields that reported to EIA during the particular year is reflected in the total, regardless of activity level. "Potential" deliverability is based on projects that are under review by jurisdictional agencies, or have been already been approved, or are under construction, as of July 2006.
Source: Energy Information Administration, Office of Oil and Gas, GasTran Natural Gas Transportation Information System, Underground Natural Gas Storage and Natural Gas Storage Projects Databases.

cavern storage grew during the period, more than one-third of all such sites underwent some level of expansion. By the close of 2005, the average working gas capacity and daily deliverability rates at salt-cavern facilities increased by 44 and 43 percent, respectively, from 1998 levels. Only two new salt-cavern natural gas storage facilities were developed and remained in service at the end of the 6-year span.

The least number of underground storage sites undergoing expansion during the period were aquifer sites. Only one new aquifer facility was installed while six aquifer sites saw working gas capacity expansions, with the largest increase being 16 Bcf. Two of these sites, and six additional, also had increases in deliverability. Nonetheless, even in this limited group the average working gas capacity and average daily deliverability rates rose by 20 and 16 percent, respectively.

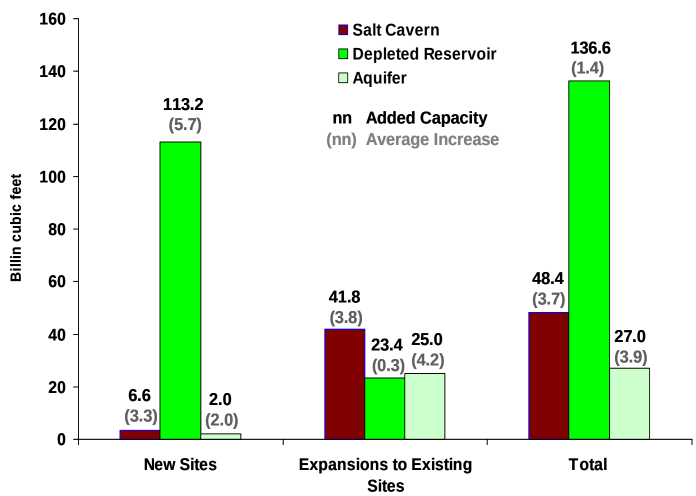
Deliverability rates from natural gas storage have increased substantially in the past 8 years. Since 1998, U.S. underground natural gas storage deliverability has increased at an average annual rate of almost 2 percent while working gas capacity has increased by slightly less than 1 percent per year (Figures 4 and 3). The continuing growth in deliverability is significant in that it primarily represents increased utilization of salt-cavern storage sites and the upgrading of a number of depleted-reservoir storage facilities. The segment of the storage industry that operates high-deliverability salt-cavern storage currently represents 16 percent of total deliverability compared with only 11 percent in 1998 (Figure 7).

Demand for Higher Deliverability Levels

Since the Federal Regulatory Commission's (FERC) Order 636 became effective in 1993, the growth in underground natural gas storage deliverability (withdrawal capability) and working gas capacity has been substantial, although the number of underground natural gas storage sites has remained virtually unchanged. After Order 636 was implemented and open-access transportation on the national natural gas pipeline system became the norm, demand for storage services grew steadily, especially from pipeline shippers who needed access to storage to meet their new load balancing responsibilities.[10]

During the intervening 12 years, while working gas capacity increased by 7 percent, deliverability grew at an even faster pace, increasing by 23 percent.[11] Moreover, between 1998 and 2005, 4.0 Bcf/d of deliverability was added with the installation of 26 new sites while 5.9 Bcf/d was added with the expansions of 63 existing underground natural gas storage facilities (Figure 6). These additions represent about 12 percent of the total deliverability currently available in the U.S underground natural gas storage market (Table 1).

Figure 5. Net Additions to Underground Natural Gas Storage Working Gas Capacity Between 1998 and 2005, by Reservoir Type



Note: Expansion data summary includes changes to working gas capacity due to facility upgrades (+), reassessment of site capabilities made as result of updated field testing (+ or -), changes due to shifts in accounting for base gas versus working gas capacity (+ or -), and changes occurring as a result of facility closeout prior to abandonment (-).
Source: Energy Information Administration, Office of Oil and Gas, GasTran Natural Gas Transportation Information System, Underground Natural Gas Storage Database.

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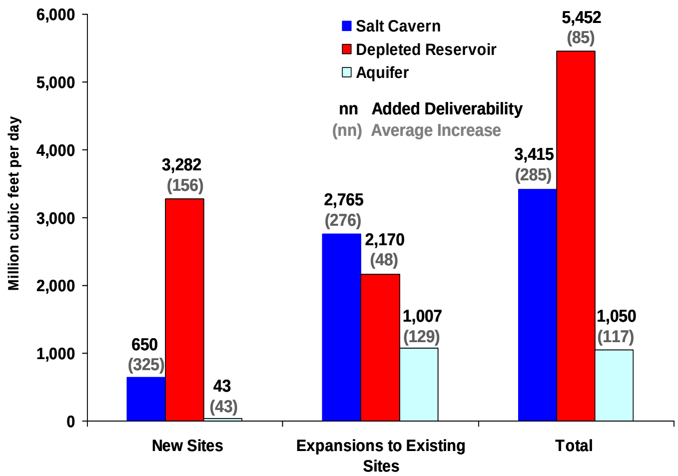
[10]For a discussion of the original objectives of FERC Order 636 in regards to the underground natural gas storage sector and its potential impact, see Energy Information Administration, *The Value of Underground Storage in Today's Natural Gas Industry*, DOE/EIA-0591 (Washington, DC, March 1995), http://www.eia.doe.gov/pub/oil_gas/natural_gas /analysis_publications/value_underground_storage/pdf/059195.pdf

[11]Computed differences are based on data in Table 1 of this article compared with Table A1 from, Energy Information Administration, *The Value of Underground Storage in Today's Natural Gas Industry*, DOE/EIA-0591 (Washington, DC, March 1995).

Figure 6. Net Additions to Underground Natural Gas Storage Deliverability Between 1998 and 2005, by Reservoir Type



Note: Expansion data summary includes changes to deliverability due to facility upgrades (+), reassessment of site capabilities made as result of updated field testing (+ or -), and changes occurring as a result of facility closeout prior to abandonment (-).
Source: Energy Information Administration, Office of Oil and Gas, GasTran Natural Gas Transportation Information System, Underground Natural Gas Storage Database.

Not surprisingly, about 47 percent of the almost 6.0 Bcf/d expansion of withdrawal capability was associated with high deliverability salt-cavern sites. These salt-cavern expansions were also much larger on average (276 million cubic feet per day (MMcf/d) per site) than that of depleted-reservoir or aquifer-storage facilities. In today's natural gas storage market, higher deliverability rates and access to facilities with flexible deliverability options are key to attracting customers such as natural gas shippers, variable-load industrial users, and natural gas-fired electric generation plants whose ongoing needs may require rapid and frequent injections or withdrawals of large volumes of natural gas.

The rapid cycling (inventory turnover) capability of salt-cavern, coupled with its ability to respond to daily, even hourly, variations in customer needs, has made it an increasingly attractive choice when developing new storage sites (geology permitting).

Although most closely associated with salt-cavern storage, high-deliverability sites may also include depleted-reservoir or aquifer storage that possess unique reservoir characteristics, utilize horizontal well drilling techniques, or use other technologies to improve deliverability and injection rates.

In 1992, when most of the 21 salt-cavern storage fields operating at that time functioned the same way as other types of underground natural gas storage fields, that is, as system support mediums and seasonal backup, the average cycling rate[12] for salt-cavern fields was 0.69 per annum (Figure 8). By 1998, the average rose to 2.42 cycles. Although the average fell to 2.28 in 2005, partly reflecting the suspension of activities at the Yaggy field in Kansas in 2003,[13] 3 of the 31 operational salt-cavern sites maintained an annual rate between 4 to 6 cycles during the year.

Principal Types of Underground Natural Gas Storage Reservoirs

Depleted Reservoir. Conversion of a field/reservoir from production to storage makes use of existing wells, gathering systems, and pipeline connections. The geology and operating characteristics of a depleted field are known. However, choices of storage field location and performance are limited by the inventory of depleted fields in any region. Most natural gas storage sites in the United States are depleted natural gas or oil fields located close to consumption centers.

Aquifer Reservoir. An aquifer is suitable for gas storage if the water-bearing formation is overlaid with an impermeable cap rock. While the geology of an aquifer is similar to a depleted production reservoir, its use as a natural gas storage medium usually requires more base (cushion) gas and greater monitoring of withdrawal and injection performance.

Salt Formation. A salt-cavern or salt-bed natural gas storage reservoir is leached from a naturally occurring salt formation. Developed mostly along the Gulf Coast, these sites offer high-deliverability flexibility of operation. Although construction is more costly than depleted field conversions when measured on the basis of dollars per thousand cubic feet of working gas, its ability to perform several withdrawal and injection cycles each year reduces the per-unit cost of each thousand cubic feet of gas injected and withdrawn.

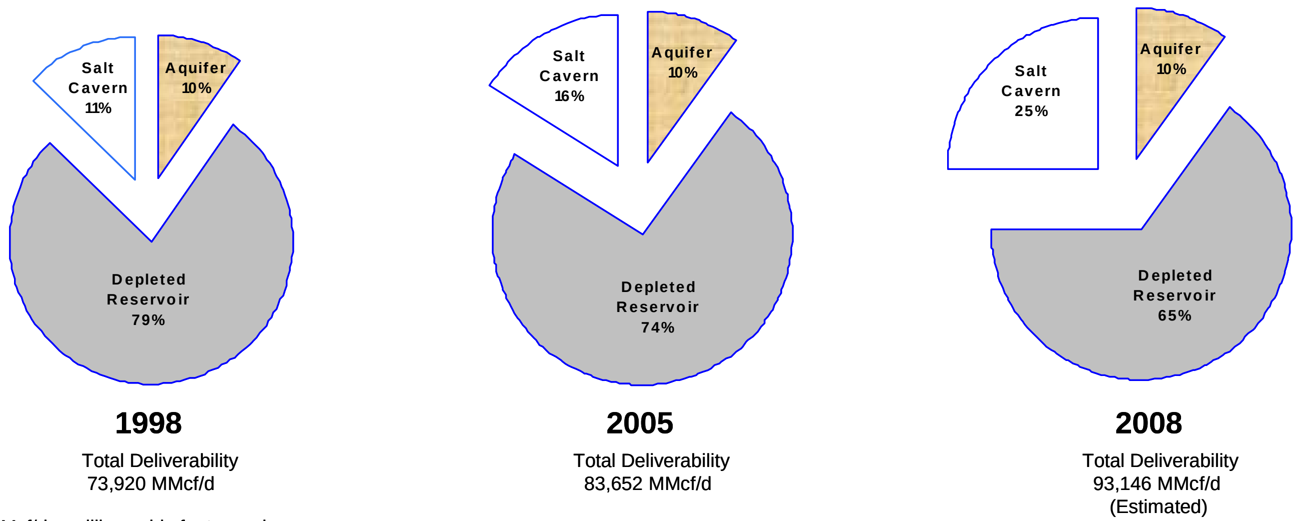
Reflecting the expansion of deliverability rates at sites other than salt-cavern facilities, annual cycling rates at aquifer and depleted-reservoir sites also have increased. Indeed, the high demand for greater deliverability rates in areas without salt-cavern geology has spurred efforts in retrofitting appropriate depleted-reservoir and aquifer storage fields with horizontally drilled wells, increasing the number of input and output wells, and upgrading compression units to increase the withdrawal and injection rates in these types of storage facilities as well. Horizontal drilling through a reservoir horizon, for instance, increases the exposure surface of the well bore, thus increasing the rate and the amount of natural gas that can be withdrawn from a well over a specific time period, i.e., higher deliverability rates.

Several States in particular have been the focus of underground natural gas storage development since the early 1990s and expansions to deliverability in particular. Since

[12] The average number of times a reservoir's working gas volumes have been turned over during a specific period of time, in this case a year.

[13] The Yaggy field experienced a gas migration loss in 2001 and ceased injection operations in 2002.

Figure 7. Salt Cavern Underground Natural Gas Storage Daily Deliverability Share Relative to Aquifer and Depleted Reservoir Storage, 1998, 2005, and 2008



MMcf/d = million cubic feet per day.
Source: Energy Information Administration, Office of Oil and Gas, GasTran Natural Gas Transportation Information System, Underground Natural Gas Storage and Storage Project Databases.

1998, storage deliverability in Michigan alone has increased by more than 1,900 MMcf/d. This has helped support the increase in demand by shippers transporting within the growing Midwest natural gas marketplace and natural gas pipeline transportation between the Chicago Hub and the Dawn hub area of Ontario, Canada (Figure 9).

Storage deliverability in Mississippi, Louisiana, and Texas has increased substantially as well, benefiting from the availability of salt-cavern facilities in their respective States. Since 1998, storage deliverability has increased by 34 percent in Mississippi, by 17 percent in Louisiana, and by 10 percent in Texas. Deliverability rates have also increased substantially in several States where depleted-reservoir storage sites have been retrofitted and upgraded to expand capabilities through horizontal drilling techniques and compression upgrades. Since 1998, for instance, deliverability rates in both New York and Pennsylvania have increased by more than 44 and 13 percent, respectively.[14]

Underground Storage Ownership

At the beginning of 2006, 123 natural gas companies operated the 394 underground natural gas storage sites located in the Lower 48 States. Of these companies, 25 were interstate companies certificated by the FERC while an additional 18 independent or local distribution companies were authorized by FERC to provide interstate storage services to intrastate companies under Section 311.[15] The remaining companies operated underground natural gas storage facilities jurisdictional to their respective State utility commissions.

Independent Operators

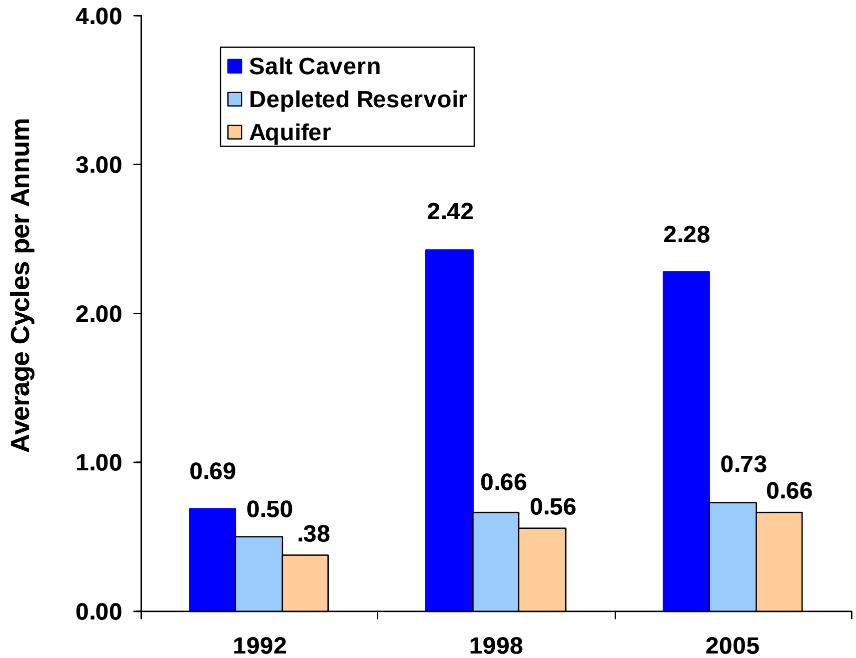
Since 1998, there has been significant growth in the percentage and level of daily deliverability and working gas capacity at sites operated by independent storage operators. Over the intervening 7 years, independent storage operators have increased their share of underground natural gas storage deliverability and working gas capacity by 7 and 4 percentage points, respectively.

Currently, 43 independent companies operate 74 underground natural gas storage facilities, accounting for about 18 percent of storage deliverability and 13 percent of current working gas capacity (Table 3), versus 11 and 9 percent, respectively, in 1998. Independent storage service operators have initiated development of many of the salt formation and other high-deliverability sites installed since the early 1990s, some of which have been expanded several times during the period.

[14]Storage deliverability levels have grown even more dramatically since 1993, increasing by 100 percent in Mississippi, 32 percent in Louisiana, and 22 percent in Texas, while in New York and Pennsylvania it increased 60 percent in both. see Energy Information Administration, *The Value of Underground Storage in Today's Natural Gas Industry*, DOE/EIA-0591 (Washington, DC, March 1995).

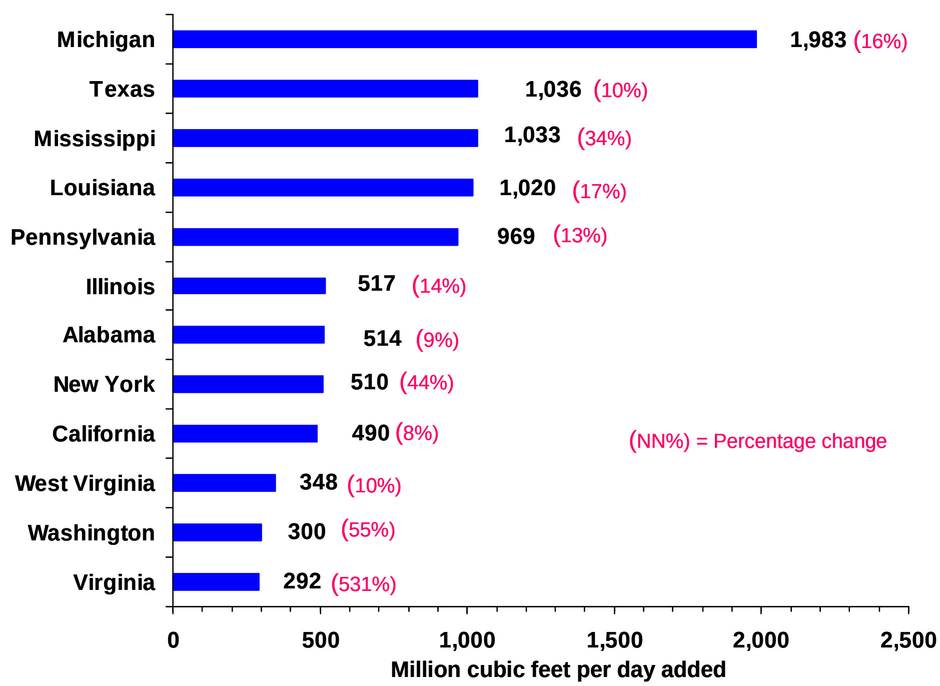
[15]NGPA Section 311 of the Natural Gas Policy Act of 1978 allows an intrastate pipeline or local gas distribution company to construct and operate storage facilities used solely to provide transportation and storage services "on behalf of" any intrastate pipeline or local distribution company, subject to certain conditions and reporting requirements.

Figure 8. Underground Natural Gas Storage Cycling Levels, 1992, 1998, and 2005



Note: Includes only underground natural gas storage sites active during the specific year.
Source: Energy Information Administration, Office of Oil and Gas, EIA Form191M, "Monthly Underground Storage Report."

Figure 9. States with the Largest Increases in Underground Natural Gas Storage Deliverability, 1998-2005



Note: Includes all storage fields including those with marginal or no activity.
Source: Energy Information Administration, Office of Oil and Gas, GasTran Natural Gas Transportation Information System, Underground Natural Gas Storage Database.

Table 3. Underground Natural Gas Storage, by Type of Owner and Reservoir Type, 2005

Type of Owner	Depleted-Reservoir Storage			Aquifer Storage			Salt-Cavern Storage			Total		
	Sites	Working Gas Capacity (Bcf)	Daily Withdrawal Capability (MMcf)	Sites	Working Gas Capacity (Bcf)	Daily Withdrawal Capability (MMcf)	Sites	Working Gas Capacity (Bcf)	Daily Withdrawal Capability (MMcf)	Sites	Working Gas Capacity (Bcf)	Daily Withdrawal Capability (MMcf)
Interstate Pipeline												
FERC Jurisdictional	157	2,055	31,821	12	121	2,509	3	21	1,500	172	2,197	35,830
Non-Jurisdictional	0	0	0	0	0	0	0	0	0	0	0	0
Subtotal	**157**	**2,055**	**31,821**	**12**	**121**	**2,509**	**3**	**21**	**1,500**	**172**	**2,197**	**35,830**
Independent												
FERC Jurisdictional	25	270	4,178	0	0	0	9	74	5,957	34	344	10,135
Non-Jurisdictional	33	155	3,183	1	1	3	6	21	1,360	40	177	4,546
Subtotal	**58**	**425**	**7,361**	**1**	**1**	**3**	**15**	**95**	**7,317**	**74**	**521**	**14,681**
LDCs & Intrastates												
FERC Jurisdictional	30	421	8,532	5	72	1,765	4	23	1,315	39	516	11,612
Non-Jurisdictional	75	536	14,216	26	205	4,049	8	35	3,244	109	776	21,509
Subtotal	**105**	**957**	**22,748**	**31**	**277**	**5,814**	**12**	**58**	**4,559**	**148**	**1,292**	**33,121**
All Types												
FERC Jurisdictional	212	2,746	44,531	17	193	4,274	16	118	8,772	245	3,057	57,577
Non-Jurisdictional	108	691	17,399	27	206	4,052	14	56	4,604	149	953	26,055
Grand Total	**320**	**3,437**	**61,930**	**44**	**399**	**8,326**	**30**	**174**	**13,376**	**394**	**4,010**	**83,632**

Note: Bcf = Billion cubic feet. MMcf = Million cubic feet. LDC = local distribution companies including intrastate pipelines. Totals may not sum due to independent rounding.
Source: Energy Information Administration, GasTran Natural Gas Transportation Information System, Underground Natural Gas Storage Database.

The shift has been even more dramatic if one looks back to 1993, when FERC Order 636 and natural gas market restructuring had yet to have an impact on the underground natural gas storage segment. Indeed, in 1993, independent operators accounted for only 7 percent of both total working gas capacity and total daily deliverability at 396 operational underground natural gas storage sites.[16] Based upon the current inventory (July 2006) of planned storage expansions and new installations, it appears that independent storage operators' share in both capacity and deliverability will increase still further by 2008.[17]

Interstate Pipeline Operators

Twenty-five interstate pipeline companies currently operate 172 underground natural gas storage facilities, more than either independent, LDCs, or intrastate pipeline operators. In 2005, their facilities accounted for about 43 percent of overall storage deliverability and 55 percent of working gas capacity in the United States (Table 3). This compares to deliverability and working gas capacity shares of 56 and 48 percent, respectively, in 1998. Interstate natural gas pipeline companies rely heavily on underground natural gas storage inventories in order to facilitate load balancing and system supply management on their long-haul transmission lines.

The Columbia Gas Transmission Company, with 36 sites located in New York, Ohio, Pennsylvania, and West Virginia operates the largest number of underground natural gas storage site in the United States. Dominion Gas Transmission Company, although having fewer sites (14), maintains greater working gas capacity and deliverability: 409 Bcf and 7.9 Bcf/d, respectively, compared with 303 Bcf and 4.5 Bcf/d for Columbia. The National Fuel Gas Supply Company, with operations only in New York and Pennsylvania, operates 31 sites, but ranks behind Dominion and Columbia with only 114 Bcf of total working gas capacity and 1.2 Bcf/d of deliverability. All three of these companies operate depleted-reservoir storage facility exclusively.

Other interstate pipeline companies with substantial underground natural gas storage operations are: Natural Gas Pipeline Company of America (NGPL), with 256 Bcf working gas capacity and 3.9 Bcf/d deliverability at nine sites in Illinois and Iowa; Texas Gas Transmission Company with 55 Bcf working gas capacity and 1.3 Bcf/d deliverability at nine sites in Indiana and Kentucky; and Southern Star Central Pipeline Company with 47 Bcf working gas capacity and 1.2 Bcf/d deliverability at eight sites in Kansas and Oklahoma.

ANR Pipeline Company and its affiliate ANR Storage Company operate the largest number of interstate underground natural gas storage fields (13) outside the Northeast region, all located in the State of Michigan. With a combined 174 Bcf of working gas capacity and 4 Bcf/d of deliverability, ANR's storage facilities are essential to the company's pipeline system operations.

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[16]Energy Information Administration, *The Value of Underground Storage in Today's Natural Gas Industry*, DOE/EIA-0591 (Washington, DC, March 1995)., Table A2. http://www.eia.doe.gov/pub/oil_gas/natural_gas/ analysis_publications/value_underground_storage/pdf/059195.pdf

[17]Energy Information Administration, GasTran Natural Gas Transportation Information System, Underground Natural Gas Storage Projects Database.

Table 4. Regional Percentage of Underground Natural Gas Storage, by Reservoir Type, 2005

Region	Depleted-Reservoir Storage			Aquifer Storage			Salt-Cavern Storage			Total		
	Sites %	Working Gas Capacity (Bcf) %	Daily Withdrawal Capability (MMcf) %	Sites %	Working Gas Capacity (Bcf) %	Daily Withdrawal Capability (MMcf) %	Sites %	Working Gas Capacity (Bcf) %	Daily Withdrawal Capability (MMcf) %	Sites %	Working Gas Capacity (Bcf) %	Daily Withdrawal Capability (MMcf) %
Central	13	14	8	18	22	19	3	0	0	12	14	7
Midwest	27	26	33	70	70	70	7	1	1	31	30	32
Northeast	33	22	23	0	0	0	10	3	4	27	19	18
Southeast	8	4	5	7	2	1	13	22	27	8	4	8
Southwest	14	26	21	2	1	0	67	73	69	17	26	26
Western	5	8	11	2	5	10	0	0	0	5	7	9
Overall	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Source: Energy Information Administration, GasTran Natural Gas Transportation Information System, Underground Natural Gas Storage Database.

The only interstate pipeline that currently operates an active salt-cavern facility is Transcontinental Gas Pipeline Company (Transco). Its Eminence facility, opened in 1971 and located in Mississippi, is used primarily to support Transco's own system requirements and operates as needed for that purpose, rather than as a high-deliverability marketing operation. The only other interstate-pipeline operated salt-cavern facility, Gulf South Pipeline Company's Magnolia facility, opened in 2003 in Louisiana, but was closed after a well bore casing collapsed later that year, causing a natural gas leak. A replacement cavern is slated for development nearby and is scheduled to go into service in 2008 or 2009.

LDC and Intrastate Pipeline Operators

The 148 underground natural gas storage sites operated by 40 local distribution companies and 15 intrastate pipeline companies account for 40 percent of storage deliverability, a 5-percent decrease from their 1998 share. They also account for about 32 percent of total working gas capacity, down from 34 percent in 1998. LDCs generally use natural gas from storage sites to serve customer needs directly, whereas intrastate pipeline companies use underground storage for operational balancing and system supply as well as the energy needs of end-use customers.

Consumers Energy Company, with 14 sites in Michigan, is the single largest LDC operator of underground storage fields in the Lower 48 States. Its sites have an overall deliverability of more than 4.0 Bcf/d and working capacity of 154 Bcf. Trailing closely is the Northern Illinois Gas Company (NICOR), which operates eight natural gas storage facilities in Illinois with a total daily deliverability level of 3.1 Bcf/d and a total working gas capacity level of 152 Bcf.

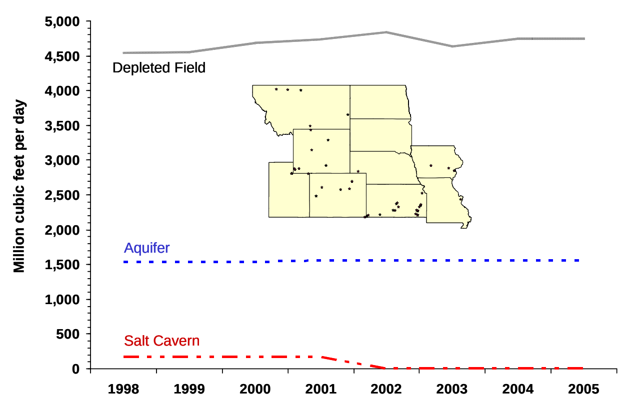
Regional Briefs

In all aspects, the underground natural gas storage facilities located in the Midwest region lead the sector (Table 1). The prevailing cold winters large population centers, large pipeline systems, and available geology have contributed to storage development in the Midwest region. The Southwest region, with its large natural gas production levels and the presence of many large salt-formations, has the second largest levels of daily deliverability and working gas capacity in the Lower 48 States.

Central Region

Approximately 7 percent of U.S underground natural gas storage deliverability and 14 percent of working gas capacity is located in the Central region (Table 4). A substantial portion of this capability is used for pipeline system load balancing and the temporary storage of excess regional natural gas production, but several sites located near market areas such as Denver, Colorado, Salt Lake City, Utah, and southeastern Kansas are used as backup storage for meeting winter peak-day demands. Of the 49 sites located in the region, 40 are depleted-reservoir sites with the remainder being aquifer-reservoir storage sites (Table 1). No high-deliverability salt-cavern storage facilities are fully active in the region. The Yaggy field, the only salt formation storage site in the region, developed a reservoir leak in 2001, and has been restricted to limited withdrawal activity since 2002.

Figure 10. Central Region - Underground Natural Gas Storage Daily Deliverability, By Reservoir Type, 1998-2005



Note: The deliverability (daily withdrawal rate) level of all underground natural gas storage fields in the region that reported to EIA during the particular year is reflected in the total, regardless of activity level.
Source: Energy Information Administration, Office of Oil and Gas, GasTran Natural Gas Transportation Information System, Underground Natural Gas Storage Database.

The largest underground natural gas facility in the United States is also found in the Central region. The Baker field, a tight-sand formation reservoir located in Montana, maintains a working gas capacity that is almost twice as large as the next largest underground natural gas storage field. However, because of its tight-sand geology it has a relatively low maximum level of injection and withdrawal rates and serves primarily as a system support facility for its owner, the Williston Basin Interstate Pipeline Company.

Between 1998 and 2005, overall deliverability increased by only 1.1 percent while total working gas capacity increased by about 1.4 percent (Figure 10). Although three new facilities were brought into service during the period, three existing ones were abandoned. Additional working gas capacity and/or deliverability were introduced into the region with the completion of eight expansion projects during the period.

Through 2008, only one new facility has been proposed within the region, the Chevron Gas Company's Windy Hill Project, to be located in Colorado. Three expansion projects have been put forward but only two have gone beyond the planning stage (Table 2).

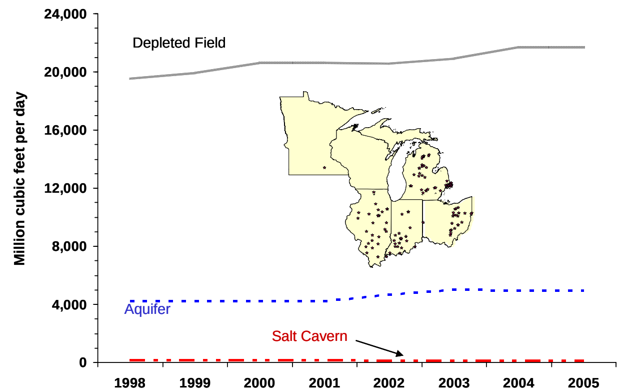
Storage facilities in the southeastern part of the region also support the interstate pipeline systems that extend from northern Texas to the Midwest region. Natural gas storage facilities owned by Southern Star Central Pipeline Company represent about one-third of the region's working gas capacity. About 13 percent of daily peak-day storage deliverability is available through local distribution companies. About 40 percent is available to the two major interstate pipelines, Northern Natural Gas and Panhandle Eastern Transmission that traverse the region.

Midwest Region

The Midwest region (Figure 11) contains the largest number of underground natural gas storage facilities (121), the highest daily deliverability level (26.4 Bcf), and the largest volume of working gas capacity (1.2 Tcf), of any of the six regions (Table 1). Its storage facilities account for nearly one-third of all U.S. working gas capacity and daily deliverability (Table 4). The region also has the largest number of aquifer storage reservoirs, with 18 located in Illinois and 12 in Indiana.

The State of Michigan alone accounts for about 18 percent of total U.S. deliverability and 16 percent of total U.S. working gas capacity, the largest share for any State in the country. Moreover, the State of Michigan is the home of a unique type of depleted–field storage facility, that is, the reef

Figure 11. Midwest Region - Underground Natural Gas Storage Daily Deliverability, By Reservoir Type, 1998-2005



Note: The deliverability (daily withdrawal rate) level of all underground natural gas storage fields in the region that reported to EIA during the particular year is reflected in the total, regardless of activity level.
Source: Energy Information Administration, Office of Oil and Gas, GasTran Natural Gas Transportation Information System, Underground Natural Gas Storage Database.

formation.[18] Twenty-six of the State's 45 sites are reef formations and account for more than half of the State's overall working gas capacity and 65 percent of its deliverability.

Between 1998 and 2005, working gas capacity in the region increased by more than 4 percent while total deliverability increased by about 13 percent, despite the abandonment of 16 marginal fields. Offsetting these closings was the opening of 5 new facilities and the expansion or upgrading of 15 existing sites.

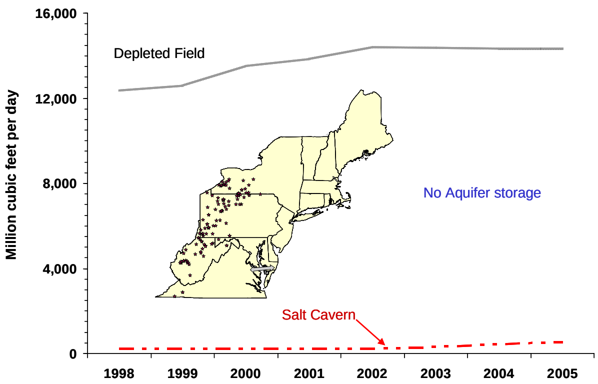
Based upon current plans for future development of storage facilities in the region, however, the steady growth rate of the recent past will taper off. In 2005 for instance, only one relatively small expansion project was completed in the region, the upgrading of ANR Pipeline Company's Lincoln-Carton-South Chester storage field group, which is intended to improve operational support for its pipeline system within northern Michigan (Figure 8). The only other planned storage expansion within the region is scheduled to be completed in 2006, ANR's Claire storage field expansion in Michigan (Table 2).

Northeast

Almost all of the underground natural gas storage fields in the Northeast region were developed from depleted natural gas production fields in New York, Pennsylvania, and West Virginia. The only non-depleted-reservoir storage sites are three salt-bed storage facilities: two in Virginia and one in New York (Table 1). Access to underground natural gas

[18]Pinnacle reef reservoirs are very suitable for natural gas storage because they tend to be tall, vertical mound formations of lime and limestone, coral and other carbonaceous materials, which give them a high porosity and high permeability. These features are highly desirous in an underground storage site because they help maximize injection and withdrawal rates.

Figure 12. Northeast Region - Underground Natural Gas Storage Daily Deliverability, By Reservoir Type, 1998-2005



Note: The deliverability (daily withdrawal rate) level of all underground natural gas storage fields in the region that reported to EIA during the particular year is reflected in the total, regardless of activity level.
Source: Energy Information Administration, Office of Oil and Gas, GasTran Natural Gas Transportation Information System, Underground Natural Gas Storage Database.

storage is essential for balancing natural gas supplies in the region with peak-day demands during the winter. In particular it is the key source of peaking supplies for the Middle Atlantic States and parts of New England. Most of the natural gas pipeline systems feeding into the Middle Atlantic States from the Southwest region were designed predicated on access to backup supplies that could be withdrawn from storage to supplement their baseload design capacity in their primary market areas.

The Northeast region has the second largest number of underground natural gas storage facilities, 107, and accounts for 18 percent of total deliverability and 19 percent of overall U.S. working gas capacity. There are more underground natural gas storage facilities located in Pennsylvania (49) than in any other State in the country.

Between 1998 and 2005, a net 2.2 Bcf/d of deliverability (18 percent) and 55 Bcf working gas capacity, (8 percent), were added in the region with the completion of 18 storage expansion projects and the development of 2 new facilities (Figure 12). Thirteen marginal sites were also abandoned during the period.

In 2005, only one project added to working gas capacity and deliverability in the region, Duke Energy's Saltville facility, located in southwestern Virginia (Figure 2). Initial operations at the site began during 2003 with expectations of adding about 1 Bcf of working gas capacity, and 100 MMcf/d deliverability, annually, until 6 Bcf of capacity and 500 MMcf/d deliverability levels are reached in 2007. The site was built adjacent to an existing salt-cavern facility that Duke acquired in 2004. The Saltville facility is one of only three salt formation facilities found in the Northeast region.

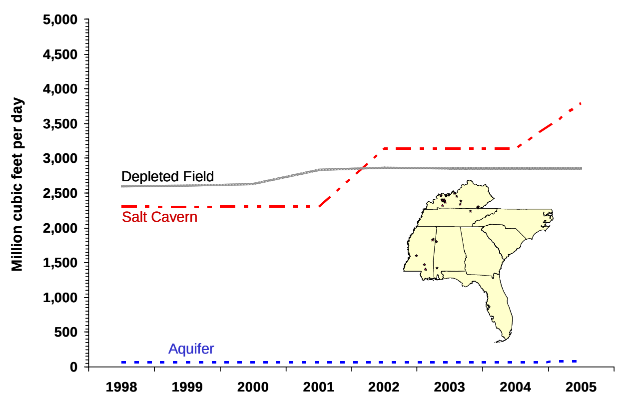
Although the Northeast region contains an extensive underground natural gas storage infrastructure, a number of its 107 fields have comparatively small working gas capacity levels (Table 1). Indeed, the average working gas capacity per field in the Northeast is 7.2 Bcf, compared with the national average of 10.2 Bcf per field. In some cases, smaller capacity storage fields tend to be less efficient and therefore uneconomic to operate in today's more competitive storage market. Not surprisingly, 9 of the 42 U.S. underground storage fields that ceased operation since 1998 were located in the Northeast region.

Over the next several years (2006-2008), however, eight underground storage projects, representing almost 39 Bcf of working gas capacity and 738 MMcf/d of deliverability, have been approved or are under review by FERC and/or State agencies. If completed, these projects would increase the region's working gas capacity and its daily deliverability from storage by about 5 percent each.

Southeast

Only three States (Alabama, Kentucky, and Mississippi) in the Southeast region (Figure 13) have active underground natural gas storage facilities (Table 1).[19] Since 1998, underground natural gas storage deliverability in the region has increased by 35 percent (1.7 Bcf/d), mainly because of additions in Alabama and Mississippi (Figure 9). In Alabama, the installation of the East Detroit depleted-reservoir facility in 2001 and several expansions to the Mcintosh salt-cavern facility increased deliverability by 9 percent (514 MMcf/d) in that State, while in Mississippi the expansions of two existing underground sites (Muldon and Petal) during the period increased deliverability by 34 percent (1,033 MMcf/d).

Figure 13. Southeast Region - Underground Natural Gas Storage Daily Deliverability, By Reservoir Type, 1998-2005



Note: The deliverability (daily withdrawal rate) level of all underground natural gas storage fields in the region that reported to EIA during the particular year is reflected in the total, regardless of activity level.
Source: Energy Information Administration, Office of Oil and Gas, GasTran Natural Gas Transportation Information System, Underground Natural Gas Storage Database.

[19]The one operational underground ground storage facility located in the State of Tennessee has been inactive for several years.

In terms of increased deliverability, these two States ranked third and seventh in the amount of additional deliverability contributed in the Lower 48 States between 1998 and 2005. In Kentucky, on the other hand, the only other State in the Southeast region with underground natural gas storage facilities, deliverability increased by only 3 percent while overall working gas capacity actually fell by 5 percent, as several marginal facilities were abandoned as uneconomic.

Prior to the initiation of industry restructuring in 1993 under FERC Order 636, the majority of the region's natural gas storage sites, including salt-cavern facilities located in the southern portion of the region, were devoted primarily to interstate system supply and load balancing. About 85 percent of the area's working gas capacity was owned by interstate pipeline companies. Since Order 636, most of these sites have been transformed into open-access storage operations where shippers contract for working gas capacity to assist them in fulfilling their contract with the pipelines to maintain a balance between their receipts and deliveries on the pipeline system. Large local distribution companies located in the Northeast and Midwest regions also use the Southeast's salt-cavern capabilities to balance their variable demand loads with their local delivery needs.

In the northern tier of the region, in Kentucky, 66 percent of the State's working gas capacity is owned by the Texas Gas Transmission interstate pipeline system. Once devoted to the pipeline for system support use, under open-access a large portion of that capacity is now devoted to supporting shippers of natural gas to northern Kentucky, Indiana, and Illinois. The remaining 34 percent of working gas capacity in the State is owned by local natural gas distribution companies who use it as a seasonal supply source and as system backup.

In 2005, two major storage developments were completed in the region. The largest increase to working gas capacity occurred at the Texas Gas Transmission (TGT) Midland facility in Kentucky. Midland is TGT's largest storage field. It provides more than 80 percent of the pipeline company's seasonal and daily storage capacity. New wells and added compression at the facility allow shippers to withdraw up to 81 MMcf/d additional volumes of natural gas, while increasing working gas space by 8.1 Bcf, a 12-percent increase. The largest increase in deliverability in the region occurred at Enterprise Products Partners LP's Petal Storage field in Mississippi, where 625 MMcf/d of deliverability and 2.4 Bcf of working gas capacity was added with the completion of a new cavern (Figure 2).

During 2005, Gulf South Pipeline Company transferred 12.9 Bcf of base gas to working gas capacity at its Bistineau, Louisiana, facility to help mitigate the loss of 4.5 Bcf of working gas capacity at its Magnolia storage field in Louisiana, which became inoperable after a well bore casing collapse in late 2003 caused a natural gas leak. The portion of Magnolia's operational capabilities devoted to system support are now fulfilled at the Bistineau, Louisiana, and Jackson, Mississippi, facilities, which are used primarily for operational purposes such as balancing the system and supporting deliveries to NNS customers on the east side of the system.

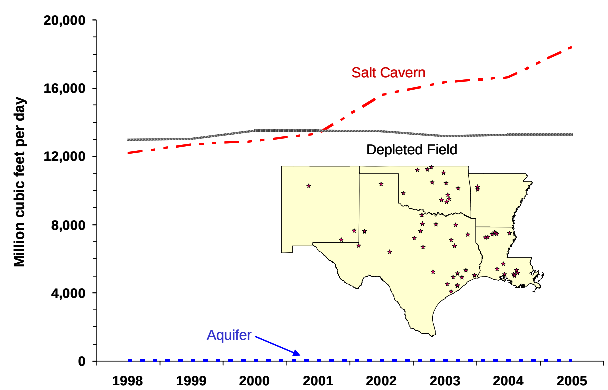
Between 2006 and 2008, an additional 35.2 Bcf of working gas capacity, and 2.2 Bcf/d of deliverability, is planned for development in the region (Table 2). Planned projects include two new underground salt-cavern storage facilities and one new depleted-reservoir field, which account for over 60 percent of the additional working gas capacity and 55 percent of new deliverability scheduled to be installed during the period. Expansions of existing facilities include the third phase of the expansion of the Petal Salt Cavern Storage facility in Mississippi.

If each of the proposed storage expansions and new site installations is actually completed by the close of 2008, daily deliverability in the region would increase by one-third while working gas capacity would improve by 23 percent.

Southwest

The largest number of high-deliverability, salt cavern underground natural gas storage sites are located in the Southwest region of the United States, in Texas and Louisiana (Table 1). Salt-cavern working gas capacity in the region, 127 Bcf, currently represents 73 percent of the total salt-cavern working gas capacity in the United States. Salt-cavern deliverability in the region also accounts for approximately 69 percent of total U.S. salt-cavern deliverability (Table 4). Moreover, those figures are expected to grow substantially between 2006 and 2008 as 13 new and/or expansion salt-cavern storage projects are slated for development during the period.

Figure 14. Southwest Region - Underground Natural Gas Storage Daily Deliverability, By Reservoir Type, 1998-2005



Note: The deliverablity (daily withdrawal rate) level of all underground natural gas storage fields in the region that reported to EIA during the particular year is reflected in the total, regardless of activity level.
Source: Energy Information Administration, Office of Oil and Gas, GasTran Natural Gas Transportation Information System, Underground Natural Gas Storage Database.

Between 1998 and 2005, working gas capacity in the region increased by only 4 percent, or 43 Bcf, while deliverability increased by 10 percent, or 2.1Bcf/d (Figure 14), primarily because of the installation of two new high-deliverability salt-cavern storage facilities and the phased-in expansions of five existing salt-cavern sites.[20] Six small underground natural gas storage sites in the region were abandoned during the period.

The overwhelming majority of added operational storage capacity in the region during the period came from expansions of existing natural gas storage facilities, more specifically in the high-deliverability, salt-cavern sector. Net working gas capacity associated with high-deliverability, salt-cavern storage grew by 35 Bcf, or 38 percent, while deliverability increased by a larger percentage, 43 percent, or 2.9 Bcf/d. Included in these additions were two major storage projects completed in 2005. One was the expansion of Unocal Global Trade Company's Keystone high-deliverability, salt-cavern site in west Texas and Kinder Morgan Texas Pipeline Company's Markham salt-cavern storage facility in southeast Texas (Figure 2).

Between 1998 and 2005 only four new storage facilities were installed in the region, and of those, three were relatively small in working gas capacity and deliverability. While five depleted-reservoir storage fields were expanded during the period, the expansions were small. Overall, net deliverability for depleted-reservoir storage in the region increased by 273 MMcf/d during the period although working gas capacity actually decreased by 18 Bcf.

In the near term, 2006 through 2008, 16 storage projects are scheduled for development in the Southwest region. Thirteen of these projects deal with high-deliverability, salt-cavern facilities (seven new facilities and six expansions), making up about 81 percent of the region's proposed new working gas capacity and 95 percent of proposed increases to deliverability. All of the proposed salt-cavern projects are being sponsored by independent storage companies, mostly in Louisiana, who have attracted customers that need flexibility in their access and use of storage services.

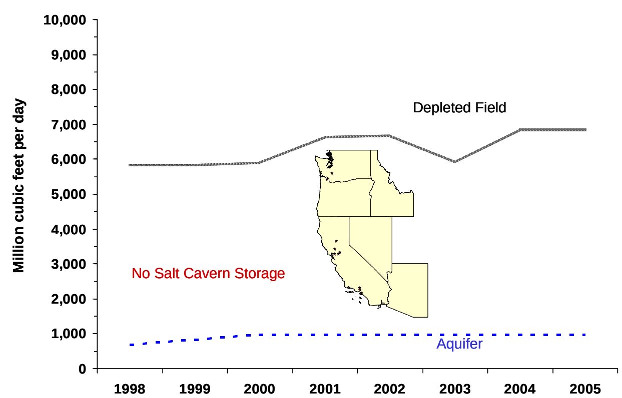
Western

Since 1998, deliverability in the Western region (Figure 15) has increased by 16 percent (1.1 Bcf/d) while working gas capacity has increased by 23 percent (56 Bcf). Contributing to these increases was the installation of two new depleted-reservoir natural gas storage facilities and the expansion of four existing natural gas storage fields (three depleted-reservoirs and one aquifer) during the period. Completion of the two new sites, Wild Goose (1998) and Lodi (2001) fields, in California, and their expansions in 2004[21] and 2005, respectively, accounted for more than half the increased deliverability in the region.

Conversely, two underground storage sites were abandoned during the period. Southern California Gas Company closed its Montebello and East Whittier storage fields in 2003, causing a temporary drop of 750 MMcf/d in the regional deliverability level for that year. The 18 operating underground natural gas storage facilities in the Western region have the highest average deliverability level, 426 MMcf/d per site, and average working gas capacity, 16.7 Bcf/d, of the regions (Table 1).

In 2005, expansions to three existing natural gas storage facilities took place (Figure 2). In addition to the Lodi field expansion, the Jackson Prairie aquifer facility[22] located in Washington State and the Mist field in Oregon underwent expansion. The latter two fields are undergoing multi-year expansions that are scheduled to continue through 2008, and perhaps beyond.

Figure 15. Western Region - Underground Natural Gas Storage Daily Deliverability, By Reservoir Type, 1998-2005



Note: The deliverability (daily withdrawal rate) level of all underground natural gas storage fields in the region that reported to EIA during the particular year is reflected in the total, regardless of activity level.
Source: Energy Information Administration, Office of Oil and Gas, GasTran Natural Gas Transportation Information System, Underground Natural Gas Storage Database.

Increasing working gas capacity at the Jackson Prairie facility, which provides vital system load support to the northern portion of the Northwest Pipeline system and access to storage services by Northwest's shipper/customers, is critical to future expansions of Northwest Pipeline system itself. Since 2001, more than 5.5 Bcf of working gas capacity, a 31-percent increase, has been built into the facility, although deliverability has not been increased.

[20]The Magnolia salt-cavern site completed in 2003 in Louisiana, the largest new natural gas storage facility installed in the region during the period, was idled in the spring of 2004 when a leak developed within the formation.

[21]The early 2004 expansion of the Wild Goose storage facility was preceded by the installation of a 25-mile, 700 MMcf/d pipeline, which interconnects with Pacific Gas and Electric Company's mainline transmission system.

[22]The Jackson Prairie facility, owned by Puget Sound Energy Inc., is the only underground natural gas storage site in the Western region that is jurisdictional to the FERC.

The on-going Mist storage expansion, which has steadily augmented both working gas capacity and deliverability at the site beginning in 1999, has increased working gas capacity from 7.4 Bcf (1999) to 14.4 Bcf (2005) while deliverability has grown from 0.24 Bcf/d to 0.38 Bcf/d. Northwest Natural Gas Company, which owns and operates the Mist facility and has an interconnection at the Jackson Prairie facility as well, needs the additional seasonal storage capacity to meet an expanding customer base. In conjunction with the expansion of the Mist storage facility, Northwest Natural Gas Company also built a 61-mile pipeline extension (completed in 2004) from the Mist field to expand service to the south and west of the city of Portland, Oregon.

Although there is a growing need for natural gas storage support to accommodate the expanding natural gas pipeline systems in Arizona, only two salt-cavern storage projects are currently being explored. One is the Coolidge site project sponsored by the Chevron and Pacific Texas Pipeline Corporation in conjunction with its proposed 2009 Picacho Pipeline Project, currently before FERC for environmental review. The other is a proposal by El Paso Natural Gas Company to study the practicality of developing a salt-cavern storage facility in Pinal County that would be linked to its southern system. For the near-term, however, it appears that Arizona will remain without any underground natural gas storage facilities.

Indeed, no new underground natural gas storage facility of any type is scheduled for development in the Western region through 2008. Furthermore, only four relatively minor expansion projects, three at the same field, are slated for completion between 2006 and 2008 (Table 2). Those are the Lodi storage field in California (2006) and the Jackson Prairie field in Washington State (2006-2008). Current expansion plans for the Mist storage field in Oregon have yet to be finalized but that site could also be expanded in both 2006 and 2008.

Outlook

A major new underground storage development project may take 3 to 5 years from the time it is initially proposed until it is finally completed. Environmental considerations or public opposition may extend it even longer. The process of developing a new storage facility is lengthy and sometimes complicated. Often the first step, the open-season procedure, is as far as a project proceeds. If not enough market interest (demand) is generated through the open-season, then sponsors may cancel or postpone the project indefinitely. Moreover, because of the long period of time that may transpire between the initial open-season and the final approval to begin construction, it is sometimes difficult for sponsors to develop and maintain firm customer commitments to their projects.

This situation, coupled with more stringent credit approval requirements demanded of potential customers in recent years, has not only resulted in the cancellation of several proposed projects, it has also caused major departures from planned project timelines. Creditworthiness issues may continue to affect some projects during the later stages of the project as well, as some potential customers have dropped out as late as the construction phase of a project, citing credit or other financial problems as a factor. For some projects such actions by clients have caused projects to be downsized, delayed, or canceled outright.

Even faced with such obstacles, however, a substantial number of new-site storage projects, with proposed in-service dates between 2006 and 2008, or later, remain viable. The current inventory (July 2006) of pending 2006-2008 underground storage projects stands at 38, several of which are multi-phase projects applicable to single storage facilities. Several additional potential projects have been announced, but plans and specifications for the projects have not been finalized. Most likely they will be rescheduled for a later period although some will also be canceled.

Of the 38 underground natural gas storage projects that have been approved, or are under review by FERC or other appropriate jurisdictional agency (Table 2), 15 are new facilities and 23 are expansions to existing facilities. These projects have the potential to add as much as 197 Bcf to existing working gas capacity and 9.5 Bcf/d to daily deliverability. If fully implemented, and not accounting for any potential abandonment of existing sites, these additions would represent an 11-percent increase in daily deliverability and a 5-percent increase in working gas capacity in the United States by the end of 2008.

The current inventory of proposed storage projects indicates that development of new high-deliverability, salt-cavern natural gas storage and expansion of existing sites will also continue over the near term. The majority (11) of the 15 proposed new natural gas storage facilities are salt-cavern sites, as are 9 of the storage expansion projects scheduled for completion between 2006 and 2008. These 20 projects, as proposed, would account for 55 percent of the additional working gas capacity and 85 percent of added deliverability over the period, far exceeding additions from depleted-reservoir and aquifer reservoir development.

High-deliverability salt cavern storage, which currently represents 16 percent of total U.S. underground natural gas storage deliverability (Figure 7), potentially could rise to a 25-percent share by 2008. The multi-cycling capability of salt-cavern storage, coupled with its ability to react quickly to daily, even hourly, variations in customer needs, has made it very attractive to storage developers, whose profitability often depends upon their capability to maximize turnover volumes.