

Gas / Electric Partnership Workshop

February 9 – 10, 2011

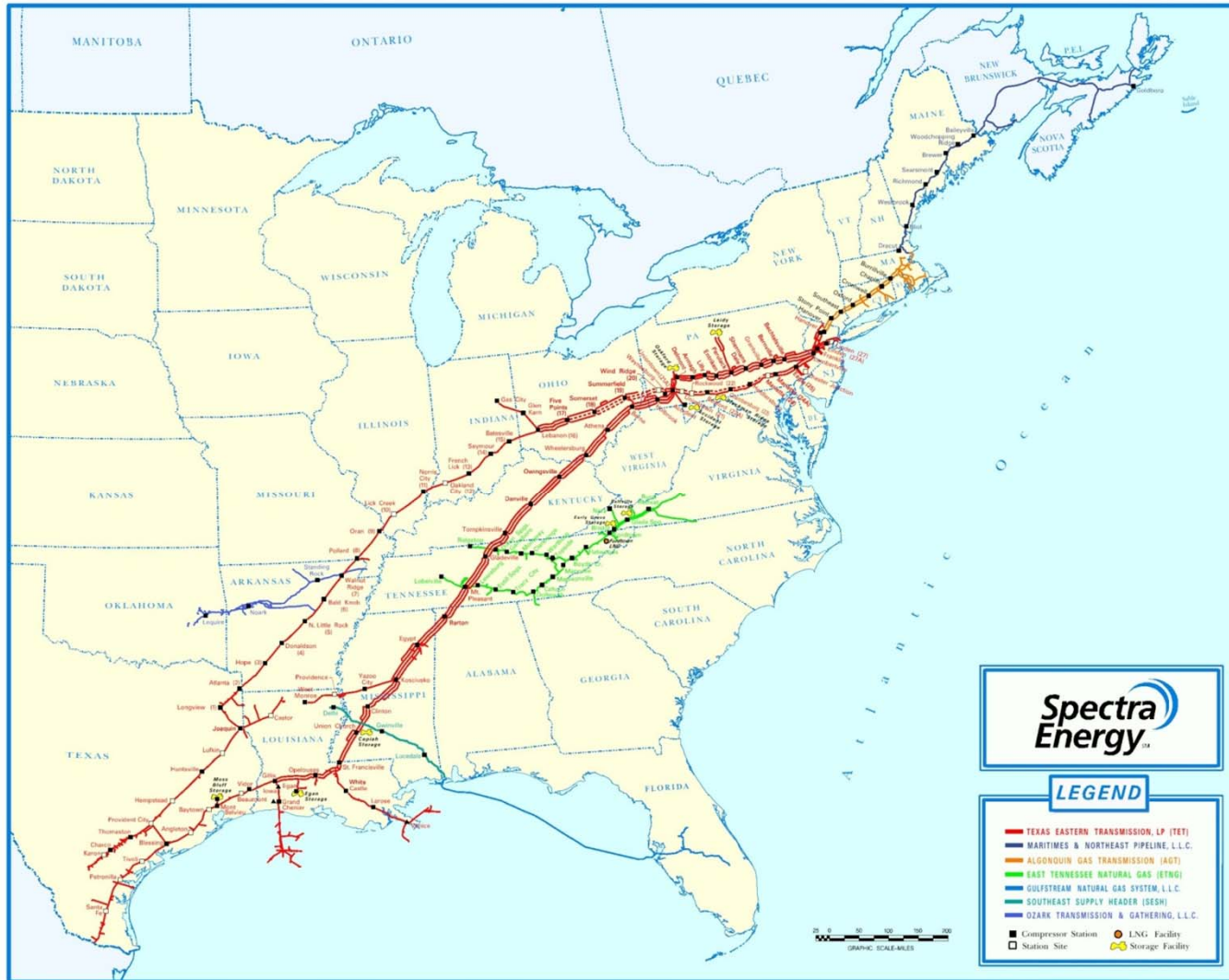
Randall Schorre
General Manager – Technical Services

Trends in Gas Storage & Requirements for Compression



- Gas storage venues
 - Gas storage operations (Pre and Post Order 636)
 - Controlling storage capacity
 - Gas storage projects (existing and proposed)
 - Trends in gas storage
 - Compression requirements
 - Life cycle cost analysis
 - Conclusions
-

Spectra Energy U.S. Asset Map



Drawings: F:\data\reorg\asset\work\NPP\01_SPECTRA_NPP\01_SPECTRA_ALL_ASSETS.dwg
 Date: 4/22/2011

Model: P:\ALL ASSETS - DCP
 User: rama_aj@vega.com

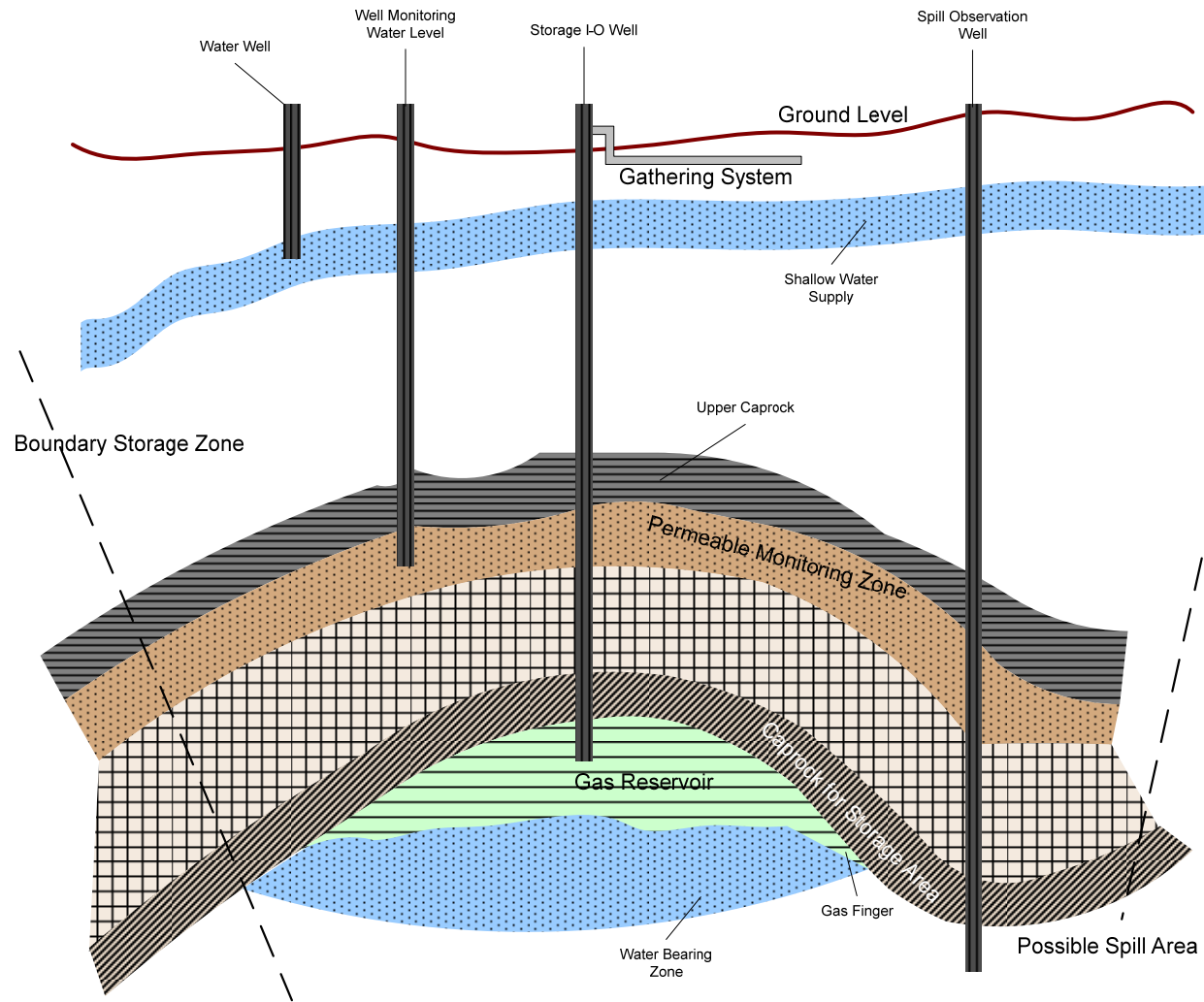
Spectra Energy US Asset Summary

- Miles of Pipeline ~12,600 miles
 - Horsepower ~2.1 million
 - Compressor Stations 127
 - Measurement & Regulation Stations ~2,000
 - Underground Gas Storage ~155 Bcf (Working Gas)
 - US Operations Employees ~1,200
 - States Traversed 26
 - 2009 System Peak Day Delivery 12,391 Mdth
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Gas Storage Venues

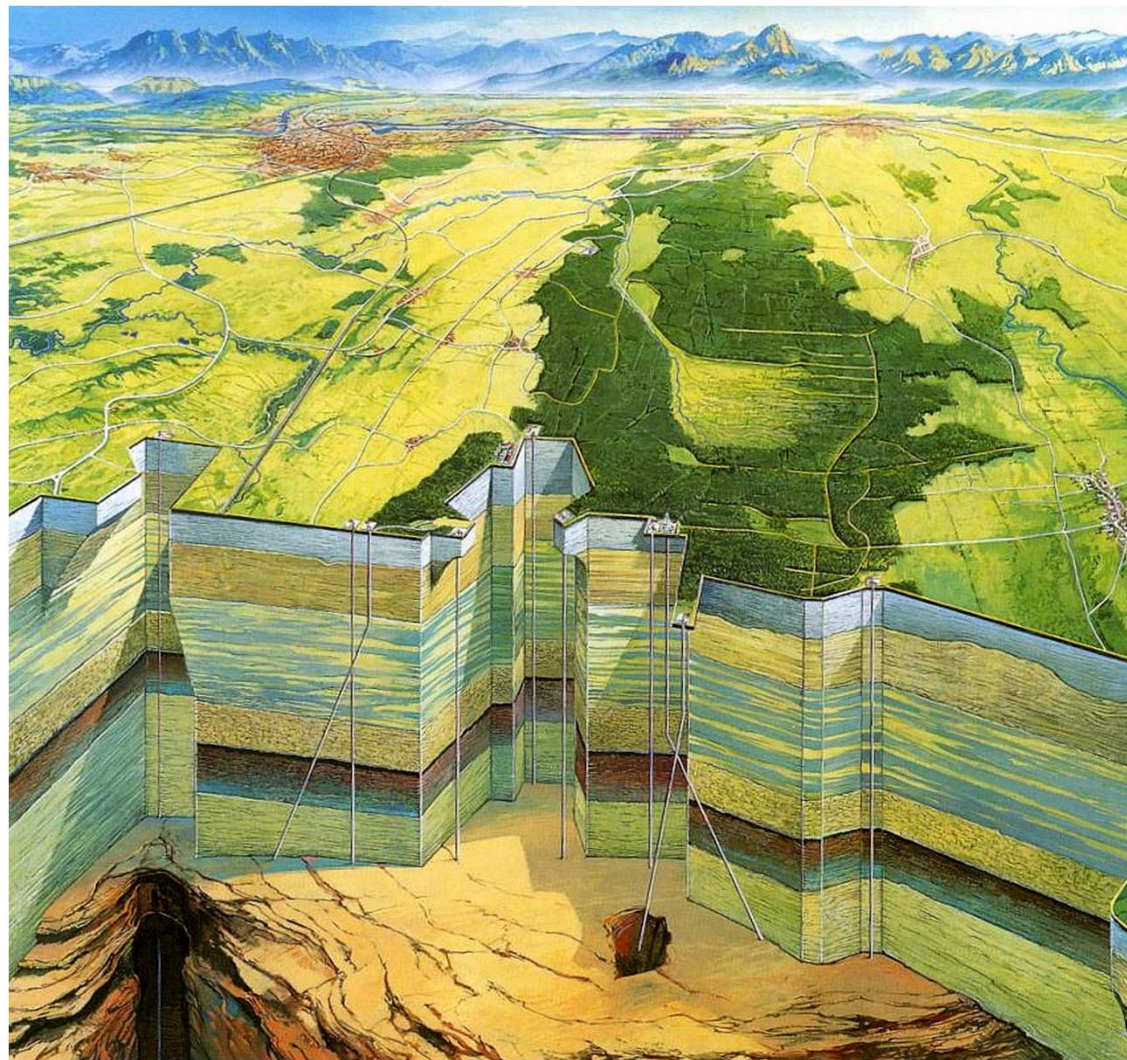
- Aquifer
- Depleted reservoirs
- Leached caverns
 - Domal salt
 - Bedded salt

Aquifer



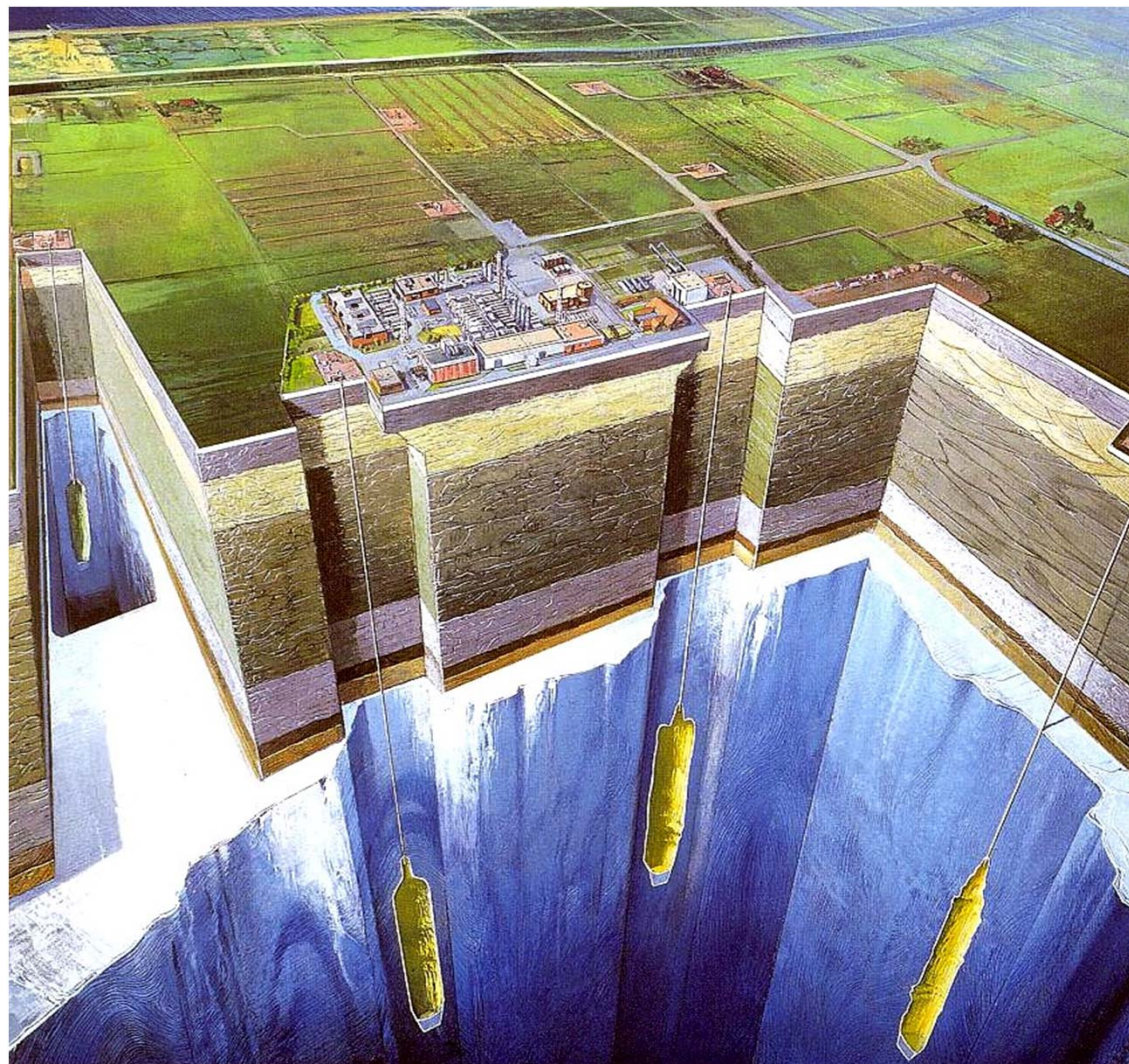
AGA GEOP Series, Book S-1, *Underground Storage*, 1990

Depleted Reservoir



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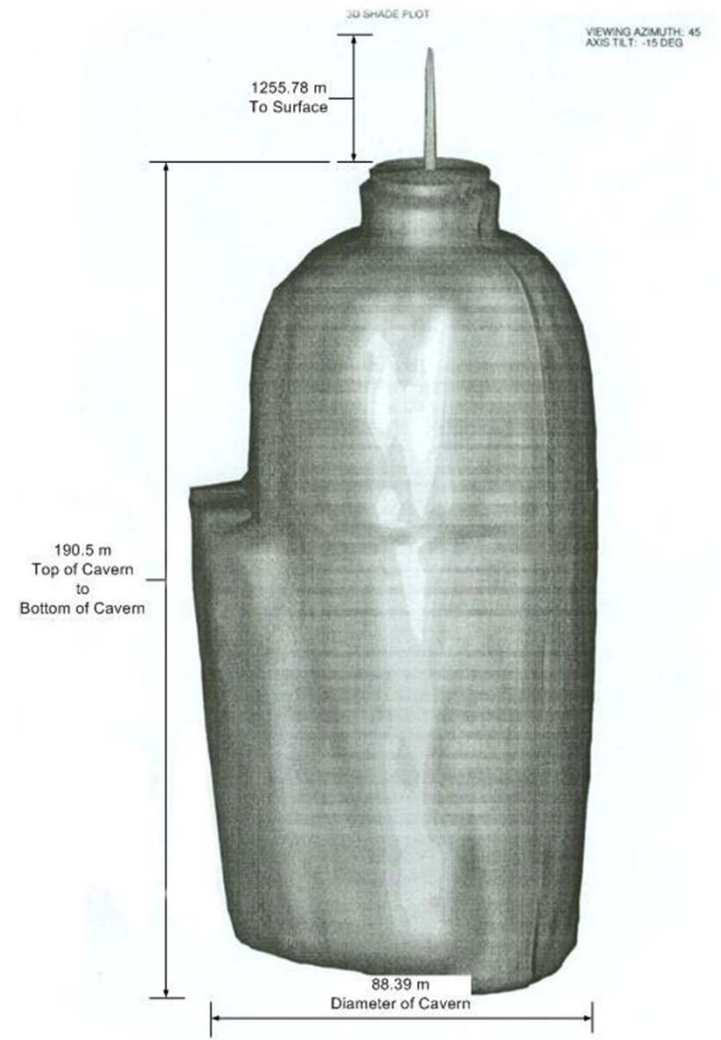
Domal Salt



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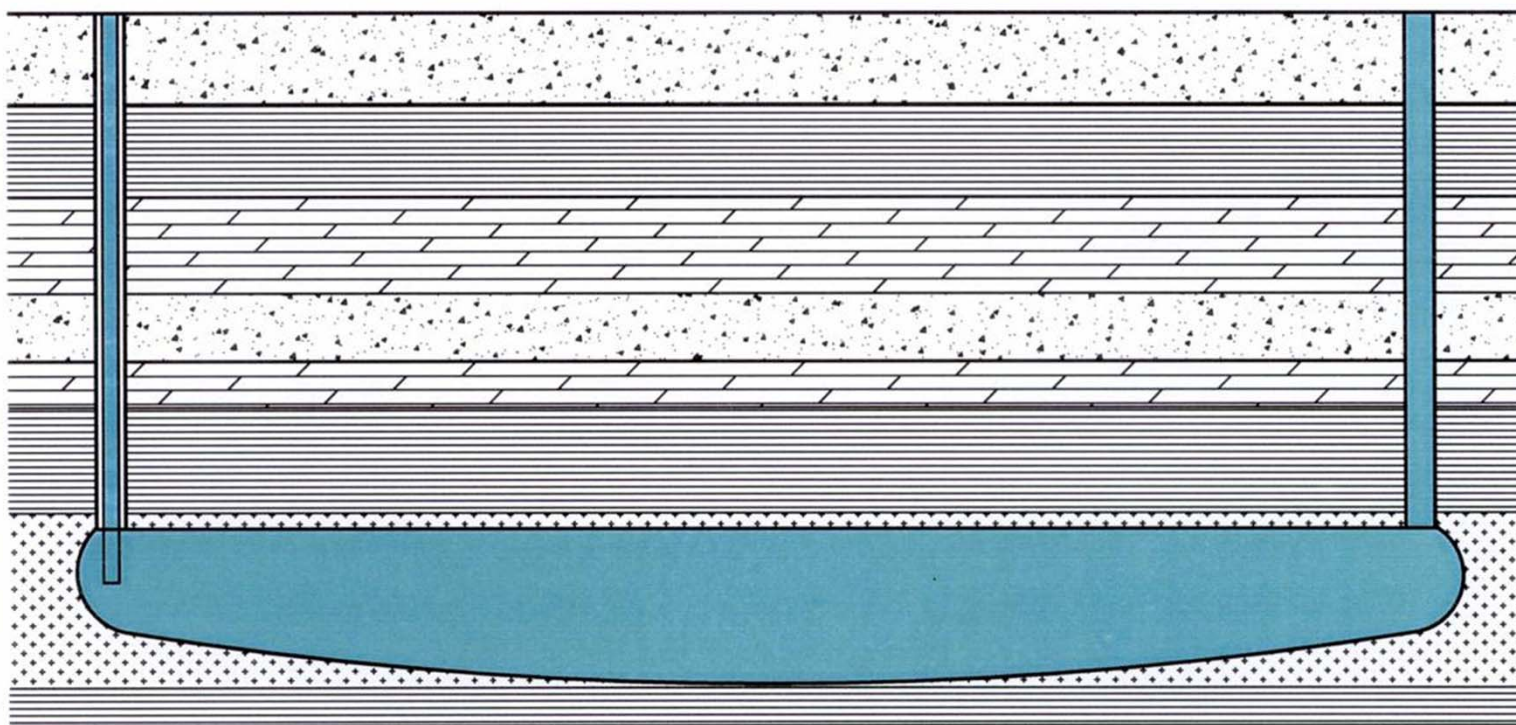
Domal Salt

- Capacity
 - 6.4 Bcf
- Depth to cavern roof
 - 4120 ft.
- Actual cavern dimension
 - Depth: 625 ft.
 - Diameter: 290 ft.

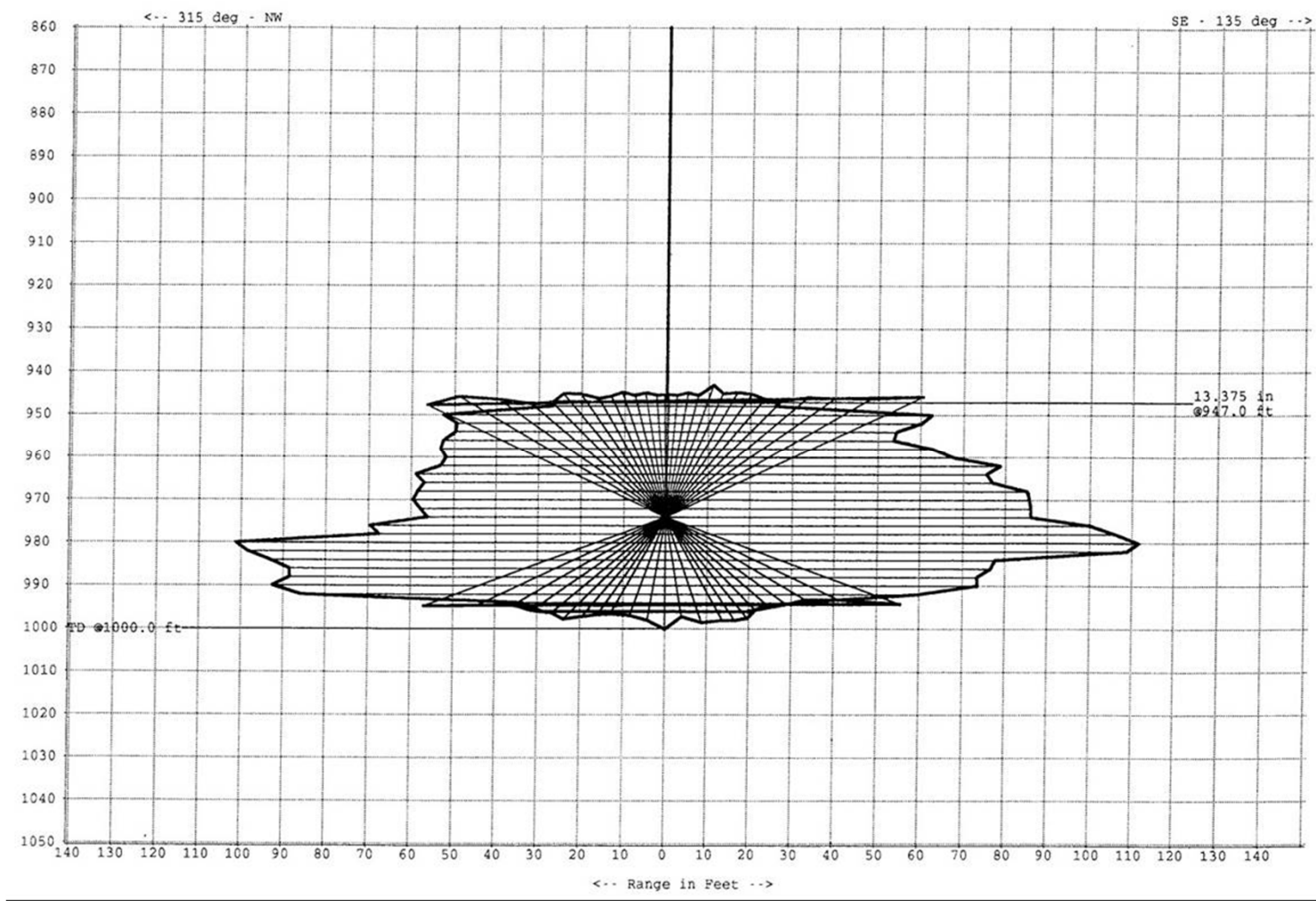


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Bedded Salt



Bedded Salt



Important Characteristics of Each Venue

	Aquifer	Depleted Reservoir	Domal Salt	Bedded Salt
Size (Bcf Total)	10 - 155	10 - 140	2 - 8 / cavern	.2 - 1.0 / cavern
Base Gas / Working Gas	65 / 35	50 / 50	20 - 30 / 80 - 70	Highly variable
Daily Withdrawal Rates (% of total capacity)	0.5%	1.0%	Up to 10%	Up to 10%
Annual Turns	1	1 to 2	Up to 12	Up to 12
Cost to Develop Greenfield Project (\$MM/Bcf of working gas)	10 - 15	10 - 20	12 - 25	Highly variable
Time to Develop				

Gas Storage Operations – Pre FERC Order 636

Storage Held by Interstate Pipelines



- Peak day commitments vs. average day capacity
 - Supply security / surety
 - Hurricanes
 - Pipeline / processing plant freeze offs
 - Deliverability limitations
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Gas Storage Operations – Post FERC Order 636



Storage Held by Marketers / Markets

- Peak day commitments vs. average day commitments
 - Supply security / surety
 - Managing gas supply costs (weighted average cost of gas)
 - Pipeline system balancing – avoiding balancing penalties
 - Supply buffer between LNG terminals and markets
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Controlling Gas Storage Capacity – Ownership and / or Contract



- Originally (Pre Order 636)
 - Pipelines
 - Today (Post Order 636)
 - Pipelines
 - LDCs
 - Power producers
 - Large commercial customers
 - Marketers
 - Independent storage developers / venture capitalists
 - Producers / suppliers
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Underground Natural Gas Storage – EOY 2007



Venue	Sites	Working Gas Capacity (Bcf)	Withdrawal Capacity (MMcfd)
Aquifer	43	390	8,393
Depleted Reservoir	326	3,528	66,130
Salt	31	173	13,703
Total	400	4,091	88,226

Source: EIA, Underground Natural Gas Storage Database

FERC Status of Gas Storage Projects

November 2010



Status	# of Projects
Certificated Storage Projects Since 2000	93
Pending Storage Projects	9
Storage Projects on the Horizon	5
Source: FERC, Natural Gas Storage Publication	

Trends in Gas Storage

- Strong demand for incremental storage capacity and associated injection / delivery capacity
 - Driven by daily / seasonal markets (power generation)
 - Driven by daily / seasonal supplies (LNG imports)
 - Evidenced by proposed storage projects and storage projects under construction
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Compression Requirements – Gas Storage Applications



- Injection / withdrawal volume volatility
 - Injection / withdrawal pressure range
 - Wide range of volume / compression ratio operating points
 - Fast response time
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Selecting Optimum Compression Equipment – Existing Installations



	Reciprocating	Centrifugal
Gas	✓	✓
Electric	✓	✓

Moving Beyond the Technology Preference to the Business Decision



- Which compression equipment for a particular application produces the lowest life cycle cost?
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Life Cycle Cost

- Initial capital outlay
 - Equipment
 - Facilities to support operations
 - Ongoing O&M expenses
 - Labor / supervision
 - Consumables
 - Repairs (scheduled / unscheduled)
 - Fuel / electric power cost
 - Function of commodity cost and equipment efficiency
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Life Cycle Cost - Fuel / Power Cost Calculation Methodology



- Identify a number of key operating points (peak day, typical days, minimum day): flow rates, suction / discharge pressures
 - Determine (estimate) percent of time operated at each identified operating point
 - Calculate annual shaft Hp-Hrs
 - Determine heat rate for reciprocating engine & gas turbine and efficiency for electric motor for each operating point
 - Calculate annual MMBtu or Kw-Hr consumed
 - Calculate annual fuel / power cost
 - Complete life cycle cost calculation
 - Consider Monte Carlo simulation for both percent operation estimate and capital cost estimate
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Trends in Gas Storage & Requirements for Compression



- What does this mean for:
 - Asset owners / project developers?
 - Equipment suppliers / engineering service providers / power providers?
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