

Natural Gas Storage R&D Program



*Natural Gas Storage
Workshop*

November 29, 2001

James R. Ammer, Project Manager
Gas Supply Projects Division



Future Needs for Storage

- **1999 NPC Study predicts that by 2015**
 - 38,000 miles of new transmission line
 - 263,000 miles of distribution mains
 - 0.8 Tcf of new working gas storage capacity
- **Tremendous growth in electric generation**
 - larger off-peak swing loads
 - peak-day requirements will increase from 111 Bcf/d to 152 Bcf/d
- **Growth in areas without conventional storage**
 - Northeast
 - South Atlantic

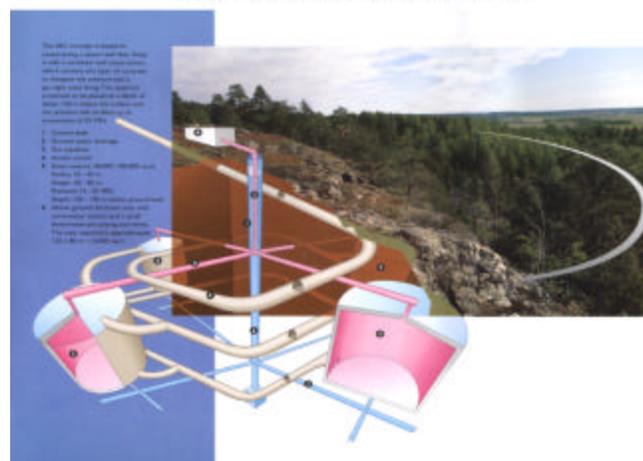


Gas Storage Technology Areas

- **Conventional Storage Reservoirs**
 - Deliverability enhancement
 - Gas measurement
 - Reservoir management
- **Advanced Storage Concepts**
 - Lined Rock Caverns
 - Hydrates
 - Salt Caverns
 - Basalt Aquifers



Lined Rock Caverns



M96001158C



Partnership Approach

- **R&D conducted with various partners**
 - Industry (Bay Gas Storage, Furness-Newburge)
 - Other research organizations (Gas Technology Institute, Southwest Research Institute)
 - National labs, universities and industry associations
- **Cost shared projects are common**
 - Field tests (National Fuel Gas, Kinder Morgan, NiGas)
 - Development of technologies (Baker Atlas)
- **Technology transfer**
 - Cooperative agreements with commercializing partner
 - Successful field demonstrations
 - Petroleum Technology Transfer Council





Conventional Storage Reservoirs

Deliverability Enhancement



Deliverability RD&D Timeline

- **1993 GRI - Maurer study set stage**
 - 5% annual deliverability decline; \$60 million to \$100 million remediation costs
- **GRI/DOE co-funded Halliburton project completed in 1998 identified major damage mechanisms**
- **DOE/GRI co-funded project completed in 1999 introduced novel stimulation treatments**
 - 29 treatments conducted in 8 fields
 - documented water sensitivity and candidate selection
- **DOE research investigating new remedial technologies**
 - sonic tool for scale removal
 - carbon dioxide treatments for HOPS damage



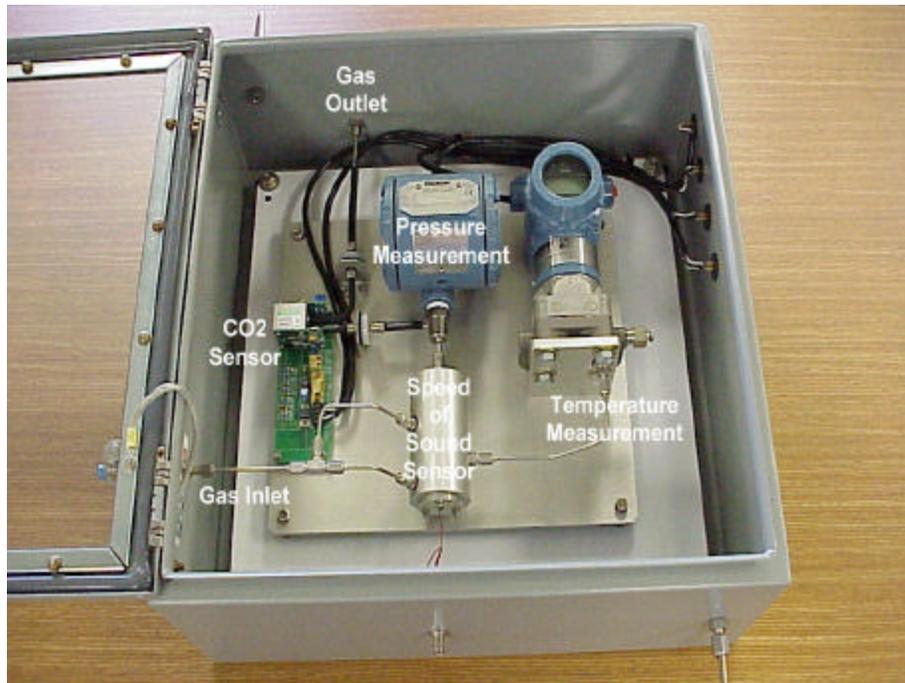


Conventional Storage Reservoirs

Gas Measurement



Energy Meter Retrofit Module Prototype



- Low cost retrofit module
- Inferential approach uses gas properties
- Transmission tariff gas
- Accuracy equivalent to gas chromatograph
- Use with any flow meter



Energy Meter Retrofit Module Prototype

Status

- **Developed algorithm for energy meter**
 - extended diluent concentrations to 20%
- **Designed and constructed prototype module**
- **Conducted initial testing at MRF**
- **Complete refinement in 2001**
- **Complete MRF and field testing by 2002**
- **Desired accuracy - 1 Btu**
- **Pursue commercialization**





Conventional Storage Reservoirs

Reservoir Management



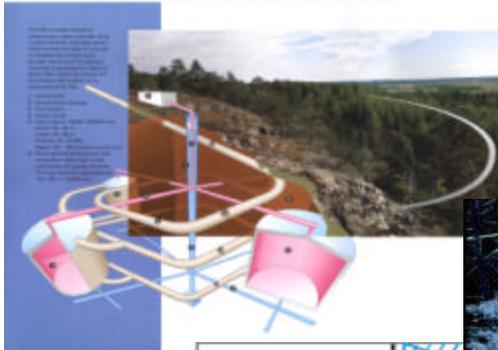
DOE Simulation Studies

- **Demonstrate the importance of geologic modeling and reservoir simulation for improved storage efficiency with an emphasis on horizontal wells**
- **Initiated in 1992**
 - no horizontal wells in storage (reported)
 - little to no use of simulation
- **Today**
 - >40 horizontal well
 - mix of simulation use
- **Published 3 SPE papers, 2 DOE reports**

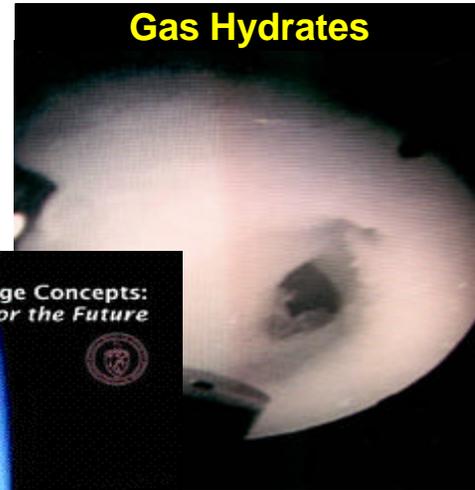


Advanced Storage Concepts

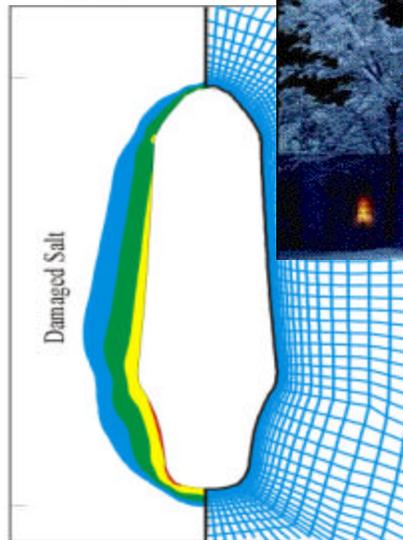
Lined Rock Caverns



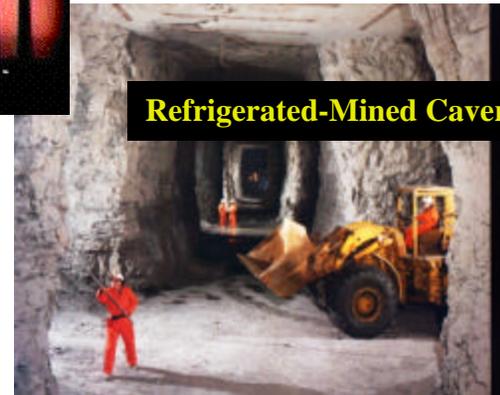
Gas Hydrates



Advanced Gas Storage Concepts:
Technologies for the Future



Refrigerated-Mined Cavern Storage





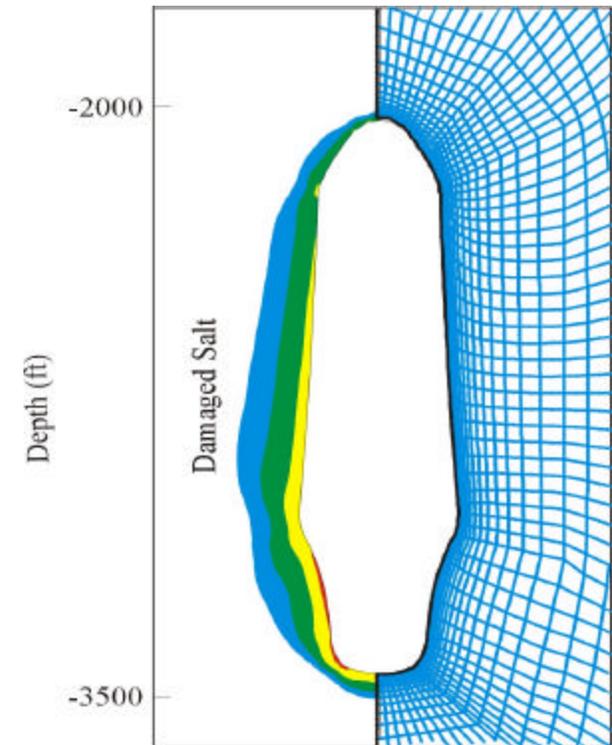
**Advanced Gas Storage Concepts:
Technologies for the Future**

The Next Step



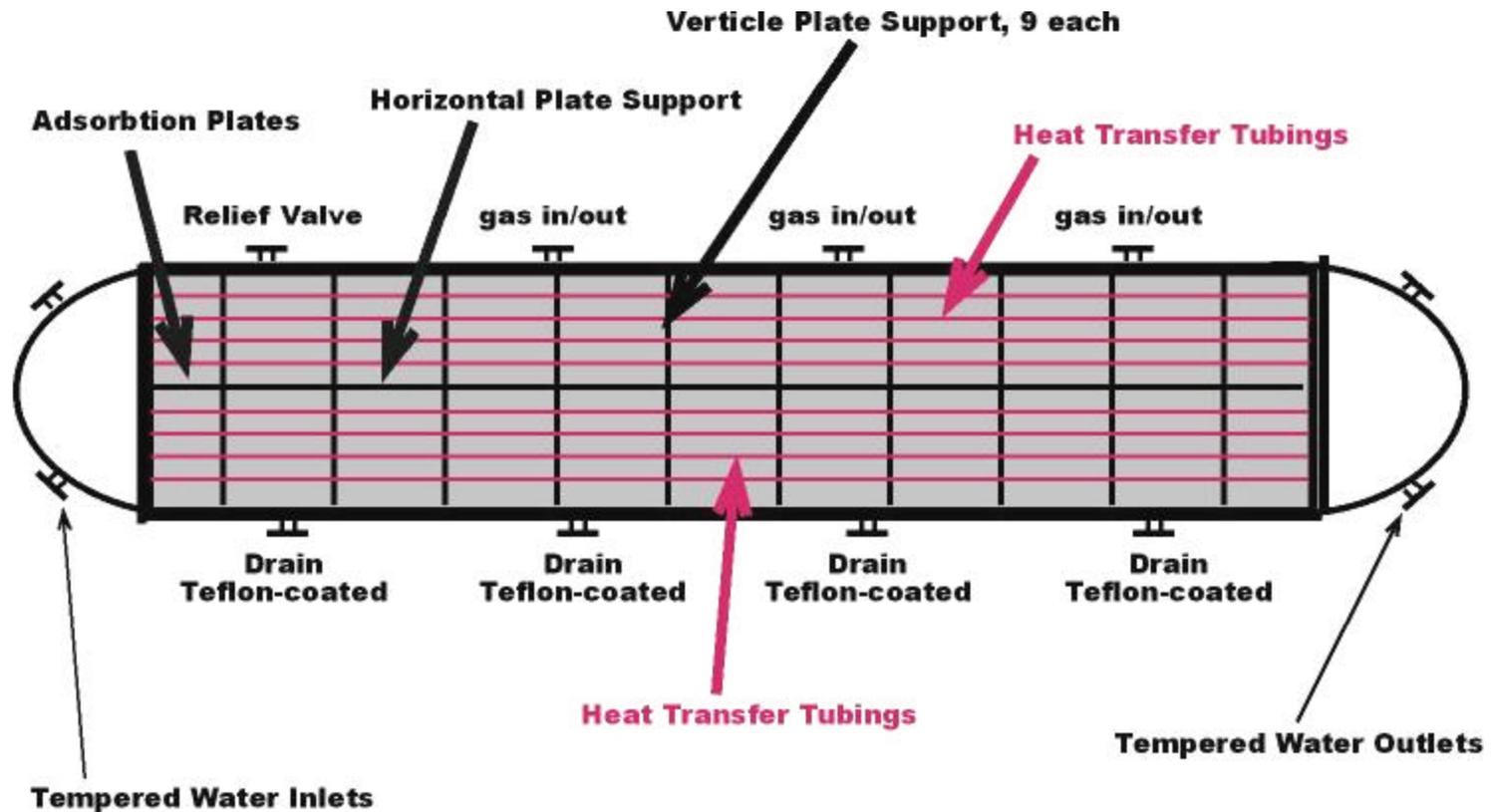
Advanced Design For Salt Caverns Proof-of-Concept

- Field-scale application of advanced design criteria
- Existing and new salt storage cavern
- McIntosh Salt Dome
- Mobile, Alabama
- RESPEC
- Bay Gas Storage Company



Hydrate Gas Storage - Scale Up

- Initial testing conducted in 39 cc cell
- New work will scale to 20 gallon tank



LRC Design Review

- **Technical review of Lined Rock Cavern concept and design methodology**
 - Independent review
 - Itasca Consulting Group, Inc.
- ***Mechanical Response of Rock Mass* completed September 2001**
- ***Steel Lining: Fatigue and Crack Growth* to be completed by June 2002**



Gas Storage in Basalt Aquifers

Columbia River Basalts

- **Columbia Basin spans 63,000 sq. mi**
 - nearly 13,000 ft of layered Miocene lava flows
 - individual flows covering over 27,000 sq. mi
- **Regional aquifers are confined between lava flows**
- **Flow tops are vesicular and very porous**
- **Anticlinal structures provide excellent targets for gas storage**



Basalt Characterization

- **Drilled the 100 Circles # 1 Well July 1999**
 - drill samples collected and analyzed
 - geophysical logs run
- **Drilled second borehole**
 - Approximately 150 feet from 100 Circles #1 Well
 - Conducted well to well flow tests
- **Acquired and processed 2-D seismic**
 - structural closure and areal extent
- **Hydrologic testing and groundwater chemistry**
- **Final Report and data sets due June 2002**



Successes

- **Deliverability Enhancement**
 - Introduced novel stimulation technologies
 - Developed a prototype Sonic Tool for scale removal
- **Advanced Storage**
 - Completed feasibility study of 4 advanced concepts
 - Completed design review for LRC: *Mechanical Response of Rock Mass*
- **Gas Measurement**
 - Developed energy meter algorithms, initiated testing, commercialization likely
- **Reservoir Management**
 - Published 3 SPE papers, 2 DOE reports

