CARBON CAPTURE AND STORAGE

# For 40 years, we've been putting $CO_2$ in its place.

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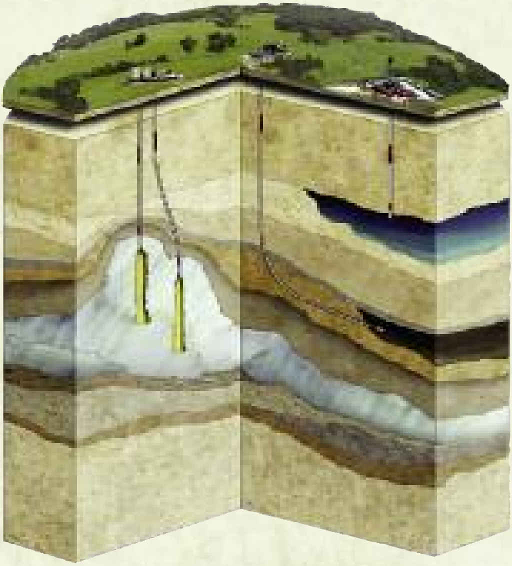
# You have $CO_2$ challenges

Safe, effective carbon capture and storage (CCS) from Halliburton, the world's leading provider of carbon dioxide ($CO_2$) solutions

## The Challenge: Effectively, Efficiently Capture and Store Excess $CO_2$

When coal, oil, gas and other materials are burned, they produce carbon dioxide. Numerous studies show carbon dioxide to be the major human-related source of greenhouse gases and the world is aggressively looking for practical ways to reduce or neutralize its carbon dioxide emissions.



## The Solution:
## CCS from Halliburton

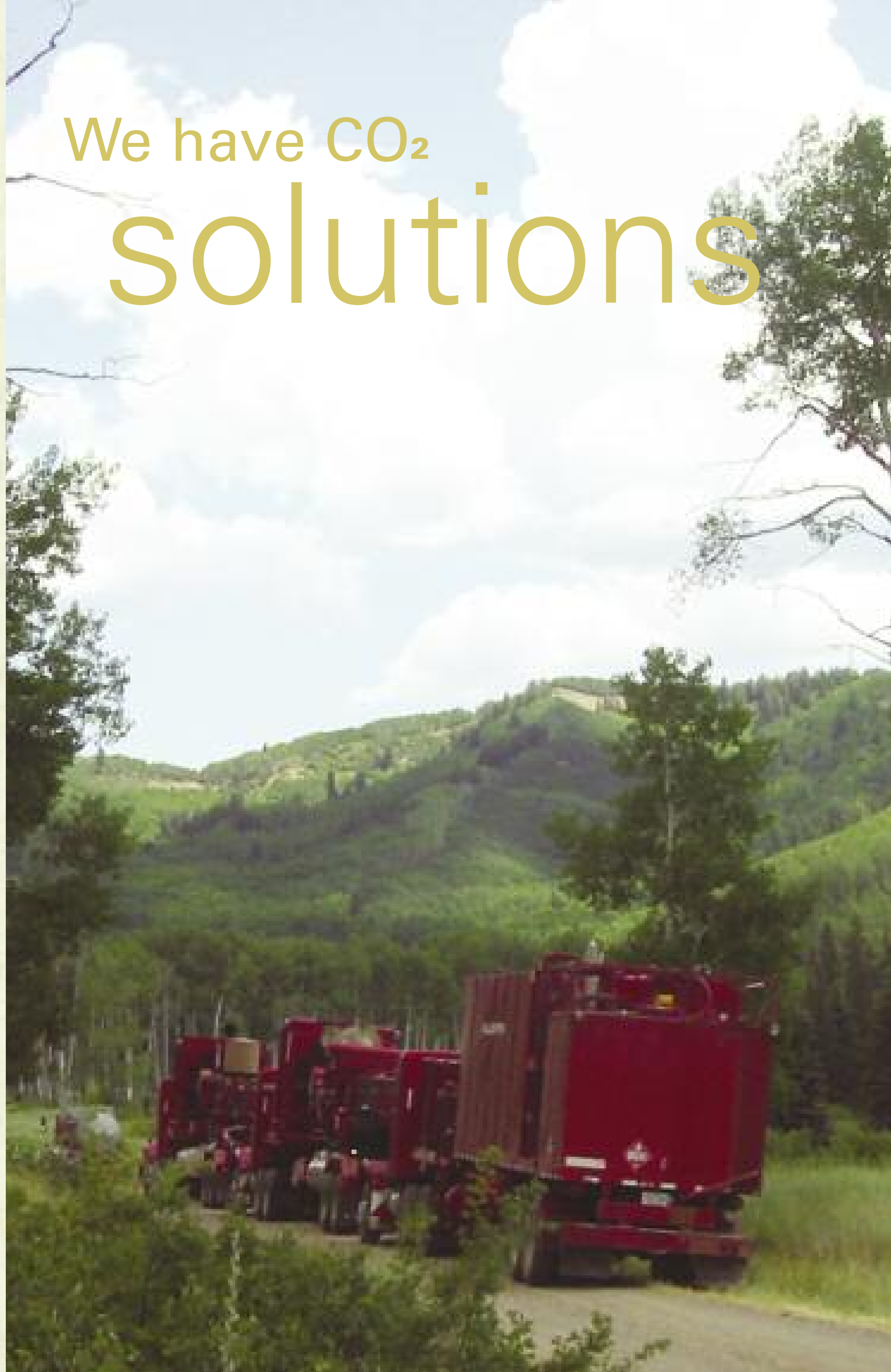
Of all the methods currently being tested and evaluated for commercial use, carbon capture and storage (CCS) is widely considered to be the most practical and effective means to reduce

emissions of $CO_2$ and other greenhouse gases (GHGs) into the atmosphere. CCS involves transporting $CO_2$ from power plants and other industrial businesses to depleted saline aquifers and oil and gas reservoirs. Once there, the $CO_2$ is injected into the reservoir via a well where it is monitored to prevent leakage.

# We have $CO_2$ solutions

For more than 40 years, Halliburton has provided $CO_2$ leadership for enhanced oil recovery (EOR)—safely and efficiently injecting $CO_2$, producing oil and recycling $CO_2$ from production in over 15,000 wells. From this experience we've assembled and refined the tools to make CCS a reality.

These components include site selection, subsurface assessment and characterization; field and well design and planning; well placement, wellbore integrity and drilling; completions and containment; operations; monitoring, verification and accounting; and regulatory compliance throughout the CCS project life cycle.



# An emphasis on safety

## $CO_2$ Storage Framework

Removing $CO_2$ from the atmosphere and then ensuring it's locked away in below-ground storage, safe and secure for many decades to come, is critical.

**Phase 1: Site Certification**

Multiple sites are appraised for $CO_2$ acceptance and leakage before the optimal storage site is selected.

**Phase 2: Operation**

In the operation phase, detailed planning, surface work, well drilling, casing and cementing are followed by $CO_2$ injection – which could vary from a few years to decades.

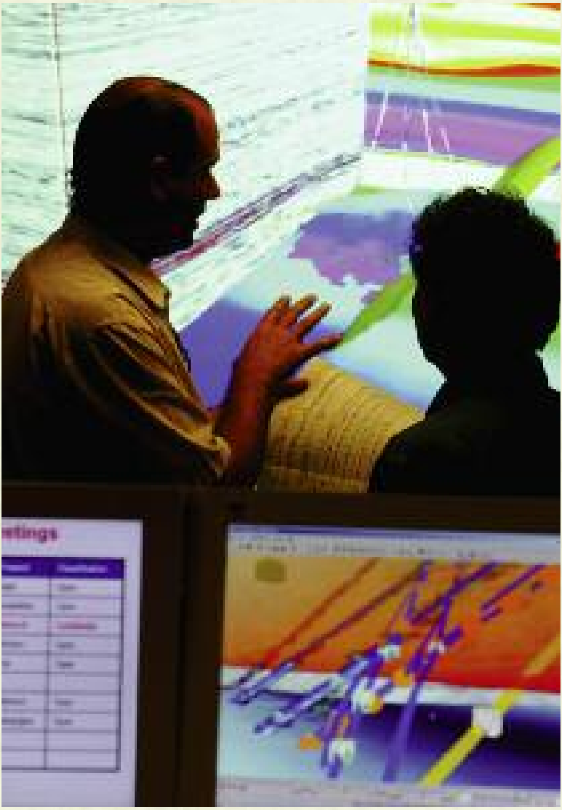
**Phase 3: Closure**

This phase employs monitoring, verification and accounting to control risks after $CO_2$ injection ceases. At this point, all systems are constantly monitored to ensure equipment is functioning properly.

**Phase 4: Post Closure**

Closure data determine if a site no longer requires monitoring—or needs additional monitoring and/or remediation.

Post decommissioning has an extremely long time horizon of hundreds, if not thousands, of years.



# Maintaining long-term security

# The industry's leading $CO_2$ technology

## Technologies and Services for $CO_2$ Storage

With over 1,500 consultants— supported by 5,000 engineers and scientists — Halliburton can provide the expertise and analysis to assist in site selection and seismic data analysis for determining safe $CO_2$ storage; reservoir modeling and simulations; risk analysis; design injection plans and more.

Halliburton's Project Management engineering teams provide a full range of services from project definition, construction and operation to planning and executing mitigation efforts.

By integrating health, safety and environment (HSE) core values into all business activities, our Project Management teams strive to proactively meet regulatory requirements and mitigate risks to lower operating costs.

For a further detailed listing of products and services, go to www.halliburton.com/ccs.

## Halliburton CCS Expertise in Action

Backed by four decades of expertise and experience, Halliburton's recent carbon capture and storage-related projects span the globe. They include:

**PEMEX $CO_2$ Processing Facility**

Faced with the challenge of reducing the environmental venting impact of $CO_2$ and natural gas, PEMEX—Mexico's national oil company—turned to Halliburton.

At PEMEX's Carmito, Mexico, $CO_2$ processing facility where for 10 years Halliburton maintained and operated $CO_2$ capturing and injecting facilities for nearby enhanced oil recovery (EOR) wells, the goal has been to sequester enough $CO_2$ to prevent 8,459,550 tons of $CO_2$ emissions from 2004 through 2013. Based on Halliburton's operational success to date, PEMEX is evaluating other opportunities and has identified 75 additional candidates for CCS projects.

**Japan CCS Project**

Japan CCS Corp. Ltd., a privately held company dedicated to CCS, recently charged Halliburton with providing engineered solution designs that would reliably deliver the wellbore integrity and zonal isolation necessary to help prevent $CO_2$ leaks during the injection period and throughout the life of the well. Halliburton delivered solutions via an unprecedented integrated problem-solving approach.

**Department of Energy (DOE) CCS Demonstration Project**

In the U.S., Halliburton was selected for a demonstration project located at Mississippi Power's Daniel project site in Escatawpa, Mississippi. Approximately 4,000 tons of carbon dioxide were successfully injected through the well and stored 9,000 feet below the surface. Halliburton's Vertical Seismic Profiling service was then deployed to document how the carbon dioxide affects the aquifer.

For more on project experience, go to www.halliburton.com/ccsprojectexperience.

# answers

## to your $CO_2$ questions

## How is $CO_2$ Stored?

The storage of $CO_2$ uses many of the same technologies that Halliburton developed for energy extraction, including well drilling, injection and reservoir simulation technology.

Geological storage options include:

- Depleted oil and gas reservoirs
- Deep saline formations onshore and offshore
- Injection of $CO_2$ into enhanced oil and gas recovery (EOR and EGR) operations
- Injection of $CO_2$ for coalbed methane recovery

## $CO_2$ and CCS *Fast* Facts

**Greenhouse gases** (GHGs) are those gases (including carbon dioxide, methane, ozone and fluorocarbons) whose absorption of solar radiation is responsible for the *greenhouse effect* (the heating of the Earth via the atmosphere's ability to capture and recycle energy emitted by the Earth's surface).

Carbon dioxide (**$CO_2$**) is composed of two oxygen atoms and one carbon atom. The main human-related source of $CO_2$ in the atmosphere is from the burning of fossil fuels (coal, oil, gas).

**Carbon Capture and (Underground) Storage** (CCS) is a process to separate $CO_2$ from industrial and energy-related sources (such as a power plant, chemical factory or steel mill), and then to transport it to a storage l ocation where it can be isolated from the atmosphere.

**Storage** refers to the process of injecting and isolating the $CO_2$ into deep geologic formations such as depleted oil and gas reservoirs or saline aquifers. Storage sites must be carefully characterized to ensure they can sequester $CO_2$ for extensive periods of time.

# $CO_2$ Resistant Cementing Solution

**Challenges**

- What kind of cement should I use and how should I place it in the annulus to ensure zonal isolation and well bore integrity?
- What cement should I choose to comply with local regulations in well construction and remediation?

**Solution**

Halliburton's WellLife® III cementing service is particularly suited to situations encountered in $CO_2$ enhanced oil recovery (EOR) and carbon capture and storage (CCS) wells where long-term zonal isolation is critical and can be at risk due to the potentially harsh $CO_2$ environment. The three steps of theWellLife III cementing service include: 1) understanding the requirements of such wells, 2) designing a slurry to survive the current and future wellbore conditions, and 3) providing redundant backup when the issues are as crucial as the global environment, long-term productivity, or both, and thus require that the seal does not fail over the planned operating life of the well and after well abandonment.

With Tuned® cements, Halliburton has created a set of fit-for-purpose solutions that allow each cement system to be designed specifically for any given set of wellbore conditions. One example, Halliburton's specially formulated CorrosaCem™ cement blends are engineered for long-term zonal isolation in particularly corrosive wellbore environments.

Halliburton goes beyond the conventional cement-design method that predominantly focuses on well-construction activities by engineering slurry designs that overcome destabilization at any point during the life of the well to retain wellbore integrity and zonal isolation.

From less harsh environments such as dry $CO_2$ at low temperatures, to the extremely harsh environment of wet $CO_2$ at high temperatures, CorrosaCem cement blends provide engineers with the means to design sealants for the life of the well. $CO_2$ in the presence of water can produce carbonic acid that, in some cases, may contact and slowly weaken cement by a chemical conversion called carbonation. In these cases, the cement may lose enough strength to potentially impair zonal isolation integrity versus other cases with no issues. Therefore, potential $CO_2$-induced corrosion of the cement sheath in CCS wells is an area that needs to be evaluated and addressed.

Two members of the CorrosaCem cement family specifically designed for $CO_2$ environments are CorrosaCem NP and CorrosaCem $CO_2$ sysetem. CorrosaCem NP systems are non-Portland-based blends that, by removing the Portland cement portion of the blend, avoid the aforementioned carbonation issue. CorrosaCem NP systems can utilize either Halliburton's proprietary ThermaLock™ (calcium phosphate) or EPSEAL® (epoxy) sealant technologies. CorrosaCem $CO_2$ blend uses field-proven Portland and reduced-Portland blends with more than 30 years of successful history. These blends are designed to minimize the carbonation effect in $CO_2$ wells. Laboratory core flow tests show that CorrosaCem $CO_2$ cement can limit $CO_2$ penetration to a shallow layer and instantly seal its permeability when exposed to $CO_2$.

The properties of Halliburton's CorrosaCem $CO_2$ cement slurries, in conjunction with decades of global experience and the application of Halliburton's best cementing practices, can provide an engineered cement sheath with improved endurance in sensitive $CO_2$ injection wells. Because carbonation is known to occur when cement sheath is exposed to $CO_2$, Halliburton's global

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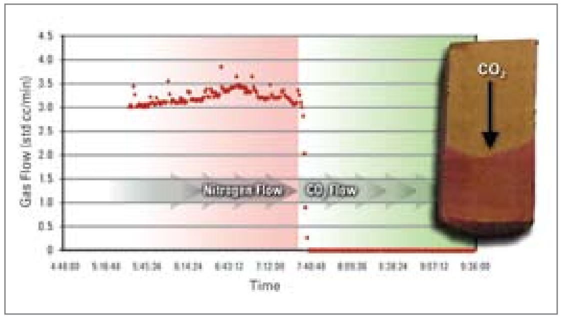
commitment to the environment and to our customers' need for engineered cementing systems has led to the development of systems that have properties that could be expected to better endure the impact of corrosive downhole environments that are prone to changes even as the well ages and reservoir-characteristics change. Halliburton's corrosion-resistant engineered-cement systems are tailored to specific operator requirements – reservoir type, reservoir properties, temperatures, pressure, and the injected gas composition are some of the factors to consider when selecting the ideal sealant.

**Highlighted Technologies and Services**

- CorrosaCem $CO_2$ cement – A family of non-foamed cement systems that are designed to survive in the corrosive environment created by the presence of $CO_2$. CorrosaSeal™ $CO_2$ cement, a foam version of these systems, is also available when reduced density or other benefits inherent in a foam system are desired or required.
- ElastiCem® $CO_2$ cement – A family of cementing solutions with enhanced mechanical properties and increased $CO_2$ resistance. The foam version of these systems is also available as ElastiSeal™ $CO_2$ cement.
- LifeCem™ $CO_2$ cement – Non-foamed cementing solutions designed for corrosive environments that exhibit superior cement sheath mechanical properties as well as react-and-respond, interventionless automatic re-sealing characteristics. The foam version of these systems is also available as LifeSeal™ $CO_2$ cement.
- CorrosaCem NP cement – A non-Portland cement and nonfoamed system that constitutes the most resistant slurry systems available to the market when the desire is to eliminate carbonation and not just minimize the effects. Elimination of the Portland cement component of these systems allows for maximum protection in all $CO_2$ environments. Foamed versions of these systems are available as CorrosaSeal cement.




Laboratory core flow test results in the figure show that CorrosaCem™ $CO_2$ cement can limit $CO_2$ penetration to a shallow layer and very quickly seal permeability when exposed to $CO_2$.

**Test conditions**

| | |
|---|---|
| BHST: | 104°C (220°F) |
| Confined pressure: | 2,000 psi |
| Initial flow: | ~3.4 std. ccN2/min |
| Final flow: | non-detectable |
| Time to STOP flow: | ~6 min] |

For answers to your $CO_2$ challenge, go to www.halliburton.com/ccs

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# Project Consulting

**Challenge**

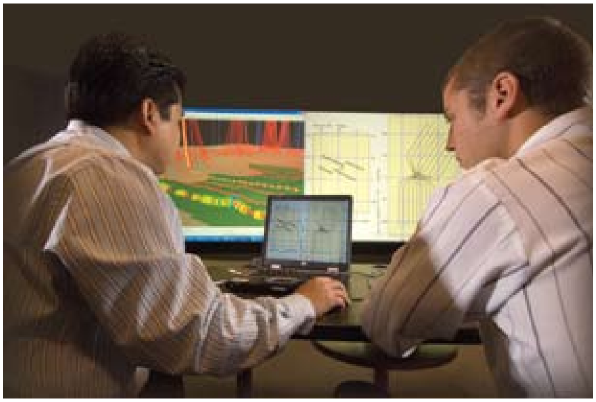
How can I expand my team to ensure I have the skills and experience I need to complete my project?

**Solution**

With over 1,500 consultants—supported by over 5,000 engineers and scientists–Halliburton can provide expertise and analysis in site selection, seismic data analysis for determining safe $CO_2$ storage, reservoir modeling and simulations, risk analysis, design injection plans and more.

**Highlighted Technologies and Services**

- Modeling for real-time evaluation of:
  - $CO_2$ injection pilot projects
  - $CO_2$ injection operations performance
- Optimize $CO_2$ injection in real-time
  - Control plume development
  - Maximize storage capacity
  - Maintain minimum miscibility pressure (MMP)
- Monitoring, verification and accounting to verify critical performance factors
  - $CO_2$ containment within reservoir and outside wellbores
  - $CO_2$ displacement efficiency
  - Sweep enhancement for enhanced oil recovery (EOR) production wells
  - Wellbore integrity inside wells to contain $CO_2$
- Approximately 70 percent of industry projects in the last five years were not completed on time or within budget. Solving this challenge requires strategic know-how from the very beginning of a project. Front-end loading (FEL) is a methodology that takes a deliberate approach to capital project planning. FEL methodology aligns an operator's technical and business goals to create a more comprehensive development plan. By integrating professionals from multiple surface and subsurface disciplines and equipping them with the industry's latest technology, the FEL approach increases project definition and lowers risk to positively impact ROI. Halliburton's FEL approach contains three critical elements: a well-defined uncertainty and optimization framework, the industry's best technologies for integrated asset modeling, and the creation of multidisciplinary teams that generate unique project insights.



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# Enhanced $CO_2$ Injection for Storage & Hydrocarbon Recovery

## Challenges

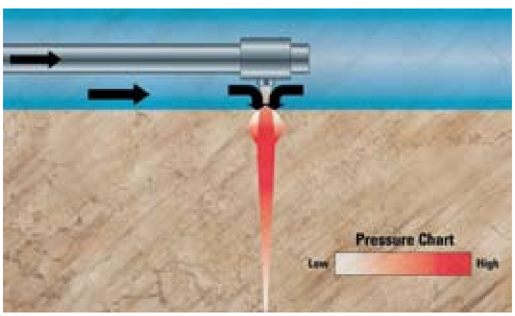
- How do I accelerate the injection rate and/or increase reservoir capacity for $CO_2$ injection?
- How do I maximize recovery from my $CO_2$ enhanced oil recovery (EOR) project?

## Solution

For decades, Halliburton has been injecting fluids and $CO_2$ into reservoirs to optimize hydrocarbon production. Now we are using those same technologies to enhance $CO_2$ injection for storage and continuing to create innovative processes and tools to address the challenges in $CO_2$ injection whether it is for storage or EOR.

## Highlighted Technologies and Services

- SurgiFrac® Fracturing Service allows the placement of a fracture in open holes to complete a long horizontal well for gas injection. During the SurgiFrac process all fluids are pumped down the tubing and use the jetting to place the fracture, thus keeping the pressure off the wellbore. Liners (slotted or perforated) can also be installed after the SurgiFrac Process.




In the SurgiFrac process, sand-laden fluid pumped through a Hydra-Jet™ tool impinges on the formation creating a cavity. As the cavity is formed, pressure on the bottom of the cavity increases, eventually initiating a fracture. Annular fluid is pulled into the fracture, helping to extend it.

- For a cased and cemented hole application, CobraMax® Fracturing Service is the best process because the proppant can be pumped down the annulus area between casing and tubing, reducing the overall treating pressure and allowing for placement of high conductivity fracs for optimum $CO_2$ injection.

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# Project Management

## Challenges

- How can I minimize non-productive time (NPT) and lost time incidents (LTI)?
- How will I manage and measure all of the resources working on the project?
- Who can I trust to drill, cement, and case my wells?
- Who can complete cased hole logging, casing inspections and $CO_2$ injection placement optimization during operation?
- Who can create and execute maintenance and remediation plans?

## Solution

Halliburton's Project Management engineering teams provide a full range of carbon capture and storage (CCS) services.

### End-to-end approach

From project definition, construction and operation to planning and executing mitigation efforts, Halliburton is available to assist in achieving your project objectives. Halliburton's ability to provide services end-to-end minimizes NPT and LTI, which can prevent cost overruns.

### Global perspective and local knowledge

Our experience includes CCS projects around the globe. Halliburton project management team's have access to Halliburton's extensive global experience, expertise, technology and infrastructure. At the same time Halliburton can provide personnel to manage your project that are familiar with the local history of your particular geological storage option ensuring a global perspective on local problems. Proven technology, experience and global reach – that's what you get when you select Halliburton as your CCS service provider.

### Regulatory requirements

Our Project Management teams strive to proactively meet regulatory requirements, integrate Health, Safety and Environment (HSE) core values into all business activities and mitigate risks to enable safe, on-time and on-budget operations.

### Streamlined service delivery

Our teams include a qualified service coordinator who manages all Halliburton and third-party providers. The coordinator leverages Halliburton's global supplier network to build locations, deliver rigs, mobilize personnel, perform on-site surveys and inspections and schedule services and equipment. This streamlined approach combined with our through application of disciplined processes helps ensure the lowest total cost for your project.

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# Site Selection and Certification

### Challenges

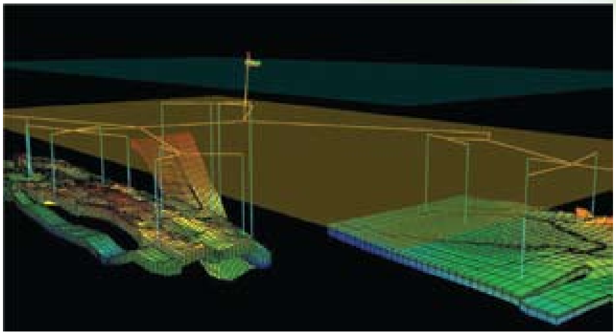
- What criteria should I consider when selecting a storage site?
- How do I characterize and identify potential leakage pathways?
- How do I quantify the reservoir properties for the storage system?
- How do I develop well plans and simulate injection scenarios?
- How do I validate the accuracy of my models?
- How should I assess risks and consider geomechanical properties?

### Solution

Whether you need to appraise potential storage sites or ensure that all of the information you need for pre-injection certification is available, Halliburton can help.

### Highlighted Technologies and Services

- Reservoir simulation and uncertainty and optimization software can provide the following:
  - Screening reservoirs or saline aquifers for $CO_2$ storage capacity
  - Quantitative estimate of $CO_2$ flow through surface pipeline networks
  - Quantitative estimate and movement of $CO_2$ plume development
  - Risk assessment of $CO_2$ leakage or non-containment
  - Probabilistic estimate of $CO_2$ plume movement in a progressive modeling framework
  - Fluid flow simulations give a clearer picture of how gas is distributed in the reservoir at any moment and at any place. This allows assessment of the working volume, the peak injection and withdrawal rates, etc.
  - Uncertainty and optimization software can be used to evaluate hundreds of scenarios quickly, taking into account the surface, subsurface and economics.



- A Vertical Seismic Profile (VSP) provides a much higher-resolution image of the subsurface in the vicinity of the well than can be obtained from surface seismic data. VSP services can be used to determine $CO_2$ plume migration over time within the reservoir.
- Surface deformation measurement technology via InSAR and tiltmeters to determine $CO_2$ plume location and movement over time.
- From traditional 2-D and 3-D seismic interpretations to powerful multivolume visualization, Halliburton provides proven, robust solutions that help ensure accurate geophysical interpretation and high productivity in the most demanding basins or reservoirs.
- DecisionSpace® Earth Modeling Software provides 3D multi-volume geocellular modeling and visualization.
- See project consulting sheet for more information on Halliburton project consulting services.

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# Monitoring and Leak Detection

### Challenges

- What monitoring techniques should I deploy to accommodate site specific characteristics, minimize risk, and meet regulatory requirements for an MVA (Monitoring, Verification and Accounting) program?
- How do I identify leaks or unplanned $CO_2$ plume migration?

### Solution

Halliburton stands alone with our comprehensive suite of measurement technologies, our risk reduction services and our ability to integrate them into a unique monitoring system to directly and indirectly measure where $CO_2$ is migrating underground both horizontally and vertically. From the ability to deploy tiltmeters with nano-radian accuracy to InSAR with huge spatial coverage, we have the ability to apply the right technology to the problem at hand. Additional offers include seismic data review, permanent downhole pressure and temperature measurement and analysis as well as fiber optic Distributed Temperature Sensing (DTS) systems which can monitor real-time temperature along the entire wellbore. Halliburton extends your vision to where it is needed most.

### Highlighted Technologies and Services

- Halliburton's unique microseismic and tiltmeter fracture mapping service involves installing an array of instruments over a project area to identify, fracture initiation and propagation and to measure reservoir level changes which cause uplift or subsidence that can be observed at surface. Microseismic mapping has been used on thousands of hydraulic fracturing jobs to measure fracture geometry, to enhance injection and production rates and recovery, and to ensure fractures do not extend outside of the placement limits. Tiltmeters can be strategically placed around the site to determine surface deformation caused by pressuring the storage formation above the initial reservoir pressure. Ground dilation may be on the order of millimeters to centimeters per year depending on the injection depth, rate and volume.
- Interferometric Synthetic Aperture Radar (InSAR) is a satellite-based technology in which a radar beam is bounced off the ground and the travel time recorded at the satellite. The measured reflection of those waves provides information on the position of the ground surface with millimeter accuracy. InSAR data is used for monitoring $CO_2$ injections by mapping the injection induced ground deformation and then converting that surface motion into reservoir level strain and volumetric changes. This analysis can help determine whether injected $CO_2$ is staying in target zone or migrating to a shallower depth.

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- High Resolution GPS employs a high precision Differential GPS (DGPS) system with an absolute vertical resolution of typically 1-2 mm, and lateral resolution in the 1 mm range. The systems can be deployed on their own to provide monitoring of structures and warn of out-of-bounds movement, or they can be integrated with InSAR and tiltmeter datasets to increase the accuracy of those measurements.
- Halliburton's monitoring capability includes distributed temperature sensing based on fiber optic monitoring technology. Additionally, permanent and retrievable downhole monitoring products provide accurate and reliable real-time data that can be used to assess the $CO_2$ storage environment and make informed decisions regarding reservoir management.
- Information from monitoring systems can be provided to Halliburton's Real Time Centers™ (RTCs™). Fully adaptable to the needs and conditions of a particular location, RTCs integrate all aspects of a project, from prospect generation to well planning, drilling, evaluation, optimization, field delineation, reservoir modeling, injection and monitoring.

  RTCs provide the ability to monitor operations and storage sites remotely while fostering efficient collaboration among team members, improving safety, helping reduce costs and, ultimately, enabling our customers to make better decisions.



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# Wellbore Placement, Drilling and Completions

### Challenges

- Does my drilling and completion plan minimize cost and maximize injectivity?
- How do I ensure I comply with local regulations on the use of $CO_2$ resistant construction materials?
- Who can I trust to help refine and execute my drilling and completion plan during construction and operation?

### Solution

Halliburton is leading the industry in drilling wells faster, safer and more accurately. We optimize drilling efficiency through increasing rate of penetration and lowering non-productive time. We place wells precisely to maximize the potential for individual well injectivity and reduce the number of wells required for injection. Further, as the global leader in completions, Halliburton provides a full range of well completion products and services.

### Highlighted Technologies and Services:

- Optimum placing of the pad, target and well paths is critical to safety, economics, and injection efficiency. Collaborative Well Planning software helps plan each of these attributes quickly and accurately. With thorough surface and subsurface visualization of both facilities and the geologic earth model.

- This technology suite can also be tied directly to real-time measurement-while-drilling (MWD) and logging-while-drilling (LWD) data feeds, supporting accurate/real-time well path positioning, engineering analysis and updating of the earth model.

- Efficient and cost effective sequestration begins with optimal placement of the injection wells. Halliburton's LWD sensors provide the sub-surface team with a detailed view of the position of the bit within each formation. Our unique StrataSteer® 3D Geosteering Service employs proprietary software and innovative downhole tools to place wells in the optimal formation.

- Course corrections can be made while drilling with Halliburton's rotary steerable systems (such as the Geo-Pilot® system), to place the well in the right location for $CO_2$ injection in to the reservoir.


- Surface data logging for intelligent rig monitoring and geological mudlogging services.

- Custom-tailored managed pressure and underbalanced drilling solutions for complex reservoirs and storage caverns helps prevent formation damage to improve $CO_2$ placement and storage capacity.

- Multilateral systems with complex insertion architecture for increased $CO_2$ injection rates and storage capacity.

- $CO_2$ resistant expandable liner hangers are available in chrome alloys. They provide the following benefits in $CO_2$ wells:
  · Ability to deploy liners to depth.
  · Gas tight seal at top of liner.

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# Remediation for $CO_2$ Containment

**Challenges**

- How do I ensure my reservoir confining zones and wellbores retain $CO_2$ for long-term security?
- How can I review and remedy poor integrity of my confining zones and wellbores during and after operations?
- If I find a leak, how do I repair it and confirm that the leak has been sealed?
- I'm planning to use existing wells for $CO_2$ injection; how can I examine their integrity and identify existing or potential leaks?

**Solution**

Halliburton is a full-service provider of containment monitoring, measurement, and sealing technologies. Together these technologies and services can detect, accurately locate and repair leaks in a storage or enhanced oil recovery (EOR) reservoir.

**Highlighted Technologies and Services:**

- Halliburton has an array of technologies available to help in determining the exact location of a leak:
  - InSAR and downhole tiltmeter and other sensors can survey the entire field for leaks.
  - Wireline intervention using technologies such as Halliburton's RMT Elite™ reservoir monitor tool which can detect $CO_2$ flow behind casing.
  - Casing inspection devices observe the integrity of the casing or tubing to find holes, cracks, or corroded areas and fluid entry or exit points Solutions include:
    - Evaluating cement placement, channels and pipe/cement bond helps determine $CO_2$ zone isolation and any potential pathways for out of zone injection that requires remediation. CAST-V™ Scanning Tool in combination with the standard Cement Bond Log services provides accurate bond log evaluation for every type of cement. The ACE℠ service provides quick, accurate information on cement bond, even when using foamed cements.
    - Downhole Camera Services, including the EyeDeal™ Camera System, provide high-resolution images that eliminate guesswork from a range of diagnostic test and troubleshooting operations.
    - Fast Circumferential Acoustic Scanning Tool (FASTCAST™) system adds speed and accuracy to open or cased hole pipe inspections and cement evaluations.
  - Core tests to evaluate well integrity (pipe, cement & rock resistance to $CO_2$), skin damage, formation fluid properties, etc. These tests can also be used for skin damage core tests to help determine $CO_2$ injectivity.
  - Hydraulic Workover (HWO) and coiled tubing units are self-contained, portable, running and pulling systems that provide an economical means of performing routine well maintenance.

- After a leak source is determined, Halliburton has a number of technologies that can be applied to seal the leak depending on the circumstances.
  - Halliburton's $CO_2$-resistant reservoir conformance technologies can be employed to repair the leak and seal off problem zones in the reservoir. The $H_2$Zero® service provides a polymer-based system recommended for sealing leaks in homogenous reservoirs. In more heterogeneous environments, Halliburton's BackStop℠ service, with its built in diverter technology, can be used to seek out and isolate high permeability zones, while allowing low permeability zones to be proportionally treated or remain untreated.

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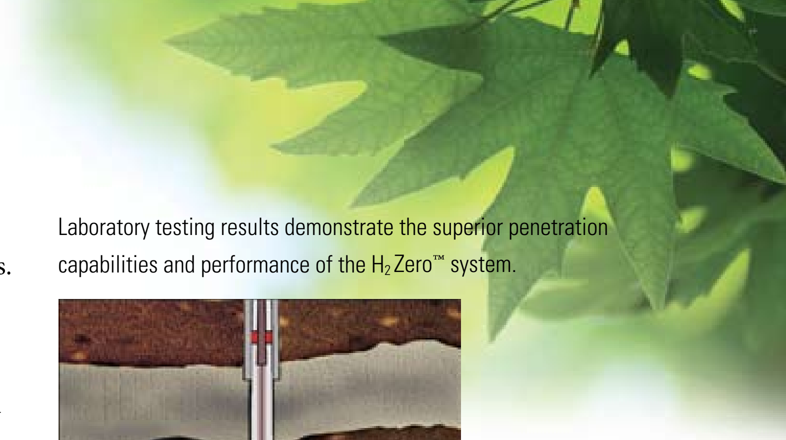
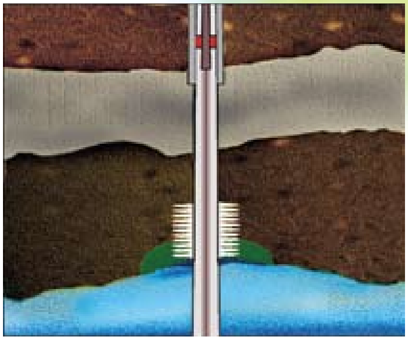


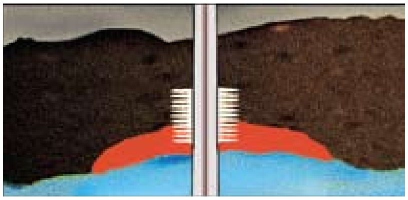
- PermSeal® sealant treatments can seal $CO_2$ formations and leak pathways in nano perm zones.
- PermTrol™ sealant treatments seal or restrict flow deep into formations that have leaks.
- WaterWeb® service treatments reduce the relative permeability of leaking formations to restrict flow of leaking fluids.
- CorrosaCem™ Cement Systems are $CO_2$ resistant cements used when cement squeezes and plugs are best for sealing.
- In the event that there is a leak in a confining zone far away from existing wells, a lateral must be drilled from a nearby well to intersect the leak and then cement or chemical sealants can be injected to seal the leak.

- Once a leak has been treated, the effectiveness of the repair can be measured by using similar techniques as those used in leak identification (see above).
- Details on Halliburton's comprehensive monitoring solution are available on the monitoring and leak detection sheet.

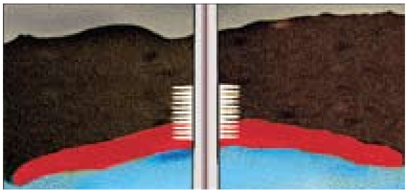
Laboratory testing results demonstrate the superior penetration capabilities and performance of the $H_2$Zero™ system.



**TEST 1** was run with a typical chromium-based polymer system. Penetration was about 0.5-feet and regained permeability about 0.28%.



**TEST 2** was $H_2$Zero™ system pumped with one half of the recommended crosslinker concentration. Penetration was 2-feet and regained permeability was less than 0.001%.



**TEST 3** shows the $H_2$Zero™ system pumped with the recommended crosslinker concentration. Gel penetration was over 4.5-feet into the formation.

For answers to your $CO_2$ challenge, go to www.halliburton.com/ccs

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**What's your $CO_2$ challenge?**

The time has come for safe, effective carbon capture and storage (CCS). For answers to your $CO_2$ challenge, go to www.halliburton.com/ccs

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