

# PROJECT facts

U.S. DEPARTMENT OF ENERGY  
OFFICE OF FOSSIL ENERGY  
NATIONAL ENERGY TECHNOLOGY LABORATORY

Carbon Sequestration

04/2008



## WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP — VALIDATION PHASE

### Background

The U.S. Department of Energy (DOE) has selected seven Partnerships, through its Regional Carbon Sequestration Partnership (RCSP) Program, to determine the best approaches for capturing and permanently storing carbon dioxide (CO<sub>2</sub>), a greenhouse gas (GHG) which can contribute to global climate change. The Partnerships are made up of state agencies, universities, private companies, and nonprofit organizations that form the core of a nationwide network helping to establish the most suitable technologies, regulation, and infrastructure needs for carbon sequestration. The Partnerships include more than 350 organizations, spanning 41 states, three Indian nations, and four Canadian provinces. The RCSPs are developing the framework needed to validate and deploy carbon sequestration technologies. They will evaluate and determine which of the numerous sequestration approaches are best suited for their specific regions of the country and are studying possible regulatory and infrastructure requirements that will be needed should policy and economics indicate that sequestration be deployed on a wide scale. The Validation Phase (2005–2009) of the Partnership Program is focused on validating promising CO<sub>2</sub> sequestration opportunities through a series of field tests in the seven Partnership regions.

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### Description

The West Coast Regional Carbon Sequestration Partnership (WESTCARB), led by the California Energy Commission, includes Alaska, Arizona, California, Nevada, Oregon, Washington, and British Columbia. WESTCARB comprises more than 80 partner organizations, including state resource management and environmental protection agencies, national laboratories and research institutions, colleges and universities, conservation non-profits, oil and natural gas companies, power companies, pipeline companies, trade associations, vendors and service firms, and consultants. WESTCARB plans to conduct one "stacked" (saline formation and enhanced gas recovery) geologic CO<sub>2</sub> storage test in California's Central Valley and one saline formation storage test in northeast Arizona. WESTCARB is also conducting terrestrial sequestration pilot projects in Lake County, Oregon, and Shasta County, California.

The six states in the WESTCARB account for more than 11 percent of U.S. CO<sub>2</sub> emissions, with the bulk of those being from California and Arizona. Total CO<sub>2</sub> emissions from the industrial and utility sectors, which have large stationary sources that are most amenable to capture, emit over 40 million metric tons of CO<sub>2</sub> per year. The region offers significant potential for sequestration in porous sediments greater than 2,500 feet deep, especially the saline formations of California's Central Valley. The West Coast Region also has a wealth of forest and rangelands where improved management practices could sequester large quantities of carbon. Technology discussions, regional meetings, and joint research is being conducted to maintain an open dialogue with stakeholders so that a regional strategy can be developed for terrestrial and geologic carbon sequestration projects that meet the area's near- and long-term needs.



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## PARTNERS

Aera Energy LLC  
Alaska Department of Natural Resources  
American Air Liquide  
American Petroleum Institute  
Argonne National Laboratory  
Arizona Electric Power Cooperative  
Arizona Geological Survey  
Arizona Public Service  
Aspen Environmental Group  
Bascom Pacific LLC  
Bevilacqua-Knight, Inc. (BKl)  
Blue Source  
BP – British Petroleum – America & Alternative Energy  
British Columbia Ministry of Energy, Mines and Petroleum Resources  
California Air Resources Board  
California Climate Action Registry  
California Department of Forestry & Fire Protection – Red Bluff, CA  
California Department of Forestry and Fire Protection  
Sacramento, CA  
California Department of Oil, Gas, and Geothermal Resources  
California Department of Water Resources  
California Energy Commission  
California Environmental Protection Agency  
California Forest Products Commission  
California Geological Survey  
California Institute for Energy and Environment  
California Polytechnic State University – San Luis Obispo

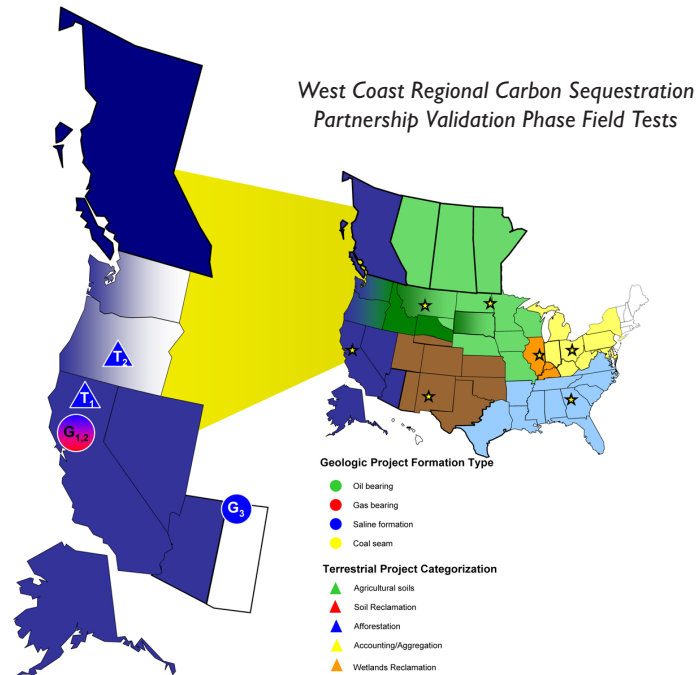
## Primary Project Goal

WESTCARB's primary goal is to validate the feasibility, safety, and efficacy of carbon storage in deep saline formations, a depleted natural gas reservoir, and in forests and rangelands. A secondary goal is to improve the geologic and terrestrial characterization begun during the Characterization Phase (2003–2005) for especially promising storage locations

## Objectives

- Conduct pilot tests to validate carbon storage technologies.
- Refine and enhance the broad regional evaluation of carbon sequestration potential.
- Identify opportunities for a large-scale CO<sub>2</sub> storage test in the region.
- Seek community input on issues surrounding pilot-scale and commercial-scale sequestration project development.

## Field Projects



## Geologic Sequestration Opportunities

California offers outstanding opportunities for CO<sub>2</sub> sequestration because of its many deep sedimentary basins and the potential of value-added benefits from enhanced oil recovery (EOR) and enhanced gas recovery (EGR). In Oregon and Washington, sedimentary basins between the Coast and Cascade mountain ranges also offer excellent sequestration opportunities – a series of basins in the western portions of both states contain sediments up to 6,000 meters (20,000 feet) thick. In Washington, the Puget Sound Basin also contains deep coal formations suitable for sequestration that may also have potential for enhanced coal bed methane (ECBM) production. In Nevada, many small basins have been identified. In Alaska, the oil and natural gas fields on the North Slope are of prime interest because of the large potential for enhanced oil recovery (EOR) using CO<sub>2</sub>. Further, a deep sedimentary basin below the Cook Inlet is near some of Alaska's major CO<sub>2</sub> sources. Finally, in Arizona, sediments underlying the Colorado plateau offer potential storage sites and are in the vicinity of major coal-fired power plants.

## **Rosetta Resources Gas Reservoir and Saline Formation CO<sub>2</sub> Storage Project (G1 and G2)**

Located at the Thornton Gas Reservoir in the Sacramento Valley, California, this stacked storage field test will examine natural gas field sequestration and saline formation sequestration via a single pair of wells (one injection well and one observation well). The project will inject up to 2,000 tons of CO<sub>2</sub> into a sand stringer in the Middle Capay Shale depleted gas zone and up to 2,000 tons of CO<sub>2</sub> into the McCormick Sand saline formation at drilling depths of 928 meters (3044 feet) and 1,040–1,070 meters (3,400–3,500 feet), respectively. The project will test the feasibility and safety of CO<sub>2</sub> storage in a depleted natural gas field with insight into the prospects for enhance gas recovery (EGR), demonstrate the safety and feasibility of CO<sub>2</sub> storage in a saline formation, and demonstrate and test monitoring, mitigation, and verification (MMV) methodologies.

### **Accomplishment Highlights:**

- A site, owned by the California Department of Water Resources, was selected for the pilot test.
- Sandia Technologies, LLC was contracted as the site project manager responsible for overseeing drilling operations and performing the CO<sub>2</sub> injection test.
- A draft Underground Injection Control (UIC) permit application was prepared for the saline experiment.

## **Arizona Utilities CO<sub>2</sub> Storage Pilot (G3)**

This project involves drilling a well approximately 1,200 meters (4,000 feet) deep to evaluate saline formation CO<sub>2</sub> storage in Arizona's Colorado Plateau region. Potential storage targets are the Naco and Martin formations. About 2,000 tons of CO<sub>2</sub> will be injected into the chosen saline formation and CO<sub>2</sub> absorption into the formation will be monitored.

### **Accomplishment Highlights:**

- Public outreach meetings were held in August 2007 in Holbrook, Arizona, to inform elected officials, safety officials, community leaders, and the public of the proposed project and to invite their questions and involvement.
- Partners developed a media release for local and statewide distribution resulting in several news articles.
- Detailed scheduling and budget updating are under way and permit applications are being prepared.

## **Terrestrial Opportunities**

### **Shasta County Terrestrial Sequestration Project (T1)**

The Shasta County, California terrestrial pilot includes afforestation of marginal lands, conservation-based forest management, and fuel reduction/biomass energy activities to reduce GHG emissions from catastrophic wildfires. In the afforestation area, native conifer and oak species are being restored to rangelands and fire-damaged forest lands, with 10 pilot projects under way ranging from about 10 to 100 acres each. In the fuel reduction/biomass energy area, the project will test forest management activities to reduce the potential for large GHG releases from catastrophic wildfires. Building on existing fire models, project researchers are developing new methodologies for rigorous area and emissions baselines, quantifying expected emissions with-treatment vs. baseline, and conducting measurement and monitoring activities. Fire-prone forests are being treated by the landowners/managers to restore forest health by removing suppressed understory trees, brush, and other fuels. Where feasible, biomass fuel is transported to a local biomass power plant to generate electricity that can offset power demand that may have otherwise been met by fossil fuel combustion. Finally, in the

### **PARTNERS (cont.)**

- California State University – Bakersfield
- Cement Industry Environmental Consortium
- Chevron
- Clean Energy Systems, Inc.
- Climate Trust
- ConocoPhillips
- DNV Research – Det Norske Veritas
- Electric Power Research Institute (EPRI)
- Errol L. Montgomery & Associates
- Golder Associates
- GreenWood Resources
- HTC Purenergy
- Jeld-Wen Timber and Ranch
- Kinder Morgan
- Lake County Resources Initiative
- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Laboratory
- Massachusetts Institute of Technology
- National Council for Air and Stream Improvement
- Nevada Bureau of Mines & Geology
- Nexant, Inc.
- Occidental Petroleum
- Oregon Department of Forestry
- Oregon Forest Resources Institute
- Oregon State University
- Pacific Forest Trust
- Pacific Gas and Electric
- PacifiCorp
- Portland General Electric
- Ramgen Power Systems
- Renewable Fuel Technologies LLC
- Rooney Engineering Inc.
- Rosetta Resources Inc.
- Salt River Project
- San Francisco Department of the Environment
- Schlumberger
- SFA Pacific

## **PARTNERS (cont.)**

Shell International  
Sierra Pacific Resources  
Southern California Edison  
Stanford University – Global Climate Energy Project  
TransAlta Centralia Generation  
Tucson Electric Power  
U.S.D,A, Forest Service  
U.S. Environmental Protection Agency, Regions 9 and 10  
U.S. National Park Service  
University of Alaska – Fairbanks  
University of California – Berkeley  
University of California – Davis  
Utah Automated Geographic Reference Center  
W.M. Beaty and Associates  
Washington State Department of Natural Resources  
Western Governors' Association  
Western Interstate Energy Board  
Western Shasta Resource Conservation District  
Western States Petroleum Association  
Wheelabrator Shasta Energy Company  
Winrock International

## **COST**

**Total Project Value**  
\$25,834,211

**DOE/Non-DOE Share**  
\$14,300,000 / \$11,534,211

## **CUSTOMER SERVICE**

**1-800-553-7681**

## **WEBSITE**

**[www.netl.doe.gov](http://www.netl.doe.gov)**

conservation-based forest management area, the project is using a partnership between a conservation group and timber companies to restore and maintain high-quality forest habitats and test the practicality and effectiveness of existing forest carbon accounting protocols.

### **Accomplishment Highlights:**

- 400 landowners contacted; 48 surveyed. 15 site-specific afforestation planting and maintenance plans developed.
- 10 afforestation pilots under way with landowner agreements signed, totaling 391 acres for planting in 2008 and 2009. Three additional agreements in negotiation.
- National Environmental Protection Act Categorical Exemption received on all projects to date.
- Site preparation complete on four afforestation projects for 2008 planting; planting complete on first three projects.
- Pre-treatment measurements complete on four fuel reduction projects; post-treatment complete on one, remainder to be completed in 2008.

### **Lake County Terrestrial Sequestration Project (T2)**

This Lake County, Oregon, terrestrial pilot includes fuel reduction/biomass energy activities to reduce GHG emissions from catastrophic wildfires, and analysis of the feasibility of afforestation using fast-growing hybrid poplar. Like the Shasta pilot, this pilot is testing forest management activities to reduce the potential for large GHG releases from catastrophic wildfires, applying new methodologies for rigorous area and emissions baselines, quantifying expected emissions with-treatment vs. baseline, and conducting measurement and monitoring activities. The two terrestrial pilot projects combined will provide insight into the transferability of fire risk reduction as a CO<sub>2</sub> emission mitigation strategy across forests of the WESTCARB region, as well as produce documentation on establishing baselines and carbon benefits measurements. This pilot is also studying the feasibility of establishing plantations of fast-growing trees on suitable agricultural or grazing land that could be harvested for biomass power on short rotations.

### **Accomplishment Highlights:**

- New 13MW biomass power plant under construction by Marubeni Sustainable Energy, and new \$6 million Collins Companies small-log sawmill complete, in part due to efforts of WESTCARB partners, the Lake County Resources Initiative, Collins Companies, U.S. Forest Service, Oregon Department of Forestry, and others.
- Pre-treatment measurements complete on two fuel reduction projects; post-treatment measurements planned for 2008.

## **Benefits**

This project provides a comprehensive assessment of the sources of, and potential storage sites for, CO<sub>2</sub> in the West Coast Region. These data are being integrated with comparable data from other partnerships to provide a source/storage site database with spatially referenced data covering most of the United States and Canada. This effort is also providing information to evaluate potential capacity and value-added benefits from EOR and EGR. The estimate of CO<sub>2</sub> storage resources in the region is up to 385 billion metric tons (425 billion tons) for saline formations and 5.1 billion metric tons (5.6 billion tons) for oil and natural gas reservoirs. Results obtained from the tests will be critical to the development of commercial CO<sub>2</sub> storage sites that can accommodate large industrial point sources in the region, including highly efficient and technologically sophisticated coal- and petroleum coke-based power plants, oil refineries, cement and lime plants, and ethanol or other biofuel plants.