the ENERGY lab

PROJECT FACTS

Carbon Sequestration

West Coast Regional Carbon Sequestration Partnership—Development Phase

Background

As part of a comprehensive effort to assess options for sustainable energy systems, the U.S. Department of Energy has selected seven regional partnerships, through its Regional Carbon Sequestration Partnership (RCSP) initiative, to determine the best approaches for capturing and permanently storing carbon dioxide (CO_2), a greenhouse gas (GHG) which can contribute to global climate change. The partnerships are made up of state agencies, universities, private companies, national laboratories, and nonprofit organizations that form the core of a nationwide network helping to establish the most suitable technologies, regulations, and infrastructure needs for carbon sequestration. Altogether, the RCSPs include more than 350 organizations, spanning 43 states and four Canadian provinces.

The RCSP initiative is being implemented in three phases. The Characterization Phase began in September 2003 with the seven partnerships working to develop the necessary framework to validate and potentially deploy carbon sequestration technologies. In June 2005, work transitioned to the Validation Phase, a four-year effort focused on validating promising CO_2 sequestration opportunities through a series of field tests in the seven regions. Presently, activities in the Development Phase (2008–2017) are proceeding as an extension of the work completed to date and will demonstrate that CO_2 capture, transportation, injection, and storage can be achieved safely, permanently, and economically at a large scale. These tests will promote understanding of injectivity, capacity, and storability of CO_2 in the various geologic formations identified by the partnerships. Results and assessments from these efforts will help in the commercialization efforts for future sequestration projects in North America.

The West Coast Regional Carbon Sequestration Partnership (WESTCARB), led by the California Energy Commission, includes Alaska, Arizona, California, Nevada, Oregon, Washington, Hawaii, and British Columbia. WESTCARB is made up of more than 80 organizations. The seven states in the WESTCARB account for more than 11 percent of U.S. CO_2 emissions, with the bulk of those being from California. The region offers significant potential for sequestration in porous sediments greater than 3,000 feet deep, especially the saline formations of California's Central Valley and Washington's Puget Trough. Depleting oil fields in the area offer opportunities for enhanced oil recovery (EOR) using CO_2.

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U.S. DEPARTMENT OF ENERGY

PARTNERS

Advanced Resources International (ARI)
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 Oil & Gas Conservation Commission
Arizona Public Service
Aspen Environmental Group
Bascom Pacific LLC
Bevilacqua-Knight, Inc. (BKi)
Blue Source
British Columbia Ministry of Energy, Mines, and Petroleum Resources
British Petroleum
California Air Resources Board
California Climate Action Registry
California Department of Forestry and Fire Protection – Red Bluff, CA
California Department of Forestry and Fire Protection – Sacramento, CA
California Department of Water Resources
California Division of Oil, Gas and Geothermal 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
California State University at Bakersfield
Cement Industry Environmental Consortium
Chevron
Clean Energy Systems, Inc.
Climate Trust
ConocoPhillips
Det Norske Veritas (DNV)
Electric Power Research Institute (EPRI)
Errol L. Montgomery & Associates
Golder Associates
GreenWood Resources

Project Description

Project Summary

WESTCARB will partner with Clean Energy Systems, Inc. (CES) to conduct a large-volume saline sequestration test at the CES Kimberlina Power Plant, approximately 18 miles north of Bakersfield, California. The plant will serve as both the source of CO_2 and the site for injection operations. The site lies in the San Joaquin Basin, part of the Great Central Valley province, with the Vedder Sandstone as the target formation. WESTCARB will inject 250,000 tons (227,000 metric tons) of CO_2 per year for four years from CES's planned Zero Emissions Power Plant (ZEPP-1).

Development Phase Site at Clean Energy Systems' Kimberlina Test Facility in Kern County, California

Injection Site Description

This large-volume CO_2 saline sequestration test will take place beneath the 40-acre Kimberlina Power Plant site at a depth of approximately 7,000 feet (2,100 meters). Clean Energy Systems currently operates a 5-electrical megawatt (MWe) demonstration plant at the location. There is space for the planned 170-thermal megawatt (MWth) California ZEPP-1 and associated CO_2 compression, conditioning, and injection systems. The Kimberlina site is located in the southern portion of the San Joaquin Basin.

Clean Energy Systems' Oxy-Combustion Gas Generator

Description of Geology

The Great Central Valley province is an elongated topographic valley approximately 450 miles long lying between the Sierra Nevada and the Coast Ranges, and extending from the Klamath Mountains in the north to the Transverse Ranges in the south. The San Joaquin Basin comprises the southern half of the Great Central Valley province. It extends about 220 miles from the Stockton Arch to its southern terminus at the northern Transverse Ranges and averages 50-70 miles wide. It is bounded on the east by the Sierra Nevada and on the west by the Central Coast Ranges and the San Andreas Fault. Favorable attributes of the San Joaquin Basin include:

- Geographic diversity.
- Thick sedimentary fill with multiple porous and permeable aquifers and hydrocarbon reservoirs.
- Thick, laterally persistent marine shale seals.
- Locally abundant geological, petrophysical, and fluid data from oil and gas operations.
- Numerous abandoned or mature oil and gas fields that might be reactivated for CO_2 sequestration or benefit from CO_2-enhanced recovery operations.

The target formation is the Vedder Sandstone, which is continuous throughout the region. Basin porosities range from 10–40 percent and permeabilities from 0.2 millidarcies to 10 darcies. Porosity and permeability decrease with depth. Hydrocarbon traps in this area are partly structural, as a result of mild folding throughout the valley, but mostly a result of large scale facies variations. Thick shale units provide good overlying seals at the site and surrounding area.

Source of CO_2

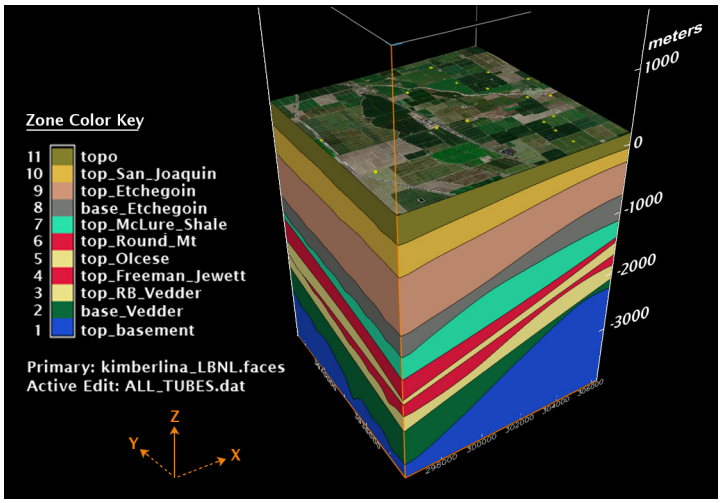
WESTCARB will procure 250,000 tons (227,000 metric tons) of CO_2 per year for four years from CES's 170 MWth ZEPP-1 power plant at Kimberlina. ZEPP-1 will be a zero emissions fossil fuel power plant using oxy-combustion technology and producing a relatively pure stream of CO_2. This CO_2 will be compressed and injected in a deep (7,000+ feet) geologic formation below the plant. ZEPP-1 is projected to come online in 2011; prior to 2011, small quantities of CO_2 for initial injection testing will be procured from the existing 5-MWe plant or brought in by truck or rail car.

Injection Operations

It is the intention of WESTCARB to utilize the CES-owned site at Kimberlina for all injection activities, thus minimizing transportation requirements. A holding (storage) facility for gases produced by the 5-MWe system is already operational at the site. Non-condensable gases will be delivered to a CO_2 compressor train for clean-up and compression. The clean-up cycle will remove residual moisture, oxygen, and other species of concern. It is anticipated that CO_2 will need to be compressed to about 1,300 pounds per square inch gauge (psig) (90 bar) for saline injection using a reciprocation compressor equipped with interstage cooling.

Simulation and Monitoring of CO_2

WESTCARB's monitoring program will be carried out in three phases. During the pre-operational phase, emphasis will be on geologic characterization, baseline data collection, and assessment of environmental and health and safety risks. Testing and coring will be conducted as the injection well is drilled. A small-scale injection test of produced brine, followed by CO_2, will be conducted to help understand storage parameters and optimize injection operations. During the operational phase, CO_2 will be injected into the reservoir; surface facilities will be monitored for elevated CO_2 concentrations to assure worker safety, equipment integrity, and protection of the environment; the location of the plume will be tracked (via periodic seismic tests); and models will be refined as data are interpreted. The post-injection phase will be used to observe the predicted arrest in movement of the plume and to detect any potential leakage out of the primary storage zone.



Geomodel of WESTCARB Development Phase Test Site

PARTNERS (cont.)

HTC Purenergy
Jeld-Wen Timber and Ranch
KinderMorgan
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 and Geology
Nexant, Inc.
Occidental Petroleum
Oregon Department of Forestry
Oregon Forest Resources Institute
Oregon State University
Pacific Forest Trust
Pacific Gas and Electric
PacifiCorp
Peabody Energy
Portland General Electric
Praxair, Inc.
Ramgen Power Systems
Renewable Fuel Technologies LLC
Rooney Engineering Inc.
Salt River Project
San Francisco Department of the Environment
Schlumberger
SFA Pacific
Shell International
Sierra Pacific Resources
Southern California Edison
Stanford University – Global Climate Energy Project
Taisei Corporation
Terralog Technologies
The Collins Companies
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
University of Hawaii – Manoa

PARTNERS (cont.)

Utah Automated Geographic Reference Center (AGRC)

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 (WSPA)

Wheelabrator Shasta Energy Company

Winrock International

COST

Total Project Value

$90,594,102

DOE/Non-DOE Share

$65,606,584 / $24,987,518

Computer simulation using the models ECLIPSE, TOUGH2, and TOUGHREACT will predict plume migration and the effectiveness of trapping via solubility, residual gas (capillary), and mineral mechanisms. During operations, comparisons between the simulated and monitored plume will be used to refine and calibrate the models and to update forecasts of plume migration. During the post-injection phase, a similar approach will be used to predict plume behavior, with a primary focus on quantifying the secondary trapping mechanisms that will immobilize the CO_2 plume.

Goals and Objectives

WESTCARB's overall goal during the Development Phase is to validate the information and technology developed under the Characterization and Validation Phases with respect to research and field activities, regional characterization, and public outreach. Specific objectives include:

- Gain a more thorough understanding of the science, technology, regulatory framework, risk factors, and public opinion issues associated with large-scale injection operations.
- Validate monitoring, verification, and accounting (MVA) methods and modeling and equipment operations.
- Refine capacity estimates of the target formation using results of the test.
- Demonstrate secure geologic storage in a saline formation concurrent with CO_2 capture operations at a power plant.
- Conduct a successful large-scale test that will reduce the cost and risk for commercial geologic carbon sequestration operations being conducted in the future.

Benefits to the Region

The WESTCARB region's large industrial sources currently emit 236 million tons (215 million metric tons) of CO_2 per year. The low end volumetric storage capacity estimate for California's Central Valley alone is 55 billion tons (50 billion metric tons), indicative of the potential to sequester large volumes of CO_2. These volumes are sufficient to warrant investigation into the commercial development of WESTCARB sinks by demonstrating that CO_2 capture and sequestration can be a viable option for mitigating GHG emissions from the region.