the ENERGY lab

PROJECT FACTS

Carbon Storage – RCSP

West Coast Regional Carbon Sequestration Partnership—Validation Phase

Background

The U.S. Department of Energy Regional Carbon Sequestration Partnership (RCSP) Initiative consists of seven partnerships with the purpose of determining the best approaches for permanently storing carbon dioxide (CO_2) in geologic formations. Each RCSP includes stakeholders comprised of state and local agencies, private companies, electric utilities, universities, and nonprofit organizations. These partnerships are the core of a nationwide network helping to establish the most suitable technologies, regulations, and infrastructure needs for carbon capture, utilization, and storage (CCUS). The partnerships include more than 400 distinct organizations, spanning 43 states and four Canadian provinces, and are developing the framework needed to validate carbon storage technologies. The RCSPs are unique in that each one is determining which of the numerous CCUS approaches are best suited for their specific regions of the country and are also identifying regulatory and infrastructure requirements needed for future commercial deployment. Each of the RCSPs are led by one organization that manages the RCSP activities, including the characterization efforts, planning and leading the small- and large-scale injection tests, and integrating the results. The RCSP Initiative is being implemented in three phases, the Characterization Phase, Validation Phase, and Development Phase. In September 2003, the Characterization Phase began with the seven partnerships working to determine the locations of CO_2 sources and to assess suitable locations for CO_2 storage. The Validation Phase (2005–2013) focused on evaluating promising CO_2 storage opportunities through a series of small scale field tests in the seven RCSP regions. Finally, the Development Phase (2008-2020) activities are proceeding and will continue evaluating how CO_2 capture, transportation, injection, and storage can be achieved safely, permanently, and economically at large scales. These tests are providing tremendous insight regarding injectivity, resource estimation, and containment of CO_2 in the various geologic formations identified by the partnerships. Results and assessments from these efforts will assist commercialization efforts for future carbon storage projects in North America.

CONTACTS

Traci Rodosta
Carbon Storage Program Technology Manager
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507
304-285-1345
traci.rodosta@netl.doe.gov

Dawn Deel
Project Manager
National Energy Technology Laboratory
3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507
304-285-4133
dawn.deel@netl.doe.gov

Sherry Mediati
Business Contact
California Energy Commission
1516 9th Street, MS 1
Sacramento, CA 95814
916-654-4204
smediati@energy.state.ca.us

Mike Gravely
Principal Investigator
California Energy Commission
1516 Ninth Street, MS 43
Sacramento, CA 95814
916-327-1370
mgravely@energy.state.ca.us

Elizabeth Burton
Technical Director
Lawrence Berkeley National Laboratory
1 Cyclotron Road, MS 90-1116
Berkeley, CA 94720
925-899-6397
eburton@lbl.gov

PARTNERS

Advanced Resources International
Aera Energy
Air Liquide
Alaska Department of Natural Resources
American Petroleum Institute
American Water Works Association
Argonne National Laboratory
Arizona Electric Power Cooperative
Arizona Geological Survey
Arizona Public Service Company
Aspen Environmental Group
Bascom Pacific, LLC
Bevilacqua-Knight, Inc.
Blue Source
BP (British Petroleum)–America
British Columbia Ministry of Energy, Mines, and Petroleum Resources
C6 Resources, LLC
Calera Corporation
California Air Resources Board
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 the Environment
California Polytechnic State University–San Luis Obispo
California State University–Bakersfield
Cement Industry Environmental Consortium
Chevron
Clean Energy Systems
Climate Action Reserve
Climate Trust
Collins Companies
ConocoPhillips
Desert Research Institute
DNV Research-Det Norske Veritas
Electric Power Research Institute
Energy Commercialization, LLC
Errol L. Montgomery & Associates
Golder Associates
GreenFire Energy
Greenwood Resources
HTC Purenergy

Project Description

The West Coast Regional Carbon Sequestration Partnership (WESTCARB), led by the California Energy Commission, encompasses Alaska, Arizona, California, Hawaii, Nevada, Oregon, Washington, and the Canadian province of British Columbia. WESTCARB includes more than 100 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.

The seven states in the WESTCARB region account for more than 11 percent of U.S. CO_2 emissions, with the bulk of those being from California and Arizona. CO_2 emissions in the region exceed 255 million metric tons of CO_2 per year. The region offers significant potential for geologic storage in porous rock formations below 3,000 feet (900 meters) in depth, especially the sedimentary formations of California's Central Valley, Arizona's Colorado Plateau, and Washington's Puget Trough. The oil-producing regions of Alaska and California also provide significant opportunities for utilization through CO_2-enhanced oil recovery. The region also has a wealth of forests and rangelands where improved management practices could store large quantities of carbon. In addition to its technical work on geologic and terrestrial storage, the WESTCARB Partnership has an important role regionally in assisting policymakers, regulators and the public in understanding the potential of CCUS technology to address the climate change mitigation goals of the western region.

Primary Project Goal

The primary objective of the DOE's Carbon Storage Program is to develop technologies to safely and permanently store CO_2 and reduce Greenhouse Gas (GHG) emissions without adversely affecting energy use or hindering economic growth. The Programmatic goals of Carbon Storage research are: (1) estimating CO_2 storage capacity in geologic formations; (2) demonstrating that 99 percent of injected CO_2 remains in the injection zone(s); (3) improving efficiency of storage operations; and (4) developing Best Practices Manuals (BPMs).

WESTCARB's overarching goal is to facilitate successful commercial-scale CCUS development in its region by: characterizing sources and geologic and terrestrial storage resources; performing regional and site-specific engineering, economic, sampling, testing, and modeling studies; and, through research and outreach activities, to identify and address CCUS implementation issues.

Objectives

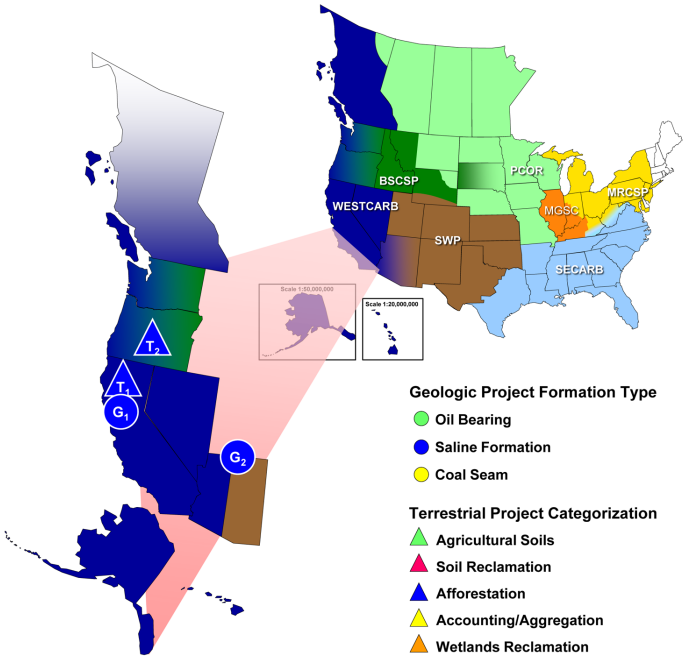
WESTCARB, with its partners, has three specific objectives and approaches:

- Working with state agencies and universities to characterize geologic and terrestrial storage potential and capacity in the WESTCARB region based on geology and geographic criteria;
- Collaborating with industry to define promising sites and facilitate the process for developing commercial-scale CCUS projects, including field, socioeconomic, and engineering studies, laboratory tests, modeling, and outreach;
- Engaging policymakers and regulatory agencies to inform CCUS policy and regulatory development, including providing technical information to assist in developing methodologies to incorporate CCUS as an accepted technology for greenhouse gas (GHG) emissions reduction.

PARTNERS (CONT.)

ION Geophysical
Jeld-Wen Timber and Ranch
Kinder Morgan
Lake County Resources Initiative
Lawrence Berkeley National Laboratory
Lawrence Livermore National Laboratory
Linde Group
Massachusetts Institute of Technology
National Council for Air and Stream Improvement
Nevada Bureau of Mines and Geology
Nexant
Occidental Petroleum
Oregon Department of Forestry
Oregon Forest Resources Institute
Oregon State University
Pacific Forest Trust
Pacific Gas and Electric Company
PacifiCorp
Peabody Energy
Portland General Electric
Portland State University
Princeton Natural Gas, LLC
Ramgen Power Systems
Renewable Fuel Technologies, LLC
Rooney Engineering, Inc.
Salt River Project
San Francisco Department of the Environment
Sandia Technologies
Schlumberger
SFA Pacific
Shell International
Sierra Pacific Resources
Southern California Edison
Stanford University–Global Climate Energy Project
StoneAxe Energy
Taisei Corporation
Terralog Technologies
TransAlta Centralia Generation
Tucson Electric Power
University of Alaska–Fairbanks
University of California–Berkeley
University of California–Davis
University of Hawaii–Hawaii Natural Energy Institute
U.S.D.A. Forest Service (Pac. Wildland)–Vallejo, CA
U.S.D.A. Forest Service (Shasta)–Redding, CA
U.S. Environmental Protection Agency, Region 9

Field Projects



Locations of WESTCARB terrestrial (T1 and T2) and geologic (G1 and G2) field projects

Geologic Storage Opportunities

California offers outstanding opportunities for CO_2 storage because of its many deep sedimentary basins and the potential for CO_2-enhanced oil recovery (EOR) and other utilization options. In Oregon and Washington, sedimentary basins between the Coast and Cascade mountain ranges offer excellent storage opportunities. A series of basins in the western portions of both states contain sediments up to 20,000 feet (6,000 meters) thick. In Washington, the Puget Sound Basin also contains deep coal formations suitable for storage that also may have potential for enhanced coal bed methane (ECBM) production. In Nevada, the storage resource is distributed amongst the small basins of the Basin and Range. In Alaska, the oil and natural gas fields and sedimentary basins on the North Slope and near the Cook Inlet are of prime interest because of their proximity to sources, accessibility and opportunities for CO_2-EOR. In Arizona, sediments underlying the Colorado Plateau and Tertiary Basins offer many potential storage opportunities for the state's large coal-fired power plants and other sources. In Hawaii, the potential for storage in basalt is being evaluated. In British Columbia, there are storage opportunities in saline formations, oil and gas fields, and unmineable coal.

Northern California CO_2 Reduction Project (G1)

WESTCARB and C6 Resources, LLC, conducted a site characterization study of the Montezuma Hills area in the southern Sacramento Basin, where decades of natural gas exploration, production, and storage provided initial structural and stratigraphic data from logs and seismic surveys. On this basis, the project team developed a geologic model to simulate the injection of 5,440 metric tons of CO_2 into a deep saline sandstone, the Anderson Formation. Results suggested that the area would be an excellent candidate for commercial-scale CO_2 storage. The area is in close proximity to large industrial and power plant sources in the San Francisco Bay area. The project was pursued successfully through the planning and permitting stages, but strategic business decisions resulted in withdrawal of C6 Resources from the project.

PARTNERS (CONT.)

U.S. Environmental Protection Agency, Region 10
U.S. National Park Service
Utah Automated Geographic Reference Center
Visage Energy
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
William J. Clinton Foundation
Winrock International
W.M. Beaty and Associates

COST

Total Project Value
$30,882,258

DOE/Non-DOE Share
$19,931,100 / $10,951,158

Accomplishments /Highlights:

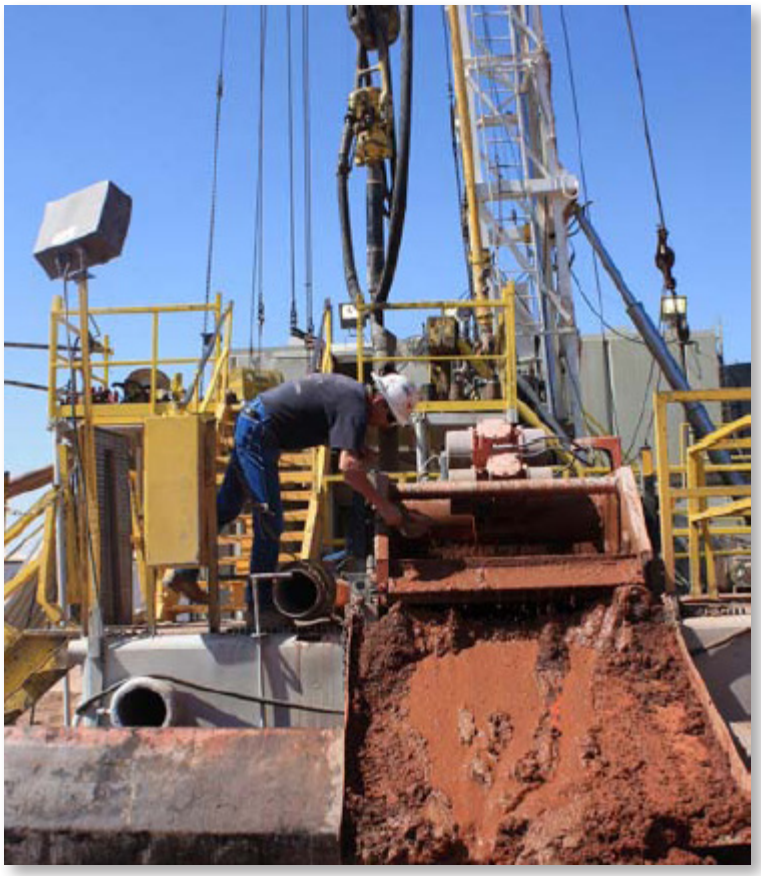
- Selected a well site and C6 signed surface and subsurface access agreements with the landowner.
- C6 submitted an Underground Injection Control (UIC) permit application to U.S. EPA Region 9 and permit applications for surface land use and construction activities to the Solano County Planning Board.
- WESTCARB and C6 successfully engaged the local community, government officials, and other stakeholders through a series of meetings, open houses, and use of informational materials. Any concerns raised were successfully addressed by the project team.

Arizona Utilities CO_2 Storage Pilot (G2)

A characterization/injection well was drilled on Arizona Public Service Company (APS) land near the coal-fired Cholla power plant. Potential CO_2 storage targets were the Naco and Martin saline carbonate formations. Due to a finding of insufficient injectivity, CO_2 injection was not undertaken and the well was not completed. This result demonstrates the importance of specific site characterization studies because subsurface heterogeneity in hydrogeologic properties can critically affect local storage capacity even within formations with high regional potential.

Accomplishments/ Highlights:

- Held public outreach meetings during August 2007 and November 2008 in Holbrook, Arizona, to inform elected officials, safety officials, community leaders, and the public about the project at the Cholla site and to invite their questions and involvement.
- Received National Environmental Policy Act (NEPA) clearance for the project. Permits included a drilling permit from the Arizona Oil and Gas Commission; a Temporary Aquifer Protection permit from the Arizona Department of Environmental Quality (ADEQ), and a Class V UIC permit from Region 9 of the U.S. Environmental Protection Agency.
- Drilled a 3,850 foot (1,170 meter) injection well at the Cholla site. Performed associated mudlogging analyses, wireline logging, rock sample collection, and drill stem tests. Researchers found highly saline waters and good sealing formations, but insufficient permeability in the target formations (Martin and Naco) to support a commercial-sized injection project to meet the needs of the Cholla plant.



Mudlogger collects samples from the Supai Formation during drilling at the Cholla site.

Terrestrial Storage Opportunities

Terrestrial storage opportunities in the WESTCARB region include afforestation (tree planting); changes in forest management to increase carbon stocks; biomass storage in wetlands; beneficial use of biochar; changes in land management and development practices; improved management of forests to reduce the severity of wildfires; and, where practical, the use of forest thinnings as fuel for biomass energy facilities. WESTCARB investigated these options through studies and field pilots with partner, Winrock International, as well as many other collaborators, including local agencies and landowners. Evaluation of afforestation of rangelands with native tree species for California, Oregon, and Washington over 20-, 40-, and 80-year time periods demonstrated that, on a dollar-per-ton-CO_2-equivalent basis, costs are lowest for the longer time spans because the trees store more carbon in their prime growing years and the initial costs of land preparation and planting thus are amortized over a larger quantity of stored carbon. The potential for riparian zone afforestation was explored in Arizona. In addition to carbon storage, it was found to provide ecosystem benefits such as improved water quality, fish and wildlife habitat, and recreation opportunities. However, factors such as the relatively slow growth rates and the long, thin areal distribution of riparian ecosystems make implementing such projects in Arizona economically unfeasible on the basis of carbon credits alone. Researchers also addressed the potential for afforestation in Oregon with fast-growing hybrid poplar trees, which are able to store large amounts of carbon in a relatively short period and could be harvested as biomass energy crops or as timber.

Shasta County Terrestrial Storage Project (T1)

WESTCARB's Shasta County, California, terrestrial pilots included afforestation of marginal lands, conservation-based forest management, and "ladder fuel" (i.e., stunted trees allowing ground fires to reach tree crowns) reduction coupled with use as biomass fuel to reduce GHG emissions from catastrophic wildfires and provide a net-negative carbon fuel source. For afforestation, native conifer and oak species were restored to rangelands and fire-damaged forest lands on 12 separate plots, ranging from 10 to 100 acres each. For ladder fuel reduction/biomass energy, the project tested forest management activities to reduce the potential for large GHG releases from catastrophic wildfires. Building on existing fire models, project researchers developed new methodologies for

rigorous emissions baselines, quantifying expected emissions with-treatment versus baselines, and conducting measurement and monitoring activities. Fire-prone forests were treated by the landowners/managers to restore forest health by removing suppressed understory trees, brush, and other ladder fuels. Where feasible, biomass fuel was transported to a local biomass power plant to generate electricity that could offset power demand that otherwise may have been met by fossil fuels. For conservation-based forest management, the project used a partnership between a conservation group and timber companies to restore and maintain high-quality forest habitats and test the practicality and effectiveness of forest carbon accounting protocols.

Accomplishments/Highlights:

- Contacted 400 landowners and obtained detailed surveys of 48 properties, resulting in the development of 16 site-specific afforestation planting and maintenance plans.
- Conducted 12 afforestation pilots with landowner agreements signed, encompassing 470 acres for planting in 2008 and 2009. Native conifer and oak species were restored to rangelands and fire-damaged forest lands on plots ranging from 10 to 100 acres each. Data were collected to determine the potential carbon benefits and costs of these projects.
- Received National Environmental Protection Act Categorical Exemption on all projects to date.
- Completed planting on 12 projects.
- Completed pre- and post-treatment (clearing) measurements and projected future growth analyses on all projects.

Researchers take measurements in a brushfield at the Lammar's pilot site in Shasta County, California, prior to clearing the site for tree planting.

Lake County Terrestrial Storage Project (T2)

The Lake County, Oregon, terrestrial pilot included ladder fuel reduction/biomass energy activities to reduce GHG emissions from catastrophic wildfires and to assess the feasibility of afforestation. Like the Shasta County pilots, this pilot tested forest management activities to reduce the potential for large GHG releases from wildfires, applying new methodologies for rigorous emissions baselines, quantifying expected emissions with-treatment versus baselines, and conducting measurement and monitoring activities. The two terrestrial pilot projects provided insight into the transferability of fire risk reduction as a CO_2 emission mitigation strategy across forests of the WESTCARB region, as well as documenting how to establish baselines and measure carbon benefits. This pilot also included studies of the feasibility of planting fast-growing trees on suitable agricultural or grazing land, which could allow short-rotation harvests for biomass power production.

Accomplishment Highlights:

- Collins Companies expanded its Fremont Sawmill operation in Lakeview by building a new $6.6 million small log mill. The mill was made economically feasible by the 20-year Interagency Biomass Supply memorandum of understanding (MOU) and 10-year Stewardship Contract effort spearheaded by the Lake County Resources Initiative, and supported by WESTCARB, the U.S. Forest Service, Oregon Department of Forestry, and others. The new mill provides an added tool for improving management of forests and hazardous fuels in Lake County.
- Completed pre- and post-treatment measurements and net impact calculations on two fuel reduction projects.
- GreenWood Resources completed the establishment of a network of nine hybrid poplar varietal test sites in western states. Test sites were managed for three years, assessed for a variety of performance standards, and biomass used for combustion fuel for ethanol conversion.
- Conducted a case study simulation by applying the ArcFuels Model to the Drews Creek watershed to evaluate the carbon losses from various treatment planning scenarios. Carbon loss functions in the ArcFuels modeling platform were developed for avoided CO_2 emissions from reducing the severity and extent of wildfire as a result of forest fuels treatment projects.

Terrestrial storage pilots promoted improved forest management practices in Lake County, Oregon, and Shasta County, California.

Benefits

WESTCARB's research has resulted in compilation of significant new data on the potential for terrestrial and geologic storage technologies to be used to mitigate GHG emissions in the western region. Regional characterization efforts have provided an assessment of the sources and potential geologic storage sites for CO_2 in the West Coast Region and data have been made available through an interactive portal on the WESTCARB website. The data collected from these projects have helped to better estimate CO_2 storage capacity and permenance within the WESTCARB region. Project data have also been integrated with comparable data from other RCSPs to provide a source/storage site database with spatially referenced data covering most of the United States and Canada, available through the NATCARB website and NETL's Atlas publications. This effort has also provided information to evaluate potential capacity and value-added benefits from EOR and ECBM as well as consideration of the potential for other utilization options in the region. The estimate of CO_2 storage resources in the region is up to 1,124 billion metric tons for saline formations and 4 billion metric tons for oil and natural gas reservoirs. Results obtained from the field tests, laboratory studies, and modeling have been critical to developing an understanding the influence of local geologic, infrastructure, and socioeconomic/demographic conditions on the success of geologic CCUS projects. WESTCARB's terrestrial storage research has provided unique datasets and analyses of the cost and storage potential for major terrestrial storage methods in the western region. In particular, the research has shown the critical role that forest management and wildfire prevention/minimization may have in reducing the region's carbon emissions from catastrophic wildfires. Beyond the technical advances, WESTCARB has also played a key role in educating the public, policymakers and other stakeholders about CCUS technology and its potential applications to reduce GHG emissions.

NT42593, December 2012