PROJECT facts

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

Carbon Sequestration

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BIG SKY REGIONAL CARBON SEQUESTRATION PARTNERSHIP—VALIDATION PHASE

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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_2), 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_2 sequestration opportunities through a series of field tests in the seven Partnership regions.

Description

The Big Sky Regional Carbon Sequestration Partnership is building on the work conducted in the Characterization Phase (2003-2005) with a focus on geologic and terrestrial field validation tests that assess the relative efficiency of alternative sequestration options, prove the environmental efficacy and sustainability of sequestration, verify regional CO_2 sequestration capacities and satisfy field test permitting and regulatory requirements. Data from validation tests will be integrated into a geographical information system (GIS) tool that will assist industry and regional planners to optimize energy development strategies. Big Sky will also conduct extensive public outreach and education and training opportunities for students and young professionals.

Carbon sequestration will play a paramount role in developing this sustainable future by enabling the region to cleanly utilize its abundant fossil energy resources (nearly 40 percent of total U.S. coal reserves) and sequestration sinks to support future energy demand and economic growth. The Big Sky Partnership Region has abundant geologic and terrestrial sink opportunities available, including areas of mafic volcanic rocks (flood basalts), reactive carbonate reservoirs (e.g., the Madison formation), and Powder River basin coals.

Primary Project Goal

The overarching goal of the Partnership is to promote the development of a regional framework and infrastructure required to validate and deploy sequestration technologies. To achieve this, the Validation Phase focuses on the most promising geologic and terrestrial field validation tests coupled with market assessments, economic analysis and regulatory and public outreach.

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Center for Advanced Energy Studies
Center for Energy & Economic Development
Cimarex Energy
Columbia University, Lamont-Doherty Earth Observatory
Crow Tribe
Det Kongelige Olje- Og Energidepartementet
Energy Northwest
EnTech Strategies, LLC / New Directions
Environmental Financial Products
Environmental Protection Agency
Heller Ehrman, LLP
IBM
Idaho Carbon Sequestration Advisory Committee
Idaho Dept. of Environmental Quality
Idaho National Laboratory
Idaho Soil Conservation Service
Idaho State University
Inland Northwest Research Alliance
Institute for Energy Technology (Norway)
Institute de Physique du Globe de Paris
Intertribal Timber Council
Jackson Hole Center for Global Affairs
Los Alamos National Laboratory
Montana Bureau of Mines and Geology
Montana Dept. of Environmental Quality
Montana Farm Bureau Federation
Montana GIS Services Bureau IT Services

Objectives

- Conduct geologic field validation tests in prominent geological formations that are located throughout the region—mafic rock formations and sedimentary rock hosted saline formations.
- Conduct terrestrial field validation tests to demonstrate and validate the technical and economic feasibility of carbon storage in the major terrestrial carbon sinks, implement monitoring and verification protocols, and assess the impacts to existing ecosystems.
- Develop a national mafic rock atlas and assess the sequestration potential of these rocks through modeling studies, laboratory testing, and insights developed from the basalt pilot project.
- Address and assess the technical and economic potential for and implications of carbon sequestration in the region.
- Establish the Big Sky Energy Future Coalition that brings together industry, academia, environmental non-governmental organizations and regulatory and governmental officials biennially to dialogue on the role carbon sequestration can play in providing a technological solution to the region's energy requirements.

Geologic Opportunities

The Partnership's primary geologic effort is to demonstrate carbon storage in mafic/basalt rock formations, a geology not yet well characterized but with significant long-term storage potential in the region and in other parts of the world. The region's Columbia River Basalt Group, for instance, covers approximately 164,000 km^2 (63,320 square miles), with CO_2 storage capacity of basalt formations in the region range estimated from 36 - 148 billion tons. Preliminary calculations show that, in basalt formations, rapid conversion of injected CO_2 to carbonate minerals can occur, with complete conversion of fluid phase CO_2 to solid phase carbonate minerals in a few hundred years. If these laboratory-based estimates can be verified in the field, basalt formations may offer a unique geologic medium for long-term, secure carbon sequestration.

Basalt Field Validation Test (G1)

This field test will involve injection of approximately 3,000 - 5,000 tons of supercritical CO_2 into a deep basalt formation in western Walla Walla County, in eastern Washington State. The site is currently undergoing evaluation and preliminary permitting to construct a coal-fired integrated gasification combined cycle plant that will have CO_2 capture and sequestration as part of the overall operational design of the plant. The test will assess the mineralogical, geochemical, and hydrologic impact of injected CO_2 within a basalt formation, and incorporate site monitoring and verification activities.

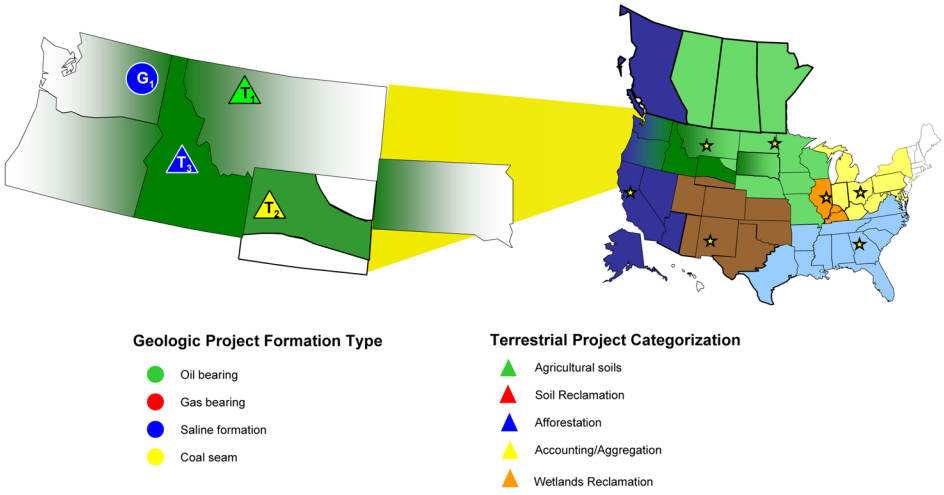
Accomplishment Highlights:

- Field Activity Plan for the field pilot study was issued.
- Simulations of CO_2 injection for two basalt flows completed.
- Two shallow soil gas probes were installed (1,000 ft apart) at approximate location of anticipated CO_2 injection well.
- Seismic survey completed 12/07/07.

Terrestrial Opportunities

The Big Sky Partnership region provides tremendous potential for GHG offsets though terrestrial carbon sequestration in forests, rangelands, and agricultural croplands. The Partnership currently has the most comprehensive terrestrial sequestration program in the nation. Big Sky will design cropland, rangeland, and forestland field validation tests and advance the Partnership's Characterization Phase market-based carbon storage methods and verification protocols to demonstrate the viability of emerging pilot carbon markets. The results of this activity could be one of the largest market-based carbon

trades in the country that is nationally recognized and in compliance with the reporting requirements of the DOE Energy Information Administration's Voluntary Reporting of Greenhouse Gases (1605b) Program. Furthermore, the Partnership will integrate results from the field tests into its economic assessment framework.



Cropland Field Validation Test (T1)

The objectives of this test are to 1) quantify and determine cropland management practices that optimize carbon sequestration in semi-arid Montana, 2) develop monitoring, mitigation, and verification (MMV) protocols to evaluate carbon sequestration for farms enrolled in carbon trading, and 3) investigate satellite image analysis as an alternative to the on-site validation of National Carbon Offset Coalition carbon contract compliance and as a means to remotely obtain cropland data used in predicting farmland soil carbon sequestration. Existing field trials at six controlled benchmark sites address the first objective by testing the effects of tillage vs. no-tillage, fallow-wheat vs. lentil-wheat crop rotations. The second objective is being addressed by an enrolled site component to develop and test MMV technologies and protocols. The MMV methods being compared to estimate soil carbon content are: 1) lab-based and "on-the-go" visible and near-infrared (VisNIR) spectroscopy, 2) laser-induced breakdown spectroscopy (LIBS), and 3) conventional laboratory methods. Finally, the third objective is being addressed via a remote sensing study that relies primarily upon analysis of Landsat Thematic Mapper (Landsat 5) satellite imagery.

Accomplishment Highlights:

Controlled study

- First round of samples from multiple fields collected and analyzed.

Enrolled site proximal soil sensing MMV

- Initial measurements using standard methods and "on-the-go" VisNIR have been completed.
- Initial simulated in situ SOC measurements using VisNIR and LIBS have been competed.

Remote sensing study

- Satellite imagery have been purchased and preprocessed.
- All cropland field reference data has been obtained for this study; which includes over 500 data points reflecting tillage, no-till, fallow, crop, and conservation reserve.
- Segmentation algorithm was used to facilitate the segmentation process. Results presented as vector-based field-level data.

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National Carbon Offset Coalition
National Geophysical Research Institute (India)
National Tribal Environmental Council
Nez Perce Tribal Council
Norwegian Univ. of Science and Technology
Oregon State University
PacifiCorp
Portland General Electric (PGE)
Power Procurement Group
PPL Montana
Puget Sound Energy (PSE)
Ramgen Power Systems, Inc.
Research Council of Norway
Ruckelshaus Institute for Environment & Natural Resources (University of Wyoming)
Russian Academy of Sciences
Sage Resources
Schlumberger
Semiarid Prairie Agricultural Research Centre
SINTEF Petroleum Research (Norway)
South Dakota School of Mines and Technology
Southern Montana Electric
State Geological Survey Units
Summit Energy
The Sampson Group
Unifield Engineering
United Power/Edison Mission Group
University of Idaho
Univ. of Wyoming GIS Center
Univ. of Wyoming Enhanced Oil Recovery Institute
Wageningen University (The Netherlands)
Western Governors' Association
Wyoming Carbon Sequestration Advisory Committee
Wyoming Department of Environmental Quality
Wyoming State Governor's Office
Yellowstone Ecological Research Center

COST

Total Project Value
$21,455,308

DOE/Non-DOE Share
$16,405,089 / $5,050,219

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Rangeland Sequestration Potential Assessment (T2)

Continuing a study begun by others in 1982, this field test will focus on determining best management practices for carbon sequestration on rangelands. The test includes soil and biomass sampling at two long-term rangeland sites in eastern Wyoming to determine the sequestration effects of grazing intensity and seasonality of grazing on native northern mixed-grass prairie, and improvement practices on degraded northern mixed-grass prairie. An assessment of sink potential for these rangelands will be performed, including potential benefits to ranchers. Findings from this field test are expected to be relevant to rangelands in Montana, and eastern Colorado.

Accomplishment Highlights:

- Completed literature review and synthesis of findings on carbon sequestration in rangelands.
- 320 soil samples collected and analyzed. This recent data shows grazing intensity has a significant influence on soil organic carbon within 0-15 and 0-60 cm soil depths.

Forestry Field Validation Test (T3)

This forestry field test will use remote sensing to identify changes in forest management for enrolled forestry sequestration sites in the Northern Rocky Mountains. This remote sensing will complement contractual, ground-based random plot sampling and allometric measurements. The primary objective is to quantify sequestration potential in forests through understanding the effects of forest management on different carbon pools in forests.

Benefits

The Partnership's efforts will benefit the United States by providing a comprehensive assessment of the sources and potential sinks for CO_2 in the Big Sky Region, which includes the northern Rockies and Great Plains as well as the inland Pacific Northwest area. This information on sources and sinks is being integrated with the data from other partnerships to provide a comprehensive database covering the entire nation. This effort will also provide information to evaluate potential pilot sequestration projects in the Big Sky Region with respect to the effectiveness, efficiency and permanence of the sequestered carbon. The project will promote cooperation among stakeholders and help ensure public acceptance of CO_2 sequestration.

Preliminary estimates of CO_2 storage potential of the storage of the mafic/basalt rock formations in the region's Columbia River Basalt group range from 36 - 148 billion tons of CO_2, which is enough capacity for over 20 years of storage of all U.S. coal-fired power plant emissions of CO_2. Additional storage potentials exist in the deep saline formations which run along the eastern slopes of the Rocky Mountains from Canada into New Mexico, in depleted oil reservoirs, and in coalbed methane fields in the Powder River Basin area. These areas, together with the basalt formations, have the potential to store up to an estimated 1,100 billion metric tonnes (1,300 billion tons) of CO_2. On a much smaller scale, but with the potential to sequester carbon in amounts that offset the region's current CO_2 emissions, are the extensive terrestrial sinks. Estimates indicate that changes in cropland management practices, for example, can sequester approximately 7.7 million tons of CO_2 per year.

The findings from the pilot sequestration tests will be transferable to other regions and countries where similar geological and terrestrial sinks exist. This transferability will be enhanced due to the extensive international partners who are collaborating on the design and implementation of these field validation tests. The project will provide the basis for large scale deployment of these sequestration options providing for both commercial technology development/transfer to rural communities and educational and workforce training in these advanced energy systems. Results obtained from the tests will be critical to the development of DOE's FutureGen Initiative which will produce both hydrogen and electricity from a highly efficient and technologically sophisticated coal-fired power plant with virtually no emissions.