



Our firm has expertise in the technologies, markets, environmental and regulatory issues, and economics of the geologic sequestration of carbon capture, utilization and storage (CCUS).

Carbon Capture, Utilization and Storage (CCUS)

Asia-Pacific Economic Cooperation (APEC) Feasibility Study: APEC Economies. For APEC's Energy Working Group, ARI produced the study "Feasibility of Accelerating the Deployment of Carbon Capture, Utilization and Storage (CCUS) in Developing APEC Economies" (APEC#213-RE-01.12), which included: (1) Assess Feasibility of CCUS/CO₂-EOR in Developing APEC Economies; (2) Develop Case-Study Assessments of Selected CCUS/EOR Prospects; and (3) APEC Developing Economy Regulatory Assessments; and (4) Identify Key Issues Relevant to CCUS/EOR.

U.S. DOE Coal-SEQ III Consortium. ARI coordinates and participates in advancement of scientifically-based simulation capabilities for CO₂ storage in coalbed methane and gas shale reservoirs in the presence of multi-component gases and other fluids in order to improve how current simulation tools model the effects of high pressure CO₂ on the integrity and swelling/shrinkage of the coal matrix and its permeability as well as proper algorithms for the adsorptive capability of wet coals.

Project Management and Reservoir Engineering Support to SECARB Carbon Sequestration Regional Partnership. As one of the U.S. Department of Energy (DOE) awarded cooperative agreements to seven Regional Carbon Sequestration Partnerships (RCSPs), in support of the SSEB and EPRI, ARI is serving as the principle project management and reservoir engineering contractor for Southeast Regional Carbon Sequestration Partnership's (SECARB's) large scale CO₂ storage demonstration project. The objective of this effort is to demonstrate integrated CO₂ capture (from a coal-fired power plant), transport, and storage. The injection is taking place within the Citronelle oilfield located in Mobile County, AL using CO₂ captured from the nearby Plant Barry. ARI prepared a detailed site plan for subsurface characterization, well drilling and monitoring activities, was responsible for the preparation of the injection permit, will conduct all monitoring activities, and provide project oversight and review.



Geologic Characterization Team Leader for SECARB Phase II Carbon Sequestration Regional Partnerships. In support of the Southern States Energy Board and EPRI, ARI's role in this ongoing project with the Southeast Region's Carbon Sequestration Partnership (Phase II) is to provide the integrating geologic framework and calculation of CO₂ storage capacity for the southeast region of the U.S. (The SECARB partnership covers Georgia, Florida, South Carolina, North Carolina, Virginia, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, and southeast Texas.) In addition, ARI is serving as the primary geological, engineering, MMV and project management contractors for the SECARB – Phase II saline aquifer CO₂ injection test. As part of this, we are preparing the detailed site plan for conducting the geologic characterization, well drilling and monitoring activities for the saline aquifers CO₂ injection test.

Project Management and Reservoir Engineering Support to SECARB Phase III Carbon Sequestration Regional Partnerships. Again in support of the Southern States Energy Board and EPRI, ARI's will be the principle project management and reservoir engineering contractor for SECARB's Phase III large scale CO₂ sequestration demonstration project. The objective of this effort is to demonstrate CO₂ storage potential in the lower Tuscaloosa Formation Massive Sand Unit. This geologic formation stretches from Texas to Florida and has the potential to store more than 200 years of CO₂ emissions from major point sources in the region. The partnership will inject CO₂ at two locations to assess different CO₂ streams and how the heterogeneity of the formation affects the injection and containment. Injection of several million tons of CO₂ from a natural deposit is expected to begin in late 2008. The project will then conduct a second injection into the formation using CO₂ captured from a coal-fired power plant in the region. The results of these projects will provide the foundation for the future development of CO₂ capture and storage opportunities.

Support to the Southwest Regional Partnership for Carbon Sequestration. For the Southwest Regional Partnership for Carbon Sequestration, directed by the New Mexico Institute of Mining and Technology, Advanced Resources is the lead organization providing engineering, planning and coordination for the partnership's CO₂ injection demonstration in the Fruitland coal of the San Juan basin. With industrial partners ConocoPhillips, Kinder Morgan and others, the demonstration will involve the drilling of a new CO₂ injection well and the injection of about 75,000 tons of CO₂ over a 12-month period. This will be the largest sequestration demonstration in coal seams for the DOE's regional partnership program.

SASOL: ECBM and CO₂ Evaluation: South Africa. Advanced Resources International is engaged in a comprehensive evaluation of the potential to use CO₂ emissions from Sasol's Condor coal conversion project in Secunda, South Africa for enhanced coal bed methane (ECBM) production and CO₂ storage in the coalfields in Botswana. The "Condor" study is comprised of several tasks and activities that correspond to the tasks and activities proposed for the India CTL study, including a review of the geologic conditions of the coalfields in Botswana



as well as calculation of the amount of CO₂ that could potentially be sequestered and the amount of methane that could be produced in the more prospective parts of the coal seams. In addition, Advanced Resources characterizes the potential impact of CO₂ storage on future coal mining opportunities in the Botswana coal fields.

U.S. Department of Energy: CO₂ Storage Assessment: U.S. ARI was awarded a contract to assess factors influencing effective CO₂ storage capacity and injectivity in selected gas shales in the Eastern United States. Project objectives include analyzing data on reservoir properties; developing a better understanding of the characteristics of shales that impact sealing integrity, storage capacity and CO₂ injectivity; verifying this understanding through small-scale CO₂ injection tests; characterizing the potential constraints to economic CO₂ storage in gas shales; assessing approaches for development of cost-effective CO₂ storage; and developing a basin-level characterization of the CO₂ storage capacity and injectivity of selected Eastern shales.

Consultation to the CO₂ Capture Project. Vello Kuuskraa, the President of ARI, currently serves as the chair of the Technical Advisory Board of the CO₂ Capture Project (CCP) a multi-company, multi-government effort to develop breakthrough technologies to reduce the cost of CO₂ separation, capture, transportation and sequestration from fossil fuel combustion streams by 50% for existing energy facilities, and by 75% for new energy facilities. The CCP is utilizing the capabilities of approximately 30 preeminent industrial concerns, national laboratories and research organizations. The project will also establish guidelines for maximizing safe geologic sequestration, for measuring/verifying sequestration volumes, and for assessing and mitigating environmental risks.

Geologic Assessment of CO₂ Storage Options and Capacity for Coal-Fired Generation in Nevada. For Sierra Pacific Resources, ARI is performing a high-level, scoping evaluation of the potential CO₂ storage options for its proposed coal-fired power generation capacity in Nevada. The emphasis of the project is on assembling sufficient information on the geologic formations and feasible storage options within the vicinity of its generation facilities. This study will review potential geologic CO₂ storage options for these sites, and identify the most prospective storage option(s) for the Ely Energy Center. Infeasible storage options will be characterized as well.

The Southeast Regional Carbon Sequestration Partnership (SECARB) recently achieved a significant milestone in advancing carbon capture and storage (CCS) technologies. On October 29, 2013, the SECARB Anthropogenic Test site in Southwest Alabama reached a carbon dioxide (CO₂) injection goal of 100,000 metric tons. This accomplishment marks a tremendous achievement for the team as it operates the world's largest fully integrated CCS project on a pulverized coal fired power plant. Additionally, in 2013, the SECARB Anthropogenic Test received international recognition by the Carbon Sequestration Leadership Forum (www.cslforum.org). ARI manages many aspects of the CO₂ storage including the MVA, modeling, permitting, and project management. Other team members include Electric Power



Research Institute, Southern Company and Alabama Power, Denbury Resources, Inc., Mitsubishi Heavy Industries America, Inc., Geological Survey of Alabama, Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory, U.S. Geological Survey, DNV KEMA, the Carbon Capture Project (CCP), the City of Citronelle, Alabama, and the Alabama Department of Environmental Management.

Geologic Appraisal of CO₂ Storage Options in Arizona. For the Southwestern Power Group (SWPG). ARI support involved the determination of the availability of any favorable target geological formations on site or within a 5-mile radius of their Bowie Power Station, an examination of potential options (if any) for beneficially using CO₂ for enhanced oil or gas recovery, and the determination of the presence of any active faults, transmissive faults or other geological formations that would prohibit CO₂ sequestration.

U.S. DOE: Assessment of CO₂-EOR Potential: U.S. Basins. For DOE, ARI developed a reservoir data base of 10 target basins for CO₂-EOR, (2) established the CO₂-EOR potential in the basin; (3) prepared a set of screening criteria for selecting fields in each basin favorable for CO₂-EOR; (4) built the cost and economic models and the GIS system, appropriate to the each basin; (5) defined the CO₂ sources being used, and the anthropogenic CO₂ sources that would be used in the future, for a combined CO₂-EOR and CO₂ storage effort; (6) examined the set of incentives, including direct funding support, that would enable CO₂-EOR to be commercially applied in each basin; and, (7) reported on the findings of this "basin-oriented" strategy. The effort estimated current and potential future demand for CO₂ for CO₂-EOR in these basins by characterizing by ongoing and undeveloped CO₂ -EOR opportunities.

Support to the National Energy Technology Laboratory. In 2005 and 2006 ARI provided lead contract support to the NETL in the development of its Carbon Sequestration Technology Roadmap and Program Plan. This work involved research and analysis of a range of topics related to CO₂ capture and storage including: CO₂ capture technologies; CO₂ leakage pathways, trapping mechanisms, and other factors affecting the permanence of injected CO₂; technologies to detect and monitor CO₂ in underground formations; and methods for modeling the fate and transport of injected CO₂. Critically important to this effort is keeping up-to-date on DOE/NETL research activities, and the activities of others, including research progress and the key findings and conclusions of this research. Carbon Sequestration Benefits (CarBen) Model. ARI has developed CarBen; a spreadsheet-based tool demonstrates the role that CO₂ capture and storage can play in the United States under future scenarios where greenhouse gas emissions are constrained. As a part of the CarBen development effort, ARI has assessed the CO₂ storage capacity of domestic oil-bearing formations, under a scenario using conventional CO₂ injection approaches and technology, and also a case with advanced CO₂ injection technology.



The TharPak consortium (www.tharpak.com) is a group of leading multinational companies and educational institutions that have deep rooted experience in coal, unconventional resources and clean coal technologies. The group has spent over 18 months analyzing publically available data collected and studies conducted on the Thar coal resource. Based on that analysis, the consortium has developed a strategy that will methodically alter the course of accessing and exploiting natural resources in the Thar region and the Indus Basin. The consortium members collectively are committed to addressing the environmental impact of its activities and all greenhouse gas and pollutant emissions will be mitigated to the maximum extent possible, while balancing costs. The unique grouping of technologies represented in the consortium offers the most efficient path to carbon capture, storage and future re-use for Enhanced Oil Recovery (EOR). ARI provides development and project management for the consortium and will lead the CCS, EOR, and unconventional resource exploration aspects of the project.

IEAGHG/DECC/UNIDO: Global Assessments of CO₂-EOR Potential and Associated CO₂ Requirements: International. ARI prepared reports for the International Energy Agency Greenhouse Gas Research Programme (IEAGHG), UK Department of Energy and Climate Change (DECC) and UNIDO that reviewed the major CO₂-EOR operations underway around the world to better understand the factors that facilitated or hindered their implementation, and developed a high-level, first-order assessment of the CO₂-EOR oil recovery and CO₂ storage capacity potential in the largest 54 oil basins of the world, using the U.S. experience as analogue. Also assessed were both traditional approaches for CO₂-EOR, along with alternative approaches that optimize both oil production and CO₂ storage. Existing CO₂-EOR operations are described, highlighting those projects pursuing or considering the co-benefits of CO₂ storage and incremental oil production. Expanding on previous work, the world-wide incremental oil production and CO₂ storage potential from CO₂-EOR is assessed assuming a set of “next generation” CO₂-EOR technologies. Other approaches to increase CO₂ storage in conjunction with CO₂-EOR are also identified and evaluated. Finally, life-cycle analyses are presented of the greenhouse gas emissions (GHG) associated with various alternatives for CO₂-EOR development.

NRDC: CO₂ Study: U.S. CO₂-EOR Potential and Associated CO₂ Requirements from GHG Emissions Reduction Policies. ARI prepared a high visibility report for the Natural Resources Defense Council (NRDC) on the U.S. oil production potential from accelerated deployment of carbon capture and storage applied for CO₂-EOR. The completion of this work culminated in a press teleconference, followed by a number of press interviews and presentations to a variety of political leaders.

World Bank: CCS Capacity Building: Jordan. ARI performed a technical assistance project in the Republic of Jordan to assess the potential application of carbon capture and storage (CCS) technology in Jordan



Natural CO₂ Field Analogues. For DOE/NETL, ARI is assessed three natural CO₂ fields as analogs for long-term sequestration, including establishing timing of CO₂ storage, geochemical and geomechanical changes during CO₂ production, and field operations.

Storage of CO₂ in Deep Coals. ARI, in partnership with Burlington Resources and BP, conducted an extensive study of CO₂ sequestration and enhanced coalbed methane recovery in the San Juan Basin of New Mexico. This study, funded by the DOE, provided groundbreaking information on the storage mechanisms and feasibility of storing CO₂ in coals.

Joint Industry/ARI Studies on CO₂ Sequestration. ARI and Shell CO₂ Company worked jointly to assess CO₂ – ECBM storage opportunities in the San Juan basin of the southwestern U.S., including reservoir simulation and facilities design. Moreover, ARI has performed dozens of geologic and engineering studies of injecting CO₂ into depleted and near depleted oil and gas reservoirs for over 20 years.

Coal Seq Conferences. For DOE, ARI organized, facilitated and documented the results of several, 2-day conferences focusing on research activities associated with the sequestration of CO₂ into unmineable coal seams. Researchers from eight different countries attended these conferences. These efforts have led to a second phase – the formation of the Coal Seq II Consortium.

CO₂ Sequestration Regulatory Guidelines Workshop. For the DOE and the Interstate Oil and Gas Compact Commission (IOGCC), ARI was asked to initiate a possible effort to develop state-initiated regulatory guidelines for addressing the geologic sequestration of CO₂. As a first step, a 2-day conference was organized by ARI in July 2002 to discuss CO₂ sequestration issues, to evaluate the extent to which existing regulatory mechanisms could address the oversight of sequestration, and to determine where modifications to these mechanisms would likely be necessary to better address the unique characteristics and concerns posed by CO₂ sequestration. The conference involved state oil and gas regulatory directors and state geologists from 13 states, along with a number of industry experts.

International Energy Agency Greenhouse Gas Programme (IEA GHG) CO₂ Storage Remediation Study. For the IEA GHG, ARI has recently prepared a comprehensive report that: 1) characterizes the potential CO₂ leakage pathways in depleted oil and gas fields and deep saline aquifers into which CO₂ may be injected and/or stored; 2) formulates site selection and reservoir screening requirements to minimize the risks of CO₂ leakage; 3) discusses modeling and monitoring techniques that would help identify potential CO₂ leakage pathways and any actual leakage, should it occur, and 4) reviews and sets forth procedures for promptly remediating CO₂ leakage from these geological formations.



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