



Our firm has expertise in the technologies, markets, environmental and regulatory issues, and economics of CO₂ enhanced oil recovery (CO₂-EOR).

Enhanced Oil Recovery

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.

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: 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.

Private Client; Market Study; U.S. Offshore. ARI prepared the study "Identifying Opportunities for Nitrogen Injection in Gulf Coast Area Oil Reservoirs". Our team conducted a screening-level study on this topic using our past expertise and the Advanced Resources' Big Oil Fields Data Base. The study addressed three potential market areas for using nitrogen for improving oil recover from Gulf Coast oil fields, namely: (1) miscible enhanced oil recovery; (2) immiscible enhanced oil recovery; and (3) pressure maintenance, substituting nitrogen for hydrocarbon gas injection. The study relied on an in-depth screening of the large (>50 million OOIP) oil reservoirs in the Gulf Coast area including: (1) Identification of Gulf Coast oil fields potentially favorable for N₂ injection, either for pressure maintenance or for enhanced oil recovery, including the criteria we have used to identify these fields; (2) Characterization of these oil fields, including their maturity and potential volume requirements for N₂ injection; (3) Mapping the location of these fields to establish the major nitrogen market concentration centers; and (4) Identifying the primary operator (operators) of these oil fields.

Vietsovetro: Feasibility Study: Vietnam. ARI conducted a CO₂-EOR feasibility study of the giant White Tiger offshore oilfield in Vietnam, Vietnam's largest oilfield, operated by Vietsovetro, a joint venture company between the Russian government and PetroVietnam. The study involved coordinating laboratory PVT and slim-tube miscibility experiments, reservoir simulation history matching and forecasting using a dual-porosity, compositional simulator, specification of facilities requirements and costs, and overall project economics.

Private Client: CO₂ Market Assessment: US Basin. For several financing consortia, ARI performed detailed market assessments of the CO₂ supply and demand potential for CO₂-EOR in the Permian Basin of West Texas. These involved characterizations of the background and history of CO₂-EOR in the basin; current demand of CO₂ for CO₂-EOR; existing, proposed and potential CO₂ supply growth from expansion of existing pipeline capacity and new natural sources, the capture of CO₂ from gas processing plants, and other potential sources; future field- and project-specific CO₂ demand potential for both existing and new CO₂-EOR projects, and discussion of upside and downside risk.

Assessment of CO₂ Markets in the U.S. Gulf Coast: U.S. For a number of clients, including oil and gas producers, electric utilities, project developers, and industrial gas suppliers, ARI has performed detailed studies of the CO₂ supply and demand potential for CO₂-EOR in the Gulf Coast, including the Texas Gulf Coast. Sometimes these assessed the market overall, and many times involved assessments and characterizations of CO₂-EOR prospects within specified distances from prospective facilities that could serve as a CO₂ source. These projects tended to



involve assessment current and potential future demand for CO₂ for ongoing projects, identify and characterize undeveloped CO₂-EOR potential and speculate on the general timing of their development, assess the potential market for CO₂ to serve future CO₂-EOR operations, examine current potential sources of CO₂ supply, characterizing potential “best prospects” for CO₂-EOR development, and describing potential

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.

Enhanced Gas Recovery

For IEA Greenhouse Gas R&D Programme (IEAGHG), Advanced Resources assessed the global potential for enhanced gas recovery and geological storage of CO₂ in shale and coal formations; as well as characterizing the impact of gas production from shales on CO₂ storage capacity in underlying deep saline aquifers.

For the U.S. Department of Energy/National Energy Technology Laboratory, Advanced Resources is currently assessing the factors influencing enhanced gas recovery, CO₂ storage capacity and CO₂ injectivity in selected gas shales in the Eastern United States; including characterizing the potential constraints to economic enhanced gas recovery and CO₂ storage in gas shales; assessing approaches for development of cost-effective approaches for enhanced production and CO₂ storage that overcome these constraints; and developing a basin-level characterization of the enhanced gas recovery, CO₂ storage capacity and injectivity potential of selected Eastern shales

Enhanced Coalbed Methane Recovery

SASOL Petroleum International: Feasibility Study, South Africa. Performed a major study of the feasibility of using CO₂ produced from their Secunda coal to liquids plant (the world's largest single point source of CO₂) for enhanced coal bed recovery (ECBM) in coal seams in Botswana. The study examined all aspects of the project including geology, reservoir simulation, pipeline planning, design and costing, carbon credit financing, legal and regulatory requirements, and full-cycle economics. Also performed a resource assessment of the various CBM blocks currently under lease in the country as a separate study.

Private Client: Assessment Study: Global. ARI's project was to characterize the prospects and opportunities for CO₂-EOR and associated storage in the U.S., North America, and around the world. Specifically, this involved developing characterizations of: (1) Current CO₂-EOR projects in the U.S. and North America; (2) Potential new CO₂-EOR prospects in the U.S. and



North America; (3) Scenarios for production growth from CO₂-EOR in North America, and the CO₂ requirements and sources that may be required to facilitate that growth; (4) Current CO₂-EOR projects outside of North America; (5) Potential new CO₂-EOR prospects outside of North America; (6) Current non-CO₂-EOR storage demonstration projects around the world; (7) Prospects for saline aquifer and other non-oilfield storage in the U.S. and North America; and (8) Prospects for saline aquifer and other non-oilfield storage outside of North America.

Private Client: Develop Roadmap: U.S. ARI developed a “road map” for the development of an integrated coal-to-liquids (CTL) and CO₂ enhanced oil recovery (CO₂-EOR) project, with the CTL plant located in southern Illinois close to the coal fields of the Illinois Basin. The purpose of the “roadmap” was to help make the CO₂-EOR opportunity, including an annual sale of 6 million metric tons of CO₂, a reality. The effort involved: (1) Preliminary Identification of Potential Oil Fields for the Integrated CTL/CO₂-EOR Project; (2) Identify the Operators and Where Possible, the Unitization Status of Each Candidate Oil Field (3) Provide a Preliminary Design and Cost for a Major (6 MMmt/yr) CO₂ Pipeline from Southern Illinois to Eastern Oklahoma: (4) Provide Representative Economics for Developing an Oil Field in Southern Illinois or Eastern Oklahoma; and (5) Task 5: Define and Develop Key Steps of the “Roadmap.”

U.S. DOE SWP: Site Coordinator and Reservoir Engineering Provider: U.S. The study at Pump Canyon (San Juan Basin) New Mexico for the Southwest Regional Partnership (SWP) on Carbon Sequestration conducted ECBM/CO₂ sequestration field test of the overlying Kirtland formation to investigate caprock integrity. CO₂ injection well drilled mid-2008 into the late-Cretaceous Fruitland coals within an existing pattern of coalbed methane wells operated by ConocoPhillips.

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.