Carbon sequestration strategies for the Southwestern United States

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Introduction

Sequestration of carbon emissions in the southwestern U.S. requires strategies tailored for its unique attributes. The region under consideration by the Southwest Regional Partnership for Carbon Sequestration includes five states (Arizona, Colorado, New Mexico, Oklahoma, and Utah) and contiguous areas from three adjacent states (west Texas, south Wyoming, and west Kansas). This region is energy rich (net exporter of electricity, coal, oil and gas), has some of the largest growth rates in the nation, and it contains two major CO_2 pipeline networks that presently tap natural subsurface CO_2 reservoirs for enhanced oil recovery. The ten largest coal-fired power plants in the region produce 50% of the total CO_2 from power-plant fossil fuel combustion, and power plant emissions are close to half the total CO_2 emissions. This paper outlines the first phase of efforts to reduce carbon intensity significantly, including unique scientific and engineering strategies specific for the southwest.

CO_2 Emissions in the Southwest Region

About 70 fossil-fuel power plants are located in the region including Arizona, Colorado, New Mexico, Oklahoma, Utah, and southern Wyoming. Their total emissions in 2001 were approximately 260 million tons. Figure 1 summarizes these emissions by state. Of the 260 million tons of CO_2 emitted from power plants in the region in 2001, about 90% comes from coal combustion. As the largest 28 emitters are all predominantly coal-fired, efforts to make significant reductions in CO_2 emissions must address the large coal-fired power plants. The ten largest power plants emit 50% of the total CO_2 from all power plants in the region (Rick Allis, written communication, 2003). We are investigating those factors contributing to the amount of CO_2 released per MW-hour, which on average is presently at 1.13 tons CO_2 emitted per MW-hour of electricity generated.

Comprehensive, EPA-funded reviews of greenhouse gas (GHG) emissions of the southwestern U.S. considered Utah (1990 and 1993), Oklahoma (1990 and 1999), Colorado (1990) and New Mexico (1990). These reviews illustrate that over 95% of all CO_2 emissions in the region are from fossil fuel combustion. Furthermore, close to half the emissions are from power plants, ranging from 57% in Utah to 44% in Oklahoma in 1990. About 25% of CO_2 emissions are from the transport sector. A comparison of EPA estimates of CO_2 emissions in 1990 and the 1991 to emissions calculated from power plant generation data shows good agreement for Utah and New Mexico, but EPA estimates for Oklahoma and Colorado appear to be more than 20% too high (Rick Allis, written communication, 2003). The EPA estimates also show over 90% of Colorado's CO_2 emissions in 1990 were offset by land use changes (for example, increases in forest carbon storage), whereas this factor was insignificant in other states in the region. We are investigating and quantifying the region's emissions as part of this work.

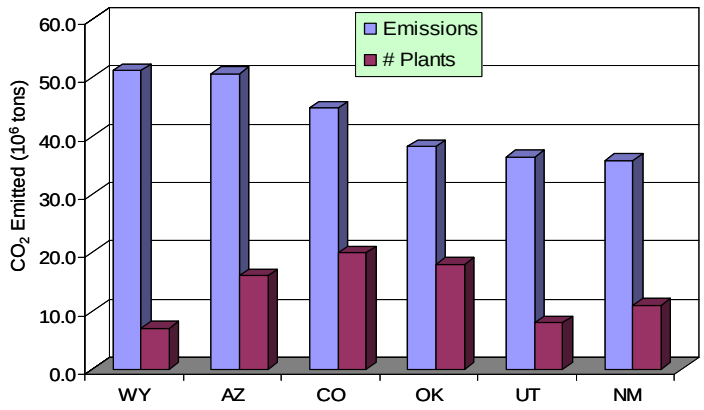

Figure 1. Summary of carbon dioxide emissions in southwestern states.

CO_2 Mitigation Strategies

In the absence of action, current total annual CO_2 emissions in the southwestern U.S. are expected to rise from to 500 million tons CO_2 per year (2001) to close to 750 million tons/year by 2012. The region can offset much of this growth through various sequestration technologies. The region contains the principal CO_2 pipeline infrastructure in the country, much potential exists to offset natural CO_2 production with flue gas CO_2 from the numerous large coal-fired plants, and diverse set of terrestrial, geologic, and mineralization options are available.

Environmental and social consequences are associated with each of these options. Quantifying the consequences is challenging because complex interrelationships link the economy, energy production, population growth, green house gas emissions, and the environment. Establishing and communicating the consequences and tradeoffs between alternative emissions reduction strategies is a possible first step to formulating an effective sequestration program acceptable to the general public. We are also developing and carrying out a unique integrated analysis approach. The analysis is based on a systems-modeling decision framework that provides a means of quantitatively comparing alternative sequestration technologies relative to their associated environmental risks, monitoring and verification requirements, life-cycle costs, and applicable regulatory and permitting constraints. This systems-decision model is being used in: 1) scenario development where policy makers and regulators explore a range of "what if" scenarios, 2) constituency development wherein industry representatives and others can examine the scenario results as a test of environmental viability and practical ability to be implemented, and 3) outreach and education where the model will be taken directly to the public and used as an aid to improve their understanding of CO_2/energy cycle issues and complexity, explain the decision process, and be directly engaged in evaluating possible sequestration options..

Identifying and Ranking Sequestration Options

Terrestrial sequestration and surface mineralization engineering (use of catalysts; see Bond et al., this volume) offer little risk, or at least known risks because these methods are controlled at the surface. Geologic sequestration, however, offers potential risks to ecosystems and the public primarily in the form of CO_2 build-up in the subsurface, unintended mixing of CO_2 in good aquifers via leakage, and possible long-term leakage to the surface from wells or fault systems. Identifying and quantifying these risks for the southwest is being carried out by assigning values of "risk factors" into the integrated assessment model, based on oilfield well data and geologic data gathered to ensure potential risks are considered when

evaluating possible sequestration sites, accounting for various monitoring methods. For the southwest, we are adapting a monitoring and verification approach tailored to site-specific requirements, including: (1) regulatory requirements, (2) location specifics, (3) process specifics, (4) monitoring methods, and (5) information management and verification.

In addition to characterizing potential risks and developing appropriate monitoring and verification approaches, we are also developing field- and regional-scale computer simulation models to evaluate sequestration processes at potential sites for pilot CO_2 sequestration tests. These process simulation models will be used along with the systems-decision model described above to rank possible sequestration sites and technologies.

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