PROJECT facts

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

Sequestration

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CONCEPTUAL DESIGN OF OPTIMIZED FOSSIL ENERGY SYSTEMS WITH CAPTURE AND SEQUESTRATION OF CO_2

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Background

There is growing concern over the effect that greenhouse gas emissions have on global warming. Considerable effort is being expended on developing technology for the recovery and sequestration of CO_2 from point sources, such as power plants.

However, these approaches will not work for diffuse sources, such as motor vehicles. To reduce emissions from this source, a new concept is required. The idea generating the most interest is that of a hydrogen-based economy. Since H_2 produces only water vapor when burned, using H2 to fuel motor vehicles would significantly reduce CO_2 emissions.

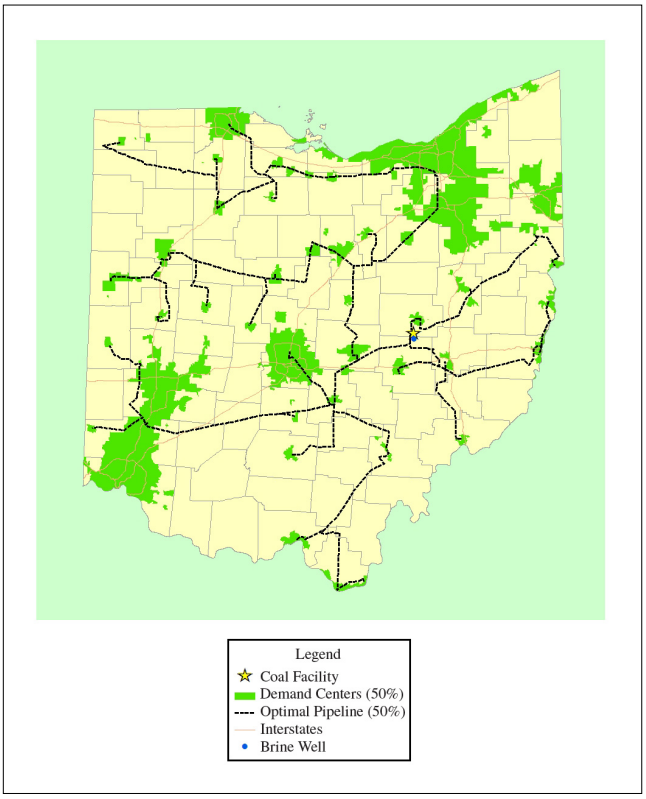
This project is developing analytic and simulation tools to better understand system design issues and economics for a large scale fossil energy system with CO_2 sequestration, including a central fossil energy complex with coproduction of H_2 and electricity and CO_2 capture, a H2 energy pipeline distribution infrastructure serving users (vehicles, etc.), and a CO_2 disposal infrastructure (CO_2 pipelines and sequestration sites). Possible transition strategies from today's energy system to one based on fossil-derived H_2 and electricity with CO_2 sequestration will also be examined.

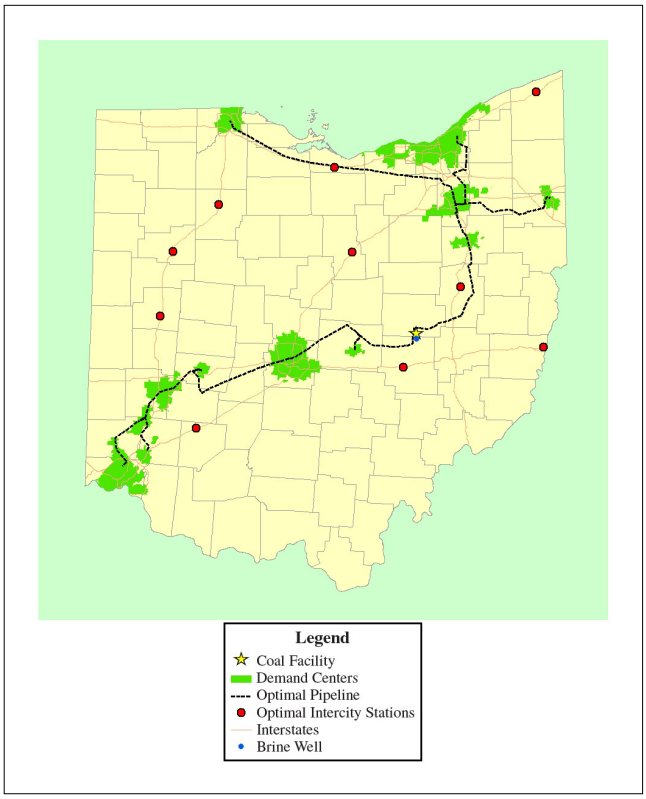
This study considers fossil energy complexes producing both H2 and electricity, from coal, with sequestration of CO_2 in geological formations, such as deep saline formations. After the cost and performance characteristics of the system components (fossil energy complex, H_2 pipelines and refueling stations, CO_2 pipelines and sequestration sites, and H_2 energy demand centers) have been determined, the design of the entire system will be studied as a problem of cost minimization. Cost minimization has two parts: 1) implementation of technical and economic models for each component in the system and 2) development of optimization algorithms to size components and connect them via pipelines into the lowest cost network serving a particular energy demand. We have carried out a geographic specific case study for the Midwestern United States, where substantial coal conversion capacity is presently in place, coal resources are plentiful, and potential sequestration sites in deep saline formations are widespread.

This project is utilizing data and component models of fossil energy complexes with H_2 production and CO_2 sequestration already developed as part of the ongoing Carbon Mitigation Initiative, a joint project of Princeton University, BP, and Ford, and utilizes hydrogen technology models from the Hydrogen Pathways Program at University of California at Davis and the H2A analysis project of the U.S. Department of Energy.

Primary Project Goal

The primary objective of this study is to better understand system design issues and economics for a large-scale fossil energy system coproducing H_2 and electricity with CO_2 sequestration. A second objective is to examine possible transition strategies from today's energy system toward one based on fossil-fuel derived H_2 and electricity with CO_2 sequestration.





Objectives

- To develop new analytic and simulation tools to model the design and evolution of fossil energy systems with CO_2 sequestration.
- To apply these simulation tools to carry out a geographically specific case study of development of a fossil-fuel based H_2 system with CO_2 sequestration.
- To minimize the cost of CO_2 disposal and delivered H_2 by co-optimizing the design of the fossil energy conversion facility and the CO_2 and H_2 pipeline networks.
- To examine possible transition strategies to a future energy system based on production of H_2 and electricity from fossil fuels with capture and sequestration of CO_2 in geologic formations.
- To develop a concept for two new pipeline infrastructures, one for H_2 distribution and one for CO_2 disposal.
- To examine how H_2 infrastructure design and cost depend on geography and environment.

Accomplishments

As a first step, a simple analytical model has been developed that links the components of the system. This model considers a single fossil energy complex connected to a single CO_2 sequestration site and a single H_2 demand center. Cost functions have been developed for CO_2 disposal cost and delivered H_2 cost with explicit dependence on input parameters (size of demand, fossil energy complex process design, aquifer physical characteristics, distances, pressures, etc.).

We have begun to explore transition strategies, such as, how H_2 and CO_2 infrastructures might develop in time, in the context of a geographically specific regional case study. We focus on the Midwestern United States, a region where coal is widely used today in coal-fired power plants, and where good sites for CO_2 sequestration are available. The goal is to identify attractive transition strategies toward a regional hydrogen/electricity energy system in the Midwest with near zero emissions of both CO_2 and other air pollutants to the atmosphere.

COST

Total Project Value
$252,956

DOE/Non-DOE Share
$202,365/$50,591

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To better visualize our results, we use a geographic information system (GIS) format to show the location of H_2 demand, fossil energy complexes, coal resources, existing infrastructure (including rights of way), CO_2 sequestration sites and the optimal CO_2 and H_2 pipeline networks. Optimization tools available in the ARCView GIS software are used to identify the lowest cost pipeline network for supplying hydrogen to users, at different levels of hydrogen demand. In future work, we plan to coordinate with other ongoing GIS based studies of CO_2 sequestration potential such as the NATCARB project. Input from these projects will be used to estimate the best options for sequestration in various parts of the United States, allowing a national assessment of fossil hydrogen with Carbon capture and sequestration.

Benefits

If the U.S. is to make significant progress on decreasing greenhouse gas emissions while simultaneously remaining economically competitive, new approaches to energy management and supply will be needed. Since fossil fuels, particularly coal, are our lowest cost energy resource, we will have to continue using them for some time into the future. This study will investigate ways to do this in an economically and environmentally acceptable way. One option, production of H_2 from fossil fuels with capture and sequestration of CO_2, offers a route toward near zero emissions in the production and use of fuels, and we need to have a better understanding of this option. This understanding, generated by this project, will be very valuable as we make future energy decisions.