ELSEVIER

Energy Policy 36 (2008) 1776–1787

ENERGY POLICY

www.elsevier.com/locate/enpol

Implications of generator siting for CO_2 pipeline infrastructure

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Received 24 October 2007; accepted 24 January 2008
Available online 14 March 2008

Abstract

The location of a new electric power generation system with carbon capture and sequestration (CCS) affects the profitability of the facility and determines the amount of infrastructure required to connect the plant to the larger world. Using a probabilistic analysis, we examine where a profit-maximizing power producer would locate a new generator with carbon capture in relation to a fuel source, electric load, and CO_2 sequestration site. Based on models of costs for transmission lines, CO_2 pipelines, and fuel transportation, we find that it is always preferable to locate a CCS power facility nearest the electric load, reducing the losses and costs of bulk electricity transmission. This result suggests that a power system with significant amounts of CCS requires a very large CO_2 pipeline infrastructure.

Keywords: Carbon capture; Carbon dioxide pipelines; Transmission lines

1. Introduction

There is increasing interest in building new coal to energy facilities, such as integrated gasification combined cycle (IGCC) electric power plants, in the US (American Electric Power, 2007a; CNNMoney.com, 2007; Cornwall, 2007; Investor's Business Daily, 2007; NRG Energy Inc., 2007; Southern Company, 2007). Many facility developers prefer coal-fueled power plants since coal is an abundant domestic source of energy that can provide a level of energy independence and security, and the use of coal provides a hedge against the volatility of other fuel prices such as natural gas price shocks and seasonal variations (O'Brien et al., 2004). Additionally, new coal gasification facilities have environmental advantages over traditional combustion facilities (Klett et al., 2002; Morgan et al., 2005; Ratafia-Brown et al., 2002); one of the largest advantages is the ability to capture carbon dioxide (Rubin et al., 2004). Post-combustion capture of carbon dioxide is also being considered, both for coal (American Electric Power, 2007b) and for natural gas electric generators. Increasing environmental pressures and the likelihood of a price on carbon dioxide emissions in the near future (Ball, 2007; Fialka, 2007; Mufson, 2007) have led project developers to announce that some future plants will be constructed with the ability to capture and sequester carbon dioxide emissions (CCS) (Gasification Technologies Council, 2006). The captured CO_2 from these facilities can be piped either to an oil field where it is sold for enhanced oil recovery (EOR) or to a sequestration (sometimes called storage) site.

As with other high-cost and long-lived investments, project economics and financing considerations play a large role in the development of a power plant (O'Brien et al., 2004). Several of these proposed new coal-based energy facilities are being developed by private firms and will operate in states with restructured electricity markets where there is no guarantee of cost recovery and profitability is a key concern (O'Brien et al., 2004). Site selection is a factor that can play a large role in firm-level profitability, as there are losses and costs associated with transporting the necessary fuel to the power plant and with delivering the produced electricity to the load. Considerable effort is spent in the facility siting process (O'Brien et al., 2004), and it is necessary to find a location where the costs of supplying fuel and delivering the output product are minimized, in an effort to increase profitability. *Ceteris*

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0301-4215/$ - see front matter
doi:10.1016/j.enpol.2008.01.038

paribus, new power facilities are located where transportation costs for inputs and outputs are minimized and where firm-level profits maximized. For new plants constructed with CCS, in addition to fuel delivery and electricity transmission costs, the costs of carbon disposal, transporting the CO_2 to the sequestration site, will factor in the overall profitability and must be considered in the siting process. When siting a coal-based energy project, the project facility developer must determine the profit-maximizing location in relation to the customer, fuel source, and CO_2 sequestration site. Fig. 1 illustrates the location of coal mines, major Midwest ISO nodes, and existing CO_2 pipelines and enhances oil recovery fields in the US.

The facility location problem has important infrastructure implications (in the US, at both state and federal levels) (Parfomak and Folger, 2007). If new clean coal generation technologies are widely deployed capacity additions to or new investment in railways, electric transmission lines and carbon dioxide pipelines will be required. The type and magnitude of the infrastructure requirements depend largely on the firm-level economics and location decisions. For instance, if transmission of electricity is a dominant cost, then new power plants will be located near the load to minimize delivery costs, requiring additional investments in both transport for fuel delivery and in longer CO_2 pipelines. However, if transporting CO_2 is a dominant cost, then new plants will be located near the sequestration site, requiring more transmission investments.

Here we examine the location problem for a coal-based energy facility from a firm-level perspective to provide guidance for increasing profitability and thereby reducing investment risks, as well as to inform state and national policies for subsequent infrastructure requirements, should CCS be widely adopted by the industry.

We have developed a model for determining the profit-maximizing facility location for a coal-based electric generator. The model allows the determination of the most important factors when siting a coal-fueled facility, given cost distributions for delivering fuel, transmitting the produced electricity to the load, and piping the CO_2 to the EOR or sequestration site.

2. Method

We consider the location of a coal-fueled facility producing electricity with CCS. We perform a probabilistic analysis to determine how the facility's annual profit is affected by the distances to the coal source, to the load where energy is delivered, and to the carbon disposal site. In this technical and economic analysis of optimal facility location, we do not consider the economics of the base facility itself, only the sensitivity of the profits to the location. Here we assume that a power producer has made a decision to construct a facility in a general location, such as the US Midwest, based on such factors as their own financing arrangements, internal hurdle rates, and expectations of profitability, and that they wish to site the facility in a location that will minimize transportation costs and maximize profits. There may be other factors that play roles in the siting process—such as availability of suitable land, state permitting requirements, and the availability of labor—but because these are very dependent on the specific project, they are not considered here. We recognize that the availability of cooling water and barge transport will likely influence most projects to site on rivers, but because rivers abound in the US Midwest we do not constrain the analysis to place the plant on a river. Similarly, we recognize that terrain will influence the construction costs for CO_2 pipelines and electricity transmission lines, and note that the terrain is broadly similar throughout the locus

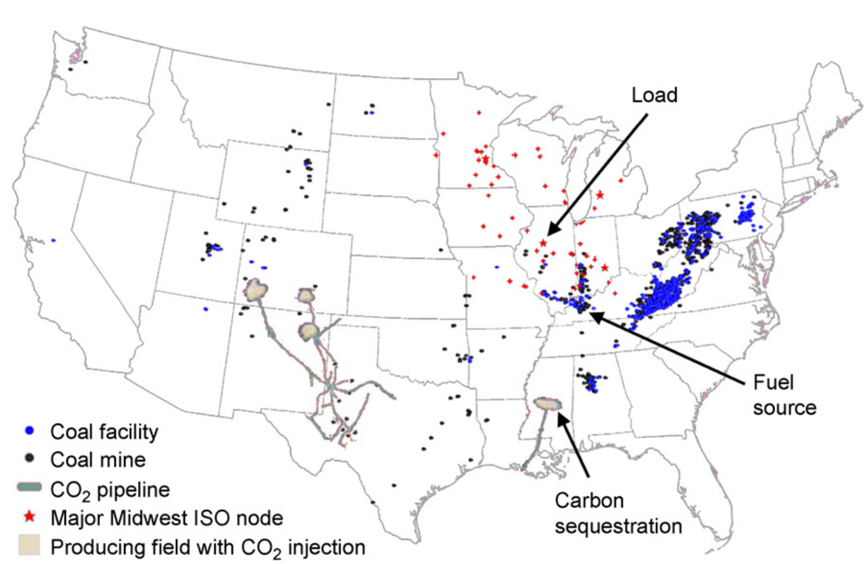

Fig. 1. Location of coal mines, major nodes in the Midwest ISO, and existing CO_2 pipelines for enhanced oil recovery. Examples of a potential load, fuel source, and CO_2 sequestration site are highlighted (IPCC, 2005; Midwest ISO, 2007; National Mining Association, 2007).