The Electricity Journal 29 (2016) 1–4

Contents lists available at ScienceDirect

The Electricity Journal

journal homepage: www.elsevier.com/locate/electr

Determining the success of carbon capture and storage projects

Dominique Thronicker[a], Ian Lange[b,*], Jacquelyn Pless[c]

[a] University of Stirling, United Kingdom
[b] Colorado School of Mines, United States
[c] Institute for New Economic Thinking at University of Oxford, United Kingdom

ARTICLE INFO

Article history:
Available online xxx

JEL Codes:
L51
Q5
H3

Keywords:
Carbon capture and storage
Regression analysis
Carbon policy
Technological change

ABSTRACT

Numerous Carbon Capture and Storage (CCS) projects have been initiated across the globe. Using data on planned, cancelled, and operational CCS projects, this paper aims to elicit characteristics that render CCS projects likely to become operational. These results suggest that a focus on storage site selection and beneficial uses of carbon dioxide would encourage CCS development.

1. Introduction

Carbon Capture and Storage (CCS) is considered an important component of a low-carbon technology portfolio towards mitigating climate change impacts at least cost (IEA, 2015; IPCC, 2014; Edenhofer et al., 2010; IEA, 2012). CCS comprises a set of technologies that facilitate the capture of carbon dioxide (CO_2) emissions at various large point sources and transport of captured CO_2 to a geological sequestration site where it is stored indefinitely. There has been some successful application of CCS in the oil and gas industry for enhanced oil recovery, but the integrated large-scale deployment of CCS in the power sector is a novel technology proven only at the pilot plant stage.[1]

Despite significant effort towards the development and demonstration of CCS in recent years, the number of CCS projects that are currently operational has fallen short of the "[. . .] breadth and depth [necessary] to allow it to play its full part" (Global CCS Institute, 2013). Globally, over a quarter of CCS projects, including "vanguard projects" (Stigson et al., 2012), have been postponed, put on hold, or cancelled altogether. The high capital intensity of large-scale CCS deployment paired with high technology risk is often cited as the main constraint to the technology's deployment (Lohwasser and Madlener, 2012; Stigson et al., 2012; van Alphen et al., 2009). A lack of economic viability of CCS is often suggested as the main reason behind project halts, leading to calls for increased public funding (Zhai et al., 2015). However, there are operational CCS projects that have proven successful despite the high capital costs. This raises the question of whether there are systemic project characteristics that render some CCS projects more likely to become operational and others are more likely to fail. The answer might expose important lessons for the success of future CCS deployment, such as which technologies, project characteristics, or policies are more likely to lead to operational CCS projects.

To the authors' knowledge, no quantitative analysis of what characterizes operational and failed CCS projects has been conducted. The CCS literature to date largely focuses on public perception and costs. As the estimated cost of reducing carbon emissions through CCS in power systems vary by a factor of five or more, the authors find that the levelized cost of electricity (LCOE) penalty, capital costs, and efficiency penalties have high variability and a strong impact on costs. Giovanni and Richards (2010) focus on what determines the costs of CCS for expanding electricity generation capacity. On the other hand, a few papers acknowledge how the effectiveness of CCS ultimately hinges upon its acceptability by the public (Itaoka et al., 2004). An understanding

* Corresponding author.
E-mail address: ilange@mines.edu (I. Lange).

[1] The Boundary Dam CCS Project in Canada is operational though there have been significant problems with its operation (Austen, 2016). Similarly, the Texas Clean Energy Project is in limbo on their funding from the U.S. Department of Energy.

http://dx.doi.org/10.1016/j.tej.2016.08.001
1040-6190/

of CCS is generally lacking (Curry, 2004), and perceived risks are sometimes higher than perceived benefits (Xuan and Wang, 2012).

While these studies are informative and highlight the importance of costs and public perception in CCS deployment, an empirical analysis examining the determinants of CCS project success is necessary for acquiring a better understanding of the potential for CCS project implementation and its contribution to climate change mitigation moving forward. As such, it is the objective of this paper to fill this gap in the literature by empirically identifying whether there are specific project characteristics or deployment effort flaws that determine successful CCS project implementation. The success or failure of the development and deployment of any large integrated project depends on many factors that are often unique to the specific project. Nonetheless, the authors believe this analysis offers useful insights from which a number of policy implications can be inferred.

The remainder of this paper is organized as follows. Section II describes the data and methods used to empirically examine the determinants of CCS project success. Section III presents the results, and Section IV provides conclusions.

2. Data and method

We compile a dataset that contains all integrated CCS projects attempted globally, irrespective of sector, size or project outcome from a number of publicly available sources. One main source is the MIT CCS project database (MIT Carbon Capture and Sequestration Technologies, 2015), which contains information on operational CCS power and non-power plant projects, as well as announced, planned, cancelled and inactive projects. Two other main sources used here are the CCS project databases of ZeroCO2 (Zero CO2, 2015) and of the Global CCS Institute (Global CCS Institute, 2015). When the latest project update was older than July 2015 or when data was missing from these sources, an online search for the most recent information on each project was conducted so all data are valid as of July 2015. Only projects that demonstrate the whole CCS process including capture, transportation and storage are included. Projects that exclusively concentrate on one part of the whole CO2 capture and storage process were omitted, as these are inherently quite different from integrated projects. However, there is no limitation imposed on the type or size of CCS project included in the dataset. Thus, very small and specific industrial CCS deployment projects also are included that do not appear in all of the online databases.

An ordered probit regression model is used to estimate whether select project characteristics increase or decrease the likelihood of a CCS project success. An ordered probit model is a series of equations each with a binary dependent variable that captures different stages of CCS project development and correlates it with the project's characteristics. The dependent variable generally moves from one extreme to another. In this case, it moves from operational (the "best" outcome) to cancelled (the "worst" outcome). The five different outcomes used here are: operational, under construction, planning, on hold and cancelled.

A number of project characteristics are considered as independent variables based upon their potential explanatory power for the outcome variables. "Size" is included and measured as the amount of CO_2 in million tons per year that the CCS project is designed to capture and store. Including this variable tests whether the size of a project influences project success, which could be because of the lack of acceptability by the public due to individuals not wishing to have CCS projects near their homes (Xuan and Wang, 2012) or because larger projects presumably require more capital investments, which determine the overall costs of CCS (Giovanni and Richards, 2010). For similar reasons, the regressions also include a "public funding" dummy as a binary variable indicating whether the project received any kind of public funding support to test whether the availability of this financial support influenced the success of the project given its potential for reducing capital costs and the importance of high capital costs in overall CCS cost. This could be a direct subsidy, a tax credit or any other instrument or mix of instruments. Such direct incentives could lower capital costs to make it more economically feasible, which could increase the likelihood of project success considering how the lack of economic viability is often suggested as a critical barrier to CCS project development (Zhai et al., 2015).

A dummy variable for "storage site confirmed" is also included, which indicates whether the specific storage site where the captured CO_2 is intended to be deposited was decided upon during the planning stage or not. Some studies note that identifying suitable storage capacity is a challenge associated with CCS (IEA, 2015 and Stigson et al., 2012), and thus we empirically test this hypothesis. Given the importance of public perception and how CCS risks are sometimes perceived to be higher than benefits (Xuan and Wang, 2012), this variable could capture the importance of obtaining a social license to operate early in the implementation process.

Furthermore, the policy environment in which the project is planned to operate could be important because of the potential for CCS to mitigate climate change impacts. To test this hypothesis, a "carbon policy" dummy is created based upon the region in which a project is located that takes the value of one for projects in Europe, Alberta and British Columbia Canada, or Norway, as this is where carbon policies exist, and zero otherwise. Each of these entities had an explicit price on carbon, either through a tax or tradable permit scheme before 2012 when most of the projects in the sample were announced. Existence of such policies could indicate that a population is more inclined to accept CCS projects or to perceive the benefits of CCS as outweighing the costs. In light of this, this variable is intended to capture whether the current policy environment enables CCS projects given the local policy objective of reducing carbon footprint.

Another dummy variable that is included is "storage", which refers to the type of subterranean reservoir (enhanced oil recovery, saline, or depleted oil and gas field) envisaged by the project for the final sequestration of CO_2. Each potential type of reservoir for sequestration is characterized by a diverse set of advantages and disadvantages (Folger, 2013), and as such, this variable aims to capture the potential influence of this selection on project success.

The "pilot project" dummy included in the regressions indicates whether the project was planned as a small pilot as opposed to a large-scale demonstration. Given the general public sentiment towards large CCS projects, the size of the system could impact whether local communities protested against the project. Furthermore, the "previous CCS experience" dummy indicates whether the project was preceded by a pilot project or, alternatively, whether the project owner has previously been involved in conducting any other CCS project. Generally, this tests whether previous CCS experience could alleviate the concerns of the public about the project and potentially increase the likelihood of project success.

The remaining variables included in the analysis are categorical and their inclusion attempts to recover information about their influence on the outcome variables. For instance, the "capture process" variable indicates the type of CO_2 capture process utilised at the emissions source. "Feedstock" is a dummy variable indicating the type of fossil fuel input from which the CO_2 emissions originate. Other variables such as industry, region of the world, and whether the project is onshore or offshore were removed from the results shown here as they were never statistically significant and the relatively small number of observations requires a parsimonious model.