Sustainability in Environment
ISSN 2470-637X (Print) ISSN 2470-6388 (Online)
Vol. 8, No. 1, 2023
www.scholink.org/ojs/index.php/se

Original Paper

Case Study in Cost Saving by CCUS Based on CO2 Transport Cost Model

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Received: January 8, 2023 Accepted: February 9, 2023 Online Published: February 17, 2023

doi:10.22158/se.v8n1p67 URL: http://dx.doi.org/10.22158/se.v8n1p67

Abstract

This study expatiated on the definition of Carbon Capture, Utilization and Storage (CCUS) technology, described the current situation of carbon emissions in the world. It analyzed transport costs for two typical projects, Petra Nova carbon capture power project and the Boundary Dam Integrated Carbon Capture and Storage Demonstration, in CO2 Transport Cost Model and compared their risk resistance.

Keywords

carbon emission, cost estimation, ccus, risk balance

1. Introduction

1.1 Background

As the industrial technology develops by leaps and bounds, carbon emissions have been paid more and more attention. The emergence of global warming, the exacerbation of glacier melting, and the rise of sea level all reminded people to pay attention to carbon emissions, carbon neutrality and CCUS technology.

And the issue of carbon emissions is the responsibility for all countries in the world. All countries in the world need to assume certain responsibilities for carbon emissions. Carbon negative technology is an important technology required for all countries. CO2, which will be emitted into the atmosphere, can be reduced by collecting, capturing, and injecting the generated CO2 into geological structures, which is one of the effective and direct CO2 emission reduction methods recognized by some scientist, but many scientists hold the view that CCUS technology was uneconomic. As a result, mastering advanced carbon negative technology will make a significant contribution to world energy conservation and emission reduction.

After the appearance of CCUS, major countries and international organizations have been trying to commercialize the CCUS projects. Among these projects, the Boundary Dam Integrated Carbon Capture and Storage Demonstration (hereinafter called BD project) is the largest commercial project in Canada and Petra Nova carbon capture power project (hereinafter called PN project) was also a commercial project but was closed in 2020.

1.2 Definition

Carbon Capture and Storage (CCS), sometimes also regarded as Carbon Capture Utilization and Storage (CCUS), is an emerging technology to capture CO2 from emission source, such as coal-fired power stations and gas power plants. Then, the captured CO2 will be transported to some institutions, which can isolate them from air. The main CCUS process is presented by flow Figure 1.

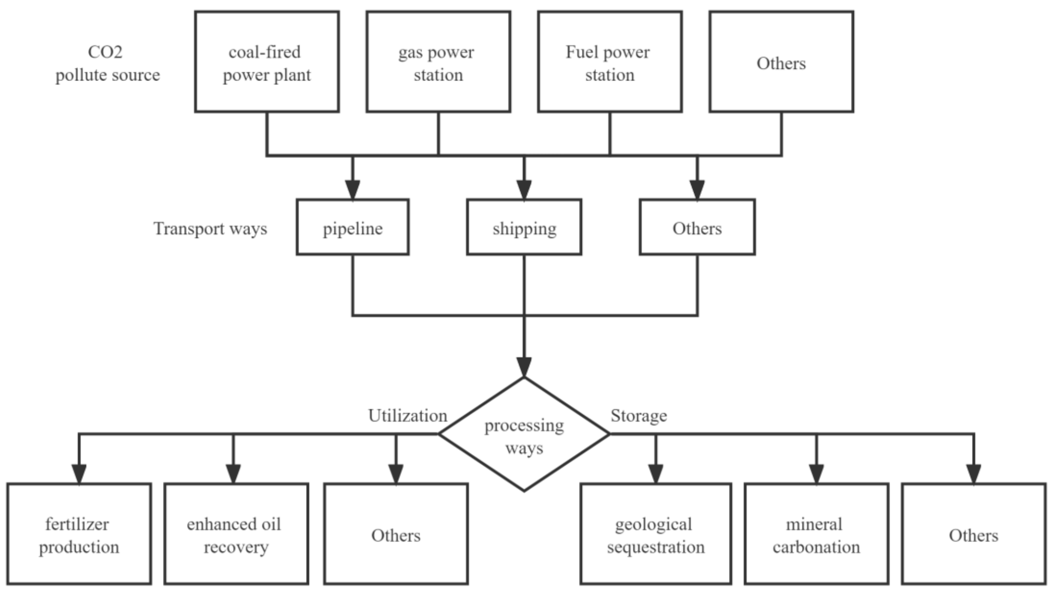

Figure 1. CCUS Technique Flow Chart

Applying and popularizing CCUS technology is mainly used to protect the atmosphere from CO2 pollution, which is releasing by burning coals, gas, petroleum, and other fuels in plants. CCUS is also a possible mean to slow down and even solve the environmental problems caused by CO2 pollution from the use of fossil fuels.

2. Method

As major countries are testing CCUS, the CO2 Transport Cost Model is effective in estimating the expenses in transporting CO2 in dense liquid phase via pipeline. This model estimated the price of CO2 per tonne to cater for one point-to-point pipeline's minimum return to investors. The pipeline's length, the average quality of CO2 transported per year (transport rate) and pipeline capacity factor distribute to the cost in CO2 transportation. The cost assumption for CO2 Transport Cost Model included the capital costs of pipeline installation and purchase, a surge tank, a central controller and pressuring pumps and the expenses of operation and daily maintaining service for the entire facility. The CO2 Transport Cost Models' default method is the Parker equation to estimate the CO2 capital cost. It concluded that material, labour force and right-of-way become three main factors to consider the cost of infrastructure instruction. The Derek equation assists the conversion from the cost of natural gas to that of CO2 by categorizing the diameters of pipelines to adjust the costs of a CO2 pipeline.

$$C_i = \left(\alpha_1 \cdot D^2 + \alpha_2 \cdot D + \alpha_3\right) \cdot L + \alpha_4$$

The C_i is the natural gas pipeline's capital cost in category i, the L in this equation refers to the pipeline's length in miles, the D refers to standard diameter of pipeline and a_i are parameters affected by the data recording the capital cost from 1991 to 2003 for the equation while i represents the parameter number.

$$C_{CO2} = C_i \cdot \beta_{CO2}$$

C_{CO2} is the capital costs of a CO2 pipeline and β_{CO2} is a factor to convert the entire costs of a pipeline for natural gas to that for CO2 based on the pipeline's diameter. In this article, the diameter is fixed at 12 inches, so the β_{CO2} is 1.

This model also took pipeline's operational costs, power requirements for boosters and associated costs in consideration. Other specific details on how to estimate the operational and power requirements for booster pump can be investigated according to the CO2 Transport Cost Model User's Manual.

This equation emphasizes the rate of CO2 transportation and the pipeline's space span as double essential cost elements for the entire transporting process. Figure 2 represents the different costs for situations for length and diameters of pipelines.

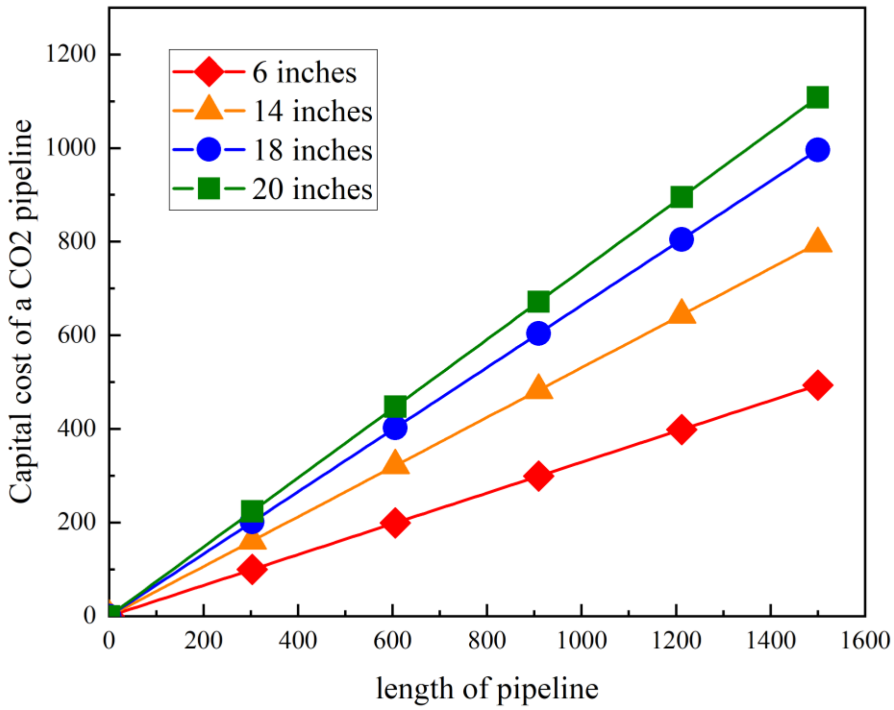

Figure 2. Capital Cost of CO2 Pipeline

The CO2 transport rate affects the overall CO2 transportation cost as well. Larger CO2-generating plants can reduce costs to a greater extent compared to smaller plants. Many CCUS researchers have proven the CO2 Transport Model is a well-utilized resource in estimating the costs of establishing CCUS infrastructure. The model has been utilized to evaluate potential costs of coal-burning power plants and chemical power plant sources in CO2 transportation.

3. Result

According to official data, the Boundary Dam Project costs nearly 1.5 billion Canadian dollars. The length of its point-to-point pipeline is 40 miles and its diameter is 12 inches. It can capture 1 MT per year and the rough cost is calculated at 19 million US dollars. The break-even price of CO2 transported for the first year is 19 US dollars per tonne.

Petra Nova Carbon Capture Power Project used 12-inch underground pipeline and transported 81 miles. The rough cost calculated by the Parker equation and the Derek equation is roughly 38 million USD dollars. The project can capture 1.6 MT per year and then the break-even price of CO2 transported for the first year is 23.75 US dollars per tonne. In Table 1, the PN project needs higher CO2 price to balance its costs when compared to the BD project, which means it has lower risk resistance.

Table 1. Comparison of CCUS Projects

Project	Carbon Captured (MT)	Cost Estimated (Million US dollar)	Break-even price ($/tonne)
PN project	1.6	38	23.75
BD project	1	19	19

4. Discussion

Nowadays, only several large-scale CCS projects are still operating. The Boundary Dam is the only available commercial CCUS project. In September 2020, the PN project was closed due to low oil prices during the COVID-19 pandemic and the consequence of the China-United States Trade War, which is consistent with the result of the equation. However, it is still a great loss of carbon neutralization because the PN project was one of the largest CCUS project in the world with great contribution to global carbon neutralization and its failure may cause reflection all over the world.

In this work, two typical CCUS projects, Petra Nova carbon capture power project and the Boundary Dam Integrated Carbon Capture and Storage Demonstration, were mentioned to introduce the application and feasibility of CCUS technology. According to the results of calculations and the comparison between them, it could be found that the PN project has lower risk resistance compared to the BD project due to the relevantly high break-even price.

Overall, although the universal application of CCUS technology is still facing many challenges and difficulties for now, like mechanical failure, high cost, and low risk resistance, it will be adopted in a large scale if the technology is innovated in the future.

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