The Effects of Policy Uncertainty and Risk Aversion on Carbon Capture, Utilization, and Storage Investments

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Abstract

Overview

Carbon capture, utilization, and storage (CCUS) is the process of capturing would-be CO_2 emissions and transporting them to suitable locations where they can either be put to productive use (utilization) or safely sequestered underground (storage). While model-based analyses suggest an important role for CCUS in cost-effective climate change mitigation pathways, investment in CCUS infrastructure has been slow to materialize. We hypothesize that the slow pace of CCUS implementation is driven in large part by a combination of policy uncertainty regarding government incentives for CCUS and investors' risk aversion. In this paper, we test this hypothesis by developing a CCUS infrastructure network optimization model formulated as a two-stage stochastic program. Future incentive levels are uncertain and risk aversion is incorporated through the use of a linearized concave objective function. We apply our model to a case study involving the Texas and Louisiana Gulf Coast under the 45Q federal tax incentives for CCUS in the United States.

Methods

To answer our research question we developed a novel two-stage stochastic program with a risk averse objective function. Our model takes the perspective of a risk-averse CCUS infrastructure planner who is tasked with developing and operating a predetermined set of CO_2 sources, sinks, and pipelines over a given set of discrete time periods. For every unit of CO_2 successful sequestered, the planner is awarded some monetary value plus an additional amount if the sequestered CO_2 is used for utilization. The time periods the model operates over are divided into two "stages". In the first stage, the CO_2 incentive values are known to the planner. However, in the second stage, the incentive values are uncertain and instead follow a known discrete probability distribution. Once network components are constructed, they can be used to capture/move/storage CO_2.

The model is a mixed-integer linear program with the continuous variables used to represent CO_2 flow between nodes in the network and binary variables used to represent construction and existance of the revelant infrastructure components. This formulation allows our model to capture the effects of economies of scale in infrastructure component size as well as the notion of time discounting which are important considerations in infrastructure planning. In order to add risk-aversion to our model we use an isoelastic utility function in profit. We use a piecewise-linear approximation in order to maintain a linear model.

We constructed a case study of the Texas and Louisiana Gulf Coast region to determine the effects of policy uncertainty and risk-aversion on total CCUS infrastructure investments as well as expected total CO2 captured.