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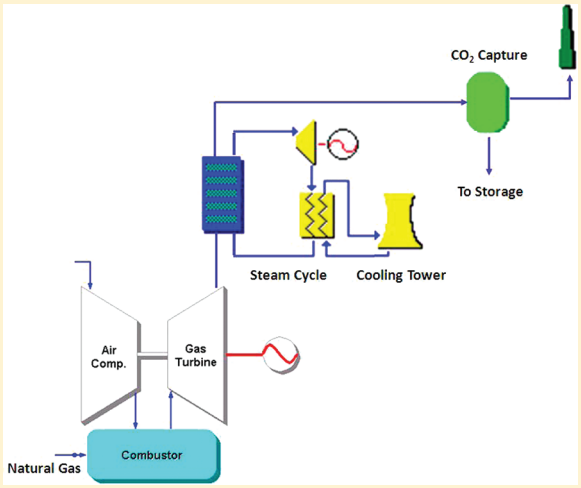
The Cost of Carbon Capture and Storage for Natural Gas Combined Cycle Power Plants

Edward S. Rubin*,† and Haibo Zhai†

†Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, Pennsylvania 15213, United States

Supporting Information

ABSTRACT: This paper examines the cost of CO_2 capture and storage (CCS) for natural gas combined cycle (NGCC) power plants. Existing studies employ a broad range of assumptions and lack a consistent costing method. This study takes a more systematic approach to analyze plants with an amine-based postcombustion CCS system with 90% CO_2 capture. We employ sensitivity analyses together with a probabilistic analysis to quantify costs for plants with and without CCS under uncertainty or variability in key parameters. Results for new baseload plants indicate a likely increase in levelized cost of electricity (LCOE) of $20−32/MWh (constant 2007$) or $22−40/MWh in current dollars. A risk premium for plants with CCS increases these ranges to $23−39/MWh and $25−46/MWh, respectively. Based on current cost estimates, our analysis further shows that a policy to encourage CCS at new NGCC plants via an emission tax or carbon price requires (at 95% confidence) a price of at least $125/t CO_2 to ensure NGCC-CCS is cheaper than a plant without CCS. Higher costs are found for nonbaseload plants and CCS retrofits.



INTRODUCTION AND OBJECTIVES

Over the past two decades natural gas has become an increasingly important source of U.S. electricity generation. Historically, natural gas has been used to provide peak-load power at a relatively high cost per kilowatt-hour during the daytime intervals when electricity demands peak and cannot be supplied wholly by baseload generators. The introduction of high-efficiency natural gas combined cycle (NGCC) power plants, coupled with declining natural gas prices in the 1990s, spurred greater interest in natural gas for baseload and intermediate loads, as well as peak power production. By 2009, gas-fired power plants contributed more than 20% of all electricity supplied to the grid, up from 10% in 1990.[1] This share is projected to grow to 47% by 2035, with natural gas accounting for 60% of new generating capacity additions between 2010 and 2035 in the Department of Energy's reference case scenario.[1,2]

Electric utilities are thus looking to natural gas as a preferred energy source in response to the bullish outlook for domestic gas supplies from new shale gas production,[3] as well as from new air quality regulations that are expected to force the retirement of many older existing coal plants. Besides reducing emissions of criteria air pollutants, switching from coal to natural gas is also a strategy for reducing greenhouse gas emissions linked to global climate change since new NGCC plants emit roughly half the CO_2 per kilowatt-hour as conventional coal-fired plants.[4] Recent studies indicate that even accounting for the higher life cycle emissions associated with natural gas produced from shale formations, NGCC power plants still have much lower GHG emissions than conventional coal-fired power plants.[5]

Despite their lower GHG emissions, recent studies also indicate that increased natural gas use in lieu of coal for electricity generation will be insufficient to achieve the large (50 to 80%) reductions in U.S. greenhouse gas emissions needed to stabilize climate change unless a portion of gas-fired plants are equipped with CO_2 capture and storage (CCS).[6,7] To date, however, most studies of CCS have focused on its potential application to coal-based power plants.[8] In this paper, therefore, we focus on CCS applied to NGCC plants. More specifically, we undertake a systematic examination of how the addition of CCS as a CO_2 reduction strategy would affect the cost of generating electricity from natural gas. We begin with a review of other recent studies of CCS costs for NGCC power plants and attempt to understand the reasons for significant differences in published cost estimates. We then undertake a more systematic analysis that includes a characterization of uncertainties and variability in NGCC plant costs with and without CCS. This analysis seeks to identify the parameters and

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