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Water Use at Pulverized Coal Power Plants with Postcombustion Carbon Capture and Storage

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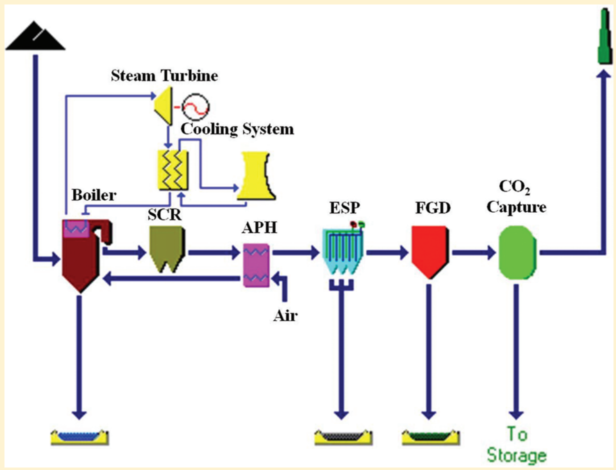
S *Supporting Information*

ABSTRACT: Coal-fired power plants account for nearly 50% of U.S. electricity supply and about a third of U.S. emissions of CO_2, the major greenhouse gas (GHG) associated with global climate change. Thermal power plants also account for 39% of all freshwater withdrawals in the U.S. To reduce GHG emissions from coal-fired plants, postcombustion carbon capture and storage (CCS) systems are receiving considerable attention. Current commercial amine-based capture systems require water for cooling and other operations that add to power plant water requirements. This paper characterizes and quantifies water use at coal-burning power plants with and without CCS and investigates key parameters that influence water consumption. Analytical models are presented to quantify water use for major unit operations. Case study results show that, for power plants with conventional wet cooling towers, approximately 80% of total plant water withdrawals and 86% of plant water consumption is for cooling. The addition of an amine-based CCS system would approximately double the consumptive water use of the plant. Replacing wet towers with air-cooled condensers for dry cooling would reduce plant water use by about 80% (without CCS) to about 40% (with CCS). However, the cooling system capital cost would approximately triple, although costs are highly dependent on site-specific characteristics. The potential for water use reductions with CCS is explored via sensitivity analyses of plant efficiency and other key design parameters that affect water resource management for the electric power industry.



INTRODUCTION

Coal-fired power plants currently account for nearly 50% of U.S. electricity supply, with coal-fired electricity generation nominally projected to increase by 19% over 2007 levels by 2030.[1] Significant quantities of water are needed for cooling and other purposes. The U.S. Geological Survey estimated the total quantity of water withdrawals for U.S. power plants was about 195 billion gallons per day in 2000, approximately 39% of all freshwater withdrawals, second only to agriculture.[2,3]Water use is becoming an increasingly important issue for low-carbon electricity generation. To mitigate carbon dioxide (CO_2) emissions from coal-fired power plants (which emit about a third of U.S. CO_2, the major greenhouse gas driving climate change), postcombustion carbon capture and storage (CCS) is receiving considerable attention.[4] However, in addition to the increased cost of electricity,[5−7] significant quantities of cooling water are required for current postcombustion capture systems.[8,9] Recent studies of the environmental impacts of CCS at power plants [10,11] do not include the effects on plant water use. Thus, there is a need for a more careful evaluation of water usage to better understand the impacts of carbon capture systems.

In power plants, water is used primarily for cooling and secondarily for operating environmental control systems. Wet cooling towers and once-through cooling are most widely used, accounting for 48% and 39% of cooling systems, respectively, at existing U.S coal plants.[12] The Clean Water Act (CWA) requires the use of best available technologies for new power plants to minimize the adverse environmental impacts of cooling water intake structures. This has promoted the use of closed-loop cooling systems instead of once-through systems.[13] In some areas of the U.S., limited water supplies have led to increasing deployment of new technologies such as dry cooling systems using air-cooled condensers (ACCs), the capacity of which approximately tripled between 2000 and 2004.[14]

In light of these concerns, the objectives of this paper are to (1) quantify and characterize pulverized coal (PC) power plant water use, especially in conjunction with amine-based postcombustion

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