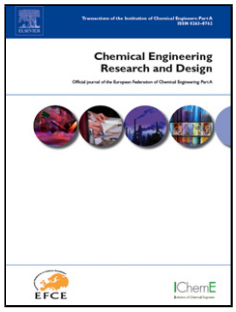

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PII: S0263-8762(17)30183-1
DOI: http://dx.doi.org/doi:10.1016/j.cherd.2017.04.001
Reference: CHERD 2638

To appear in:

Received date: 15-12-2016
Revised date: 8-3-2017
Accepted date: 2-4-2017

Please cite this article as: Patrick Brandl, Salman Masoudi Soltani, Paul S Fennell, Niall Mac Dowell, Evaluation of cooling requirements of post-combustion CO_2 capture applied to coal-fired power plants, *<![CDATA[Chemical Engineering Research and Design]]>* (2017), http://dx.doi.org/10.1016/j.cherd.2017.04.001

Evaluation of cooling requirements of post-combustion CO_2 capture applied to coal-fired power plants

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Abstract

Whilst CO_2 capture and storage (CCS) technology is widely regarded as being an important tool in mitigating anthropogenic climate change, care must be taken that its extensive deployment does not substantially increase the water requirements of electricity generation. In this work, we present an evaluation of the cooling demand of an amine-based post-combustion CO_2 capture process integrated with a coal-fired power plant. It is found that the addition of a capture unit translates into an increase in the total cooling duty of $\approx$ 47 % (subcritical), $\approx$ 33 % (supercritical) and $\approx$ 31 % (ultra-supercritical) compared to a power plant without capture. However, as the temperature at which this cooling is required varies appreciably throughout the integrated power capture process, it is found that his increase in cooling duty (MW) does not necessarily lead to an increase in cooling water usage (kg_{H_2O}/MW). Via a heat integration approach, we demonstrate how astute cascading of cooling water can enable a reduction of cooling water requirements of a decarbonised power plant relative to an unmitigated facility. This is in contrast to previous suggestions that the addition of CCS would double the water footprint.

Keywords: Water-energy nexus, Carbon Capture and Sequestration, Carbon Capture Readiness (CCR)

1. Introduction

1.1. Background and Motivation

The link between climate change [1, 2, 3] and anthropogenic CO_2 emissions [4, 5, 6, 7] has been overwhelmingly acknowledged [8, 9]. The 2015 United Nations Climate Change Conference (COP21) saw a historic international agreement with 193 countries agreeing to work to limit the global temperature rise to no more than 2 °C above pre-industrial levels by the end of the century. Recently, this agreement has gained further momentum with an announcement that the two biggest emitters, the United States and China [10, 11, 12], will both ratify the Paris Agreement. In many countries, the power generation sector is responsible for the majority of CO_2 emissions - for example, thermal power generation from fossil fuels contributed to 25% of the United Kingdom's total CO_2 emissions in 2015 [13, 14, 15]. Thus, it is broadly agreed that CO_2 capture and storage (CCS) will play an important role in climate change mitigation [16, 17, 18]. It has been shown that the UK's future energy mix should accommodate CCS [19, 20] in order to deliver secure energy supply and to meet UK's climate targets of reducing its CO_2 emissions by 80% from 1990 levels by 2050 at least cost [21].

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