Detailed Benchmarking of Post Combustion CO_2 Capture Technologies for Four Reference Power Plant Cases: Economic Assessment

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Introduction

Amine based carbon capture plants are considered for short term demonstration to achieve reduction of CO_2 emissions of power plants. The impact of post combustion capture (PCC) on the performance of different types of power plants and evaluation of the potential improvements (either in solvent formulations or process design) has been studied many times in the recent years.

Several of these studies show different process schemes for the capture process which decrease the operating costs but increase the process complexity; however, degree of complexity and its cost have not been made explicit. If there is an estimation of capture investment costs, it is often based on technology suppliers quotes without disclosing all assumptions behind them.

This work presents the detailed technical and economic performance of a baseline amine capture process updated to 2008 economics. This baseline allows for comparison of different capture technologies when applied to different power plants, coal type and integration philosophy. The work serves also as basic benchmark for other type of solvent systems that may be applied in the future as capture media[2].

The simplicity of the method allows for fast assessment of potential capture solvents. Moreover, this type of study can be used to asses the influence of selected process parameters or configurations on the overall economic performance. The value and applicability of the method is shown by evaluating the performance and economics for four different power plant cases.

Design and Economic Framework

The economic model is analogous to the parametric model of Abu-Zahra et al. (2007)[3], which calculates the design and cost of all important process equipment. Most of the technical assumptions have been revised either by pilot testing, by contacting technology suppliers or by simulation with commercial software. The revised technical and economic assumptions are inline with the benchmarking work performed in other EU projects.

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[2] Currently an evaluation of the use of an AMP/piperazine solvent is conducted, of which the results will be available early 2011.

[3] Abu-Zahra, M. R. M. et al. (2007). "CO2 capture from power plants: Part II. A parametric study of the economical performance based on mono-ethanolamine." International Journal of Greenhouse Gas Control **1**(2): 135-142.

As benchmark, a standard absorption process using MEA (30%wt) has been used. A fixed CO_2 removal rate of 90 % was assumed. Economics are updated to 2008 with accuracy of +/- 30 %.

Base Cases

Out of the cases studied, the following cases will be discussed:

- Natural gas-fired 430 MWe Combined Cycle Gas Turbine plant (CCGT)
- Advanced Supercritical Bituminous coal-fired 800 MWe PF plant New Build (ASBC NB)
- Advanced Supercritical Bituminous coal-fired 800 MWe PF plant Retrofit (ASBC RF)
- Lignite-fired 1000 MWe PF plant (LF)

Results

Selected technical and economic parameters are shown in the table below:

Parameter	Unit	CCGT	ASC NB	ASC RF	LF
Net electricity, Baseline	MWe	423	754	735	920
Net electricity, With capture	MWe	357	550	492	663
Lost power	MWe	66	204	243	257
Net electrical efficiency, Baseline	% (LHV)	58.3	45.5	46.3	49.2
Net electrical efficiency, with capture	% (LHV)	49.2	33.4	31.0	35.5
Efficiency Penalty	% Points	9.1	12.1	15.3	13.7
CO_2 captured	Mton/yr	1.0	3.9	3.7	5.2
Specific investment cost without capture/ with capture	€/kWe, gross	810/1139	1955/2680	1974/2860	1835/2484
Baseline CoE	€/MWh	54	57	55	40
With Capture CoE	€/MWh	72	90	99	69
Cost of CO_2 avoided	€/tonne CO_2	60	51	68	42

Overall the results are as expected with efficiency penalties of around 12-15 % points for solid fuel plants and 9 % points for the CCGT case. However, the performance and economic results for the 800 MWe retrofit are less favorable than the new build and show the significant disadvantages of a turbine design which is not optimized for capture.

It is evident from the cost reported above, that CO_2 capture is going to be more expensive than often reported in literature. However, due to the fact that the economic estimates are based on price levels of 2008, current costs may have fallen somewhat from that peak. The process and methodology of this work can be regarded as a reference for future work.

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