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Exploitation of daily electricity price fluctuation by cyclic solvent storage in a carbon capture plant

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1. Introduction

The energy sector is evaluating many options for carbon capture and storage. Mainly amine systems are foreseen in short term application of post combustion carbon capture (PCCC). A great deal of the research is directed at options for reduction of the energy demand of the capture process. However, for an optimal economic process one need to consider in conjunction also the flexible operation of a carbon capture plant.

The need for a flexible PCCC is connected to the strong fluctuation of the electricity prices. It seems logical to connect the operation mode of PCCC to the demand of electricity (ie electricity price). This study aims to maximize the income from electricity by turning off the stripper at the moment the electricity price peaks. During this time the rich solvent is stored in a tank, while lean solvent is retrieved from a different storage.

2. Approach

An example of the variation of the electricity price in the Netherlands is given by APX group[1] and is shown in Figure 1. In case of a coal-fired power plant, the boiler usually supplies a constant energy flow to the generator. When a capture plant is attached, part of the energy is directed towards the reboiler of the capture plant.

The arrangement of a flexible capture plant can be seen in Figure 2. Both rich, and

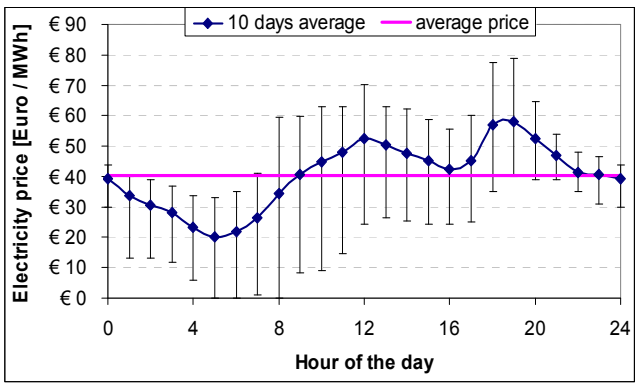

Figure 1: Fluctuation of electricity prices over the day, including their fluctuation range.

[1] http://www.apxgroup.com/marketdata/powernl/public/tlc_2010_prices.pdf

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lean solvent are stored cold in order to reduce degradation.

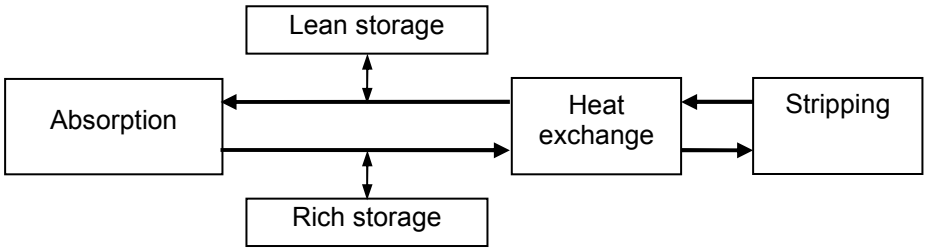

Figure 1: Arrangement of the storage tanks in a standard amine based capture process.

We have examined the economic potential for this flexible storage plant. In the case considered, stripping is stopped at the peak of electricity prices for three hours and the absorption liquid is regenerated in the remaining time.

In case of a 800 MW advanced supercritical power plant, the calculated electricity production for four different cases can be found in Table 1. The capture process is affected as follows:

- The lean-rich heat-exchanger, stripper, reboiler, condenser, compressor and transport lines have a 14% larger capacity than in a basic capture plant. The difference in investment was neglected in this study.
- Two storage vessels with enough volume to store 3 hours of 3.4 m^3/s solvent flow: 37000 m^3 each. This leads to an additional investment of 16.2 M€ for the two tanks (including installation).
- 37000 m^3 of extra solvent: 11.6 M€

With a depreciation over 25 years, 5% interest and 4% maintenance, the yearly cost of the investment in tanks and solvent will be 2.45 M€. Using the price curve in Figure 1 together with the electricity prices in Table 1, the increase in electricity sales income can be calculated. The difference in sales income between a standard capture process and the process with solvent storage is 5 M€.

Table 1: electricity production in an 800 MW ASC plant with basic capture (*) and with capture with solvent storage (**)

PARAMETER	UNIT	Without capture	With capture*	stripper off**	stripper on**
Gross electricity output	MWe	819	684	819	665
Auxiliary power consumption	MWe	65	135	87	144
Net electricity	MWe	754	549	732	521

It can be concluded that the gain in yearly income is substantially larger than the yearly cost of the extra solvent and storage. Therefore, the concept of cyclic solvent storage is interesting and should be further explored.