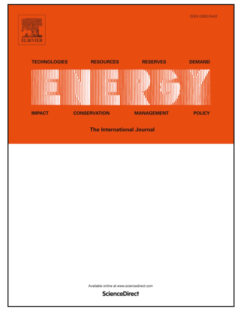


# Process simulation of an efficient temperature swing adsorption concept for biogas upgrading

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# Process Simulation of an Efficient Temperature Swing Adsorption Concept for Biogas Upgrading

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**Abstract**

In this work, a simulation tool for an integrated temperature swing adsorption (TSA) carbondioxide $(CO_2)$ capture process is introduced and used to study the feasibility of the process for biogas upgrading applications. The TSA process consists of interconnected multi-stage fluidized bed columns and utilizes solid amine sorbents for selective adsorption of $CO_2$. The simulation tool has been developed in the process simulation software IPSEpro™ and performs mass- and energy balance calculations that are based on a suitable adsorption equilibrium model. Changes of the adsorbent $CO_2$ loadings and the corresponding heating or cooling requirements are calculated for the individual fluidized bed stages of the adsorber and desorber column. The adsorption equilibrium calculations have been performed, using a Langmuir model that was fitted to $CO_2$ adsorption data of an amine functionalized solid sorbent material. Within this work, the qualitative impact of the regeneration temperature and the stripping gas feeding rate on the overall process performance has been studied. Furthermore, the feasibility for integration of a high temperature compression heat pump (HP) has been assessed. The HP recovers heat from the adsorber to drive adsorbent regeneration within the desorber. Results obtained from this work clearly indicate a great potential of the multi-stage fluidized bed TSA process for biogas upgrading, especially in combination with the proposed heat pump configuration.

*Keywords:* TSA, biogas upgrading, heat balance, optimal heat pump integration

## 1. Introduction

Today, biogas is primarily used for local heat and power production in gas engines. However, a growing economic pressure in the power sector as well as seasonal lows in district heat demands, set the need to find alternative applications for biogas. One promising option is to upgrade biogas to bio-methane and to feed it into existing natural gas grids. Here, the capture/separation of carbondioxide $(CO_2)$ [1] from biogas usually represents the step that has greatest impact on energy demand and on the overall investment costs. [2, 3]. In the past, several technologies have been applied to capture $CO_2$ from biogas, whereas none of them showed to be superior in terms of separation costs [2, 3]. Nevertheless, among the available technologies today, chemical absorption by means of amine scrubbing shows several advantages such as an outstanding methane recovery rate and the fact that the biogas is treated at low pressure. Chemical absorption is a mature and well known technology, which was developed in the first half of the last century. The process utilizes an aqueous amine solution as solvent that is circulated between the absorber and the desorber or stripper. The gaseous $CO_2$ in the raw biogas can reversibly react with the liquid solvent. To maintain regeneration of the high $CO_2$ loaded liquid solvent, the regeneration column is operated at 100°C (373K) to 140°C (413K) at atmospheric pressure [4]. At the bottom of the column a reboiler is installed to provide the necessary heat. Nowadays, aqueous solutions of 30%w monoethanolamine (MEA) are commonly considered as