# Comparison of CO2 separation options for geo-sequestration: are membranes competitive?

**Author:**
Ho, Minh; Allinson, G; Wiley, Dianne

**Publication details:**
Desalination
v. 192
Chapter No. 1-3
pp. 288-295
0011-9164 (ISSN)

**Publication Date:**
2006

**Publisher DOI:**
http://dx.doi.org/10.1016/j.desal.2005.04.135

# COMPARISON OF $CO_2$ SEPARATION OPTIONS FOR GEO-SEQUESTRATION: ARE MEMBRANES COMPETIVE?

**Minh T. Ho[1,3], Guy Allinson[2,3], Dianne E. Wiley[1,3]**

1. *UNESCO Centre for Membrane Science and Technology, The University of New South Wales, Anzac Parade, NSW, Australia 2052, Tel: 61-2-9385 4339, Email: minh.ho@student.unsw.edu.au*
2. School of Petroleum Engineering, The University of New South Wales, Australia
3. *Australian Cooperative Research Centre for Greenhouse Gas Technology (CO2CRC)*

## Introduction

With the growing international concern over the issue of global warming, geological sequestration of $CO_2$ is becoming an increasingly favoured option as a greenhouse mitigation option. Previous studies examining the economic feasibility of $CO_2$ capture and storage have shown that the recovery step for $CO_2$ can account for up to 70% of the total mitigation cost, and can range from $35/tonne $CO_2$ avoided to $264/tonne $CO_2$ avoided [1]. For $CO_2$ recovery from low pressure, high temperature systems such as coal fired power plant flue gases, the capture cost using gas separation membranes may range from $45/tonne $CO_2$ avoided to $98/tonne $CO_2$ avoided [2].

In this study, the economics of separating $CO_2$ from multiple greenhouse emission sources by a range of technologies including polymeric gas separation membranes, amine chemical absorption and pressure swing adsorption has been investigated. The sources include both low-pressure coal fired power stations, high-pressure gas fired power stations and other industrial processes. The aim of this study is to understand the cost variations and processing challenges that exist for full implementation of $CO_2$ capture and storage.

## Method

Using a mathematical process and economic model [3] developed by the University of New South Wales for the Australian Cooperative Research Centre for Greenhouse Gas Technology (CO2CRC), the capture cost for recovering the feed gas $CO_2$ was examined for polymeric gas separation membranes, amine chemical absorption and pressure swing adsorption. For the membrane system, various commercially available polymeric membranes were examined in single, multi-stage and hybrid configurations.

The economic analysis for this study includes not only the costs for capture, but also costs of storage, permitting a full comparison of 'end-to-end' sequestration costs. The economic model allows for the estimation of cost for capture and storage for any source of $CO_2$ emission to one of the 64 geological storage sites in Australia. The model includes factors to account for source gas composition and operating parameters, transport compression, pipeline and storage facilities. The total capital, operating, annualised costs, as well as the geo-sequestration mitigation cost taken as $/tonne $CO_2$ avoided is determined for each case study. In this paper, the storage sites for all sources were assumed to be located offshore.

## Results

The analyses shows that considerable $CO_2$ removal rates of up to 90% using gas separation membranes can be achieved, and the economic competitiveness depends on both the membrane characteristics and characteristics of the feed gas. For low-pressure systems, utilisation of reduced trans-membrane pressure through improvements to the selectivity and permeability of the membrane can improve the capture cost to a level comparable to other low cost traditional technologies such as amine absorption or pressure swing adsorption. For example, doubling of the selectivity and permeability of 'typical' commercial membranes towards $CO_2$ can reduce the total mitigation cost by up to five percent as shown in Figure 1.

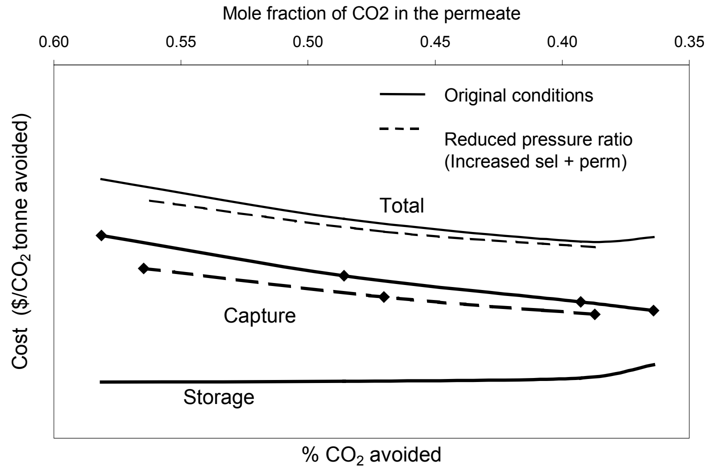


Figure 1. Change in cost for $CO_2$ capture with improved membrane selectivity and permeability

For low pressure feed gases such as power plant flue gases, the results indicate that, using a gas membrane separation system, the lowest geo-sequestration cost per tonne of $CO_2$ avoided occurs when a mixed gas with a $CO_2$ content of about 55% is sequestered. For standard polymeric gas separation membranes, the cost of the compression accounts for a significant amount of capital and operating cost, and without improvements in membrane characteristics is not as economical as amine chemical absorption as shown in Figure 2.

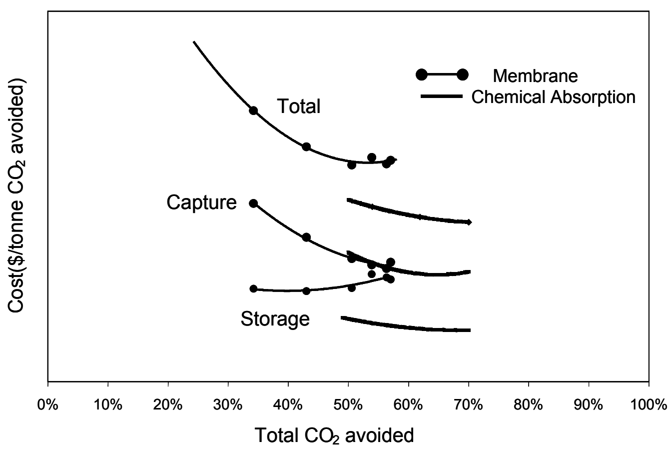


Figure 2: Costs of $CO_2$ capture, storage and sequestration (total) for different capture technologies

**Acknowledgments**

The authors of this paper would like to acknowledge the Australian Cooperative Research Centre for Greenhouse Gas Technology for their financial support.

**References**

[1] Reiner, P., Audus, H. and Smith, A. (1994) Carbon Dioxide Capture from Power Plants, IEA Greenhouse Gas R&D Programme, Cheltenham, England.
[2] Hendriks, C. A. (1994) Carbon dioxide Removal from Coal-fired Power Plants, Kluwer Academic Publishers, Dortech, The Netherlands.
[3] Allinson, G. and V. Nguyen. 2000. The economics of $CO_2$ sequestration in Australia. *Fifth International Conference on Greenhouse Gas Control Technologies*, Australia, 979-984.
[4] Ho, M.T, Leamon, G, Allinson, G. and D.E. Wiley. 2004. The economics of $CO_2$ and mixed gas sequestration from stationary source emitters. *Seventh International Conference on Greenhouse Gas Control Technologies*, Canada