# II.C.3 Hydrogen Production via a Commercially Ready Inorganic Membrane Reactor

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Contract Number: DE-FC26-03NT41852

Start Date: March 2006
Projected End Date: March 2008

## Objectives

- Improve the efficiency (both capital and operating cost) of hydrogen production for coal-based power generation via a commercially ready membrane reactor.
- Achieve $CO_2$ capture with minimum or no parasitic energy consumption using the previously mentioned technology.
- Construct and operate a bench-top reactor to demonstrate the above benefits.

## Introduction

The main objective of this project is to improve the efficiency (both capital and operating cost) of hydrogen production for coal-based power generation via a commercially ready membrane reactor. In addition, this proposed technology can achieve $CO_2$ capture with minimum or no parasitic energy consumption. Moreover, gas clean-up can be streamlined as a result of the implementation of this proposed hydrogen production technology. A bench-top reactor will be constructed and operated to demonstrate the above benefits. Then, we will conduct a pilot-scale demonstration of this commercially ready membrane reactor to replace existing two-stage packed bed reactor; thus, hydrogen separation, $CO_2$ capture, and contaminant removal can be integrated into the power generation system with the proposed hardware and process.

The membrane reactor proposed here has resulted from the teaming of two industrial companies: combining the hydrogen selective membrane from Media and Process Technology Inc. with a stainless steel porous substrates/modules provided by Pall Corp. Further, the feasibility of the proposed technology has been demonstrated via mathematical simulation by the University of Southern California (USC).

## Approach

The approach is based on simulation studies that indicate nearly complete conversion of CO and recovery of hydrogen from the coal gasifier off-gas via the one-stage water-gas-shift (WGS) reaction using a membrane reactor (MR). In this project, a commercially ready hydrogen selective membrane will be fabricated. A miniaturized MR will then be constructed for performing a bench-top experimental study to verify process feasibility and to refine our existing mathematical model. Hydrogen production cost reduction resulting from (i) stochiometric steam/CO ratio, (ii) steam sweeping to achieve a high hydrogen product recovery, and (iii) concentration of $CO_2$ in the reject side of MR will be estimated. Peripheral benefits, including streamline of gas clean up requirements as a result of the proposed WGS-MR will also be experimentally verified. Finally, a pilot-scale MR will be designed, constructed and operated at our facility to demonstrate its readiness for field test as the next step.

## Accomplishments

- Study of the membrane deposition on the modified Pall substrate has been completed.
- Hydrogen and nitrogen single component permeances were measured in the temperature range 25-300°C to characterize the hydrogen separation efficiency of the membrane.
- Hydrothermal stability was studied at 220°C, and steam partial pressures of 20 and 50 psig.
- Deposition of the membrane on the modified Pall substrate has been completed, with promising results.
- A membrane reactor has been designed and constructed. This reactor is being used for the screening study of WGS reaction and catalyst.
- During a 100-hour field test, MPT's membrane showed excellent hydrogen permeance and selectivity in the presence of hydrogen sulfide, ammonia and hydrocarbons.

- Pre- and post-treatment requirements have been established in consultation with Johnson Matthey.

## Future Directions

- This task will focus on (i) hands-on experience of the operation aspect of this miniaturized membrane reactor, and (ii) generation of the performance database for verifying the simulation results earlier.
- Establish the long-term operation stability of the WGS-MR.