Technology Readiness Level: 4
Component and/or Breadboard Validation in Laboratory Environment

Eltron Research & Development

Tech Brief

Maximum, Economical CO_2 Capture for IGCC Power Plants

Eltron's Carbon Capture Process Technology is the most economical solution for clean power generation from coal, biomass and other hydrocarbons, providing more carbon capture and greater thermal efficiency at a lower cost.

In partnership with the Department of Energy (DOE), Eltron Research & Development Inc. is developing a process technology that separates hydrogen from carbon dioxide, enabling clean power generation and carbon capture in coal-fired Integrated Gasification Combined Cycle (IGCC) power plants.

With prices soaring and domestic reserves depleting, natural gas is no longer the inexpensive, clean alternative for the utilities that it once was. The one reliable and inexpensive utility fuel readily available in the near term is coal. As attention swings back to coal, the need to solve the emissions problem created through its use is heightened.

The Department of Energy and industry have numerous technology initiatives for clean energy from coal. The most significant of these, the FutureGen project, aims to mitigate the environmental effects by advancing technological solutions including carbon capture. While some of the details of FutureGen are changing, the project will still revolve around IGCC systems and greater attention will be applied to Carbon Capture and Storage (CCS).

CCS technologies adoption will depend upon both government regulation and demonstrated process economics. Eltron Research & Development Inc. is pursuing the most economical solution for carbon capture in IGCC power plants. At the core of the process is a proprietary membrane system that separates hydrogen from carbon dioxide and enables economical and clean power generation from coal by providing improved carbon capture, greater thermal efficiency and a cost reduction over conventional technologies. Membrane performance data as well as comparative techno-economic modeling results demonstrate that a process containing Eltron's Membrane System is economic in multiple configurations. Models show up to $11/MWh cost of electricity savings over current technology and 6% higher heating value (HHV) efficiency while capturing 95% CO_2. At a slightly higher cost, over 99% carbon capture is also possible with this technology.

Benefits of Eltron's Carbon Capture Process Technology for IGCC-CCS include:

- Enables 95-99.4% carbon capture when integrated with warm gas cleaning, depending upon process configuration.
- Separates and maintains carbon dioxide at operating pressures to minimize compression costs for pipeline transportation and sequestration.
- Simultaneously produces a high pressure hydrogen/nitrogen stream for power generation from next-generation turbines.
- Process design is economic in multiple configurations; current models show up to $11/MWh cost of electricity savings over current technology.
- HHV efficiencies up to 6% higher than current technologies.
- Compatible with commercial technology for required levels of sulfur, NOx, mercury, and particulate removal.
- Hydrogen recoveries of over 90%.
- High hydrogen permeate pressures.
- Essentially 100% pure hydrogen produced, since the membrane works by transporting dissociated hydrogen across the membrane material.

Eltron's technology for carbon capture is compatible with synthesis gas derived from natural gas, liquid hydrocarbons, coal, petroleum coke and biomass.

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Eltron's technology exceeds DOE's requirements for carbon capture and hydrogen generation for power production in coal-fired IGCC plants.

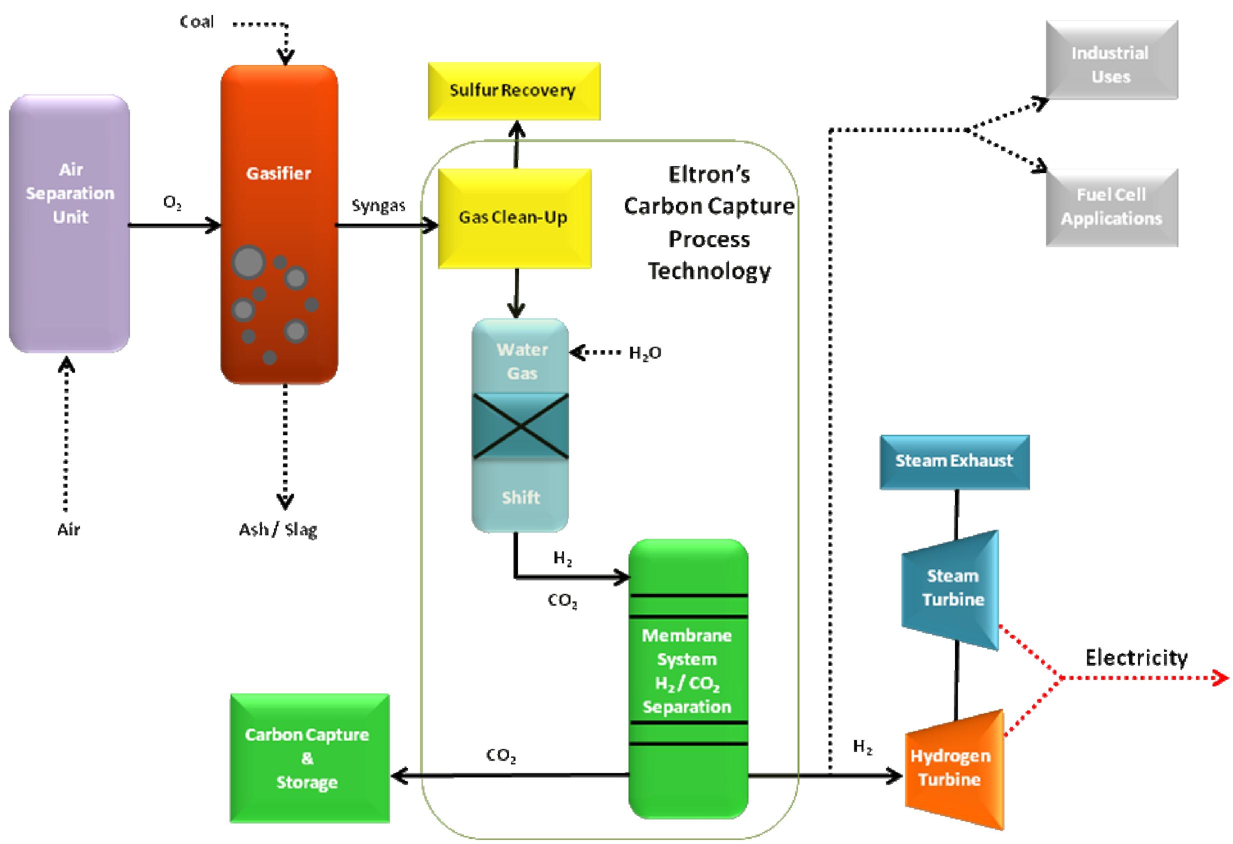

Figure 1. IGCC-CCS employing Eltron's Carbon Capture Process Technology.

Technology Description Summary

At the core of the Eltron's Carbon Capture Process Technology is a proprietary membrane system that can operate at high pressure and high temperature, simultaneously capturing carbon dioxide for storage and producing high-purity hydrogen from a water-gas shift feed stream. Current modeling shows that Eltron's process and associated technology has the potential to capture more carbon than current technologies, at a lower cost of electricity for IGCC power plants.

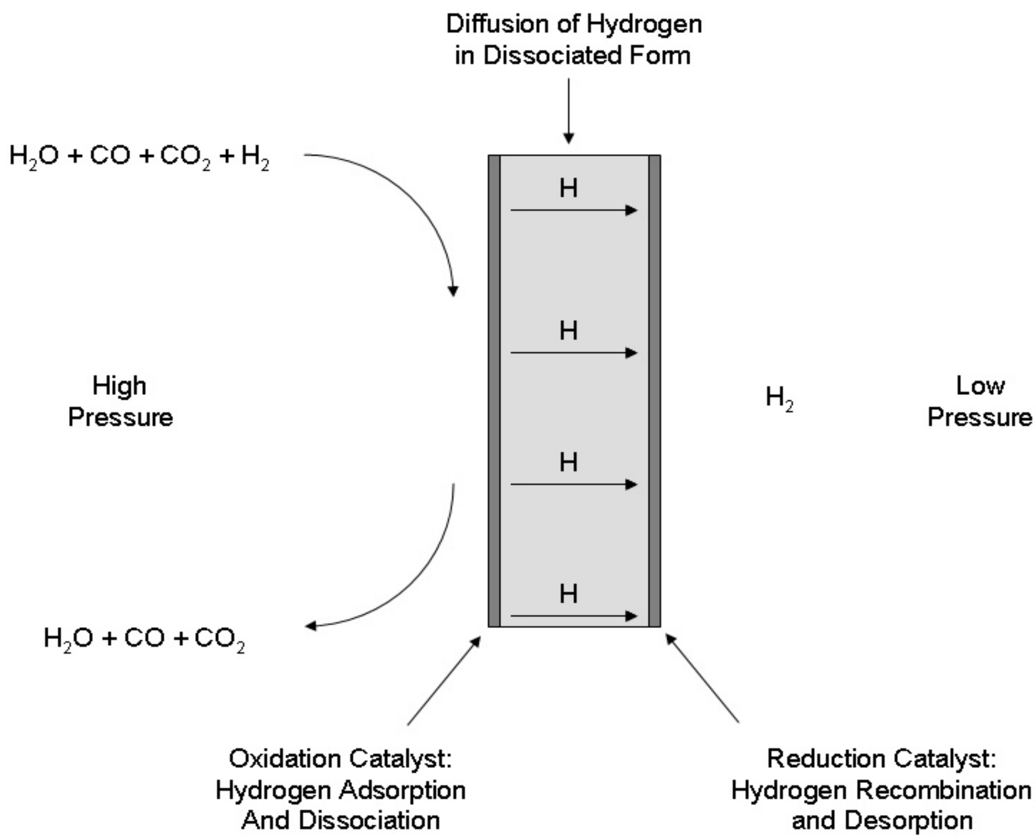

Figure 2 shows the general concept for how Eltron's Membrane System works. A dense, multilayer membrane is used to separate hydrogen from a high pressure water-gas shift feed stream. The bulk membrane is a dense metal alloy with high hydrogen permeability. On each side of the bulk membrane is a catalytic layer. On the high pressure (or feed side) of the membrane, a hydrogen-dissociation catalyst is employed. On the low pressure (or permeate side) of the membrane, a catalyst is used to reduce dissociated hydrogen back to molecular H_2. In the presence of a hydrogen partial pressure driving force, hydrogen is transported across the membrane in dissociated form. The system can be operated with a sweep gas for direct injection into a hydrogen turbine or without a sweep gas for pure hydrogen production. The system results in pure hydrogen on one side of the membrane and a high pressure stream of CO_2 and steam with a small amount of CO on the other side of the membrane.

There are two key parts to Eltron's dense metal alloy membranes. The first is the bulk hydrogen separation metal. This metal alloy must have a high flux, possess the mechanical strength to withstand high total differential pressures and high hydrogen partial pressures, and must not alloy with the catalyst layers on either side of the metal alloy. Figure 3 shows the hydrogen flux of a 230 micron thick metal alloy membrane tested at 340°C with a 40% hydrogen feed stream at 450 psig. A sweep gas was used on the permeate side of the membrane at 50 psig. Figure 3 shows that, under these conditions, the membrane had a stable permeation or hydrogen flux rate of 180 mL/min/cm^2.

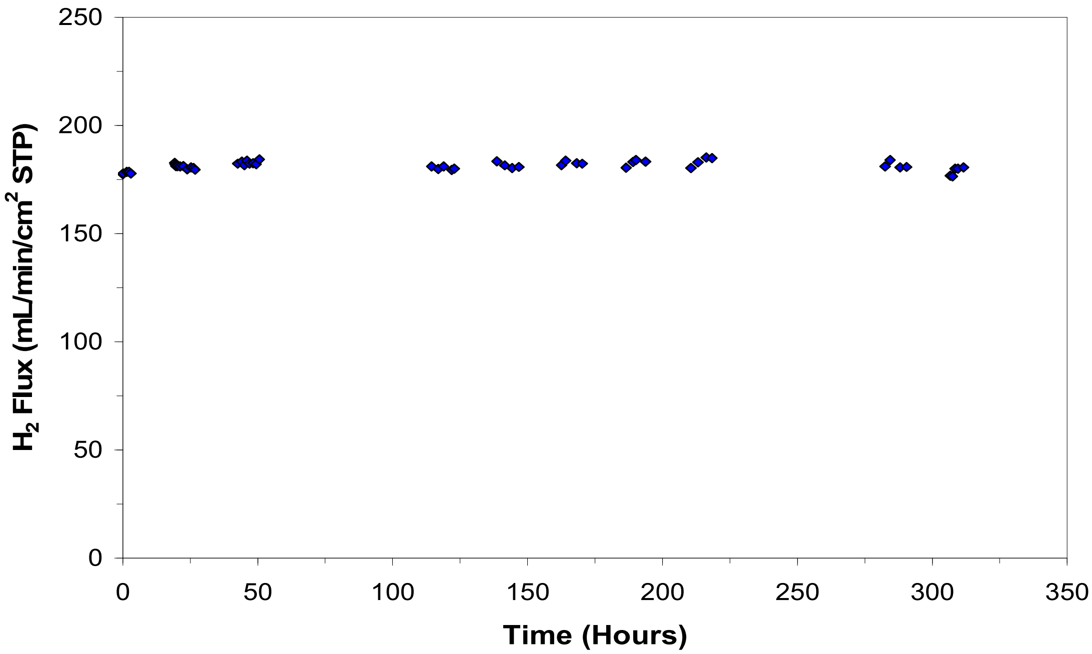

Figure 3. H_2 flux vs. time at conditions for an alloy membrane tested at 340˚C and 400 psig differential pressure across the membrane.

The second key part to Eltron's membrane is the catalyst layers deposited on either side of the bulk metal alloy membrane. On the feed side of the membrane, the catalyst layer must effectively dissociate hydrogen, be resistant to a reasonable amount of hydrogen sulfide, and must not react with the bulk membrane.

Eltron has tested multiple catalyst compositions. Figure 4 shows the hydrogen flux results for 140 micron thick membranes tested with two different catalysts. These tests were performed under the same temperature and pressure conditions as in Figure 3.

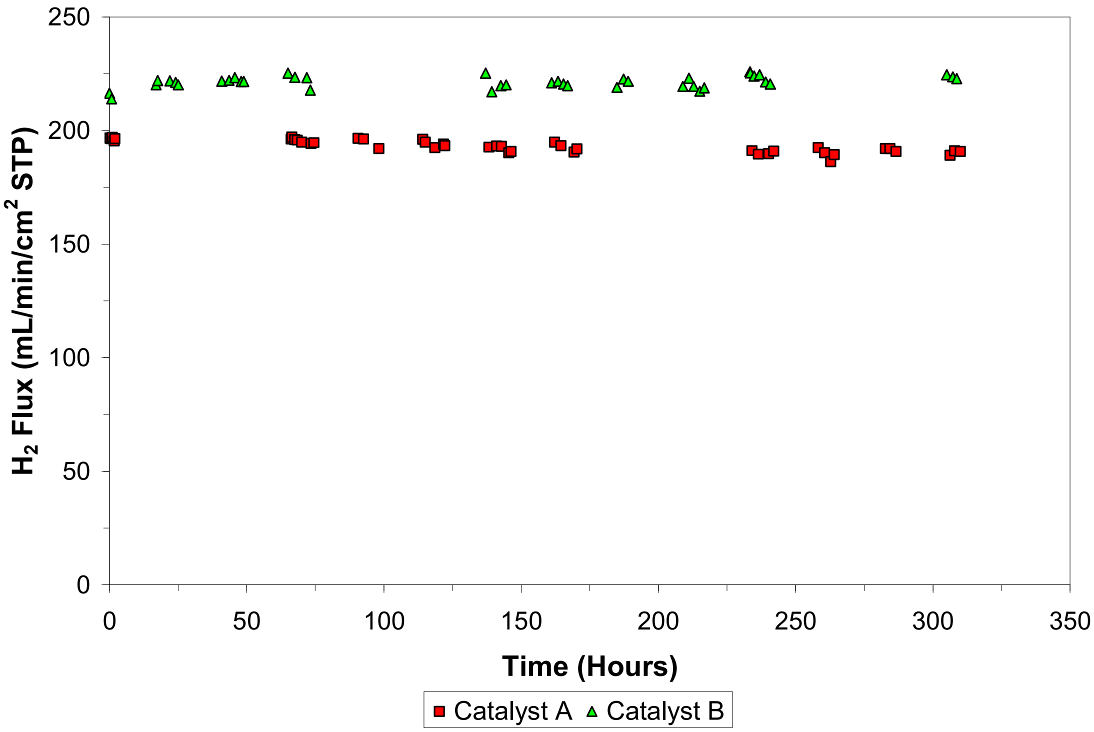

Figure 4. H_2 flux vs. time at conditions for alloy membranes tested with different catalysts at 340°C and 400 psig differential pressure across the membrane.

Figure 4 shows a stable flux rate was observed for each membrane. The membrane with Catalyst B had a slightly higher flux rate than Catalyst A.

Ultimately, the entire membrane must be capable of being scaled-up economically and demonstrate an economic hydrogen flux under expected operating conditions over the lifetime of the membrane.

Eltron has demonstrated the ability to scale-up membrane testing under conditions expected in an IGCC power plant. Figure 5 shows hydrogen flux vs. the difference in the square roots of the hydrogen partial pressure on each side of the membrane for a 63.3 cm^2 membrane tested at 380°C, pressures up to 450 psig, and a feed stream composition composed of 41% H_2, 3% CO, 16% CO_2, and 40% steam. The membrane achieved a flux rate of 5 L/min or 1.5 lbs/day of hydrogen.

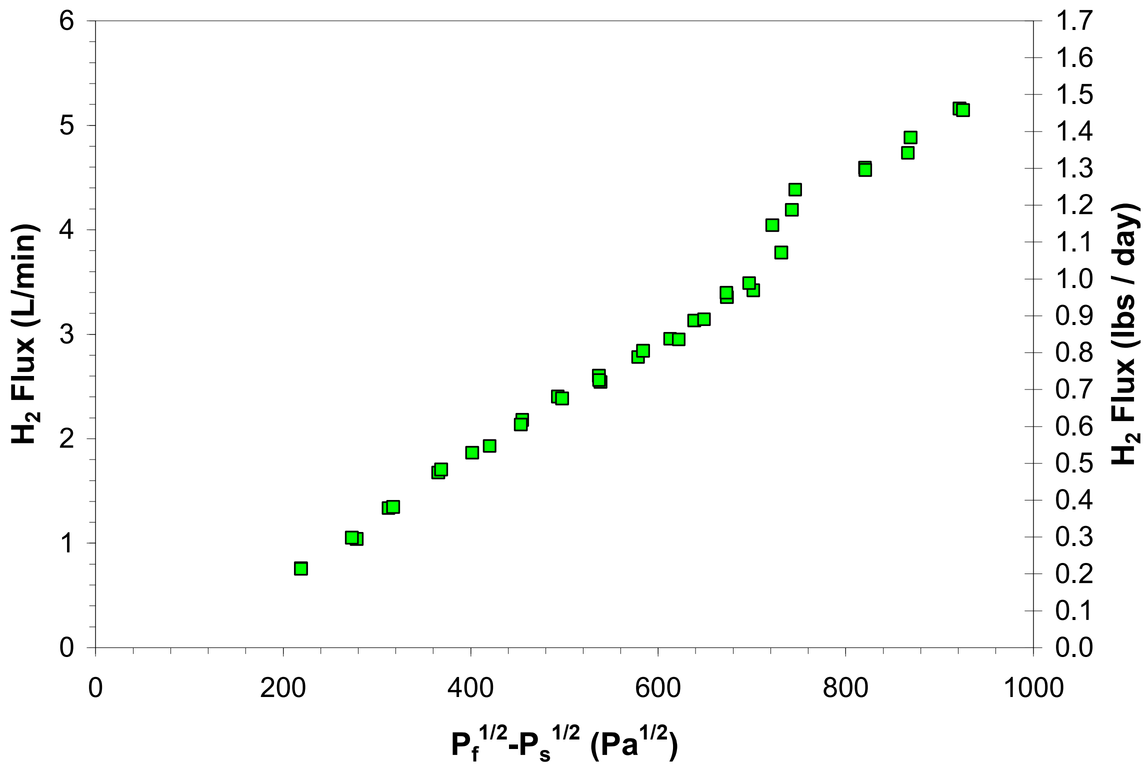

Figure 5. H_2 flux in L/minute and lbs/day vs. the difference in the square roots of the hydrogen partial pressure on each side of the membrane for two parallel membranes tested up to 450 psig under a simulated water-gas shift feed stream.

Eltron is currently conducting lifetime testing under expected IGCC operating conditions including feed gas composition, pressure and temperature. These tests are being performed in a reactor skid, shown in Figure 6, specifically designed for lifetime testing.

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Figure 6. Eltron's Lifetime Reactor Test Skid

In addition to complete technical data, Eltron has detailed modeling results of complete IGCC-CCS power plants demonstrated that simultaneous H_2 separation and CO_2 capture using Eltron's Carbon Capture Process Technology provides economic and environmental advantages. This information can be provided upon request.

This technology has been developed under funding from the Department of Energy, DE-FC26-05NT42469: *Scale-Up of Hydrogen Transport Membranes for IGCC & FutureGen Coal to Hydrogen Production Plants.*

Contact Us

To discuss the possibility of entering into a business relationship with Eltron, contact the Business Development Group at business@eltronresearch.com.

Eltron Research & Development

Eltron Research & Development Inc.
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