WHITE PAPER: Low-cost Coal to Hydrogen for Electricity with CO2 Sequestration

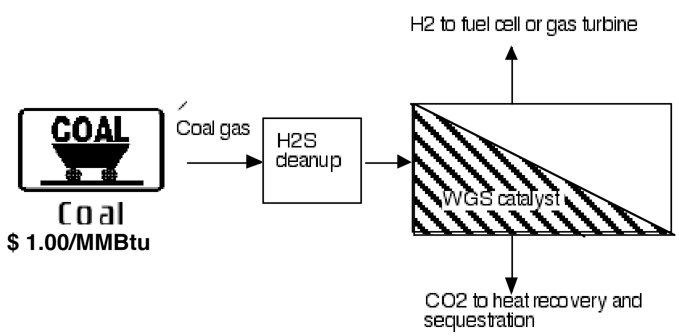
Dr. Robert E. Buxbaum, REB Research and Consulting co.
12851 Capital St. Oak Park, MI 48237
www.rebresearch.com

January 21, 2009

Currently, the average cost of Electricity in Oakland county, MI is 10.64¢/kwhr, or $31.17/ MMBtu. Much of this electricity is made from burning coal, a commodity costing $1 to $2.50/MMBtu, or less than 1/10 the price of electricity. This large difference between the cost of coal and value of the electricity produced with it supports the capital cost for electric generator building, the maintenance cost of electric distribution, and a small profit for the utility stock-holders. It is desirable to switch to a cleaner-burning alternative, like natural gas, but the prices are near prohibitive. Current gas to electric generators are only about 40% efficient, and when natural gas prices rise to about $12/MMBtu, as they did last summer, electric production becomes unprofitable even at 0% financing for capital expenditures.

I would like to suggest an approach to clean coal power based on coal gasification, plus membrane –reactor based extraction of hydrogen from the coal gas to feed a gas-turbine electric generator. The general scheme is shown in the figure below. The Department of Energy (DoE) has supported decades of research into the clean coal power, and there are now several attractive coal gasification designs that are commercially mature. One of these, the GE system, produces coal gas at about 800 psi., with a hydrogen content approaching 40%. A significant fraction of the remaining gas from this process is CO (carbon monoxide), and the rest, largely CO_2 (carbon dioxide). My suggestion is to scrub the coal gas of H_2S, cool it (making steam in the process), and then to perform the water gas shift (WGS) reaction in a membrane reactor of the sort that my company, REB Research & Consulting has been developing for the last 15 years.

A membrane reactor like the one shown below combines, in one vessel, a membrane extractor for hydrogen with the WGS catalyst that helps turn CO and steam into hydrogen and CO_2. By making the hydrogen in a membrane reactor, the range of temperatures and pressures for hydrogen generation is expanded greatly from what it would be in an ordinary reactor. Thus, fewer stages, and fewer heat exchangers are necessary that would be practical in an ordinary system. Further the CO_2 is delivered relatively pure for easy sequestration. The design shown is thus a newer version for a FutureGen electric generator, but one with fewer components and that can be scaled to smaller sizes easily.



Another advantage of the use of a membrane reactor here derives from the delivery pressures of the hydrogen and CO_2. The hydrogen from the reactor is delivered at a relatively low pressure, typically about 15 psi, while the CO_2 is delivered at the full, gassifier pressure, about 800 psi. The low hydrogen pressure is not a major disadvantage for use in gas turbine electric generators, and it is ideal for use in fuel cells. Fuel cells can be damaged by hydrogen pressures much higher than this. The high CO_2 pressure, meanwhile, diminishes the compression cost for CO_2 sequestration. That is, CO_2 at this pressure is easily compressed to 1000-2000 psi for easy liquefaction, transport and disposal in underground gas wells. We believe that CO_2 disposed of in such wells will be permanently removed from the biosphere. Further, disposal in gas wells can have a positive value to the nation by helping to pressurize the underground reservoir, and thus helping enhance natural gas recovery from communicating well-heads. Because of this, we can hope to sell the pressurized CO_2 at a profit. The process shown above is not the only possible FutureGen design, but I believe the above advantages over earlier designs are significant.

Keywords: Clean coal, Hydrogen, Membrane reactor, FutureGen, Carbon sequestration, Electricity.