Renewable Energy Storage by CO_2 Recycling

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The United States has significantly greater renewable energy resources (e.g. solar, wind, biomass, etc) than can effectively be utilized by the electric grid due to the intermittent nature of the generation and remoteness of the renewable resources from large load centers. A further barrier to greater exploitation of renewable energy is that in some locales the renewable energy may be competing with very low cost generation resources.

Many countries are considering taxing CO_2 emissions which will increase the cost of power generation methods that generate CO_2. The most common method currently considered for dealing with CO_2 emissions is the capture of the CO_2, pressurization, and then sequestration in either rock formations or saline aquifers. This is relatively costly in both capital investment and operation of the equipment. It is anticipated that separation, capture, pressurization, pumping, and sequestering of CO_2 could cost as much as $91 per ton of CO_2. Since a typical 500 MW coal fired power plant can generate more than 500 tons of CO_2 per hour, this can significantly increase the cost of generated electricity. Also, there is the possibility that the CO_2 could escape from sequestration at some point in the future subjecting the companies generating the CO_2 generators to a perpetual and unquantifiable liability.

An additional concern faced by the country is the cost and assured availability of transportation fuels. The United States now imports over 50% of its petroleum based fuels. There is a strong need to develop domestic resources of transportation fuels to the maximum extent possible. If a means of storing intermittent renewable energy and off-peak nuclear energy as liquid transportation fuels could be developed, this storage would reduce imports of petroleum and refined products. The energy security of the United States would be improved.

Ceramatec is currently involved with a number of projects that have the potential to assist in solving the problems identified above. The Office of Naval Research (ONR) is currently funding a project related to co-electrolysis of steam and CO2 to produce synthesis gas. ONR is also funding a project for development of an advanced Fischer Tropsch catalyst that increases yields in the liquid range. A United States Army project is providing experience on the integration of small power systems. Finally, funding is being provided by Wyoming on the generation of liquid fuels from Wyoming coal.

It is possible that renewable electricity can be stored in liquid transportation fuels by creating synthesis gas through co-electrolysis of steam and carbon dioxide. By using the solid oxide fuel cell materials set in conjunction with a non-carbon electric energy sources (e.g. wind, solar, etc), it is possible to generate synthesis gas (CO and H_2) and oxygen from CO_2 and H_2O. This high temperature co-electrolysis (HTCE) process uses both thermal and electric energy inputs to electrolyze the CO_2 and H_2O at high thermodynamic efficiency. This is possible because the high temperature co-electrolysis reactions are endothermic, and the heat generated by resistance in the electrochemical device is chemically recuperated in the process. The synthesis gas generated from the CO_2 and H_2O can be converted to liquid transportation fuels via the Fischer Tropsch process. This presentation will describe the process and the results of experiments that generated both synthetic natural gas and liquid fuels. An emphasis will be placed on use of wind and solar as non-carbon sources of electricity that could be used to recycle carbon dioxide generated by coal fired power plants.