# High Temperature Electrolysis Dividends to the Pre-Consumer Hydrogen Economy

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We already have an established pre-consumer hydrogen economy. Hydrogen is essential to refining clean burning fuels, upgrading non-conventional feedstocks, producing and processing food, electronics, glass, metals, chemicals and in some locations even producing synthetic fuels. Unfortunately, virtually all of the 50 million tons of global hydrogen production each year is fossil fuel derived. Hydrogen production by steam methane reforming, or gasification of coal and petroleum coke produces more $CO_2$ and less energy per unit fuel value of hydrogen created than using the fossil fuel directly. Clearly this situation is counter to the vision of a hydrogen economy in which sustainable energy resources are efficiently converted, stored, distributed and re-converted using hydrogen as an energy carrier with no net greenhouse gas emissions or fossil resource depletion.

The popularly held view of the hydrogen economy is centered on the concept of a hydrogen fuel cell vehicle. The auto industry has enthusiastically adopted this vision. With the partnership of industry and government enjoyed over the past several years, these vehicles are rapidly approaching initial market introduction. The fuel production and distribution infrastructure has not responded so rapidly. Outside of a few major metropolitan areas and a West-Coast corridor, the prerequisite hydrogen production, distribution and dispensing infrastructure does not exist. This presents a chicken-and-egg dilemma to progressive consumers who enjoy the affluence and commitment to environmental issues and new technologies that will characterize early adopters. Further, only fossil derived hydrogen will be available, negating in large measure the intended benefit of the hydrogen vehicle.

Ceramatec, Inc and the Idaho National Laboratory are applying solid oxide fuel cell (SOFC) technology to hydrogen production by high temperature steam electrolysis (HTSE). This technology utilizes solid oxide fuel cell (SOFC) stacks to electrochemically extract oxygen from steam, producing high purity hydrogen without the use of fossil fuels. The electric energy demand of HTSE is from half to two-thirds that of conventional water electrolysis. This energy can be supplied by a generation mix including wind, concentrator solar, new hydro from existing impoundments, and nuclear. Electrolytic hydrogen production is better able to accommodate the variable nature of a renewable generation portfolio, anchored by nuclear or hydro, than the electric grid. Addition of a large dispatchable hydrogen production load provides a means of storing renewable energy and enables grid stability with a higher fraction of intermittent sources in the mix.

A change-over from fossil hydrogen production to renewable hydrogen using HTSE would immediately reap benefits of greenhouse gas reductions and sustainability, even before full implementation of hydrogen as a transportation fuel. A HTSE system can also electrolyze $CO_2$ and steam directly to synthesis gas (hydrogen and carbon monoxide) suitable for fuel synthesis. The product $H_2$ to CO ratio of can be controlled to match the desired type of synthetic fuel product by varying the feed ratio. The resultant synthesis gas has been used to produce methane and Fischer-Tropsch liquid fuels. This has the potential to convert the existing vehicle fleet and refueling infrastructure to renewable, carbon-neutral domestically produced energy.