What are fuel cells?

Fuel cells are electrochemical energy conversion devices - much like batteries. The primary difference is that fuel is supplied to a fuel cell system rather than contained within the system. Fuel cells are highly efficient, produce few pollutant emissions, and generate little noise. These attributes make fuel cells attractive in a wide range of applications, including portable power, distributed power generation, vehicle propulsion and auxiliary power on-board vehicles such as trucks, automobiles, marine vessels, and aircraft.

Presently, there are five major fuel cell types. BWXT is using its material, metallurgical, and manufacturing expertise to focus on solid oxide fuel cells (SOFC). A SOFC uses a hard ceramic electrolyte instead of a liquid and operates at temperatures up to approximately 1,800 degrees Fahrenheit. These fuel cells are best suited for large-scale stationary power generators.

The key is manufacturability.

Widespread use of hydrogen fuel cells is elusive because the materials and technology to construct them are prohibitively expensive. This is where BWXT's manufacturing and materials expertise is its most valuable. SOFCo's goal is an unsurpassed, all-ceramic stack with superior performance and reliability at competitive costs. To realize this concept SOFCo combines state-of-the-art SOFC materials with the manufacturing technology for multi-layer ceramic (MLC) techniques used by the computer industry.

It's a novel and new approach, but it has significant advantages over competing programs. First, its design eliminates the use of metal interconnects and ceramic seals - major sources for stack performance degradation. Second, there is less susceptibility to thermal cycling problems between the fuel cell and interconnect. Third, there is increased power density because of reduced internal resistance. Finally, low-cost, high-volume, and quality manufacturing has already been established in the microelectronics industry where MLC techniques are applied.

Recognizing the advantages to SOFCo's method, the DOE awarded the company with a $17 million contract in 1999 to demonstrate its feasibility under the Affordable Multi-layer Ceramic Manufacturing for Power Systems (AMPS) program. In early 2002, the novel "all-ceramic" stack design was successfully demonstrated.

Today, the development of this technology continues under the DOE's (SECA) program. SOFCo, who is partnered with Cummins Power Generation under the SECA program, is developing an SOFC power system for Class A recreational vehicles (RVs), which will run on liquid propane or natural gas. Beginning in 2001, the SECA contract is a 10-year, three-phase cooperative agreement, valued at $74 million. The first components were recently delivered to Cummins for integration into a system prototype.

Now, where is the hydrogen?

Without hydrogen, and more explicitly hydrogen in large quantities, hydrogen fuel cells will be just another technological shipwreck on the shoals of reality. Fortunately hydrogen is fairly plentiful. Unfortunately, it tends to be bound up with other atoms. To make the entire system efficient the goal has to be to find methods to release the hydrogen that do not overwhelm the efficiency gained in the fuel cell. The other method is to generate hydrogen as a by-product of an existing system. BWXT is pursuing both methods. Reformation is the process of producing hydrogen from fossil fuels. Fuel processors convert readily available or easily transportable gaseous and liquid fuels into the hydrogen-rich syngas that fuel cells need to function. Since 1994, SOFCo, a leader in advanced fuel reformation techniques, has reformed many fuels, ranging from natural gas to diesel fuel.

Teaming with Ballard Power Systems and Gibbs & Cox, SOFCo produced a conceptual design of a 2.4-MW ship-service fuel cell, including a reformer using NATO-F76 fuel, for the Office of Naval Research (ONR). It then demonstrated critical components under military marine conditions. Subsequently, under another ONR and related contracts, SOFCo designed and built a 500-kW integrated fuel processing (IFP) system that produces PEM-suitable fuel gas. Testing of the system will begin at the Idaho National Engineering and Environmental Lab in 2004.

The company was also awarded a contract with the Defense Advanced Research Projects Agency (DARPA) and the Army Research Office to complete a successful 300-hour demonstration of a proprietary, 50-kW, JP-8 fuel processor integrated with a planar, solid oxide fuel cell. The fuel processor achieved greater than 70 percent conversion efficiency, closely matching the maximum theoretical efficiency for that operating condition. The same system was demonstrated with high conversion efficiency using sulfur-laden naval distallate (NATO-76), gasoline, and natural gas.

The second (and longer term) method of generating hydrogen is through the use of high temperature gas nuclear reactors. Although still in the development stages, the Idaho National Laboratory is taking the lead in developing a Fourth Generation (GENFOUR) reactor that will produce power and hydrogen. BWXT, the world's leader in nuclear fuels, is developing the high temperature nuclear fuel required by this process.

Global Warming. Acid Rain. Arctic ice receding….the lure of a hydrogen economy and the more efficient engine. Every technological shift is beset by hidden dangers. But man is naturally an explorer, and new knowledge and new paths into the future are the explorer's goals. BWXT has been the engine behind past technological shifts and has emerged consistently as an industry leader. It may be too early to tell what the final shape of the hydrogen economy will actually be, but BWXT is committed to working with its customers to continue to produce the extraordinarily high quality products they demand for their high-consequence applications.

BWXT, SOFC, and Ohio

Recognition of technological advancements in the field of fuel cells has garnered BWXT's SOFCo several prestigious awards and honors in Ohio:

- The *2003 Emerging Technology Award* from Ohio Governor Bob Taft and the Ohio Department of Development (ODOD).
- An Ohio House of Representatives proclamation recognizing SOFCo's "tremendous record of technological innovations"
- In early 2003, SOFCo received two grants totaling $1.75 million from ODOD under Governor Taft's Third Frontier initiative. One was for a 2005 demonstration of a 1-2 kW stationary power system and the second for fundamental research in sulfur tolerance of fuel cells and fuel processors.
- SOFCo will benefit from nearly $4 million in state awards to Stark State College of Technology for construction of an Advanced Prototyping User Center. The center will house the production equipment needed to manufacture ceramic fuel cell components. SOFCo will be the initial tenant in the facility when it is completed in 2005.