NUCLEAR ENERGY RESEARCH INITIATIVE

Hydrogen Production Plant Using the Modular Helium Reactor

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Collaborators: Idaho National Engineering & Environmental Laboratory; Entergy Nuclear Inc.; Texas A&M University

There is a large and growing demand for hydrogen both in the United States and worldwide, with the bulk of the hydrogen being produced by steam reforming of methane. Hydrogen, along with electricity, are expected to dominate the world energy system in the long term. As the United States and the rest of the world transitions to a hydrogen economy, hydrogen will be used increasingly by the transportation, residential, industrial, and commercial sectors of the energy market. Eventually, an alternative source of hydrogen will be needed because

(1) the demand for natural gas is outpacing its production, and

(2) steam reforming of natural gas is not environmentally friendly because it produces the greenhouse gas CO_2.

A promising alternative source of hydrogen is to use process heat from a high-temperature nuclear reactor to drive a set of chemical reactions that produce hydrogen. Preliminary evaluations have shown that the sulfur-iodine (SI) process can produce hydrogen with high efficiency when driven by the 850°C to 950°C process heat from a Modular Helium Reactor (MHR). The SI process produces highly pure H_2 and O_2, with formation, decomposition, regeneration, and recycle of the reagents H_2SO_4 and HI. Preliminary economic assessments have shown that an MHR-driven SI plant can produce hydrogen economically, especially if the cost of natural gas increases because of increased demand. The MHR's high-temperature capability, advanced stage of development relative to other high-temperature reactor concepts, and passive-safety features make it ideally suited as the heat source for producing hydrogen. The work proposed here is the next logical step-to develop a conceptual design for a hydrogen production plant that integrates an MHR reactor system with an SI-cycle hydrogen production plant. Figure 1 shows an artist's conception of the integrated plant, referred to as the H2-MHR. As an added measure of safety, the reactor system is located below grade and isolated from the H_2 production system through the use of intermediate heat exchangers. The H2-MHR represents a significant advancement of nuclear technology and offers a safe and potentially economical source of clean, renewable hydrogen.

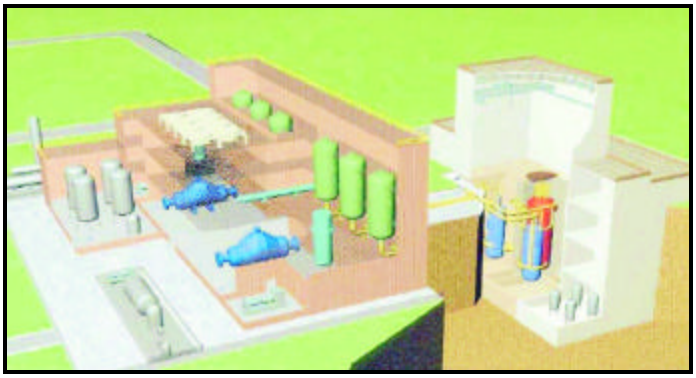

Figure 1. The schematic of the H2-MHR plant shows the modular helium reactor integrated with an H2 production plant (source: Generation IV Higher Temperature Reactor Materials Workshop, La Jolla, CA, March 18, 2002; figure prepared by Japan Atomic Energy Research Institute).

The proposed project will span a three-year period. During the first six months of the project, a systems-engineering approach will be used to prepare a *Plant Functions and Requirements* document. This document will provide the basis for developing the conceptual design of the H2-MHR plant. Annual reports will be issued at the end of Project Years 1 and 2 to document the work performed during these years. An *H2-MHR Conceptual Design Report* will be the final deliverable, to be issued at the end of Project Year 3. The work proposed here supports all of the NERI program objectives and will provide the Department of Energy, utilities, and energy-

policy planners with precisely the type of information needed to make decisions regarding additional research and development for producing hydrogen using nuclear energy.

A team consisting of General Atomics (GA), Idaho National Engineering and Environmental Laboratory (INEEL), Entergy, and Texas A&M has been assembled to perform the proposed work. GA will be the lead organization and will be responsible for project management, plant definition, reactor system design, and plant integration. Texas A&M will have lead responsibility for developing the hydrogen production system design. INEEL will have lead responsibility for performing plant assessments, trade studies, and sensitivity analyses. Entergy, a major nuclear utility with a strong interest in hydrogen production, will function as a non-funded participant and will periodically review the design work from the perspective of a potential customer. Each organization is highly qualified and highly motivated to work on this project.