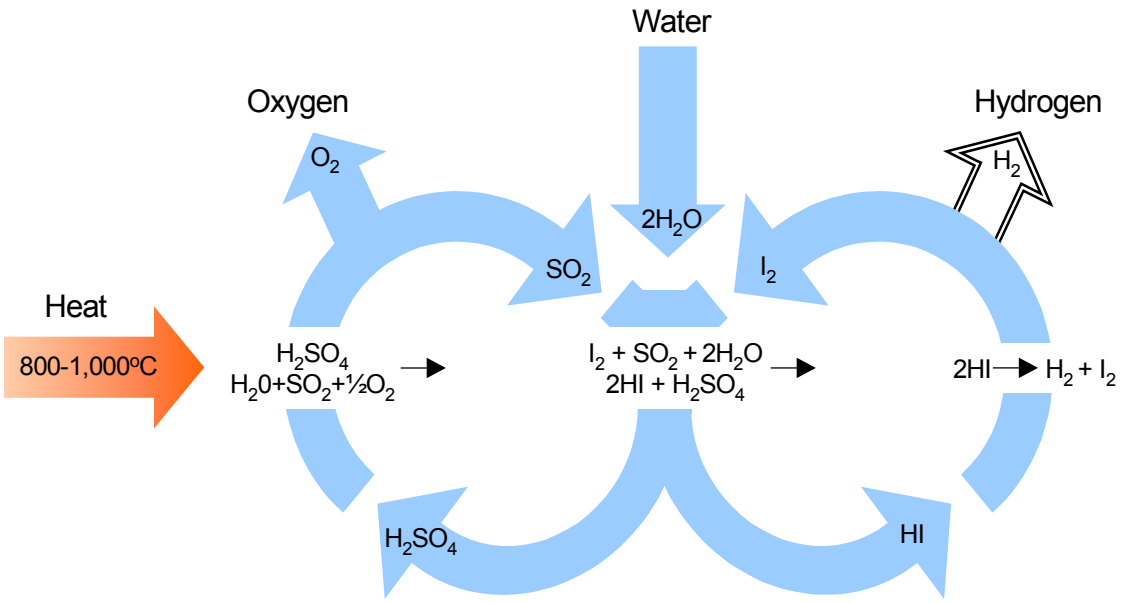
2.2 HYDROGEN

2.2.1 HYDROGEN PRODUCTION FROM NUCLEAR FISSION AND FUSION

Technology Description



Hydrogen is a carbon-free fuel that can be used in vehicles, homes, businesses, and power plants, and it can serve as a chemical feedstock. When hydrogen is produced from fossil fuels, CO_2 appears as a concentrated byproduct. Advanced nuclear fission and fusion systems can be used to produce hydrogen without generating CO_2. Very high-temperature, high-efficiency nuclear power plants can produce electricity to electrolyze water vapor and supply temperatures sufficiently high to drive chemical cycles for hydrogen production. Implementing these hydrogen technologies will reduce carbon emissions significantly below what is possible with nuclear-generated electricity alone.

System Concepts

- Very high-temperature, high-efficiency nuclear systems are used to drive processes for hydrogen production by electrolysis of water vapor and chemical cycles for water decomposition.
- Solid metallic alloys are used to store hydrogen without high pressurization or liquefaction.

Representative Technologies

- Very high-temperature, high-efficiency gas fission reactor.
- Lead bismuth-cooled or molten-salt-cooled fission reactor.
- Fusion reactor using gas, liquid-metal, or molten-salt cooling.

Technology Status/Applications

- Very high-temperature reactors cooled by gas or molten salts are being developed.
- Fusion technology is in development and making steady progress.
- Gas-cooled reactors operate in Japan at the temperatures of interest.
- Chemical cycles for the decomposition of water to yield hydrogen are being designed.
- Electrolysis of water vapor rather than liquid water is showing economic promise.
- Fuel-cell-powered vehicles using hydrogen are being developed and demonstrated by industry.

Current Research, Development, and Demonstration

RD&D Goals

- Economic hydrogen production without generation of CO_2.
- High-temperature, high-efficiency fission and, when available, fusion power plants to produce electricity to generate hydrogen from water economically.

- High-temperature reactors to drive chemical cycles for hydrogen production.

RD&D Challenges

- Develop reactor designs and materials that operate at temperatures high enough to achieve needed efficiencies.
- Overcome barriers to economic hydrogen generation by electrolysis.
- Develop chemical processes for water decomposition that operate efficiently and reliably.
- Demonstrate production and large-scale storage of hydrogen using a nuclear power plant.

RD&D Activities

- Preconceptual design of gas-cooled and lead-bismuth-cooled reactors and hydrogen production systems are underway as part of the Nuclear Energy Research Initiative.
- Concept development for high-temperature blanket/cooling systems is underway as part of the fusion program.

Recent Progress

- Chemical cycles for hydrogen production are being evaluated, and the conceptual design is being prepared for a gas-cooled reactor to couple to the most promising cycles.
- Japan's gas-cooled, high-temperature test reactor operates at 950°C.
- Recent analyses indicate that, because of low fuel costs, fission systems could provide cost-effective off-peak electricity for electrolysis at either onsite or offsite filling stations.

Commercialization and Deployment Activities

- Very high-temperature, high-efficiency test reactors are being developed in Japan.
- Fuel cell-powered vehicles will create demand for hydrogen in addition to existing demand of the process chemical industry.
- Conceptual design of high-temperature reactors has been initiated as part of the Nuclear Energy Research Initiative. High-temperature operation will make reactors competitive with other methods of electrical power generation.
- Partnering with industry to demonstrate hydrogen production using electricity during off-peak demand periods has been proposed.
- Fusion plants could be commercialized late in the second quarter of this century.

Market Context

- The potential for carbon emissions reductions using these technologies is enormous, including consideration of the GHG reduction from the significant improvements in the efficiency of electrical power generation.
- Hydrogen fuel cell vehicles will create a demand for hydrogen as a transportation fuel in addition to the demand by the process chemical industry. Petroleum industry demand for hydrogen will grow as the use of lower-quality crude oils becomes more common in refining.
- Extends the applicability of large fission energy resources and essentially unlimited fusion energy resources to the transportation sector.