Idaho National Engineering and Environmental Laboratory

Advanced Reactor Development and Nuclear Hydrogen RD&D at the Idaho National Engineering and Environmental Laboratory

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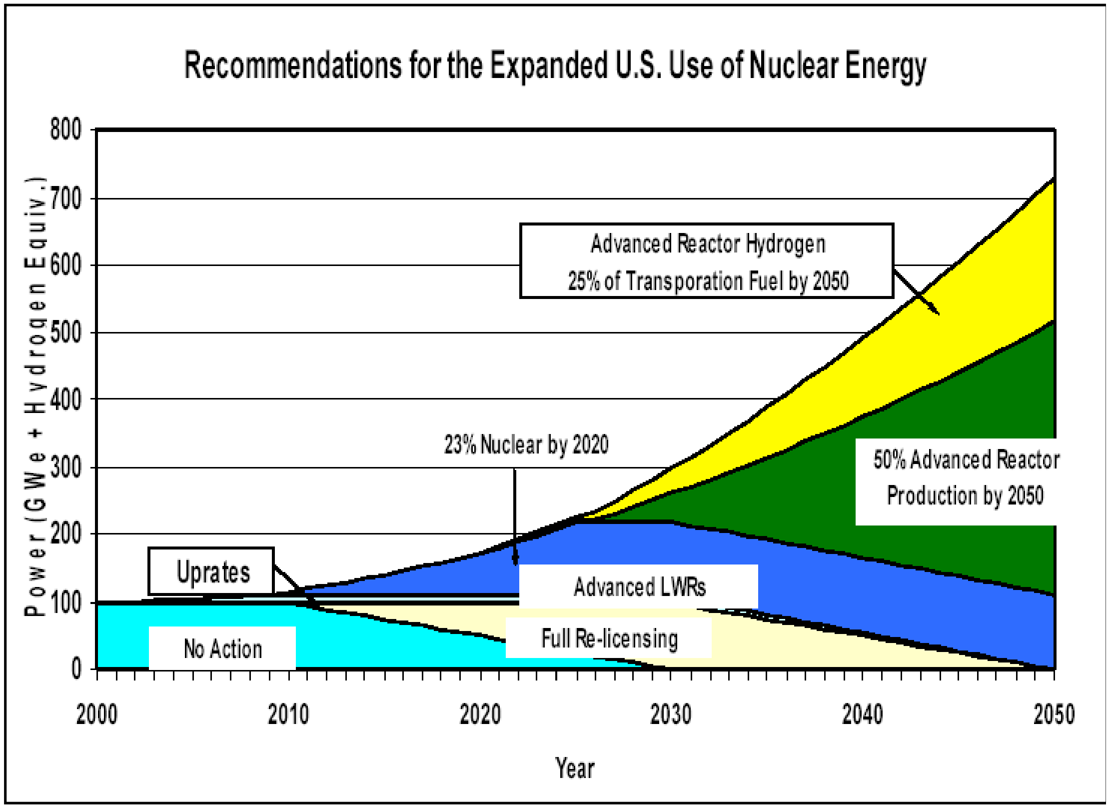
Energy Security and Environmental Quality are Strong Drivers for Increased Use of Nuclear Energy

- *Economic Growth and Prosperity are Tied to Abundant, Affordable, and Secure Energy Supplies*
- *Preservation of the Environment and Avoidance of Adverse Human Health Impacts Increasingly Demand Clean Energy Supplies*
- *Depleting Fossil Fuel Supplies and Rising Fossil Energy Prices Motivate Nations Toward Energy Supply Diversity*
- *U.S. Must:*
  - *Reduce Reliance on Foreign Oil Supplies in the Transportation Sector*
  - *Avoid Becoming too Reliant on Foreign Gas in the Heating Sector*
  - *Maintain Diversity of Supply in the Electricity Sector*
- *The Major World Economies in the U.S., Europe, and Asia Have a Responsibility to Lead in the Development and Deployment of Sustainable, Secure, and Clean Energy Supplies (. . .Nuclear Energy)*

The Potential for Nuclear Energy in the First Half of the 21st Century is Tremendous

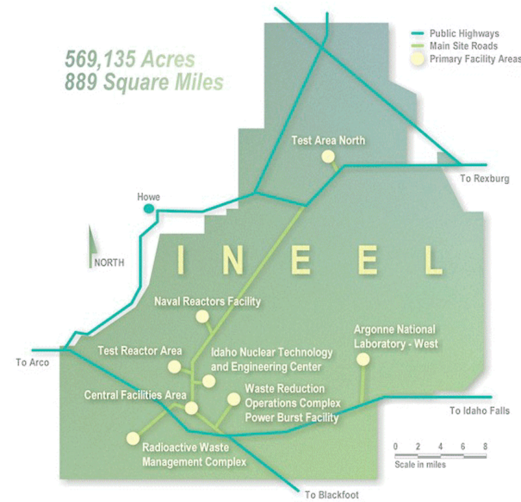
- 50% of U.S. electricity produced by nuclear power by 2050
- 25% of U.S. transportation fuel produced by nuclear energy (nuclear-produced hydrogen) by 2050
- Demonstrate a closed fuel cycle system by 2020
- Demonstrate a global nuclear energy system consisting of intrinsic and extrinsic safeguards that reduces proliferation risk.



Designation of INEEL as a DOE NE LAB

"First, INEEL will be the central command center for the federal government's Generation IV nuclear systems research."

Second, an "Idaho Advanced Fuel Cycle Technology Initiative will be the focal point for developing and demonstrating separation technologies for treating and reducing spent nuclear fuel and high level waste."



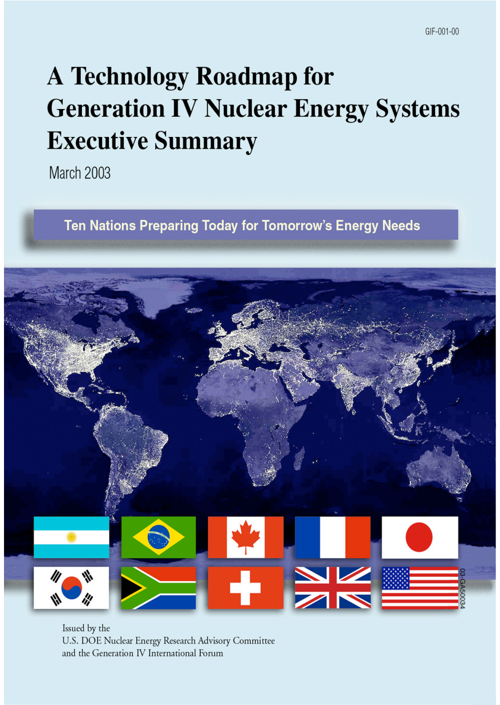
– Spencer Abraham

July 15, 2002

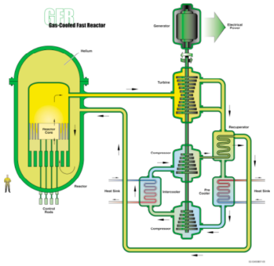
Generation IV Technology Goals

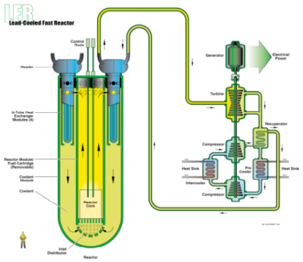
- Generation IV Program Goals are Aimed at Developing Advanced Nuclear Systems that are Deployable by 2030 or Earlier and:
  - Have Adequate Fuel Resources and Reserves for Many Years and a Sustainable Fuel Cycle
  - Are Economically Competitive With Other Energy Alternatives
  - Are Even Safer and More Reliable Than Current Technology
  - Are Exceptionally Proliferation Resistant and Have Additional Protection Against External Threats

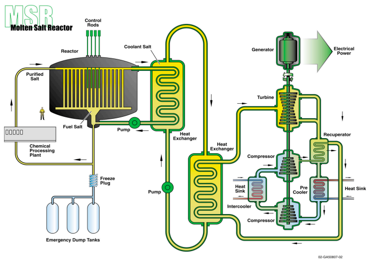
March 2003

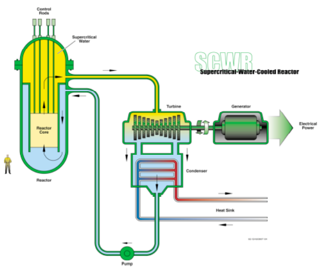


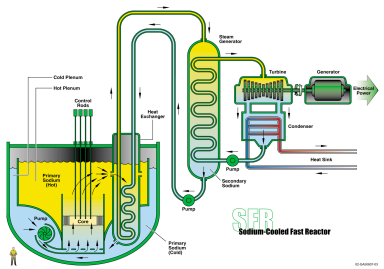
http://gif.inel.gov/roadmap

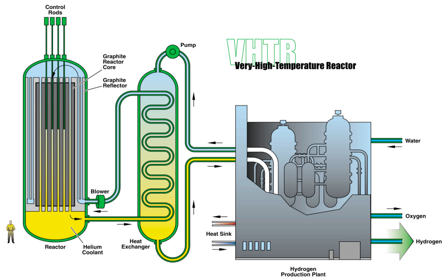






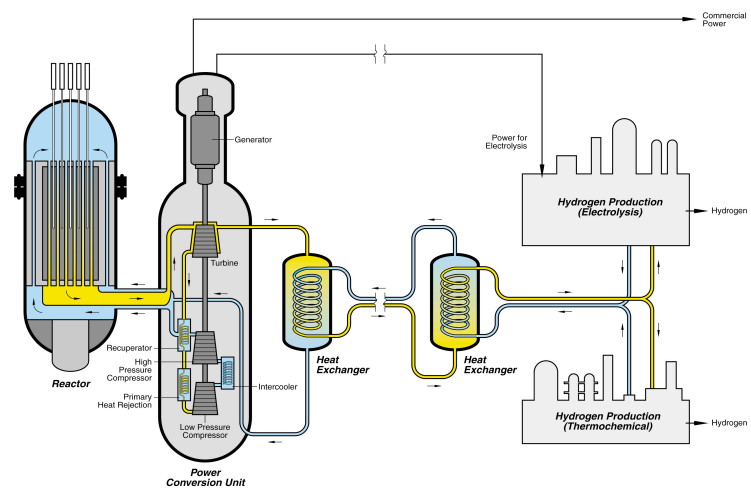






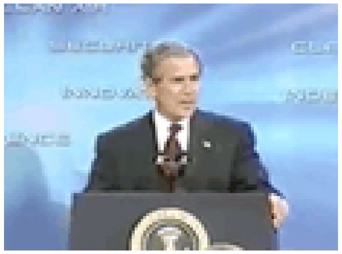
The Very-High-Temperature Reactor Illustrates the Approach to Achieving the Generation IV Goals

- Greatly Simplified Modular Design Lowers Capital Cost
- High Outlet Temperature Improves Thermal Efficiency
- Hydrogen Production Potential Opens New Markets
- Strong High Temperature Graphite-Ceramic Core Materials Improve Safety
- Passively Safe to Loss of Coolant Accident
- Efficient Plutonium "Burner"
- Deep-Burn, Once-Through Fuel Cycle with Graphite-Ceramic Fuel is Highly Proliferation Resistant
- Below-Grade Siting Improves Physical Protection Against External Forces



- 150-300 MWe Modular Design
- High-Temperature Graphite Core
- Strong Graphite-Ceramic Coated-Particle Fuel
- 1000°C Helium Coolant Outlet Temperature

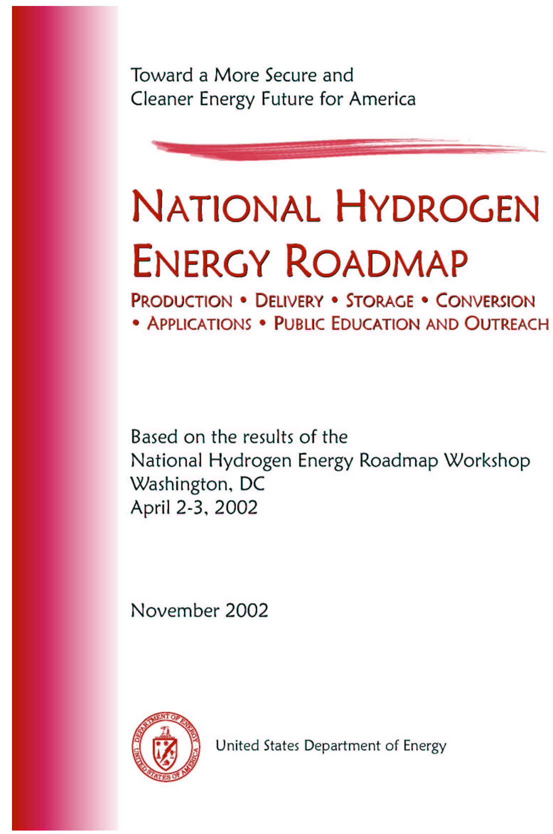
Hydrogen is the key to energy security



President Bush's Freedom Fuel Initiative *"with a new national commitment, our scientists and engineers, will overcome obstacles to taking these [fuel cell] cars from laboratory to showroom, so that the first car driven by a child born today could be powered by hydrogen and pollution-free"*

George W. Bush, State of the Union Speech, January 2003

- Displaces imported oil
- Emissions-Free Transportation Fuel
- National Hydrogen Energy Roadmap identifies major hydrogen production technologies
  - Steam Reforming of Natural Gas (with Carbon Sequestration)
  - Water "Cracking" using Nuclear Heat
    - Thermochemical
    - Thermoelectrical
  - Coal Gasification (with Carbon Sequestration)
  - Other Renewables and Bioproducts



Toward a More Secure and Cleaner Energy Future for America

NATIONAL HYDROGEN ENERGY ROADMAP

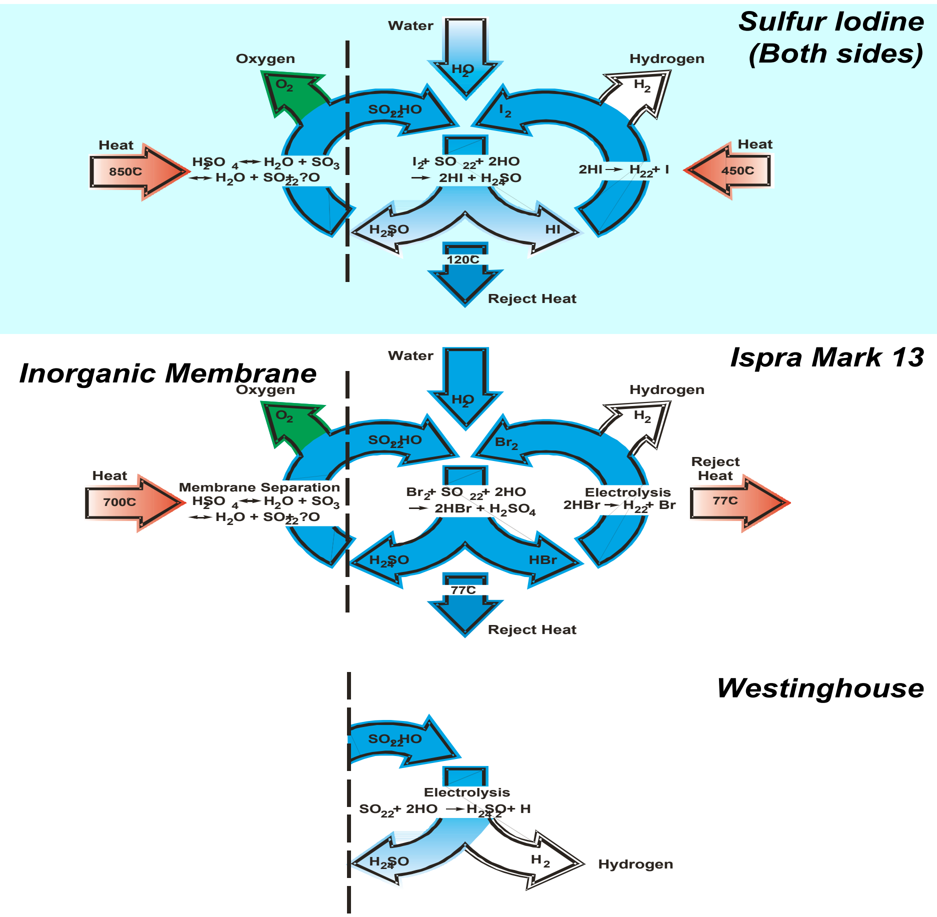
PRODUCTION • DELIVERY • STORAGE • CONVERSION • APPLICATIONS • PUBLIC EDUCATION AND OUTREACH

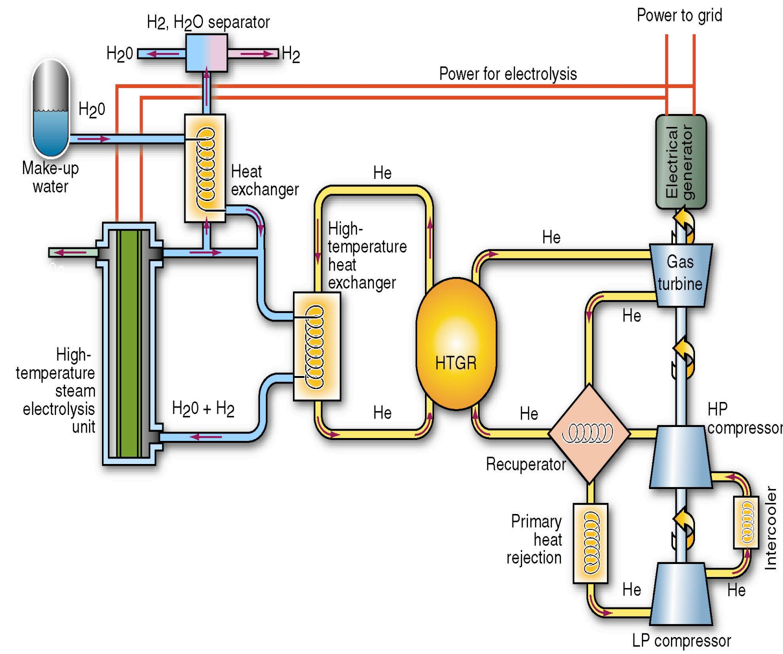
Based on the results of the National Hydrogen Energy Roadmap Workshop
Washington, DC
April 2-3, 2002

November 2002

United States Department of Energy

Nuclear Hydrogen Production Technologies



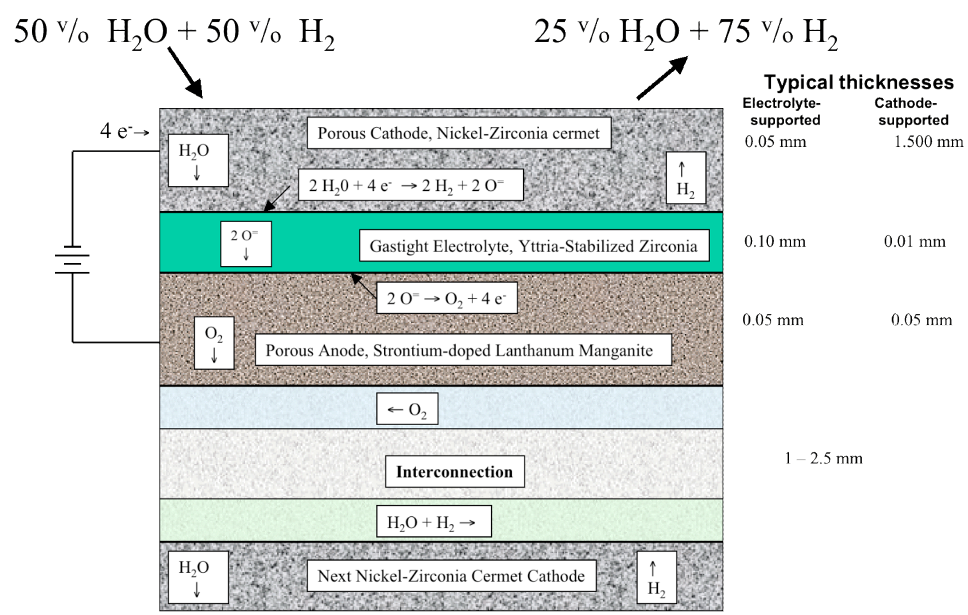


Thermo-Chemical Water Splitting

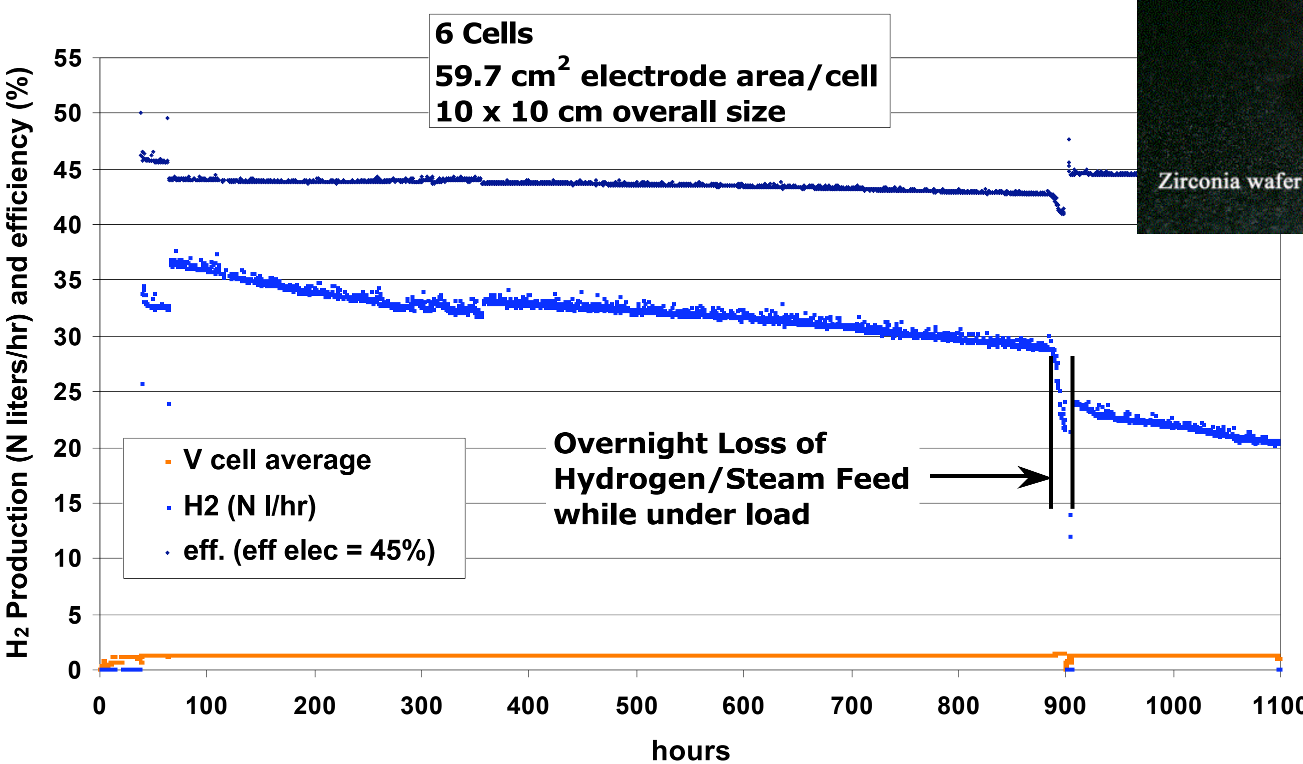
High Temperature Electrolysis

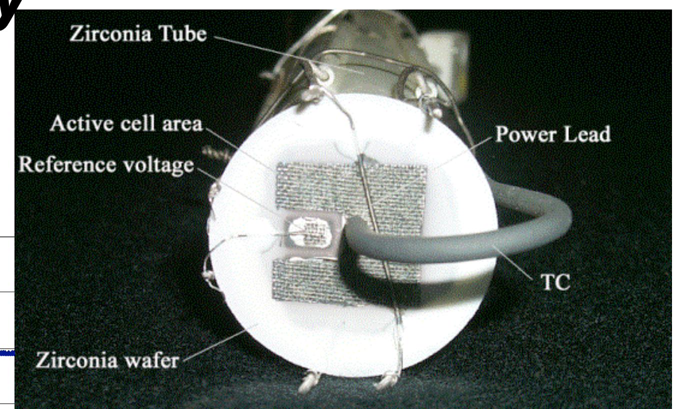
High Temperature Electrolysis (HTE)

- HTE Electrolyzer Similar to a Solid Oxide Fuel Cell (SOFC)
- Use of High-Temperature Steam Reduces the Electrical Energy Required for Electrolysis with a Net Reduction in Total Energy Required for H_2 Production.
- Target H_2 Production Efficiencies Exceeding 50% and H_2 Cost Less Than $2/kg
- SOFC Technology and Materials R&D Leveraged from DOE FE Programs (cost is a major issue)
- HTE RD&D Focused on:
  - Conceptual Design of an HTE Plant Coupled to a VHTR (Cost and Performance Assessment).
  - Demonstrate Cell Performance at Scale



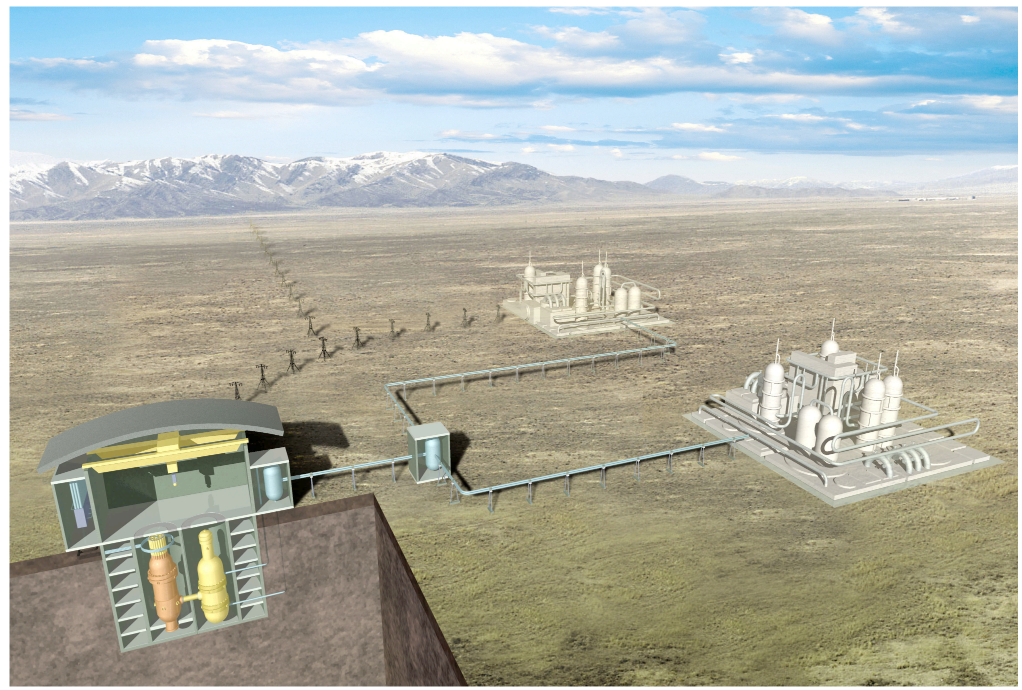
A Six-Cell High Temperature Electrolysis Stack Operated at 850°C Under Test for >1100 Hours Produced 32 Normal Liters/Hour at Nearly 45% Net Efficiency





The Next Generation Nuclear Plant Demonstration Program in Idaho Includes the Reactor-Hydrogen System Interfaces and the Balance of Plant Systems

- *Intermediate Loop Working Fluid, Materials, Engineering Design*
- *Heat Exchangers*
- *Isolation Approach Between the Reactor and Hydrogen Plant*
- *Regulatory Approach*
- *Gas Handling, Storage and Process Support Systems*
- *Hydrogen Plant Economics*
- *Safety and Risk Analysis*



Nuclear Energy has an opportunity to contribute to a more secure and prosperous tomorrow