Idaho National Engineering and Environmental Laboratory

Very High Temperature Reactor (VHTR)

Finis H. Southworth
Co-Chair, GIF VHTR Steering Committee

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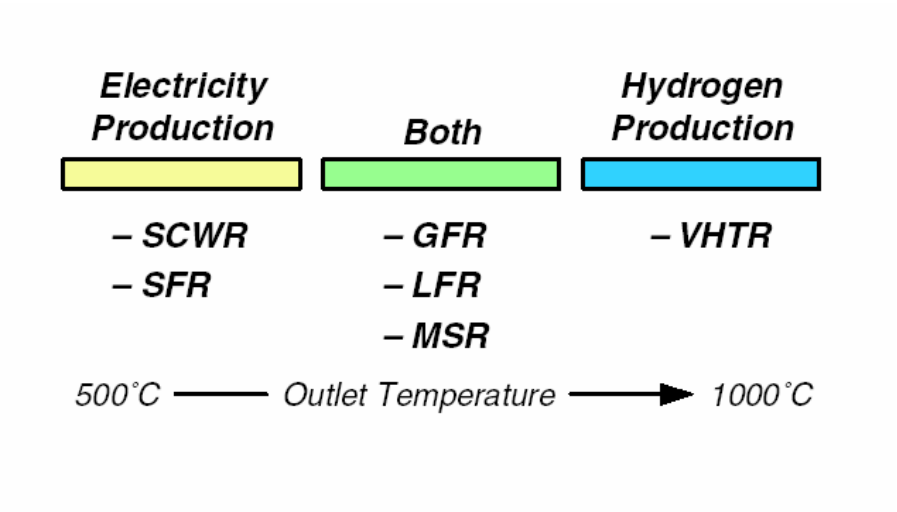
Mission

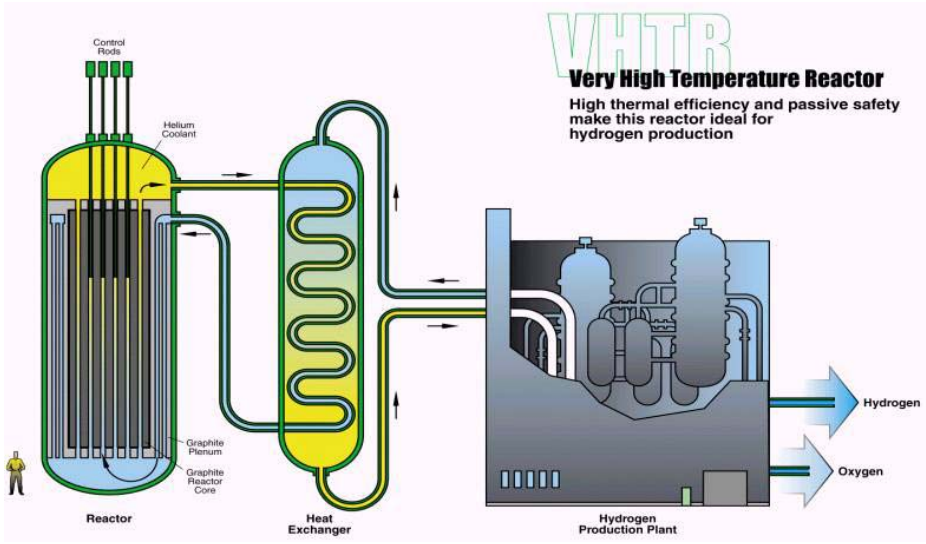
- *The Generation IV Roadmap identified reactor system concepts for producing electricity and hydrogen that excelled at meeting the goals of superior economics, safety, sustainability, proliferation resistance, and physical security.*
- *One of these reactor system concepts, the Very High Temperature Gas Cooled Reactor System (VHTR), is also uniquely suited for producing hydrogen without the consumption of fossil fuels or the emission of greenhouse gases.*
- *DOE has selected this system for the Next Generation Nuclear Power (NGNP) Project, a project to demonstrate emissions-free nuclear-assisted electricity and hydrogen production by 2017.*



VHTR Description

- *Reference reactor concept - nominal 600-MWth helium-cooled graphite moderated prismatic core or a nominal 400 MWth pebble type core*
- *Core outlet temperatures above 1000° C*
- *At an efficiency of 50%, such a plant would produce over 200 metric tonnes of hydrogen (equivalent to 300,000 gallons of gasoline) per day*
- *Estimated by the Roadmap to be deployed by 2020; this may be accelerated to 2015 – 2017 for a demonstrator*

- *Thermal neutron spectrum and a once-through uranium cycle, with an option for a closed cycle*
- *Dual Mission Capability*
  - *Hydrogen production (HT electrolysis, TC water splitting) and other process-heat applications*
  - *High efficiency electricity (greater than 45%)*



VHTR Builds Upon Near Term Gas Reactors

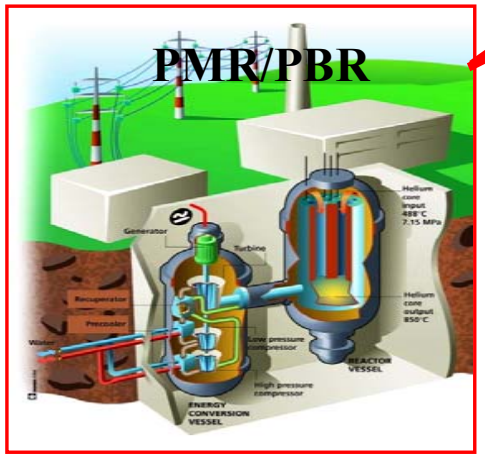
R & D
- Fuel particles
- Materials
- He systems technology (850°C)
- Computer codes
- Fuel cycle

GFR

VHTR

Improved sustainability

> 950°C for VHT heat process



R & D
- Fast neutron fuel
- Fuel cycle processes
- Safety systems

R & D
- VHT materials
- IHX for heat process
- ZrC coated fuel
- I-S cycle H2 production

Objectives for Priority VHTR R&D

The most pressing R&D issues associated with the VHTR are:

Design and Safety

- *Pre-conceptual design, safety studies, product contamination transfer, integration and economics*

Fuel and Fuel Cycle

- *SiC & ZrC coated particles, fuel behavior modeling, burn-up extension*

Materials and Components

- *Materials and components development & characterization, corrosion and irradiation tests*
- *Intermediate Heat Exchanger and Isolation valve etc*
- *Materials behavior modeling*

Hydrogen Production

- *Thermo-chemical properties database and rate constant measurements*
- *Laboratory-scale integral test, pilot-scale experiments*
- *Materials (corrosion) and components development (isolation valve)*
- *Connection technology: demonstration phase*

High Performance Helium Turbine

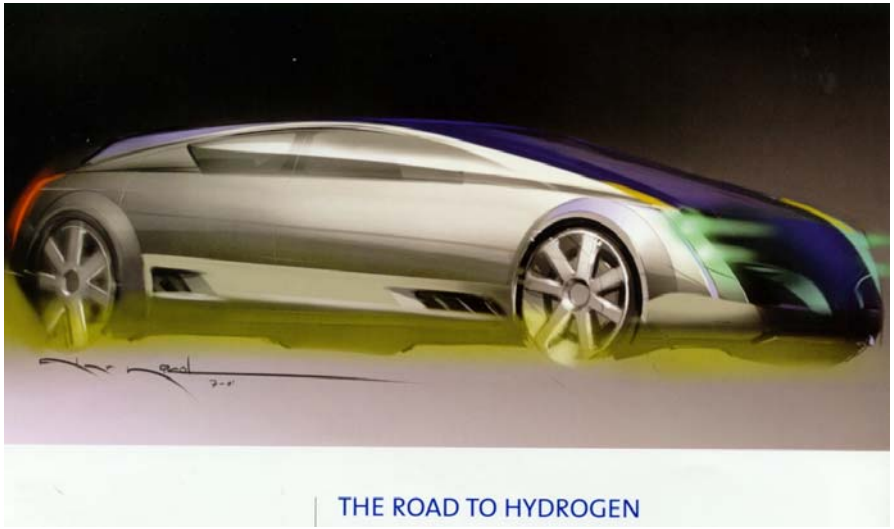
- *Development of very high temperature turbo-compressor*
- *Development of other key components for HT Brayton conversion system*

NGNP Program Objectives

- *Demonstrate a full-scale prototype NGNP by the year 2017*
- *Demonstrate high-temperature Brayton Cycle electric power production at full scale*
- *Demonstrate nuclear-assisted production of hydrogen (with about 10 % of the heat)*
- *Demonstrate by test the exceptional safety capabilities of the advanced gas cooled reactors*
- *Obtain an NRC License to construct and operate the NGNP, to provide a basis for future performance-based, risk-informed licensing*
- *Support the development, testing, and prototyping of hydrogen infrastructures*

Hydrogen Production and Use Is a Major Administration Initiative (1)

- *The U.S. hydrogen industry currently produces nine million tons of hydrogen per year for use in chemicals production, petroleum refining, metals treating, and electrical applications.*
- *Nine million tons of hydrogen per year is enough to fuel 20 to 30 million fuel cell cars, or enough to power 5 to 8 million homes.*
- *The current use is experiencing rapid growth as more and more hydrogen is used to convert the lower-cost Western hemisphere heavy crude oils to gasoline.*
- *As hydrogen powered cars are developed, the worldwide demand for hydrogen will eventually rival that for electricity.*



Hydrogen Production and Use Is a Major Administration Initiative (2)

- *Although hydrogen is the most abundant element in the universe, it does not naturally exist in large quantities or high concentrations on Earth.*
- *Steam reforming of methane accounts for more than 95% of the current hydrogen production in the U.S.*
- *Unfortunately, steam methane reforming diverts valuable natural gas from home heating uses and releases large quantities of carbon dioxide into the atmosphere.*
- *Hydrogen production currently uses 5% of the natural gas consumed in the United States.*
- *A much more environmentally friendly method of producing hydrogen would be to crack water at high temperatures using nuclear heat or solar energy.*

Interest in VHTR R&D Projects

- Design and Safety
  - CH, FR, KR, JP, UK, US, EU

- Hydrogen Production
  - CH, FR, JP, KR, US, EU, CA

- Fuel and fuel cycle
  - FR, JP, KR, UK, US, RSA,EU,CH

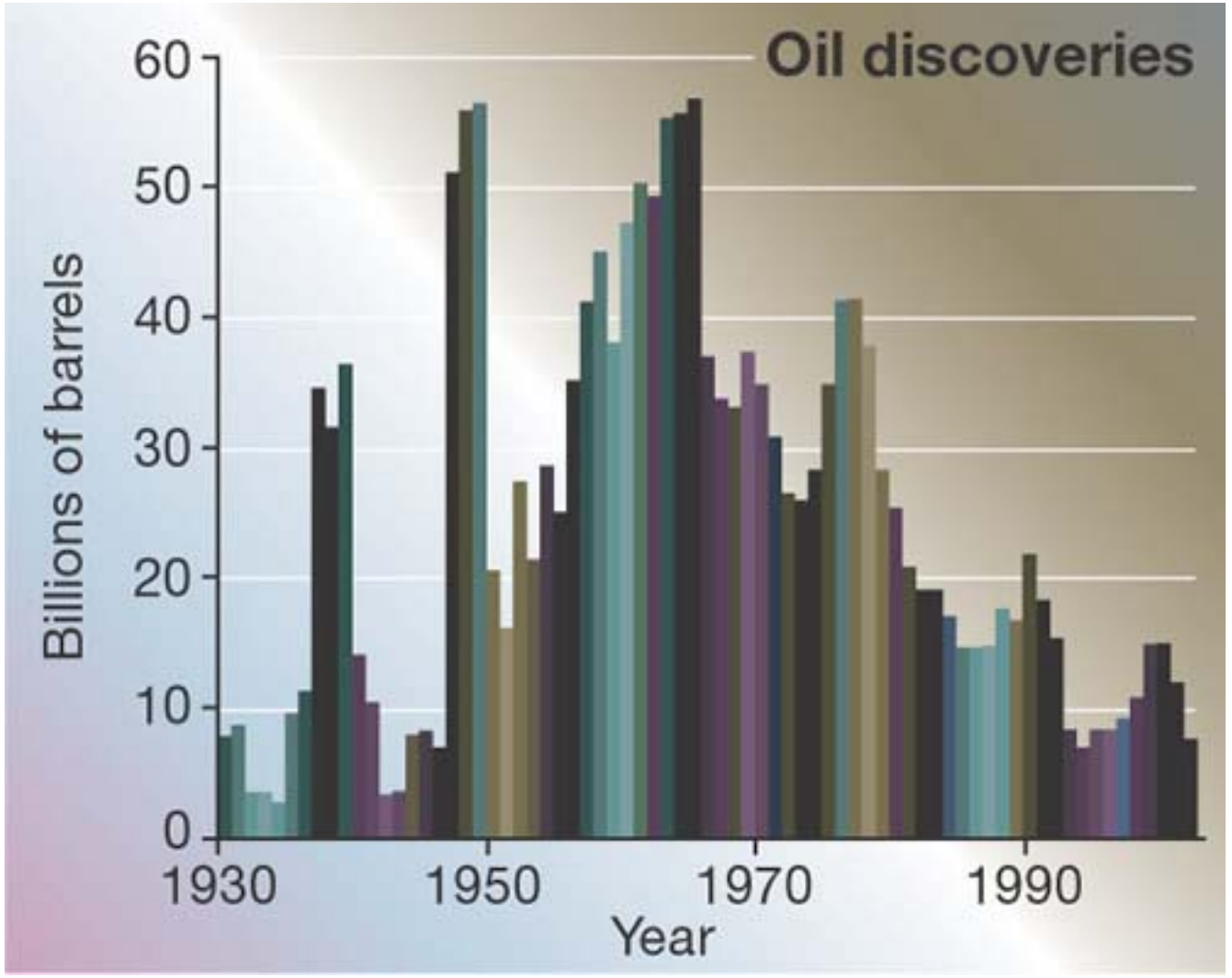
- High Performance Gas Turbine
  - FR, JP, US, CH, EU

- Materials and components
  - CH, FR, JP, KR, UK, US, RSA,EU

Oil Discoveries Worldwide

(Source: Nature 17 June 2004, p.694)

We are heading for a hydrogen transportation economy, the only questions are (1) the form of hydrogen in the vehicle (gasoline, methanol, hydrogen, etc.) and (2) where it is used (refinery, tar sands plant, vehicle).



The purpose of the AGR Fuel Program is to provide qualified fuel for the NGNP