Nuclear Energy and Hydrogen Production
A United States Perspective

3rd IPHE Steering Committee Meeting

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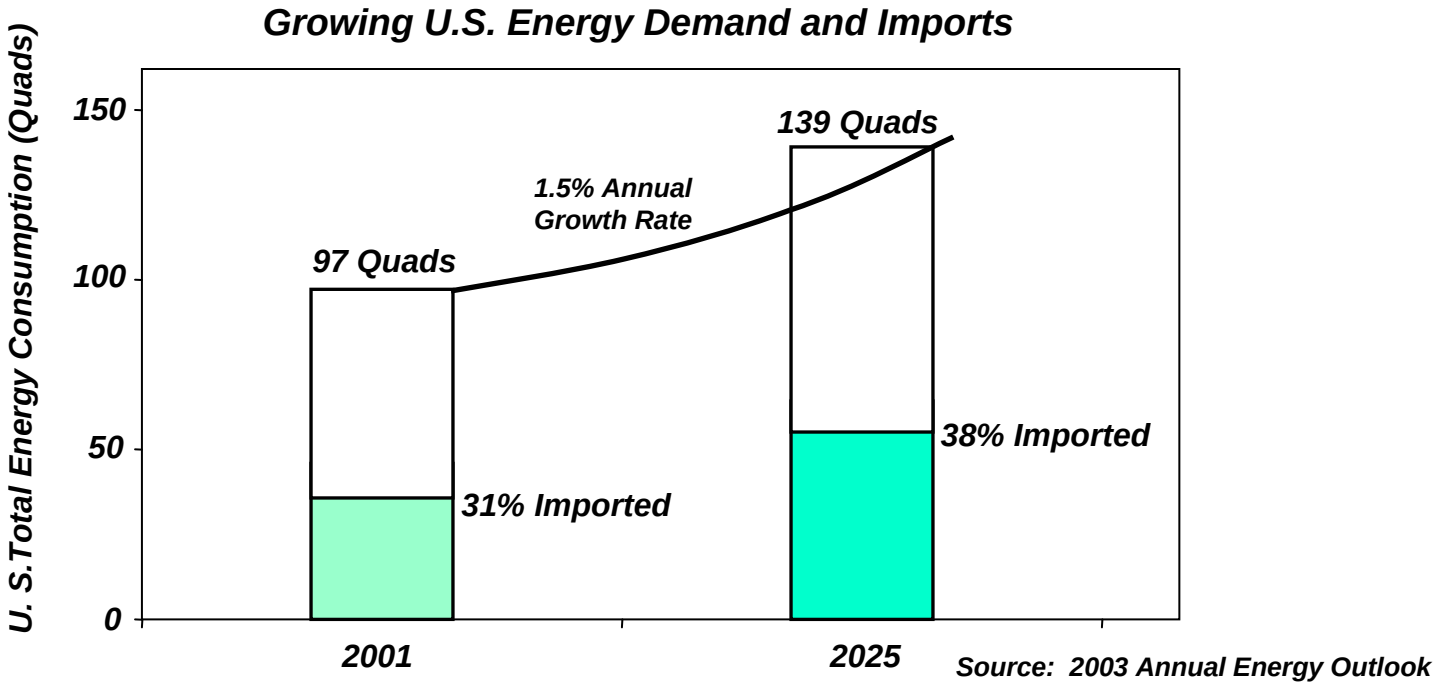
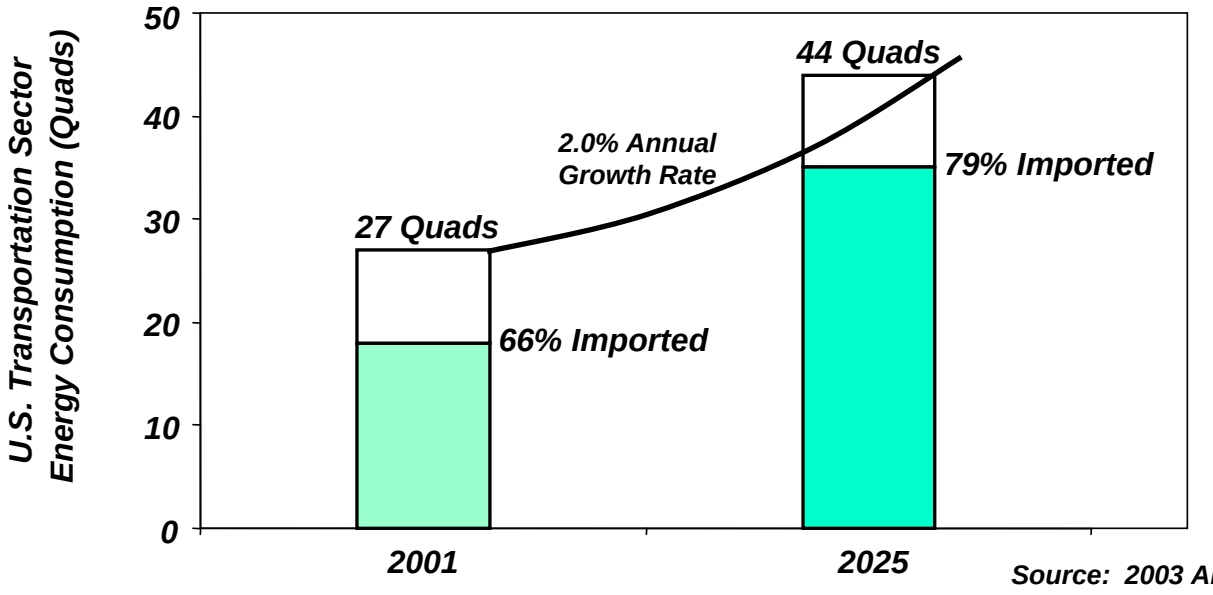
Forecast for U.S. Energy Growth:
Energy Demand Will Increase by 43 Percent by 2025



- **Annual outlook is 1.5 percent growth in U.S. energy to 2025**
- **Most growth is in natural gas and coal**
- **Imports will increase by 75 percent by 2025**
- **Nuclear can contribute if deployed in the near-term**

Energy for Transportation:
A Potential Vulnerability

Growing U.S. Transportation Sector Energy Demand and Imports



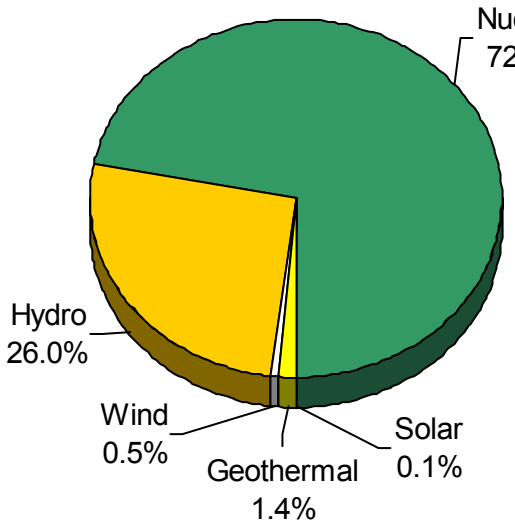
Source: 2003 Annual Energy Outlook

- **Transportation sector is experiencing the fastest growth in energy use -- demand will grow by 63 percent by 2025**
- **A large increase in imports appears inevitable**
- **Energy security and stability is undermined by increasing reliance on imports**

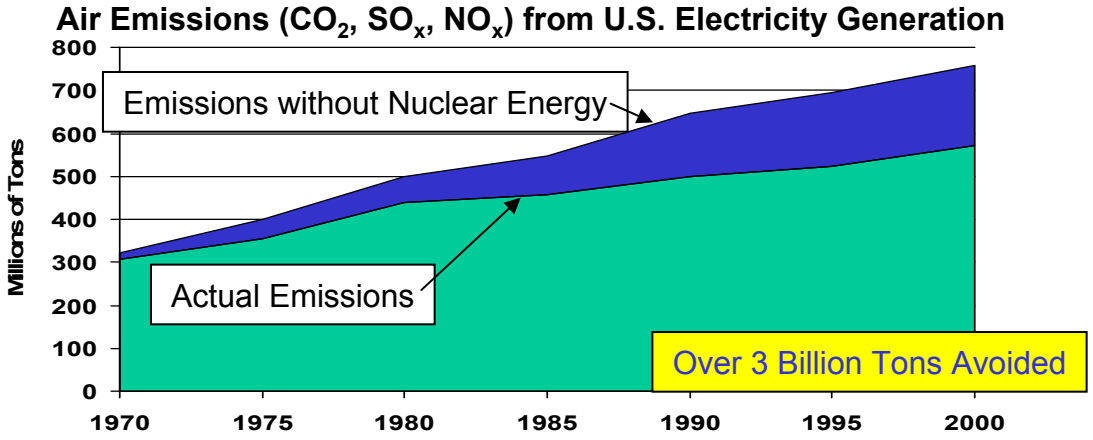
Nuclear Power Is Helping Today

♦ Cleaner Air

- Emission-free generating sources supply almost 30 percent of U.S. electricity
- Nuclear energy provides the greatest share of clean energy -- almost three quarters
- In the U.S., nuclear power avoids about 175 MMTC each year



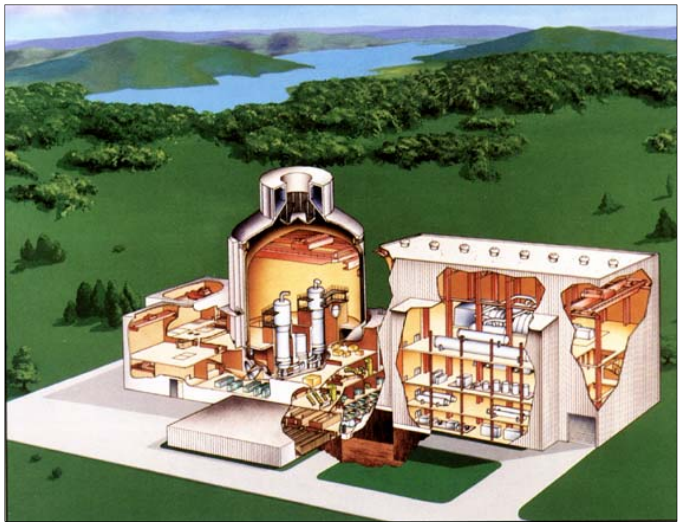
Source: EIA



Sources: Nuclear Energy Institute, EPA, and EIA

And Nuclear Power Can Help Tomorrow

- **Reliable, domestic base-load energy**
- **No carbon emissions**
- **Sustainable, long-term energy supply**
- **Supports use of advanced energy infrastructures to**
  - Increase the efficient use of energy
  - Reduce overall environmental impacts
  - Deal with transportation fuel needs through production of hydrogen



Generation IV: An International Initiative

- **This international collaboration began in January 2000**
- **Its purpose: to bring next-generation nuclear energy system technology to a state of maturity allowing for commercial deployment**
- **Generation IV reactors will offer improvements in:**
  - Reactor safety and reliability
  - Proliferation resistance and physical protection
  - Economic competitiveness
  - Sustainability

- **The effort is led by the Generation IV International Forum**

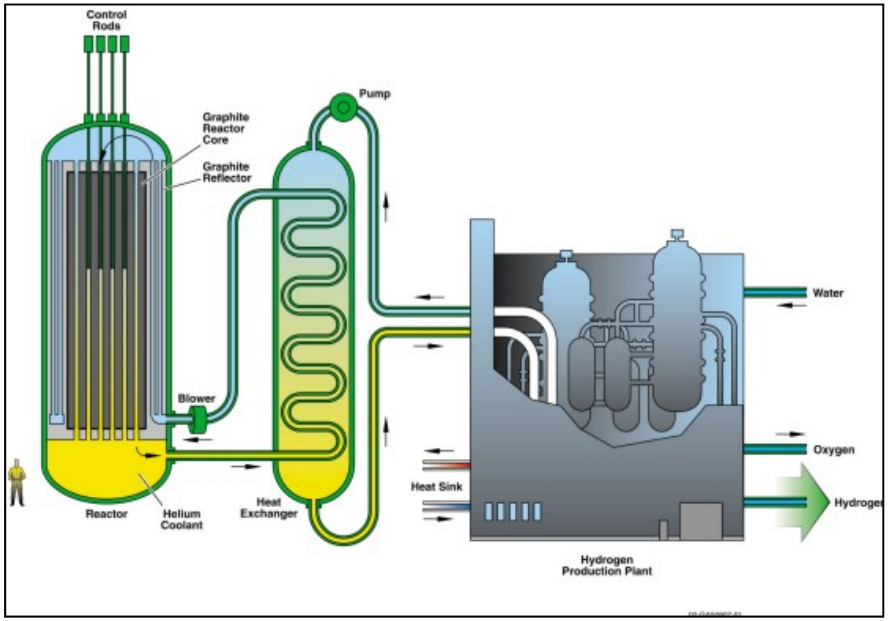
U.S.A. | United Kingdom | Switzerland | Rep. Korea | South Africa | Japan | France | Canada | Brazil | Argentina | European Union

Generation IV Nuclear Energy Systems Initiative

The Next Generation Nuclear Plant (NGNP)

What Does the NGNP Represent?

- **A very promising future option for economic, commercial-scale generation of hydrogen**
- **A better, safer, more economic nuclear energy plant**
- **A single NGNP could produce 200,000 gge H_2 each day – for less than $2.00/gge**



How Will We Get There?

- **Early investment in key materials, fuels, and H_2 production technology**
- **Aggressive, well planned collaboration and cost-sharing with international partners and the private sector**

Next Generation Nuclear Plant (NGNP)

Attributes

- Helium coolant 1000ºC outlet temp
- Modular 300-600 MW_{Th}
- Helium Brayton cycle conversion with high efficiency
- Clean and efficient hydrogen production

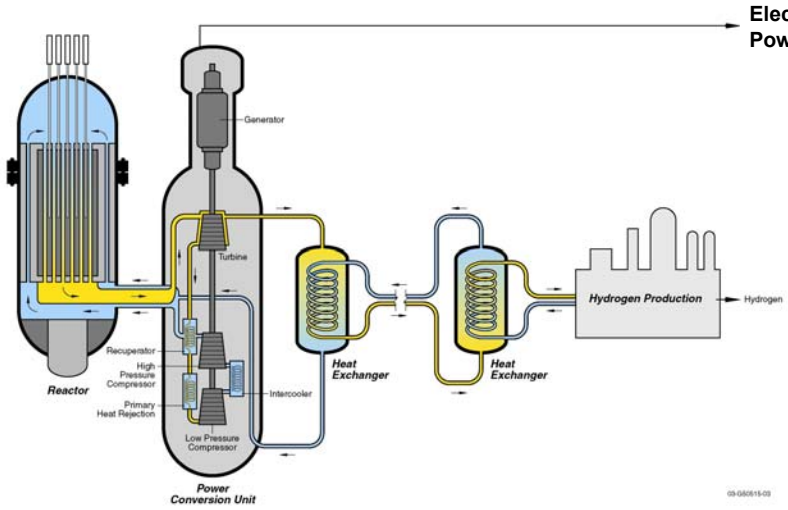
Benefits

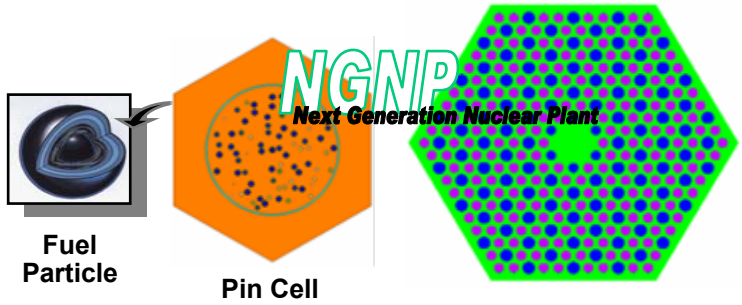
- Ultra-safe system
- Meltdown-proof fuel
- High temperature provides high efficiency

Technical Challenges

- High temperature materials
- Fuel performance and reliability
- Hydrogen production technologies
- Intermediate heat exchanger
- Waste generation

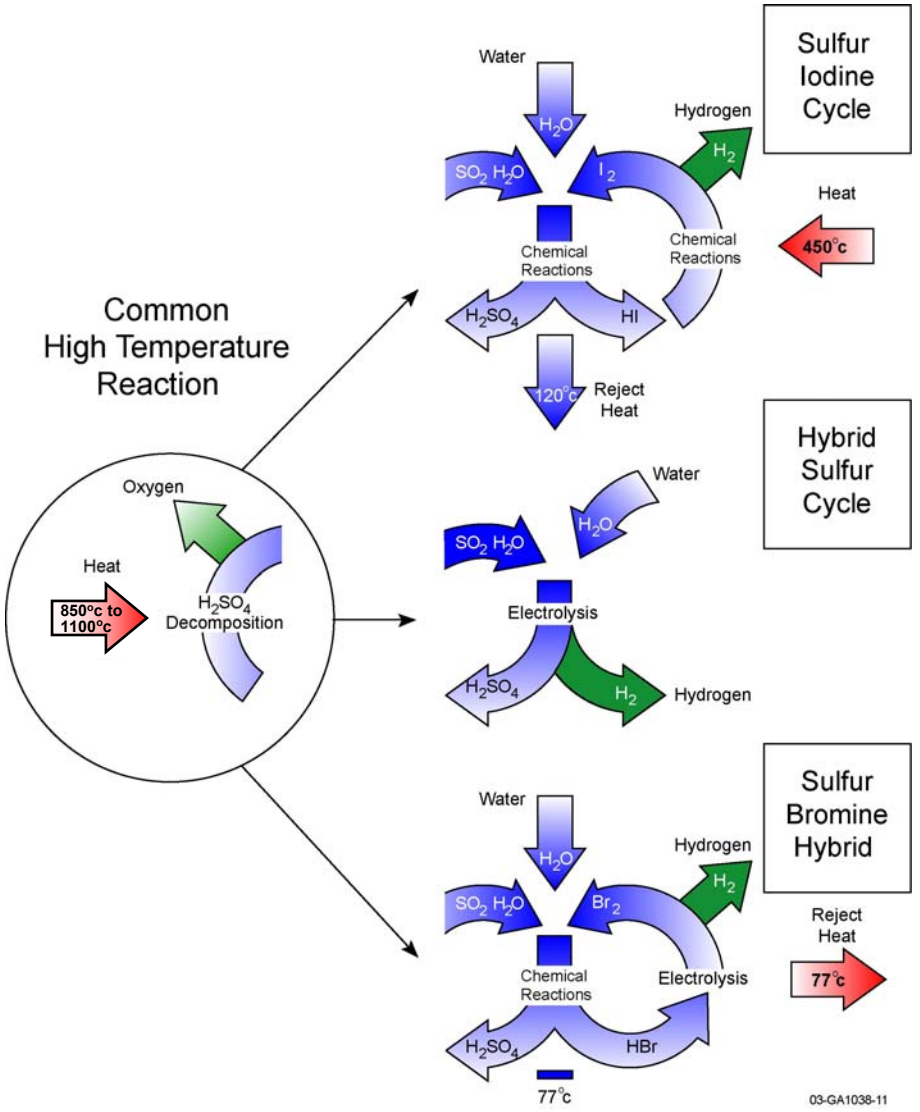
Next Generation Nuclear Plant





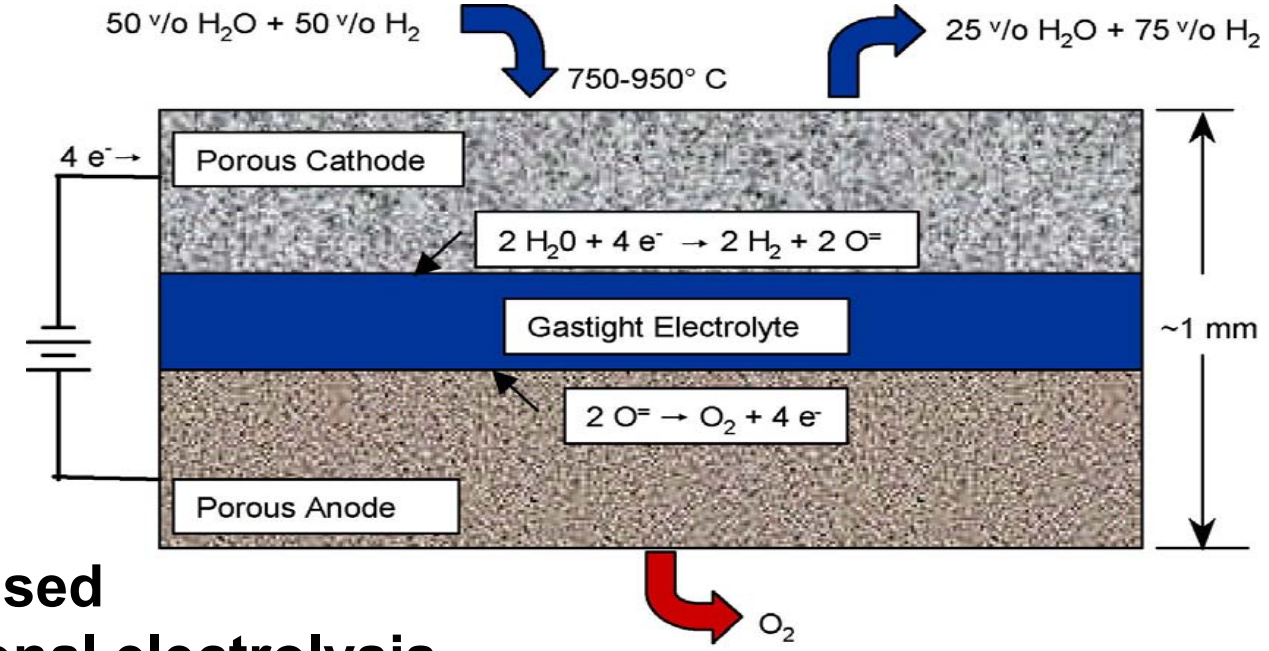
U.S. Research to Produce Hydrogen
Sulfur-Based Cycles

- **Use a series of chemical reactions to split water into hydrogen and oxygen**
- **All process chemicals recycled**
- **Most extensively demonstrated thermochemical process**
- **Increased viability based on number of process options**



U.S. Research to Produce Hydrogen
High-Temperature Electrolysis

- **High overall efficiencies**
- **Demonstrated viability**
- **Builds on Solid Oxide Fuel Cell technology**
- **Less electricity used than in conventional electrolysis**
- **R&D funded collaboratively by Energy Efficiency/ Renewable and Nuclear offices**

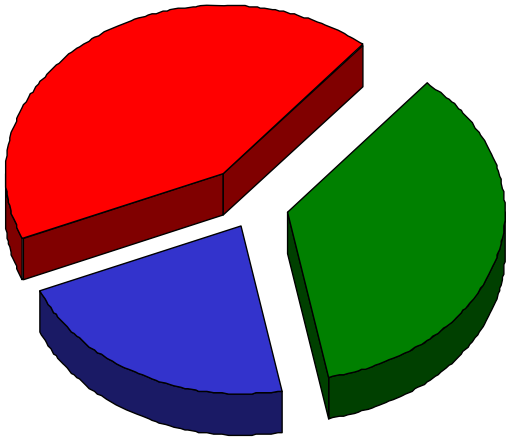


Fiscal Year 2005 Hydrogen Production Funding ($40M)

The Department of Energy's Offices of Fossil Energy, Nuclear Energy, and Energy Efficiency and Renewable Energy are collaborating on cost-shared hydrogen production R&D:

Coal - $17.3 million (FE)

- Advanced, simpler production and separation of pure hydrogen gas from synthesis gas (CO and hydrogen)
- Research on alternate liquid route to produce hydrogen requiring limited infrastructure change



Nuclear – $8.9 million (NE)

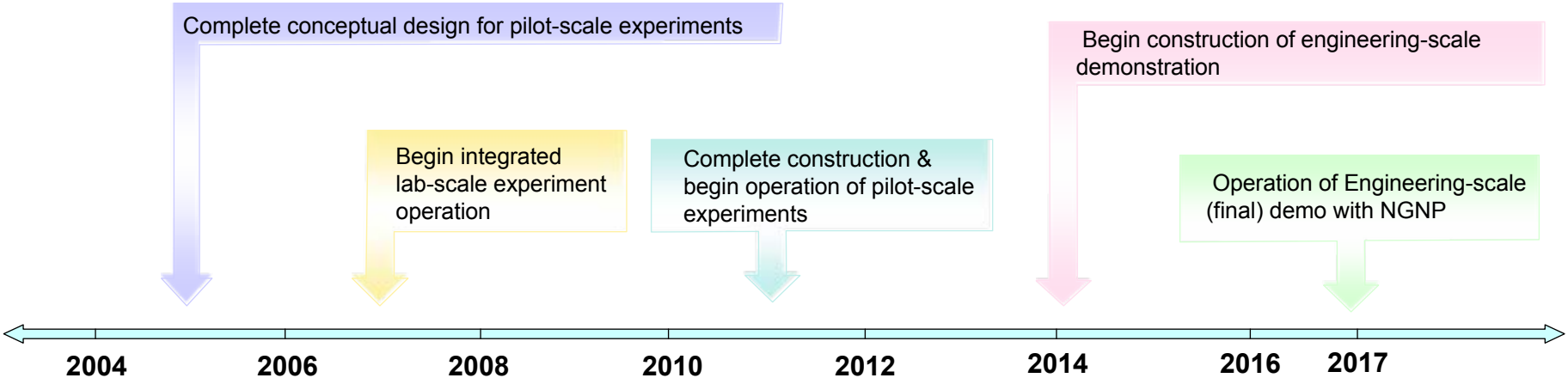
- High-temperature water-splitting technologies for nuclear energy systems

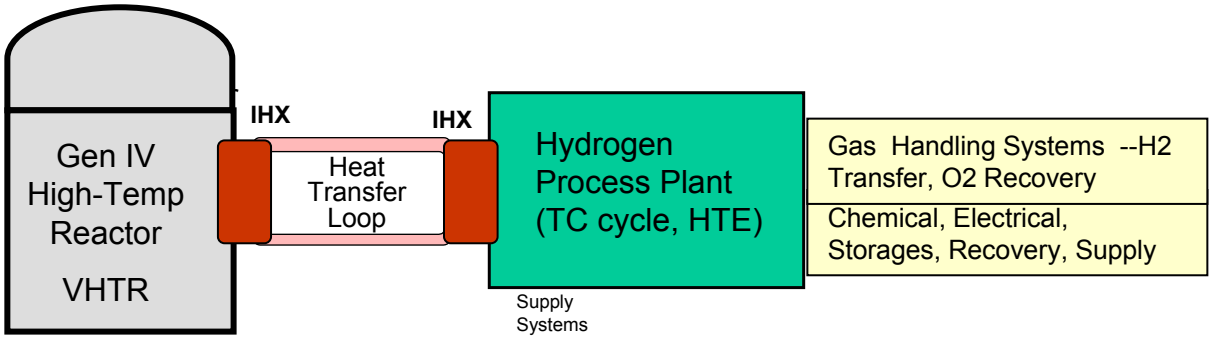
Renewables - $25.1 million (EERE)

- Direct water splitting using solar energy
- Biomass reforming
- Advanced electrolysis from wind power and solar power
- High-temperature water-splitting technologies using solar energy systems

Energy Independence through Diversity of Domestic Supplies

National Hydrogen Fuel Initiative Set A Far-sighted Vision Towards An Emission-free Future





NHI's goal is to develop advanced hydrogen production technology to demonstrate economic, commercial-scale hydrogen production.

Conclusion

- **Current nuclear plants are a success in today's electricity market and will continue operating through mid-century**
- **New plants (Generation III) are being built in Europe and Asia, and U.S. utilities are actively considering these technologies for the U.S. market**
- **Next-generation technologies (Generation IV) are under development and may be available in the 2020s for:**
  - Cost-competitive electricity production
  - Commercial-scale production of hydrogen
  - Production of plentiful clean water