Nuclear Energy's Role in Our Future

Kathryn McCarthy, Ph.D.

Deputy Associate Laboratory Director
Nuclear Programs
Idaho National Laboratory

University of California, Los Angeles
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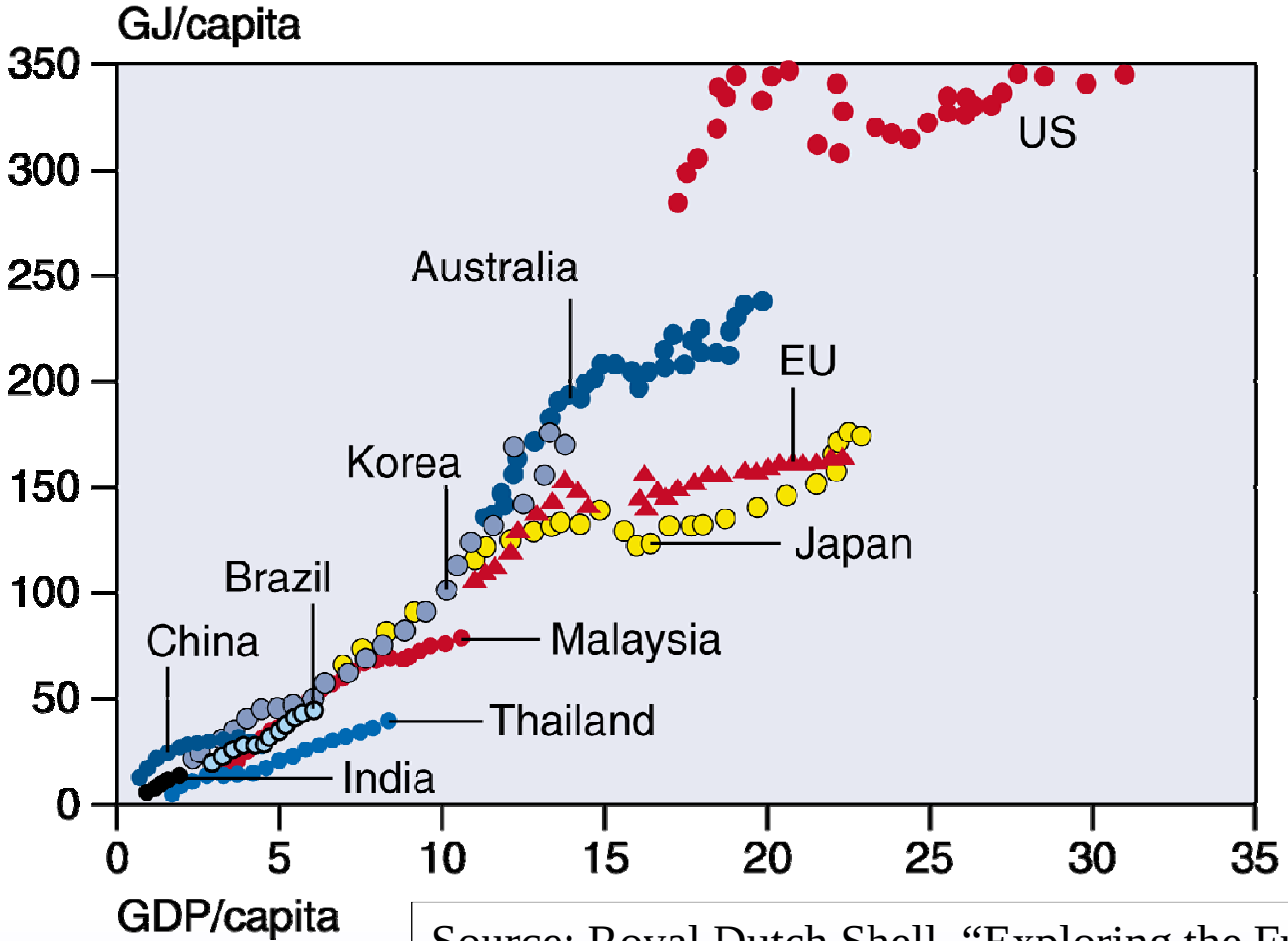
Outline

- Global Energy Needs
- U.S. Energy Needs
- Nuclear Energy's Role
  - Electricity
  - Transportation
- The Global Nuclear Energy Partnership

Energy is the Fuel of National Prosperity



Source: Royal Dutch Shell, "Exploring the Future - Energy Needs, Choices and Possibilities

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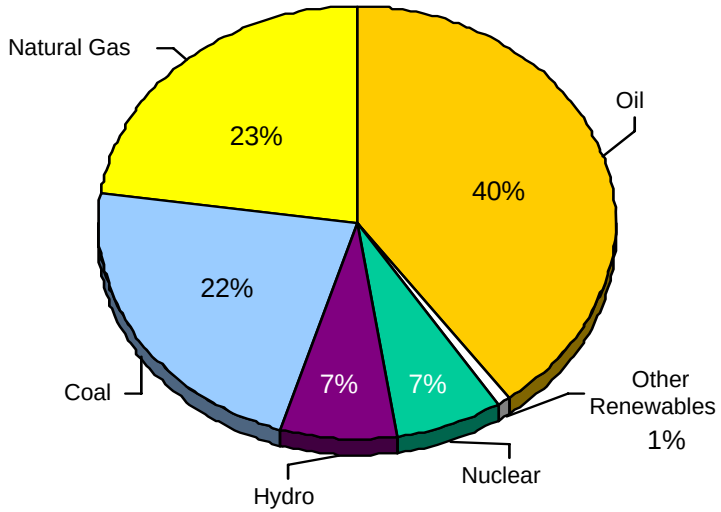
Current Energy Situation

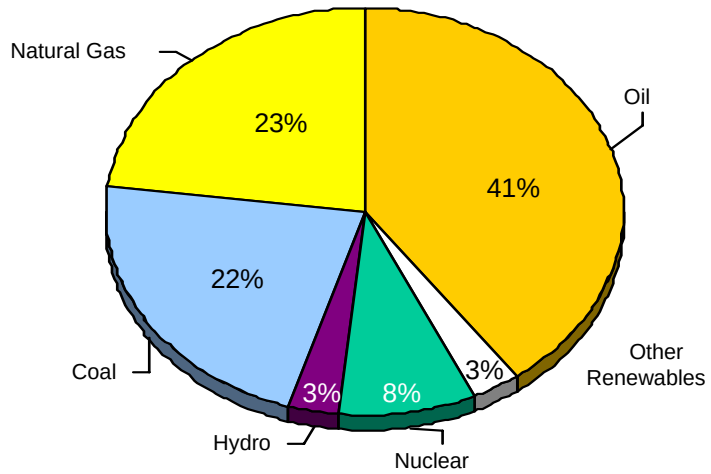
The world uses almost 400 quadrillion* Btu of energy each year. This is roughly equivalent to using 180 million barrels of crude oil each day.

280 million people use almost 100 quadrillion* Btu of energy each year -- about 25 percent of the world's consumption

Sources of Energy Consumption - World



Sources of Energy Consumption - U.S.



Still, 2 billion people lack access to adequate, convenient electricity

1 quadrillion BTUs is equivalent to the energy in a mile-long coal train (11,000 tons) every 2 hours, every day, for a year

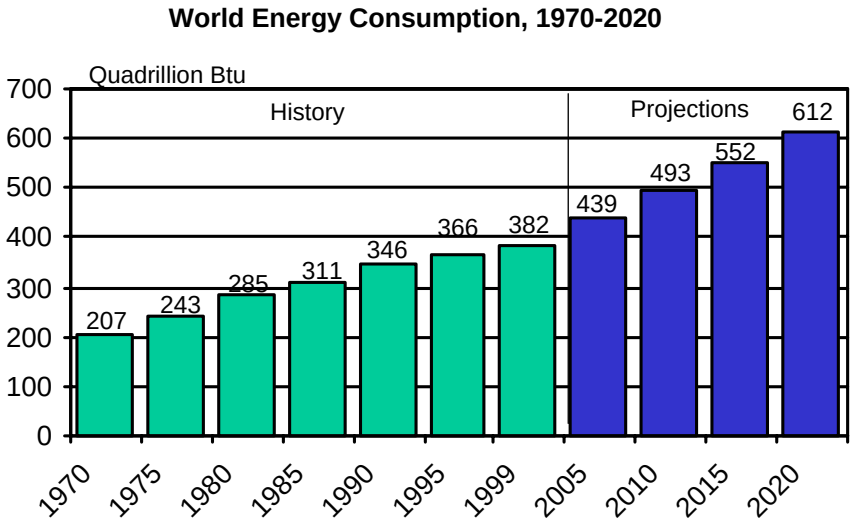
Demand for Power

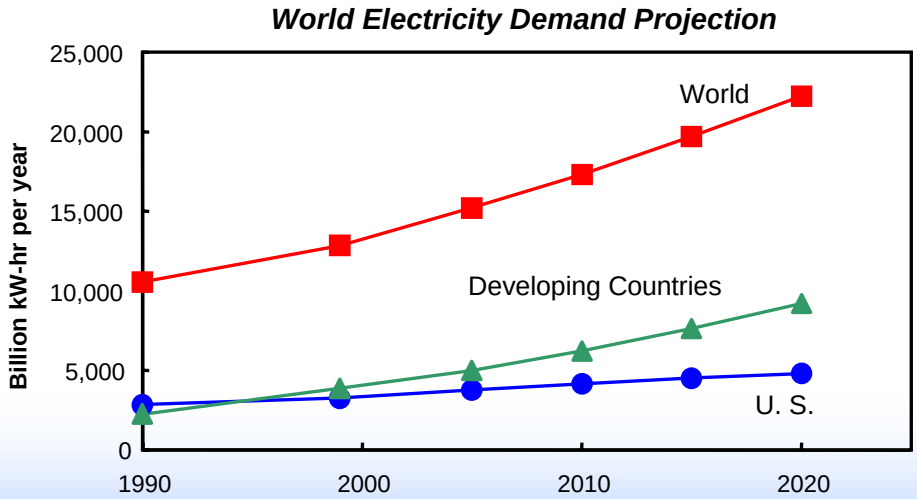
World Demand for Energy

- Growing at a rate of 2.3 percent per year

World Demand for Electricity

- Growing at a rate of 2.7 percent per year
- 2,330 GW of new world electrical generating capacity needed by 2020
  - 423 GW will be needed in the U.S. by 2020





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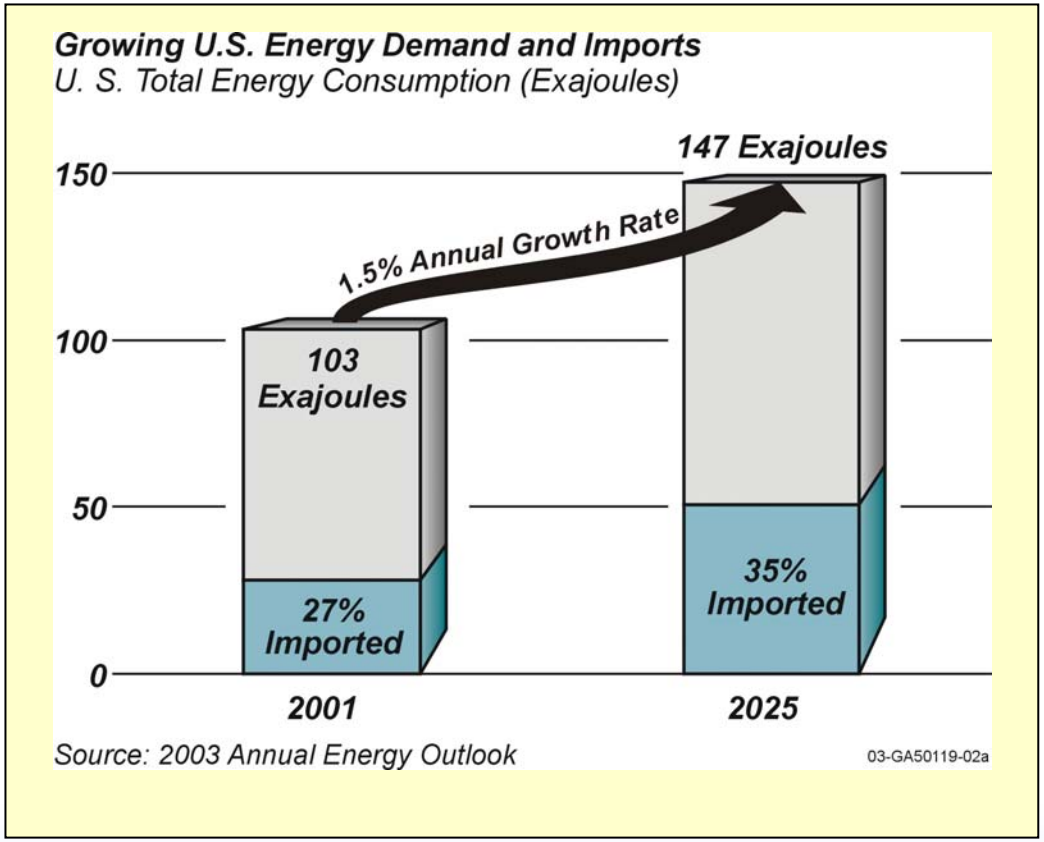
Forecast for Energy Growth in the U.S.

- Annual outlook is 1.5% growth in U.S. energy to 2025
- Most growth is projected to be in natural gas and coal
- Imports will increase
- Nuclear could change this picture



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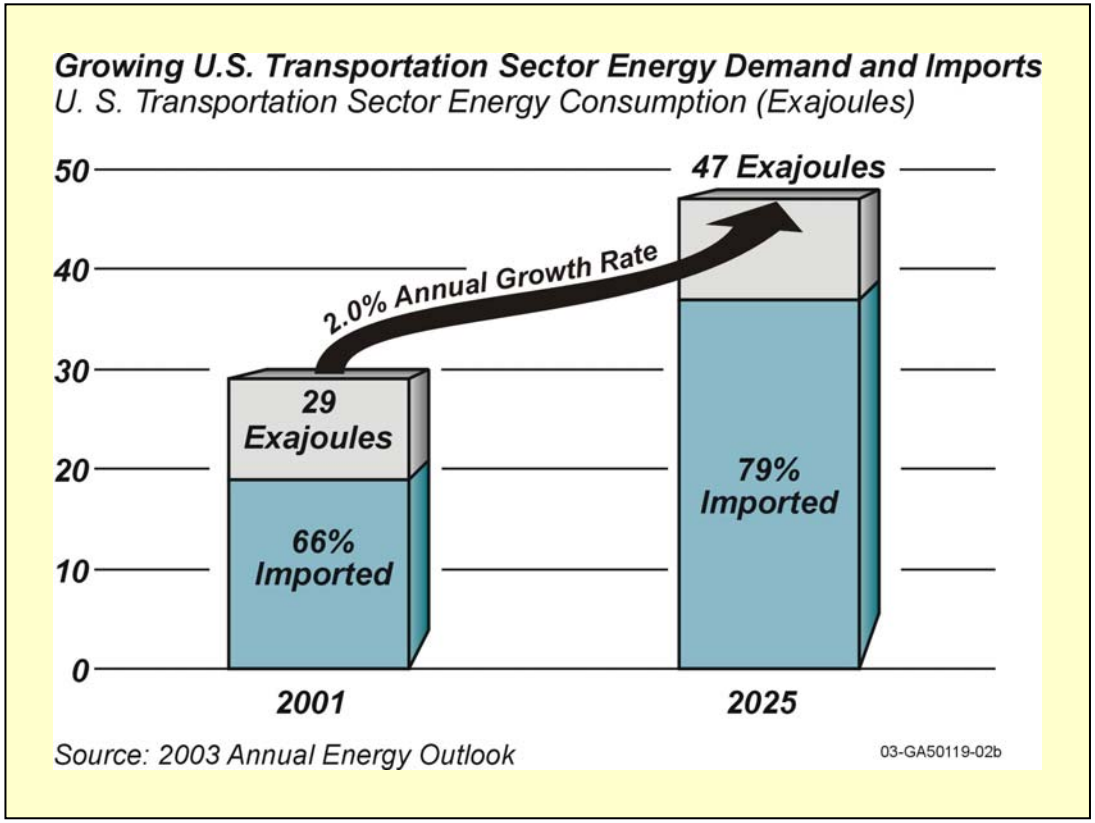
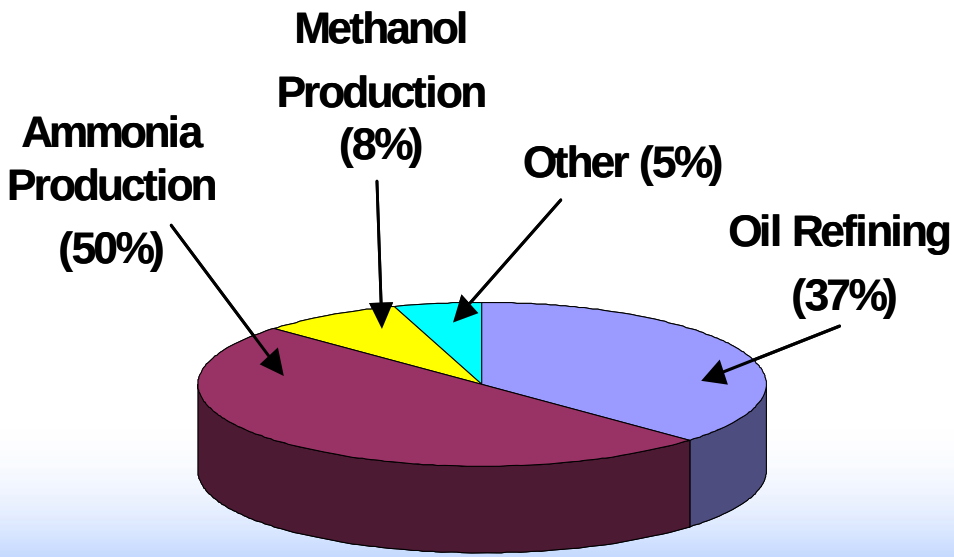
Growth in transportation sector energy demand in the U.S.

- Transportation sector growth leads electricity and heating
- 28% of US energy is used for transportation
- Outlook is for a disproportionate increase in imports
- Increasing dependence on imports clouds the outlook for energy security and stability
- Hydrogen could change this picture



A hydrogen economy--the future, or a current reality?

- **Hydrogen is the most abundant element in the universe, but it does not naturally exist in its elemental form in large quantities or high concentrations on earth.**
- **The world consumption in 2002 was 50 million tons H_2/yr, produced primarily by steam reforming of methane**
  - US consumption: 12 million tons H_2/yr, increasing 4-10%/year
- **We are now using greater than 5% of North American natural gas for H_2 production, affecting home heating costs**
- **The current H_2 production releases 320 million metric tons CO_2/yr**



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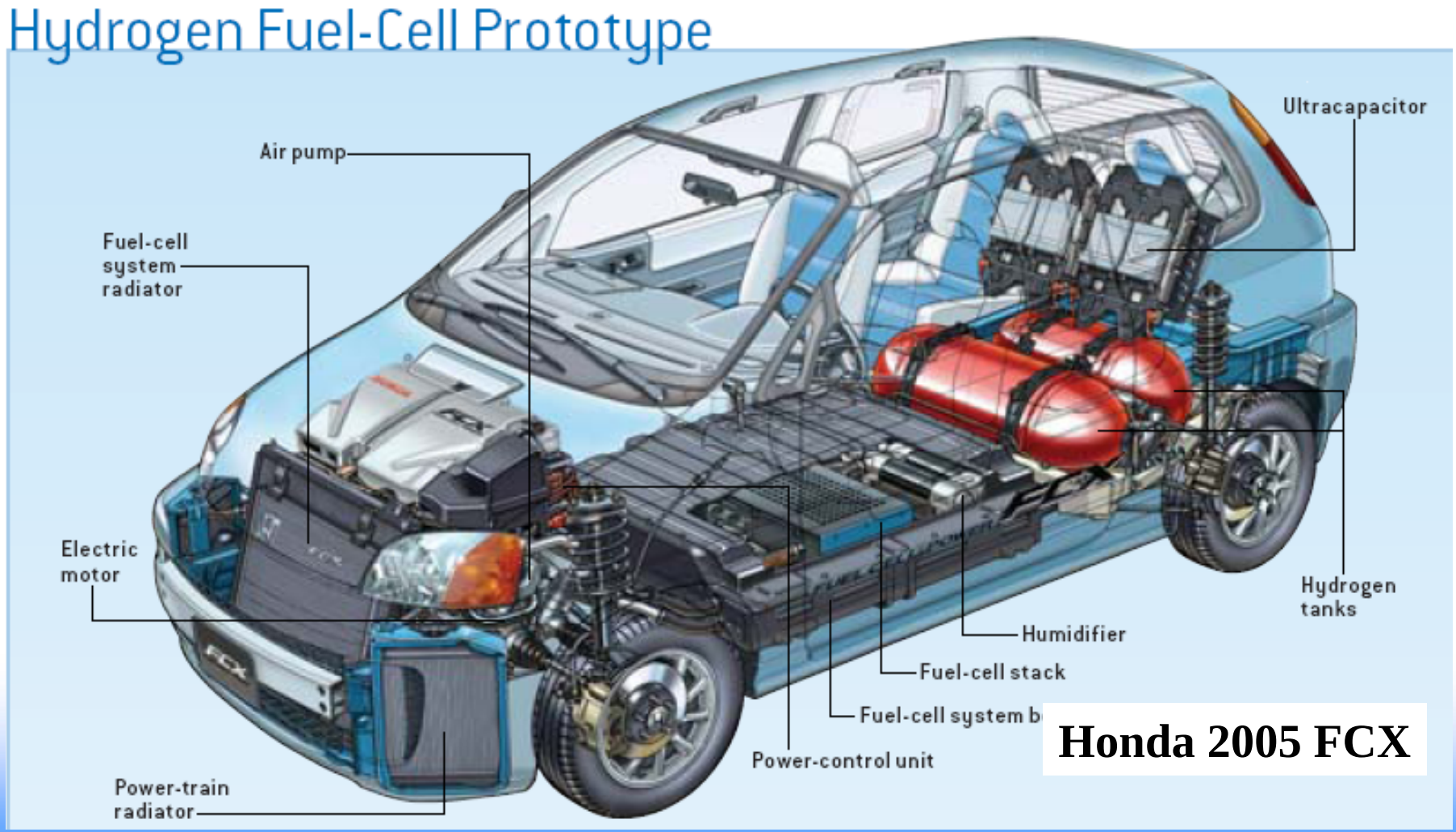
Replacement liquid fuels will first be from heavy oils and tar sands

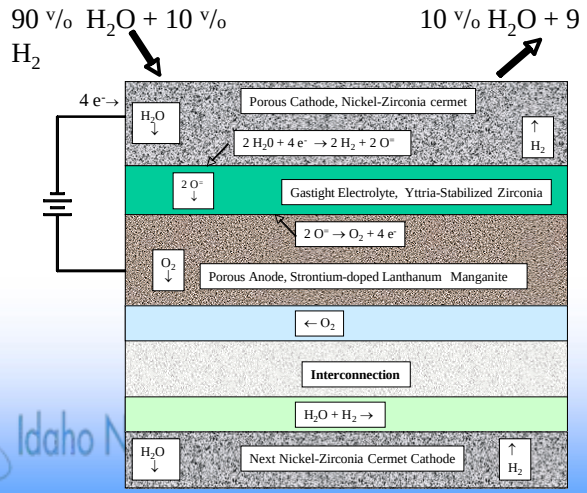
- Large quantities of tar sands and heavy oils are located in the western hemisphere (Canada, Mexico, Venezuela, and the United States)
- Requires cheap hydrogen (heavy oils and tar sands require more hydrogen to "sweeten" than higher grades
- Synthetic fuels can be produced with hydrogen and carbon gas emissions from industrial processes

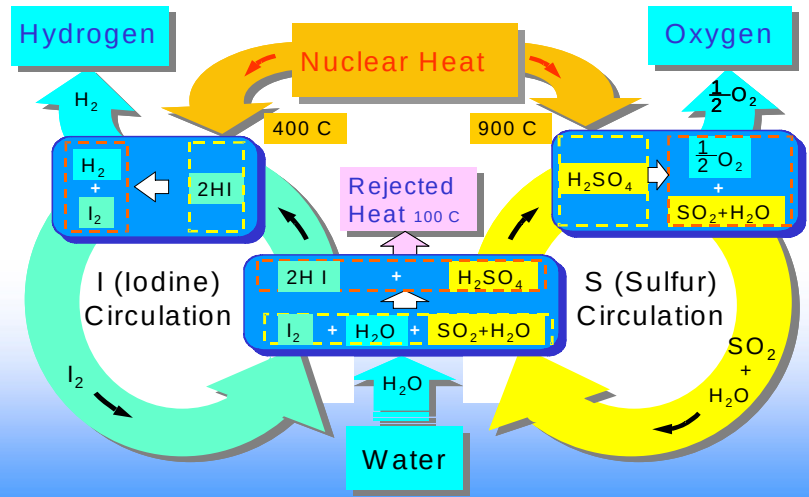
Eventually we will have viable fuel cells - hydrogen fuel and water out the tailpipes



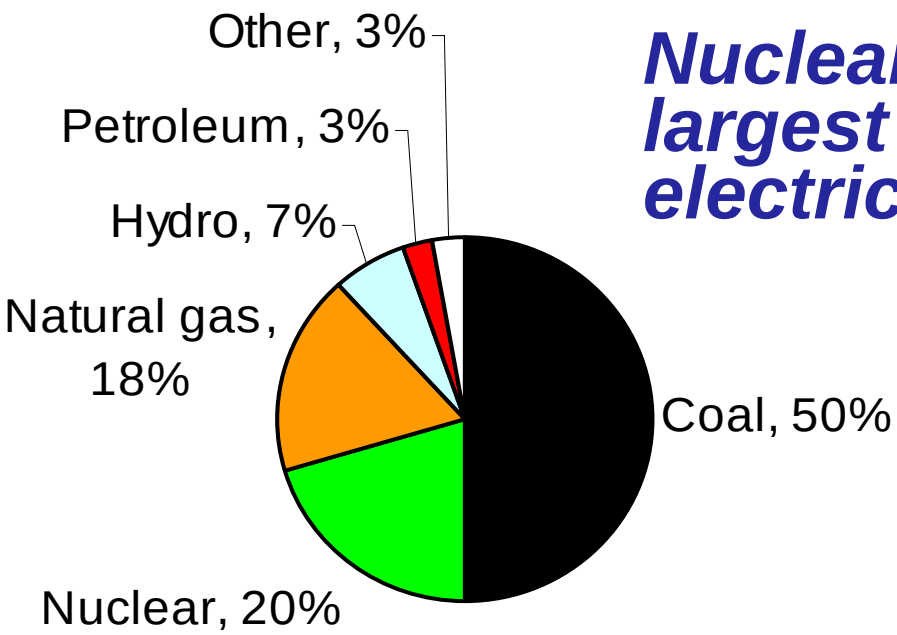
Nuclear energy can be used to produce hydrogen without greenhouse gas emissions

- Conventional electrolysis using nuclear-generated electricity
- High temperature electrolysis using nuclear electricity and heat
- Thermochemical cycles for water splitting
- Hybrid cycles combining thermochemical and electrolytic steps

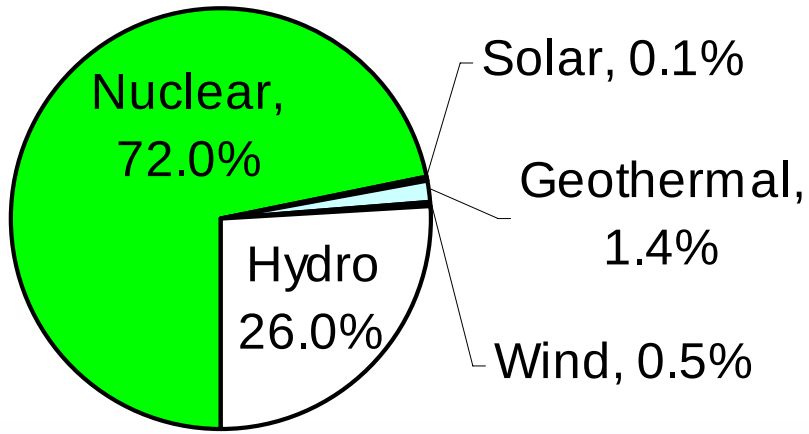




Nuclear Power Must Remain a Part of Our Energy Portfolio



Nuclear is the second largest source of U.S. electricity



Nuclear energy is the dominant non-fossil energy technology

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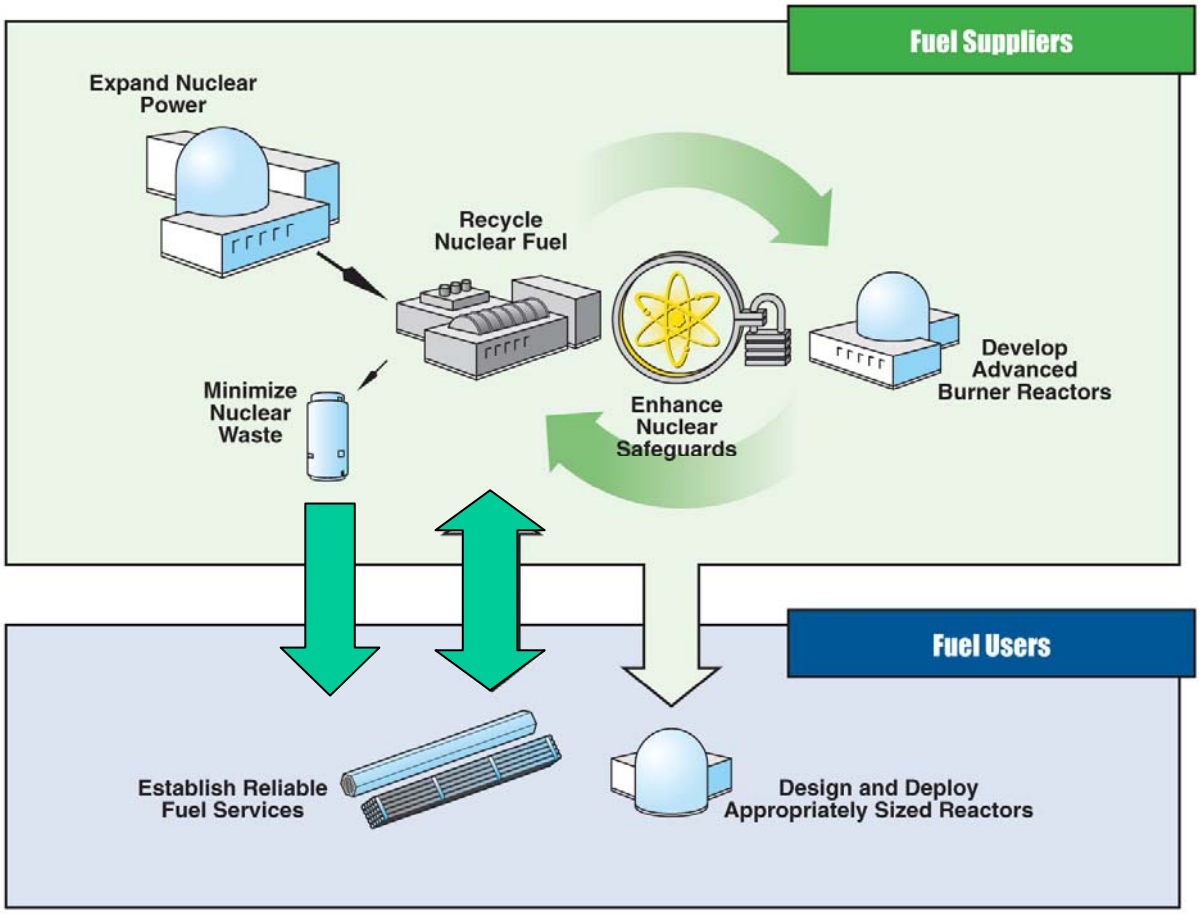
The Grand Challenge for Nuclear Energy

Create a technically achievable, economically competitive, and environmentally sustainable nuclear energy option for the nation and world that earns public confidence and trust.

The US unveiled the Global Nuclear Energy Partnership in February 2006

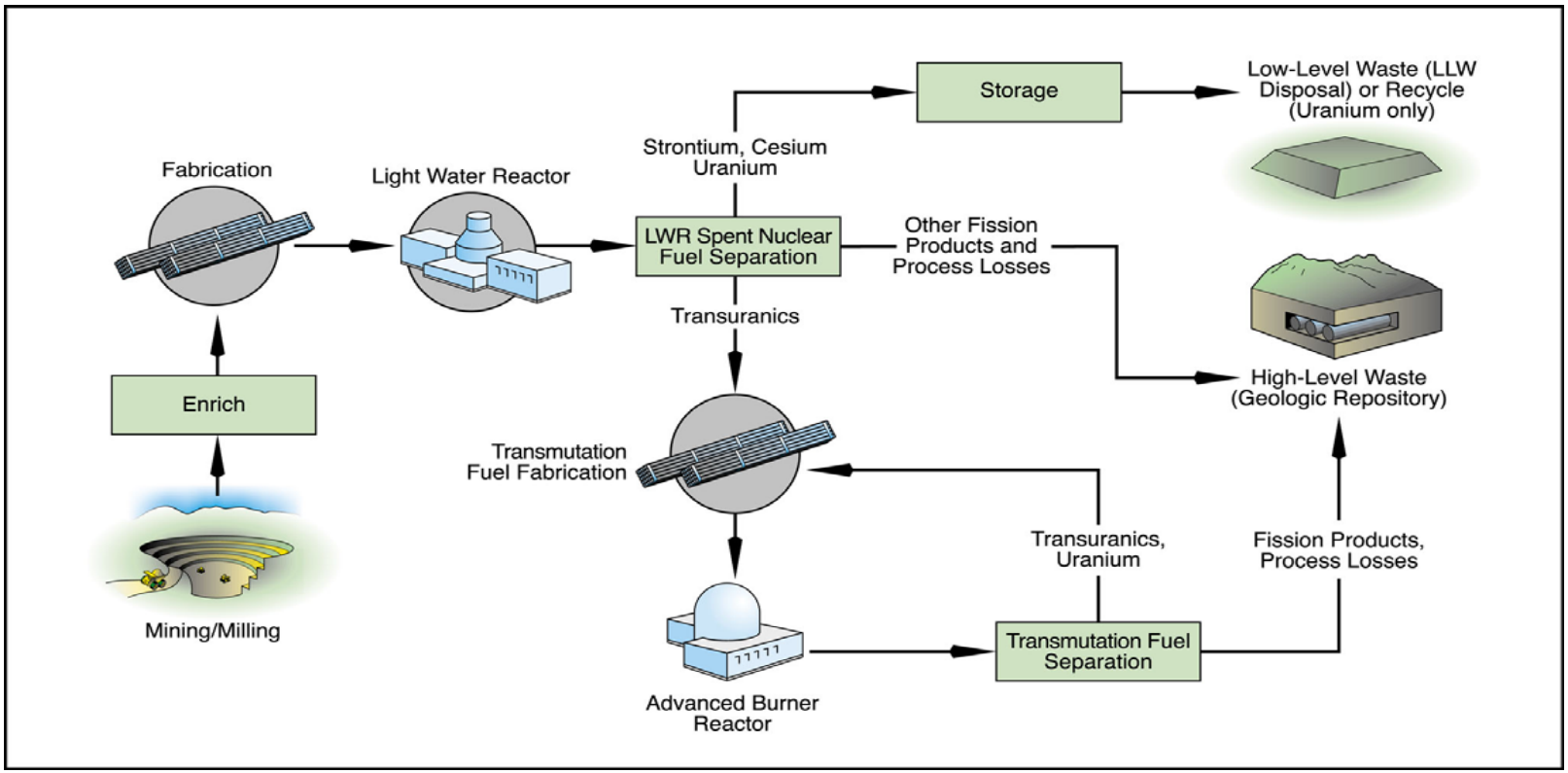
- **Reduce the current and future burden related to geologic disposal of spent nuclear fuel in terms of waste volume, heat load, radiotoxicity, and number of repositories needed**
- **Recover the energy value contained in spent nuclear fuel for future energy production needs**
- **Reduce the proliferation risk associated with the use of nuclear energy globally.**

An international fuel service is an essential part of reducing proliferation risk

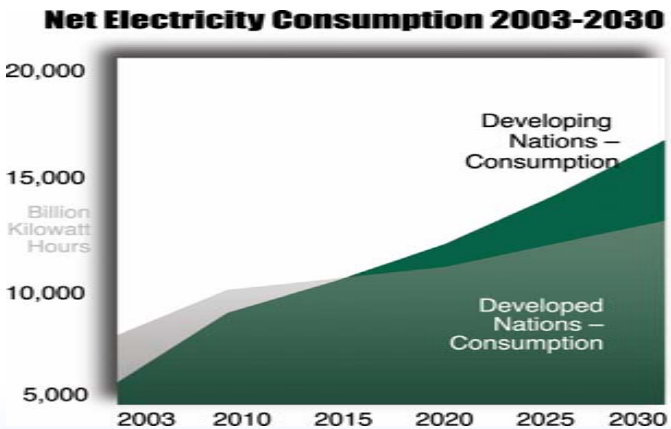


- ***Fuel Suppliers:*** operate reactors and fuel cycle facilities, including fast reactors to transmute the actinides from spent fuel into less toxic materials
- ***Fuel Users:*** operate reactors, lease and return fuel.
- ***IAEA:*** provide safeguards and fuel assurances, backed up with a reserve of nuclear fuel for states that do not pursue enrichment and reprocessing

GNEP Deployment System



Why GNEP?



- **Faced with dwindling oil reserves, concerns about global climate change and air emissions, many countries are taking a new look at nuclear energy**
- ***If nuclear energy is the answer to the world's increasing demand for clean base load energy, how does the world deal with potential weapons proliferation and nuclear waste issues and at the same time satisfy individual countries' national interests?***
- **A new international framework is needed that depends on the cooperation and support of the world community coupled with advanced recycling technologies**

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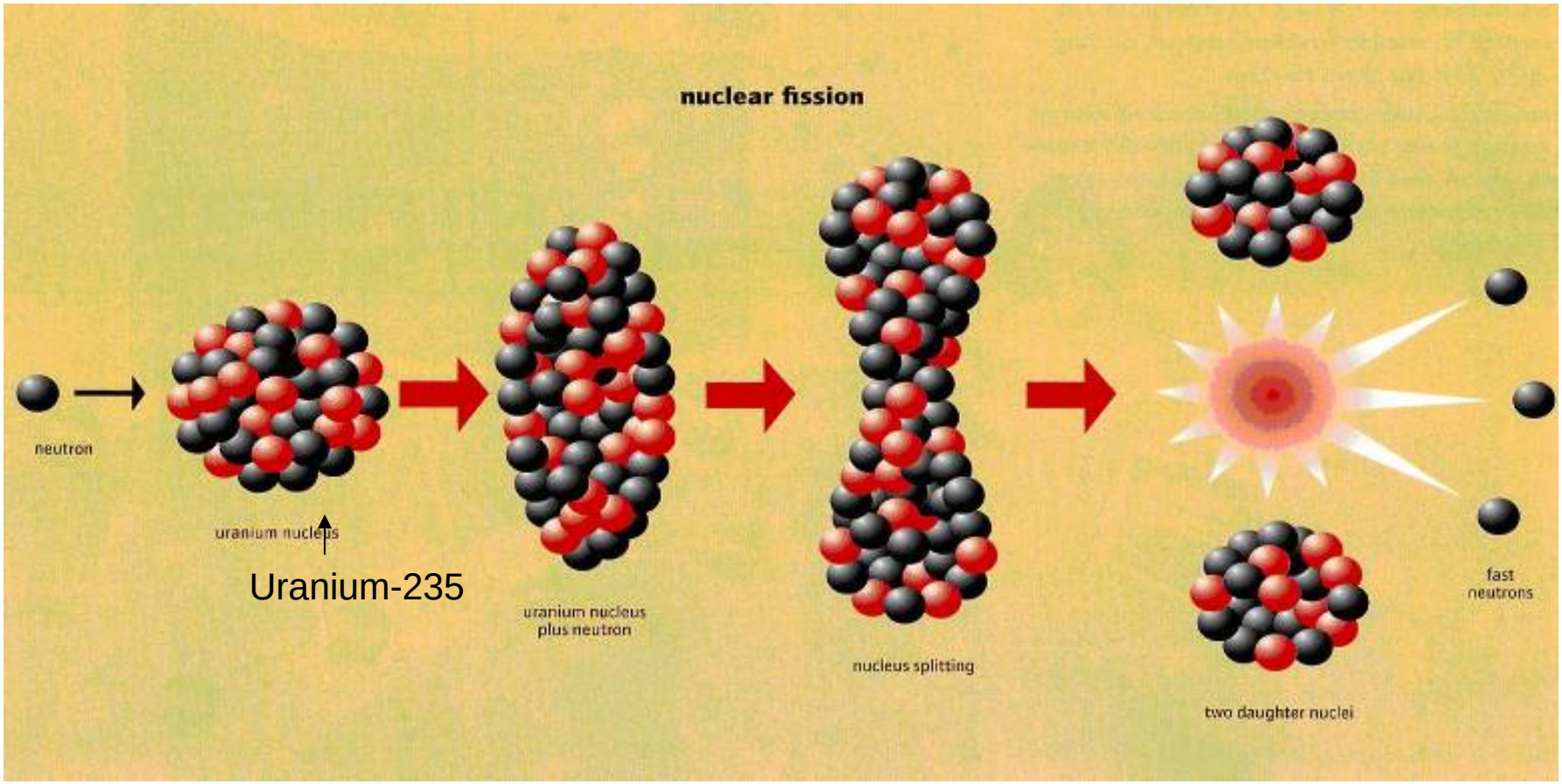
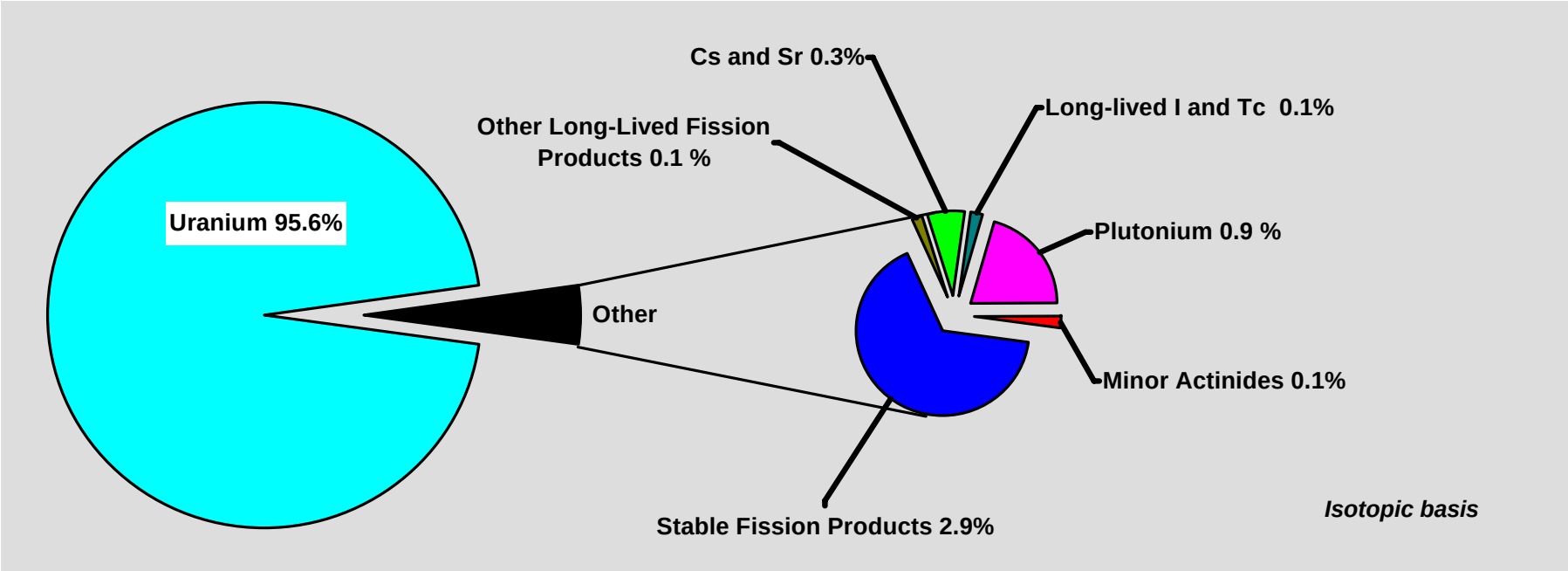
GNEP Builds on a Solid Foundation of U.S. and International Nuclear Experience

- Benefits from more than 50 years of scientific, engineering and commercial experience
- Builds on past and current work on advanced reactor and fuel cycle technologies
- Tangible progress has been made by international and U.S. researchers on new advanced recycling technologies
- Efforts harness the capabilities and expertise of our national labs, universities, and international and domestic industry
- We are securing international partners with recycling experience
- Public-private partnership work

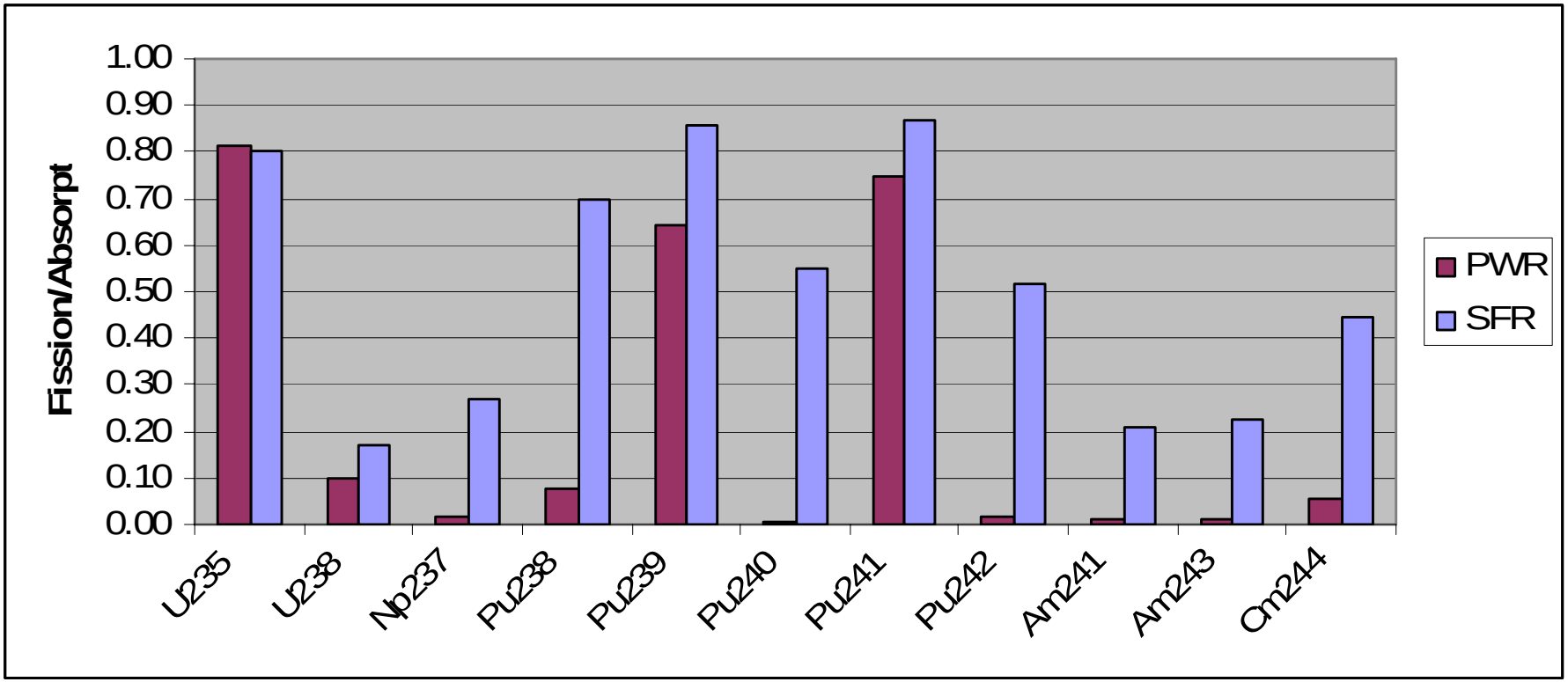
Nuclear Fission



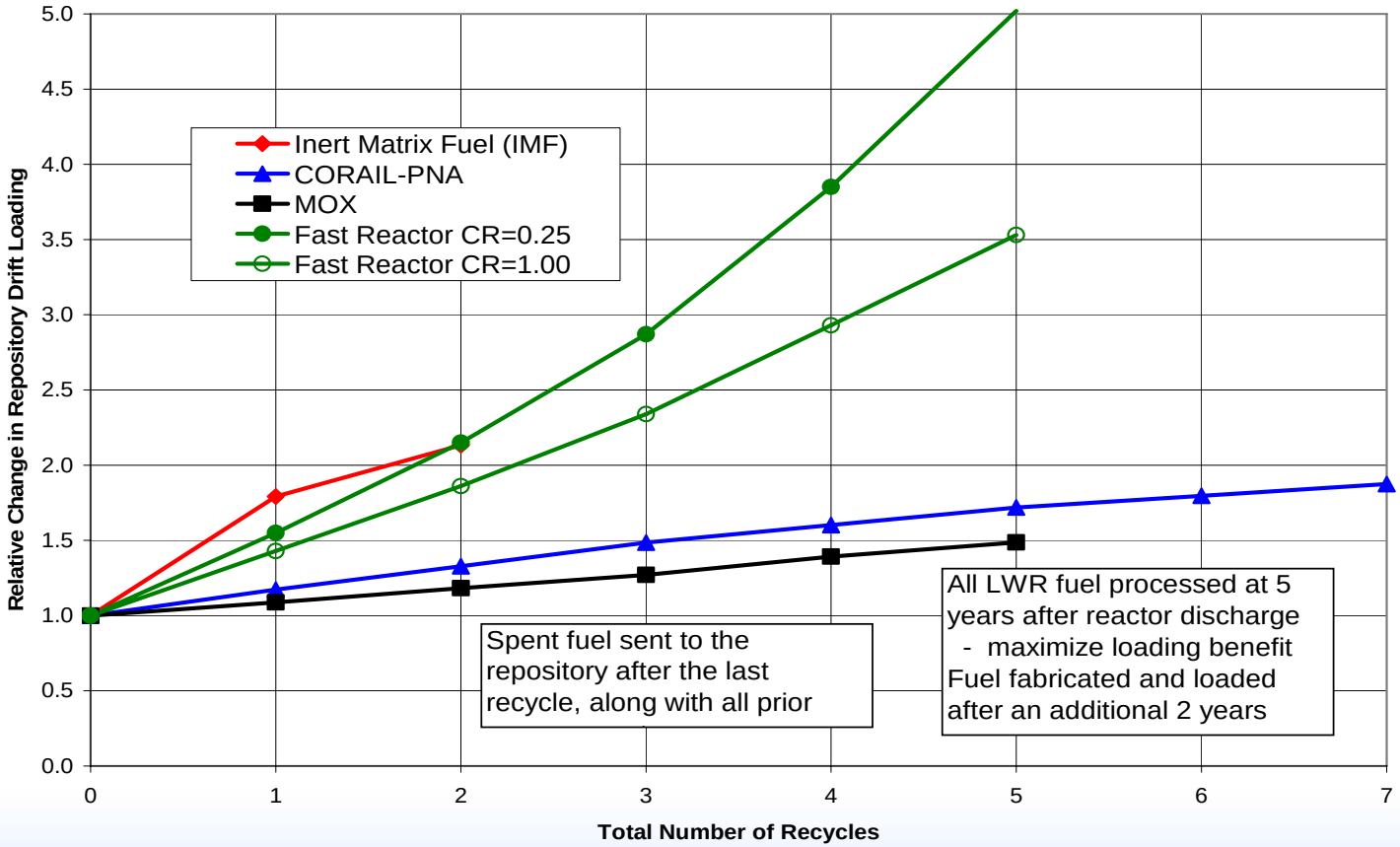
Spent Nuclear Fuel (less cladding)



The fast reactor spectrum favors fission vs absorption



Repository Loading Benefit from Fast and Thermal Recycle



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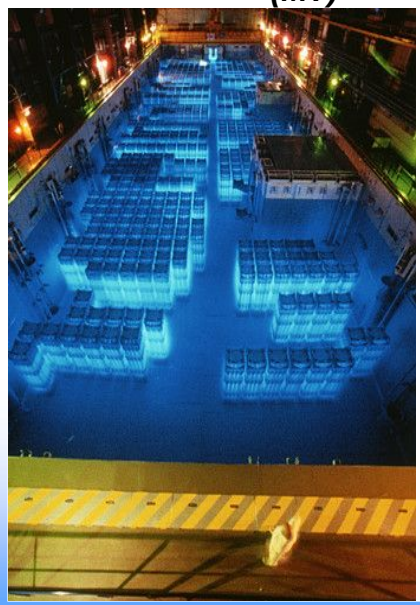
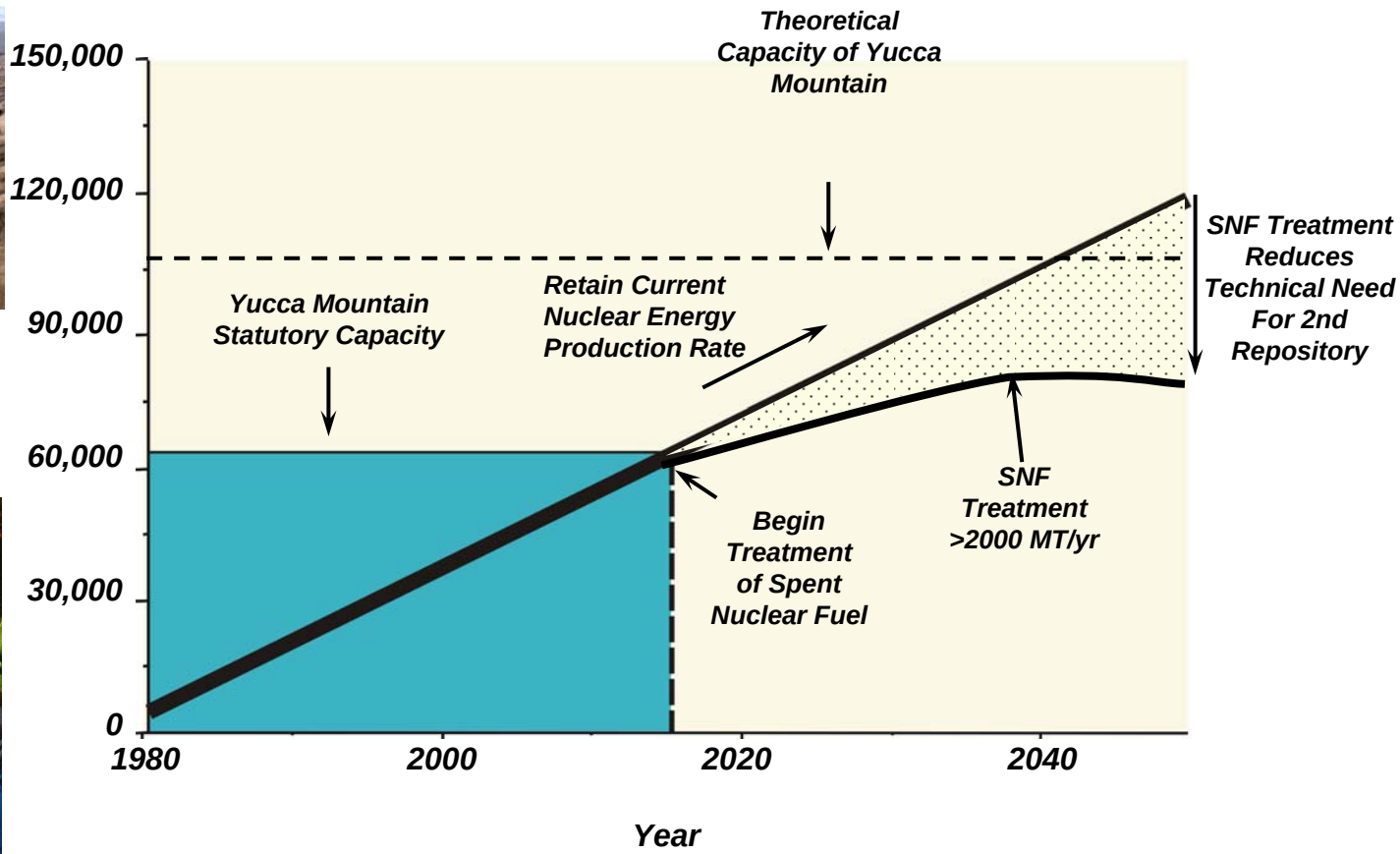
Benefit of Spent Nuclear Fuel Treatment





The Nuclear Waste Policy Act requires the Secretary of Energy to inform Congress before 2010 on the need for a second geologic repository for spent fuel

Potential Future Energy Scenarios

Future Energy Scenario	Total Discharged Fuel
1. Legislative Limit	70,000 MT = Based on the legal capacity of the first repository per the Nuclear Waste Policy Act (63,000 MT of initial heavy metal for commercial waste, 7,000 MT for defense waste)
2. Existing License Completion	90,000 MT = Based on existing spent fuel inventories plus a plant-by-plant extrapolation of future discharges developed using current discharge rates until the end of each operating license, including known license extensions as of 10/2003 – result rounded.
3. Extended License Completion	120,000 MT = Based on existing spent fuel inventories plus a plant-by-plant extrapolation of future discharges assuming on all operating plants having one 20- year extension, result rounded.
4. Continuing Level Energy Generation	250,000 MT = Based on extension of the current average annual spent fuel discharge rate of 2100 MT/yr through the year 2100. No growth in nuclear power compared to today.
5. Continuing Market Share Generation	600,000 MT = Extension of the current average annual spent fuel discharge rate through 2100 with 1.8% compounded market growth starting in 2004. Steady electricity market share for nuclear power compared to today.
6. Growing Market Share Generation	1,500,000 MT = Extension of current average annual spent fuel discharge through 2100 with 3.2% growth in nuclear power. Expands nuclear power market share, including potential entry into transportation market via hydrogen generation.

Closing the fuel cycle could avoid additional repositories this century

Nuclear Futures		Existing License Completion	Extended License Completion	Continuing Level Energy Generation	Continuing Market Share Generation	Growing Market Share Generation
Cumulative spent fuel in 2100 (MTiHM)		90,000	120,000	250,000	600,000	1,500,000
		Existing Reactors Only <-----		-----> Existing and New Reactors		
Fuel Management Approach		**Number of Repositories Needed**				
----> No Recycle	Direct Disposal (current policy)	2	2	4	9	22
	Direct Disposal with Expanded Repository Capacity	1	1	2	5	13
Recycle <----	Limited Thermal Recycle with Expanded Repository Capacity	1	1	1	3	7
	Repeated Combined Thermal and Fast Recycle	(requires new reactors)		1	1	1

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Nuclear Energy is an important part of the world energy solution

- Nuclear energy will enable clean domestic energy production while reducing U.S. dependence on foreign sources
- Nuclear energy will support the growth of economies worldwide
- Nuclear energy will reduce the environmental impact of energy use worldwide
- Expansion of nuclear energy is needed to support growing energy needs
- The Global Nuclear Energy Partnership will ensure the safe, secure expansion of nuclear energy

Nuclear Energy will contribute to a more secure and prosperous tomorrow