

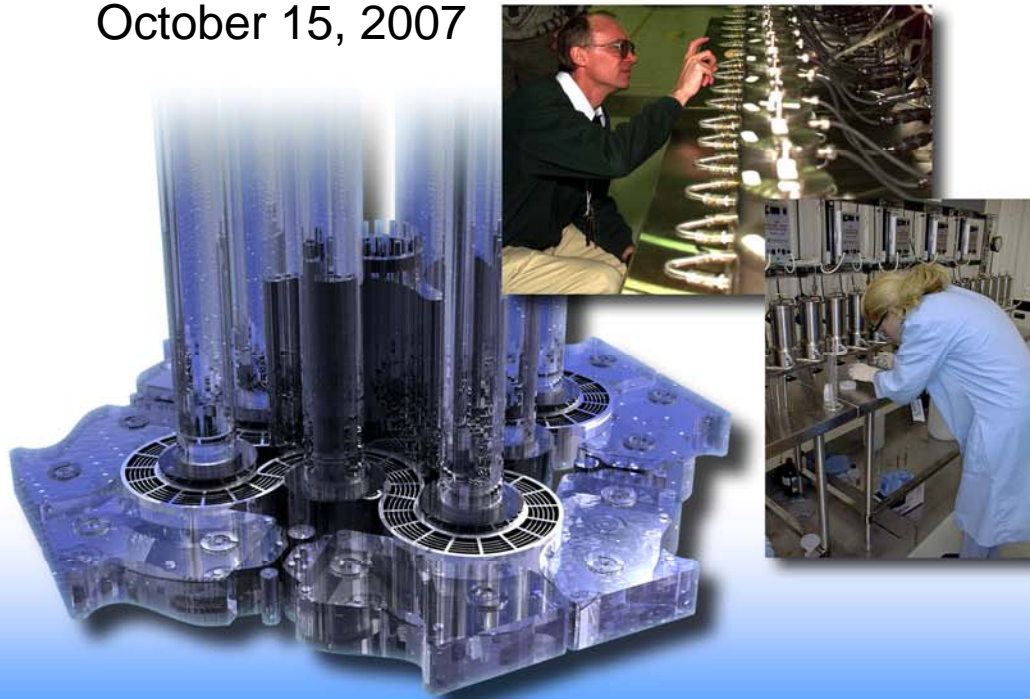
Clean, Safe Nuclear Energy

The Energy Challenge 2007 Industrial Physics Forum

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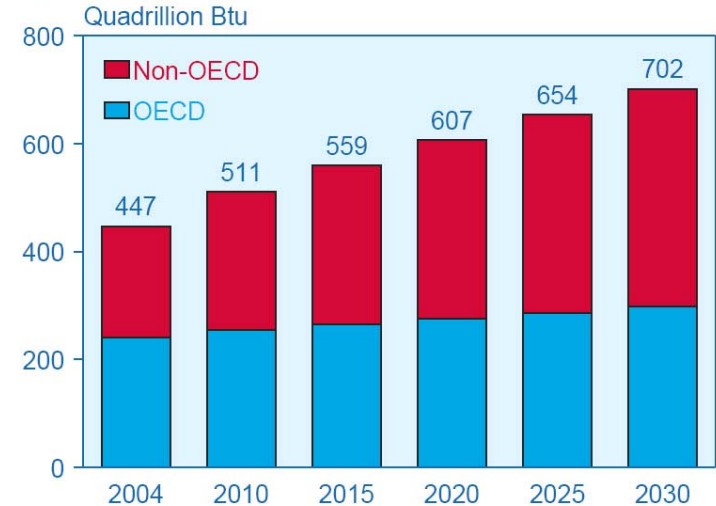
October 15, 2007



World energy demand is growing substantially

- World energy consumption to increase by 57 percent through 2030
- Total energy demand in non-OECD countries will increase by 95 percent compared to 24% in OECD.
- Uncertainty of supply and price of natural gas and volatility of oil
- Challenge of lowering greenhouse gas emissions and mitigating global warming

World Marketed Energy Consumption by Region, 2004-2030



Sources: **2004:** Energy Information Administration (EIA), *International Energy Annual 2004* (May-July 2006), web site www.eia.doe.gov/iea. **Projections:** EIA, System for the Analysis of Global Energy Markets (2007).

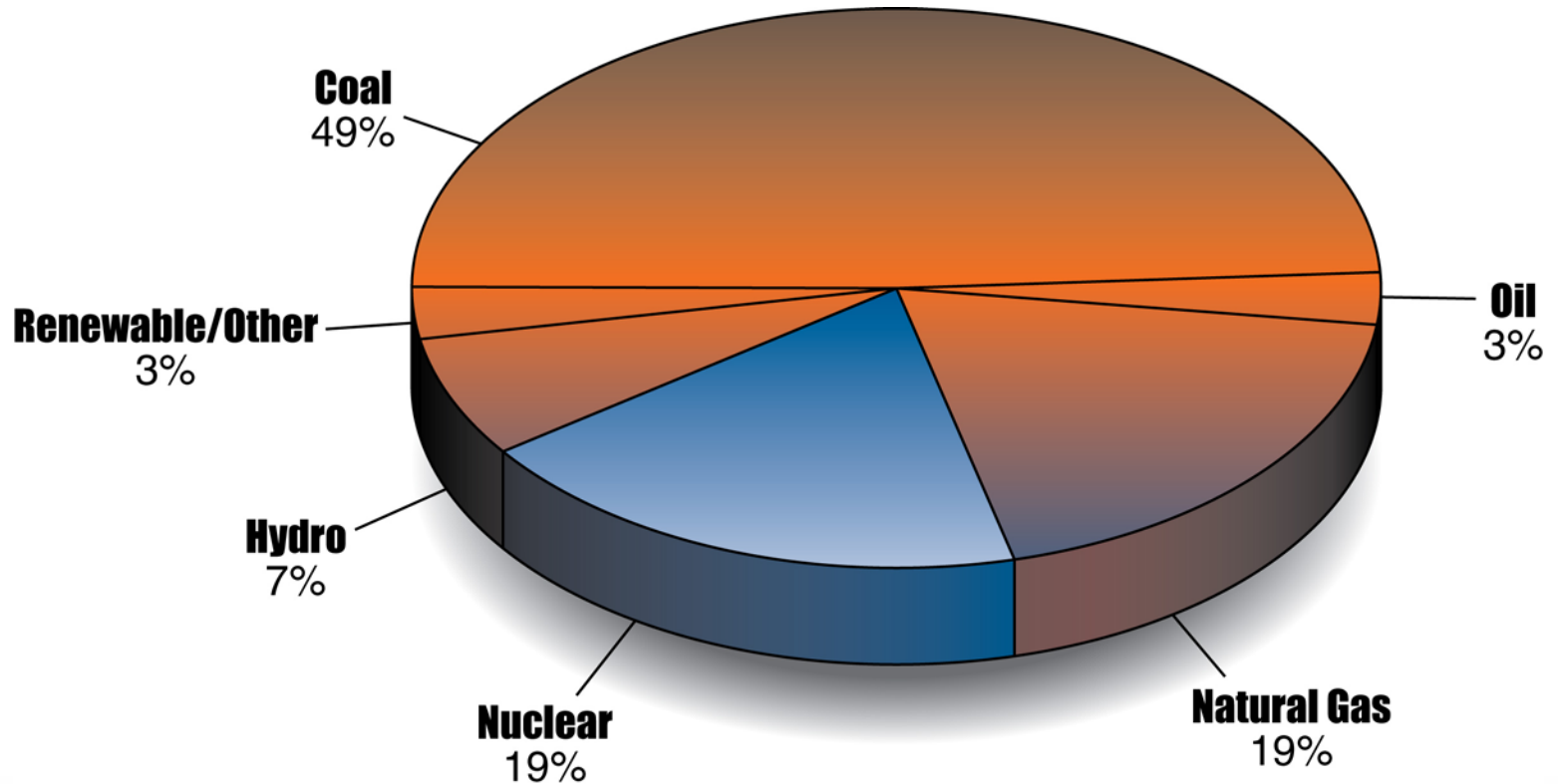
The world is turning increasingly to nuclear energy for sustainable development

U.S. energy outlook today: a balanced portfolio

- **Energy efficiency**
- **Baseload capacity**
 - **Nuclear power** - Near zero emission
 - **Fossil fuels** - Sustainable with hydrogen, carbon sequestration and clean coals
- **Peak load capacity**
 - **Solar** - Renewable, distributed power
 - **Wind** - Peak loading balancing
 - **Hydroelectric** - Best sites in use, future small scale production
 - **Geothermal** - TBD



U.S. electricity net generation (thousand megawatt hours)



Nuclear energy benefits reflected in U.S. policy and politics



It's in our vital interest to diversify America's energy supply -- the way forward is through technology. We must continue changing the way America generates electric power, by even greater use of clean coal technology, solar and wind energy, and clean, safe nuclear power.

President George W. Bush (*State of the Union, January 23, 2007*)

... In the early days of my life in Congress, I was an opponent of nuclear energy because of questions on how to dispose the waste...the technology has changed and I bring a more open mind to that subject now because I think we should look at this technology, and compare it to the alternatives...it has to be on the table."

House Speaker Nancy Pelosi (*February 8, 2007*)

American attitudes toward nuclear energy have changed – 7 out of 10 Americans favor nuclear energy for electricity

News headlines affirm renaissance



Investing In The Mighty Atom

Paul M. Murdock, 03.07.07

“Now, with rising geopolitical tensions and growing concerns about petroleum supplies and global warming, discussion of the "nuclear option" is back in vogue.”



Brown's Vision for a Nuclear Britain

“Gordon Brown, U.K. Prime Minister Elect, to give the go-ahead for a new generation of nuclear power stations...to signal support for a dramatic renewal of nuclear power ... that will see the building of up to 8 new stations, possibly within 15 years.”

May 20, 2007 (Reported in The Guardian)



60 MINUTES



CBS NEWS VIDEO

France: Vive Les Nukes

Steve Kroft, 04.08.07

“...what the world needs now is an efficient means of producing large amounts of carbon free energy. One of the few available options is nuclear, a technology whose time seemed to come and go and may now be coming again.”

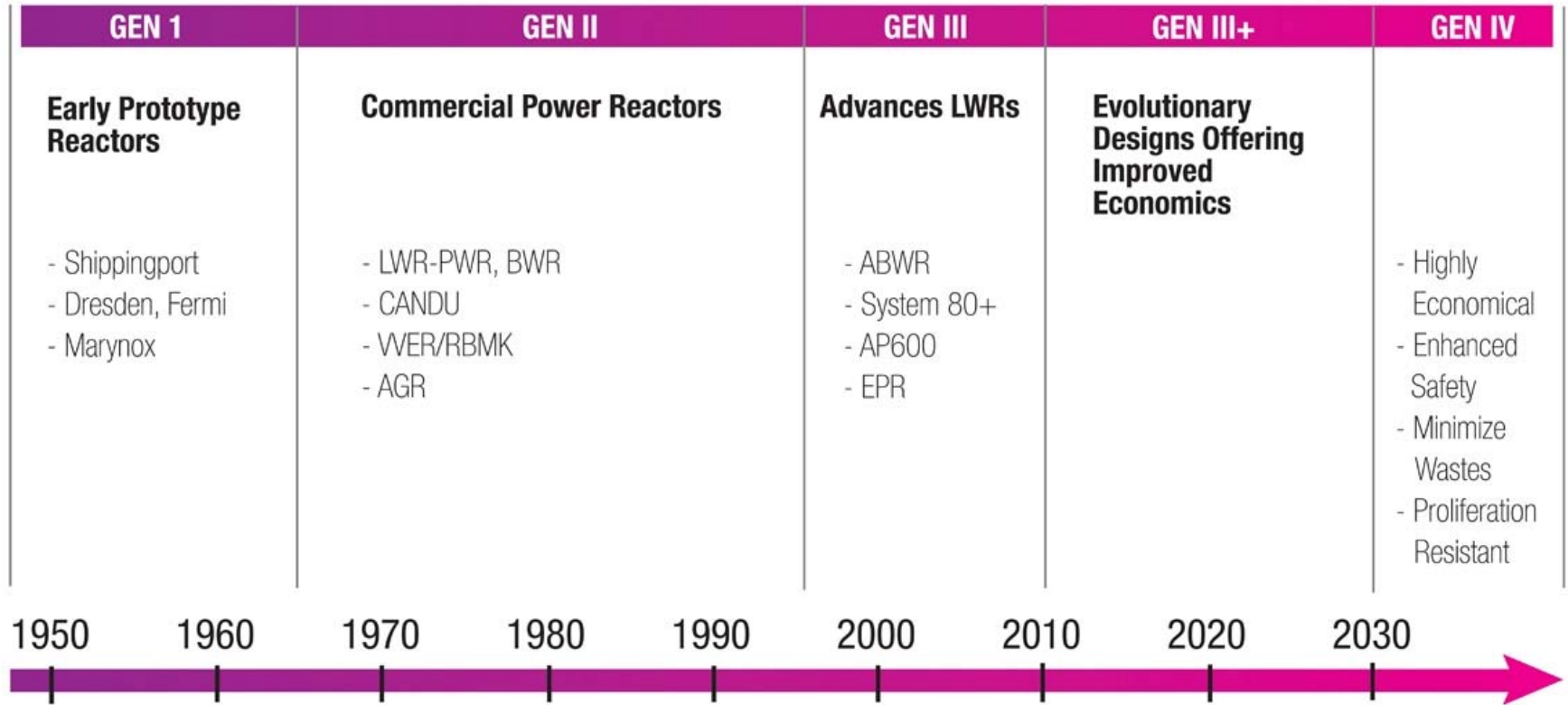


Europe warms to nuclear energy

Jeffrey Stinson, 06.04.07

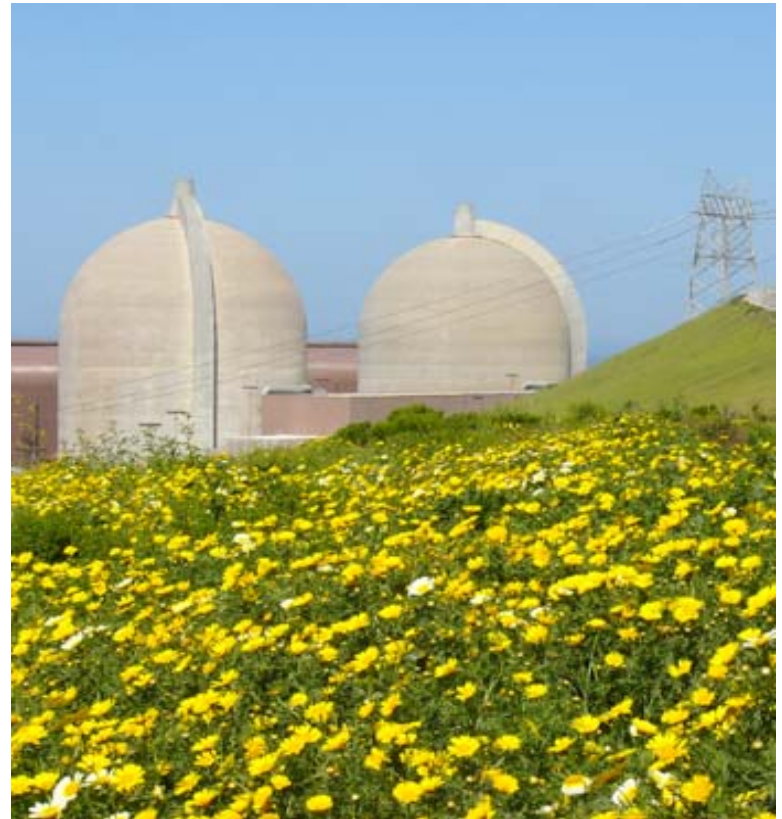
Source gets new look amid climate change, rising oil and gas prices

Expanding reactor options



Generation III: solid nuclear power plant economics

- Strong safety record
- High average capacity factor
 - 89.8% in 2006
- Decreasing production costs
 - 30 percent in the last ten years
 - 1.66 cents/KWH in 2006
- Performance excellence through power uprates
 - Gain of 4,183 MWe
- Renewals continue
 - 48 complete
 - 38 filed or announced
- Life after 60?



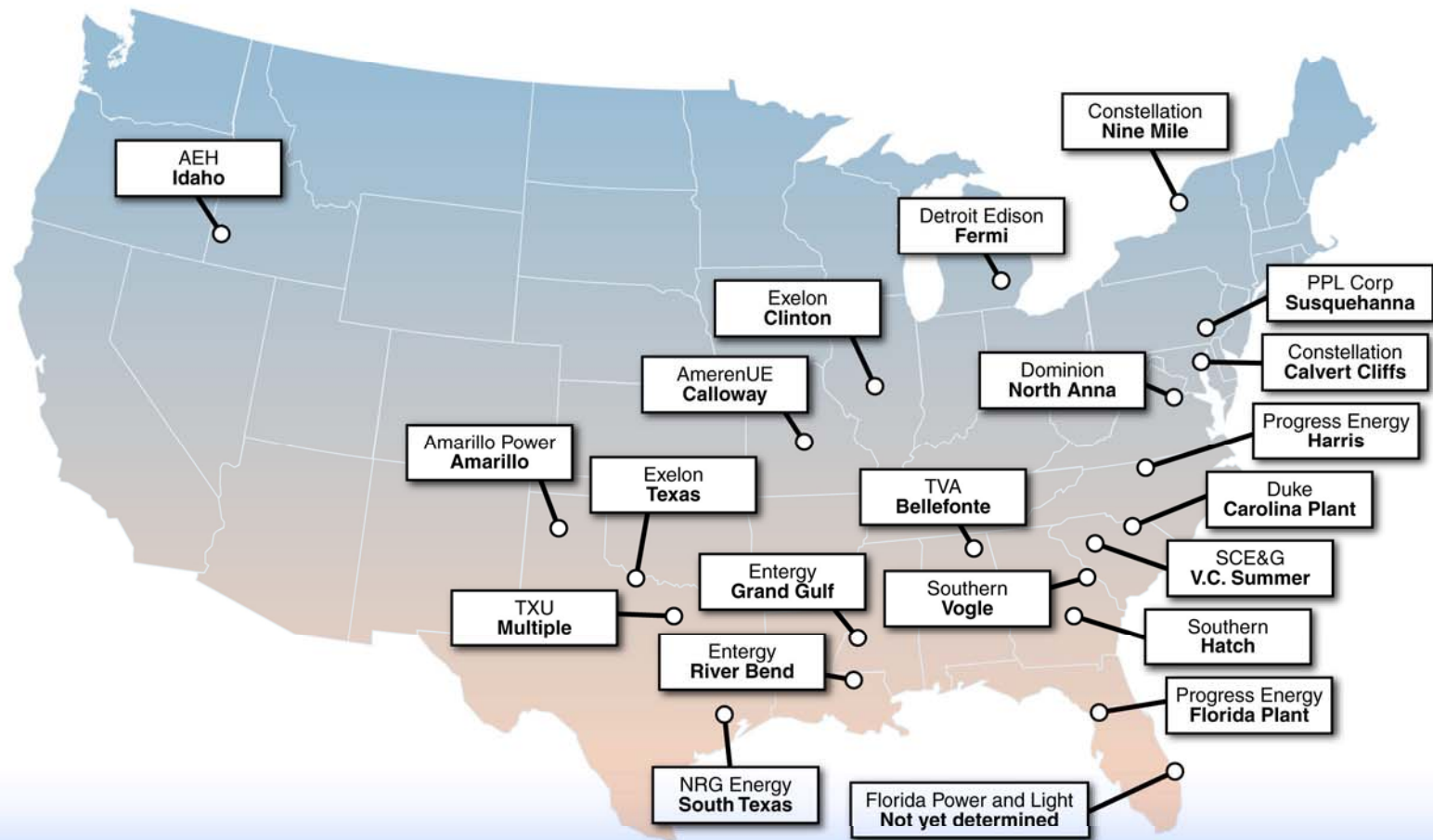
In 2006, nuclear energy represented 71 percent of U.S. emission free generation, roughly equivalent to annual passenger car emissions

Generation III+ : building a new generation of nuclear power plants

- NRC accepting applications for design certifications and operating licenses
- Nuclear Power 2010 launched by DOE in 2002
 - Reduces technical, regulatory and institutional barriers to building new plants
 - Shares costs between government and private industry to meet future energy needs
- EPACT 2005 enacted federal risk insurance, production tax credits and loan guarantees for low emission technologies
 - DOE final rules offer guarantees for 100% of project debt, up to 80% of project cost



More than 30 notifications to NRC from potential first movers



Generation IV: developing advanced nuclear energy systems



U.S.A.

Russia

Switzerland

South
Korea

South
Africa

Japan

France

Canada

China

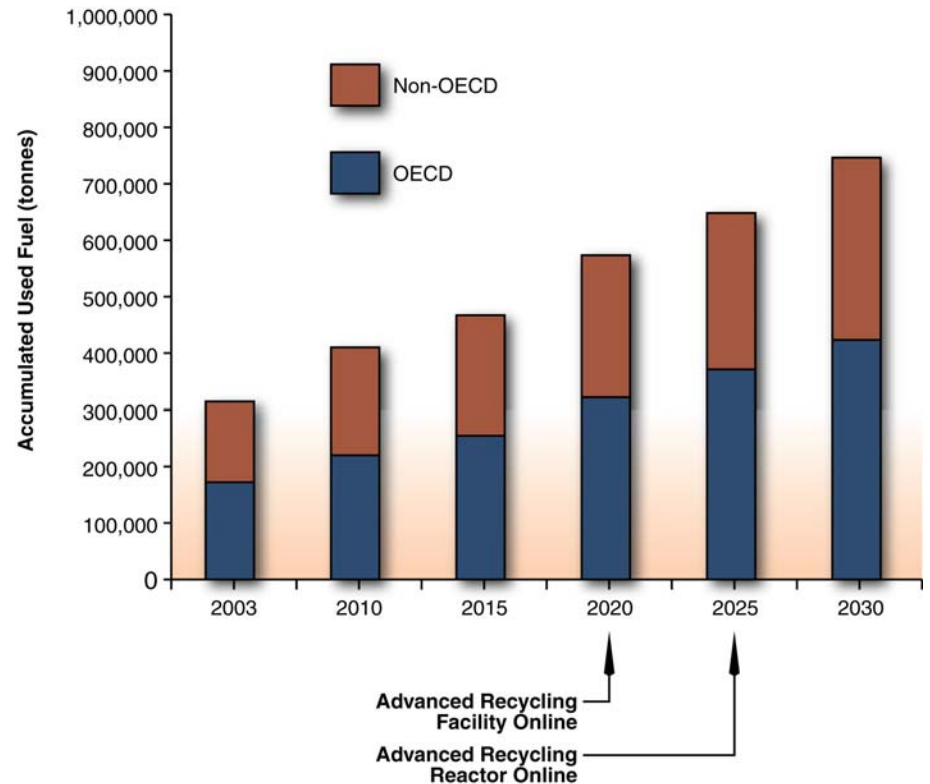
Euratom

- Governments sponsoring R&D necessary to establish the viability of next generation nuclear energy systems
- Requirements/challenges
 - U.S. focus is on very high temperature reactor (VHTR) for process heat and hydrogen, and sodium cooled fast reactor (SFR) for actinide burning
 - System arrangements for SFR and VHTR were signed last year
 - Project arrangement for SFR advanced fuels signed this year
 - Numerous other project arrangements nearing signature
 - Significant benefit to investment from international collaboration

Globalizing the benefits of nuclear energy: a closed fuel cycle is necessary

- As nuclear expands, a greater number of states will consider developing their own fuel cycle facilities
- Nuclear waste will become a major issue for global expansion of nuclear energy
- In the longer-term future, uranium resources could be strained

A global partnership and advanced recycling technologies are needed to ensure that nuclear energy expands safely and securely



Global Nuclear Energy Partnership launched in February 2006

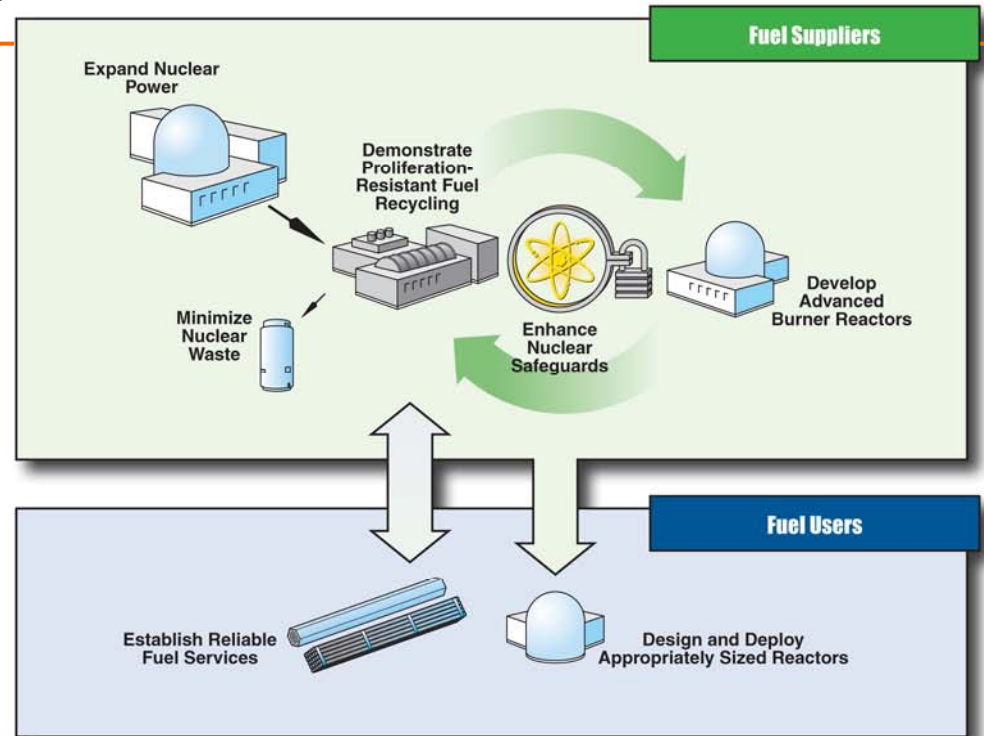
- GNEP proposed to establish the foundation for safe and secure expansion of nuclear energy in the U.S. and worldwide
 - President's FY 2007 budget proposes \$250M
 - FY 2008 budget proposes \$405M, including \$10M for safeguards technologies
 - Broad international support for GNEP



“...my Administration has announced a bold new proposal called the Global Nuclear Energy Partnership...we will develop and deploy innovative, advanced reactors and new methods to recycle spent nuclear fuel.”

International elements of GNEP support nonproliferation efforts

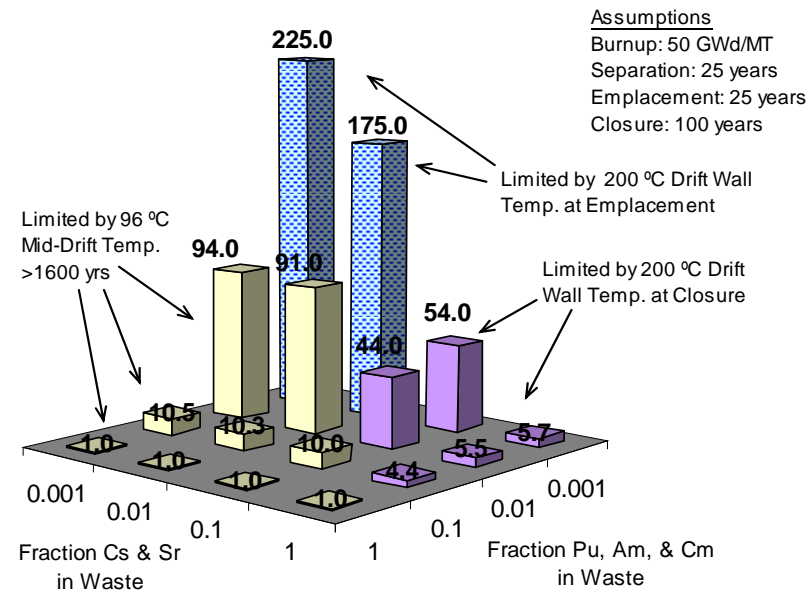
- **Fuel Suppliers:** Operate reactors and fuel cycle facilities, including fast reactors to transmute the actinides from spent fuel into less toxic materials
- **Fuel Users:** Operate reactors, lease and return fuel
- **IAEA:** Provide safeguards and fuel assurances, backed up with a reserve of nuclear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



GNEP makes diversion and misuse of fissile materials more difficult, more costly, and acquisition of sensitive fuel cycle technologies more difficult to justify as part of a peaceful nuclear program

GNEP reduces environmental burden of nuclear waste

Potential Drift Loading Increase Factor for Spent LWR Fuel

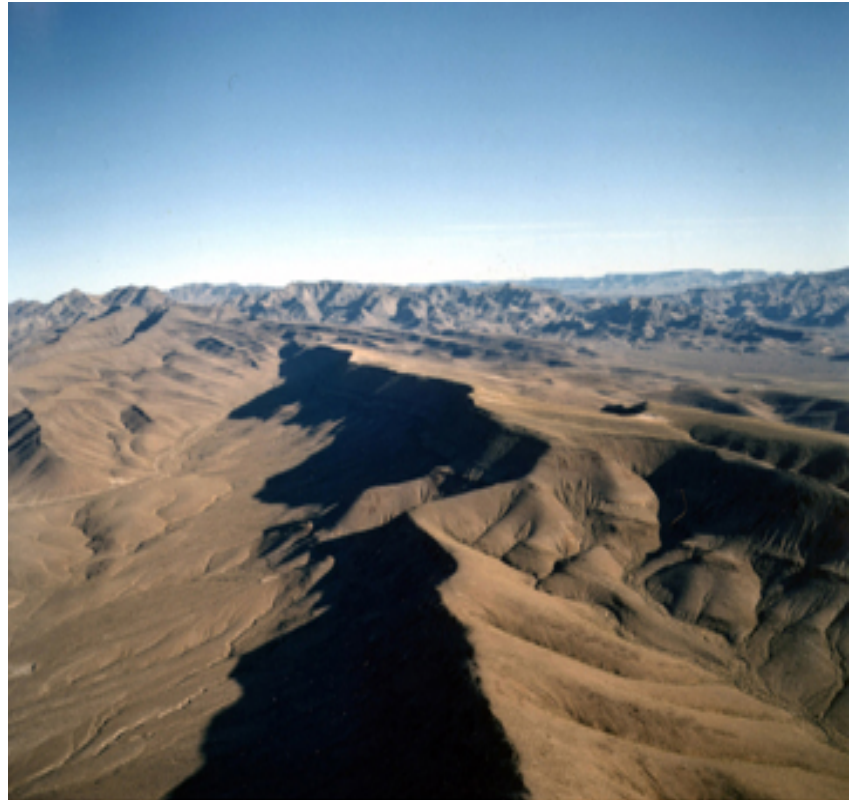


- Spent nuclear fuel is processed to remove the most hazardous radionuclides, e.g., the actinides
 - Substantially lowers environmental impact per unit of energy produced
 - Enables options for far greater utilization of a repository
 - Repository loading is constrained by temperature limits that are reached due to decay heat generation
- Processing must also remove fission products to limit decay heat
- Yucca Mountain is needed regardless of fuel cycle scenario

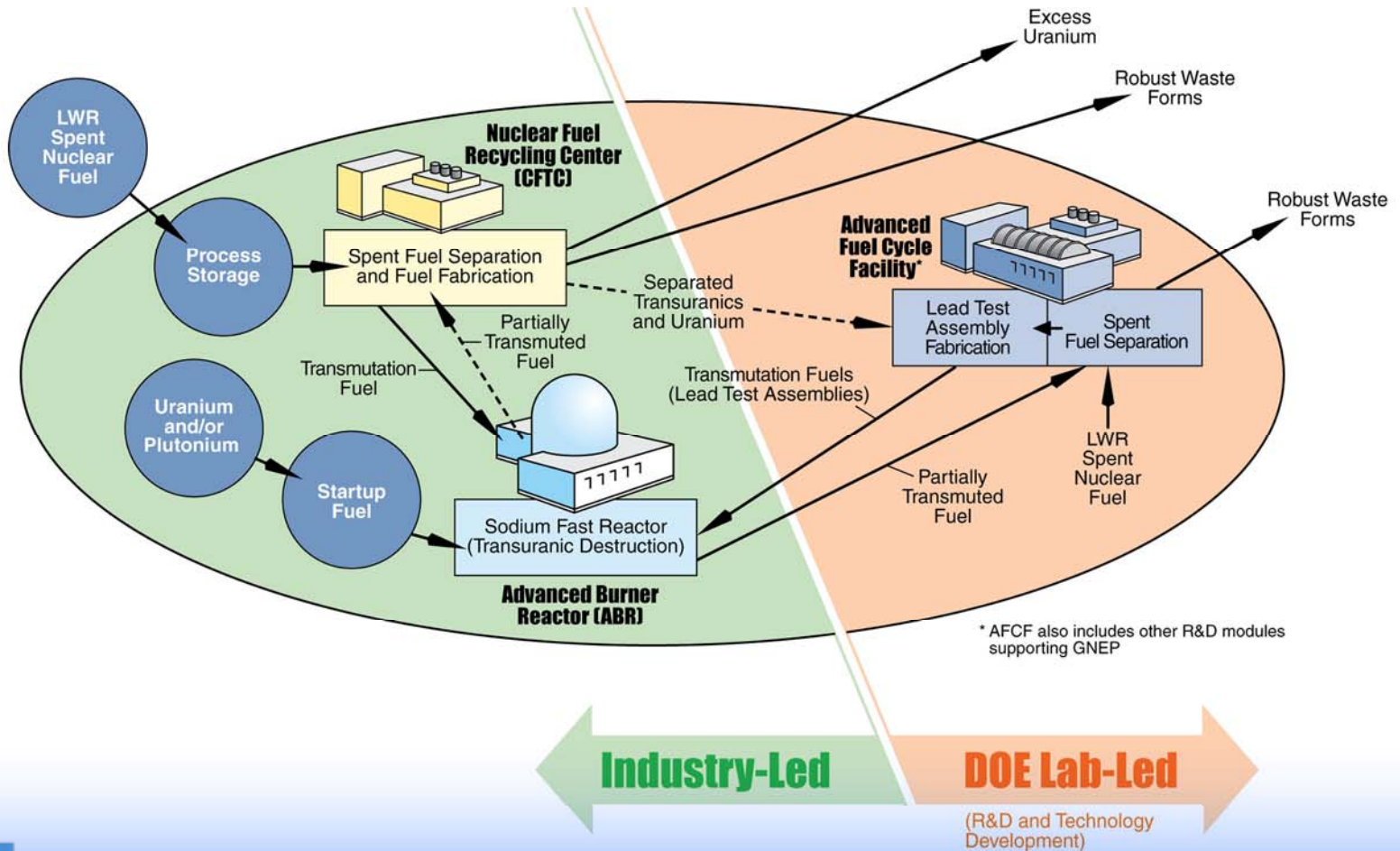
GNEP strategy will also enable greater utilization of energy content contained in nuclear fuel

GNEP is compatible with development of the geologic repository

- Licensing process for the repository proceeding in parallel with demonstration of an advanced fuel cycle
- Licensing regulations allow for subsequent license amendment as required to accommodate waste forms from an advanced fuel cycle
- Processing the spent nuclear fuel, would result in geological disposal of waste much less hazardous, creating options for use of geologic repository space
- **DOE has recently proposed doubling the statutory capacity of Yucca Mountain**



GNEP technology facilities



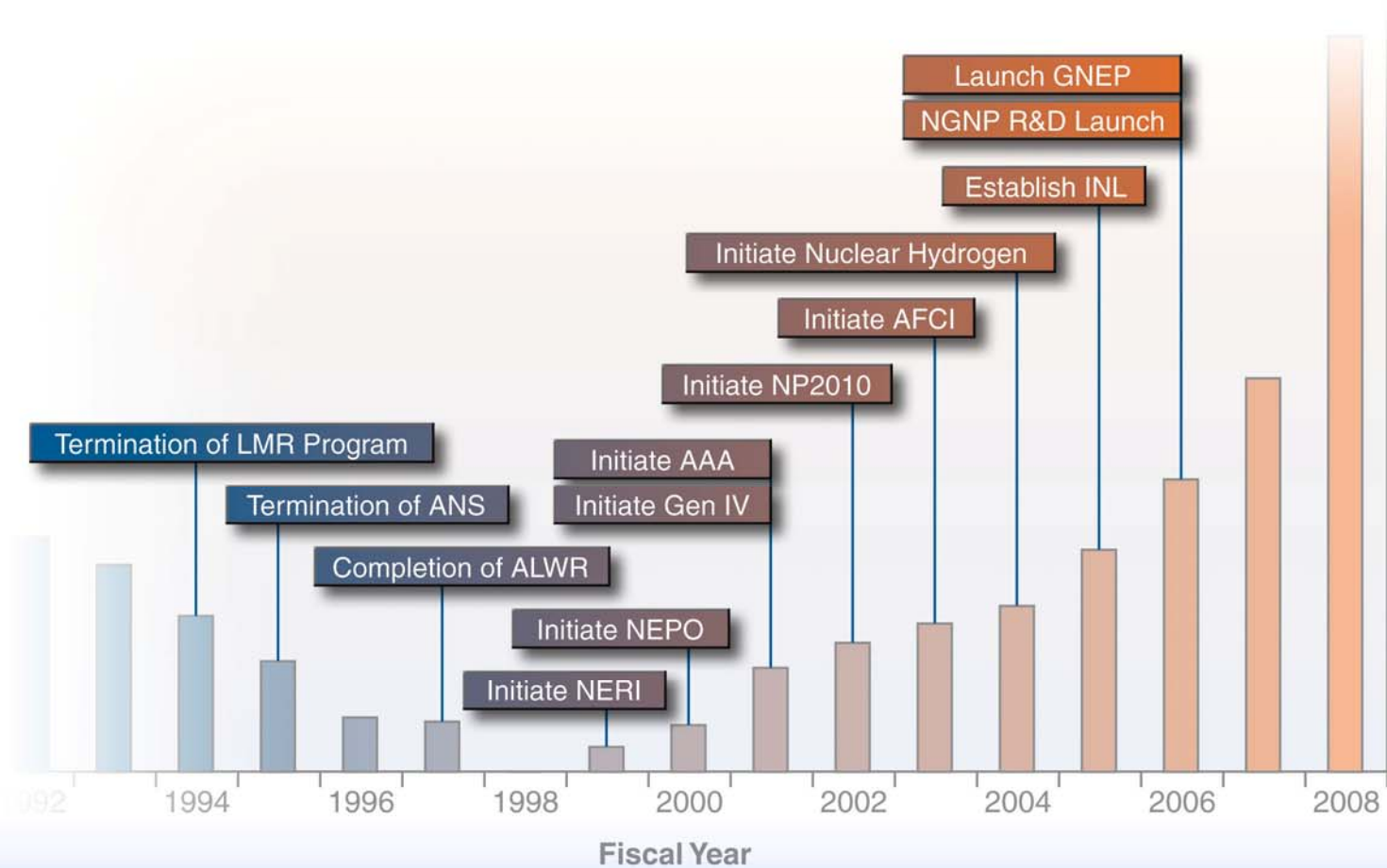
International support for GNEP is strong

- U.S. has engaged with advanced fuel cycle countries, reactor and candidate reactor countries
- U.S. and five other supplier nations proposed reliable fuel supply initiative at IAEA GC September 2006
- Co-sponsored IAEA workshop on infrastructure needs for developing countries (Dec 2006)
- Bi-lateral civil nuclear cooperation agreements in place with Russia and Japan



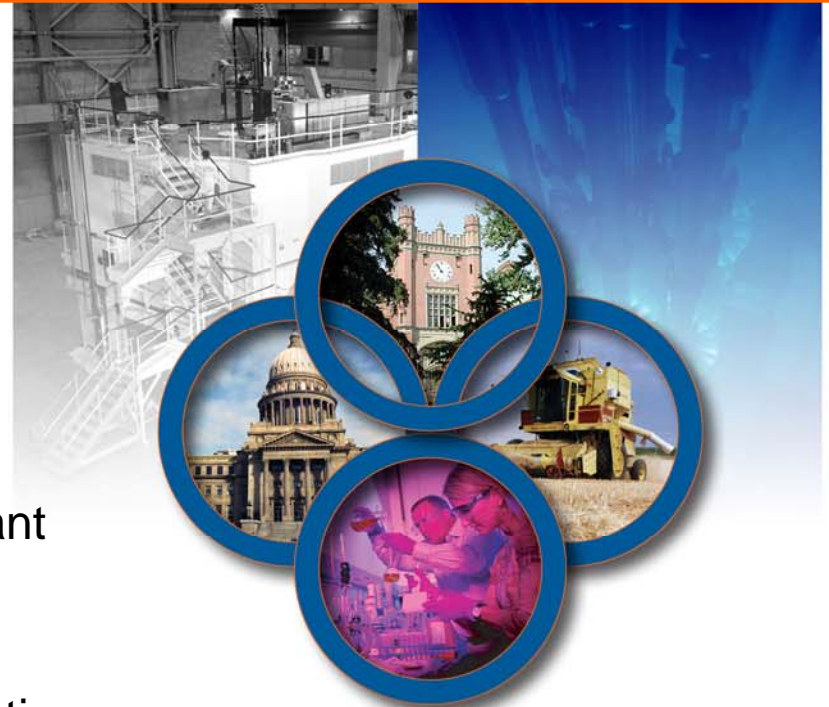
May and September 2007 Ministerial Meetings result in 16 countries joining GNEP and signing Statement of Principles

U.S. nuclear energy research investment is rebounding



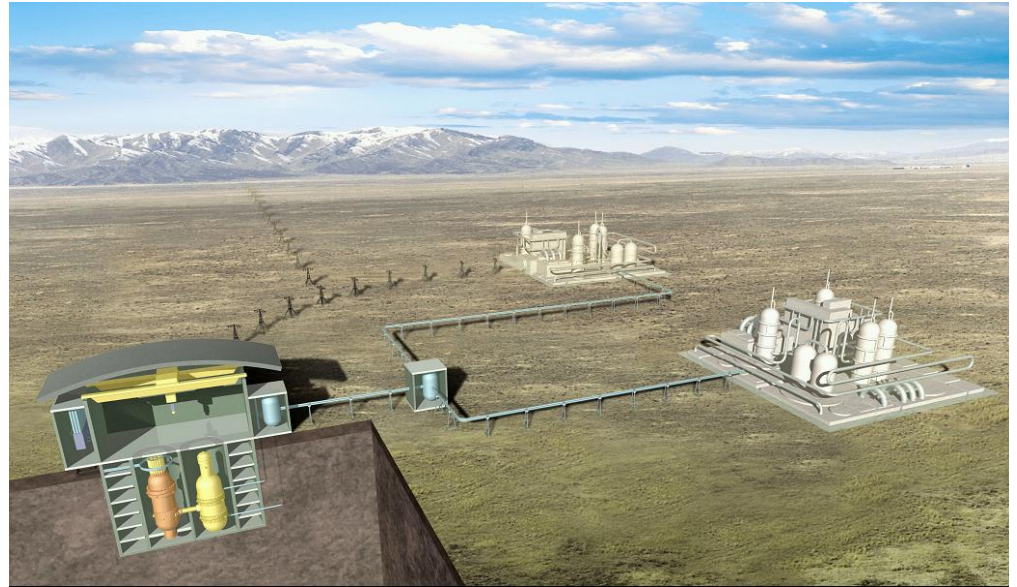
Idaho National Laboratory: building on our nuclear energy legacy

- INL laid the foundation for today's nuclear power plants
- As the NE lab, advance the R&D programs of the Department and serve a systems integration role in cooperation with other labs, universities, international partners, industry
 - Gen IV/Next Generation Nuclear Plant
 - GNEP
 - Life after 60?
- Creation of user facilities are key to creating a national nuclear lab
- Nuclear systems integration and materials knowledge directly transfers to other energy and research needs



Next Generation Nuclear Plant: moving Gen IV nuclear technologies to the market

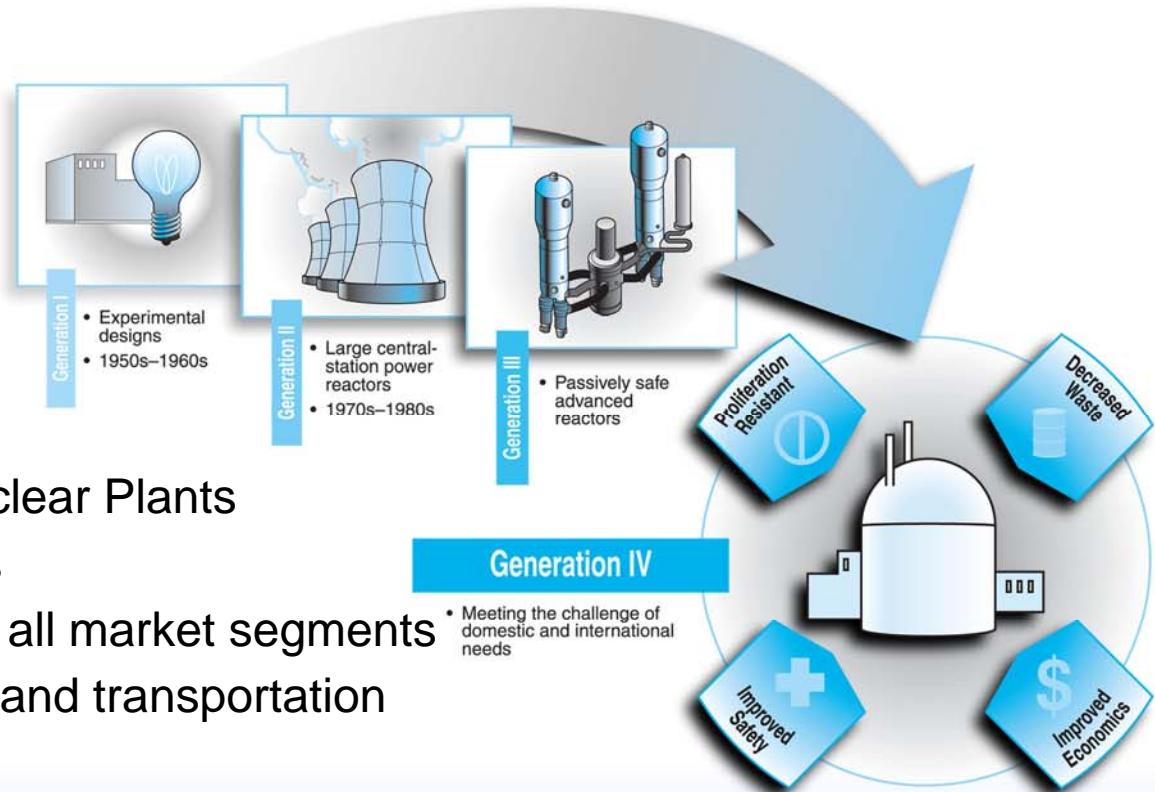
- Advanced reactor technology for process heat, hydrogen and electricity
 - Bringing nuclear to the industrial energy market
- Requirements/challenges
 - Particle fuels development
 - Graphite and high temperature materials development
 - VHTR Design and Safety Analysis Computational Methods
 - Requires infrastructure, hardware and computational investments
 - Requires regulatory framework



A public/private alliance leads the development of NGNP

The nuclear renaissance has begun

- Global expansion of nuclear energy has begun
- Moving to a closed fuel cycle is a necessary evolution
 - But when?
- International support for GNEP is strong and moving forward
- Expanded energy options
 - Gen III+ LWRs
 - Next Generation Nuclear Plants
 - Sodium fast reactors
- Using nuclear energy in all market segments
 - Electricity, industrial and transportation
 - Waste management
- When will a new build occur in the U.S.?



Supplementary Material



Clean and reliable electricity

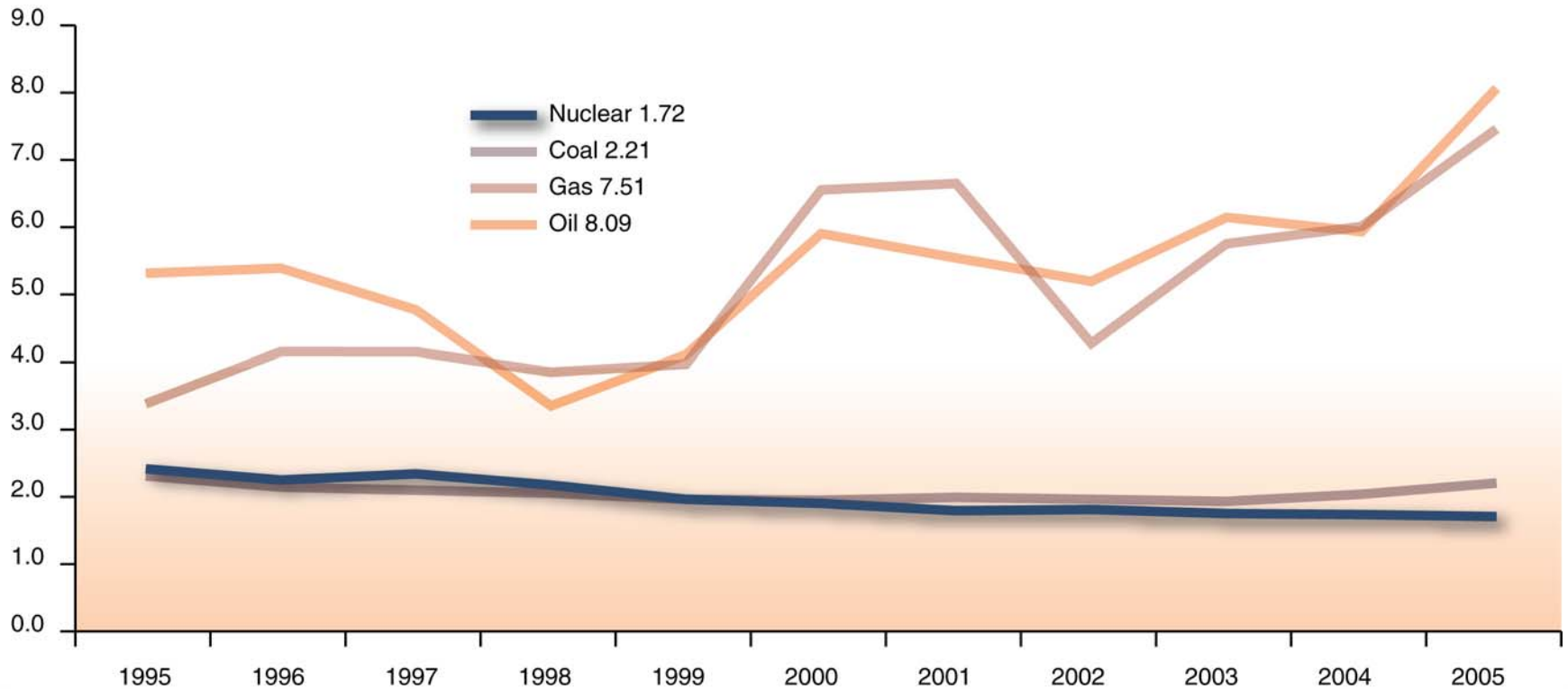
- Nuclear generated electricity in the U.S. avoids about 700 M MT of CO₂ annually
- Life cycle emissions are comparable to wind, geothermal, and hydro

The Environmental Protection Agency (EPA) identifies the following average emission levels in the production of 1 MWh of electricity, pounds of Emissions per MWh

Emissions (\$)	Coal	Oil	Natural Gas	Nuclear
Carbon Dioxide	2,249	1,672	1,135	0
Sulfur Dioxide	13	12	0.1	0
Nitrogen Oxide	6	4	1.7	0

U.S. electricity production costs

1995-2005 (averages in 2005 cents per kilowatt-hour)



New nuclear plant status

Utility	Site/State	Technology	COLA Submission Expected Date
Dominion	North Anna, VA	ESBWR (1 unit)	November 2007
NuStart (TVA)	Bellefonte, AL	AP1000 (2 units)	October 2007
NuStart (Entergy)	Grand Gulf, MS	ESBWR (1 unit)	November 2007
Entergy	River Bend, LA	ESBWR (1 unit)	May 2008
Southern Nuclear	Vogtle, GA	AP1000 (2 units)	March 2008
NRG	South Texas Project, TX	ABWR (2 units)	Submitted Sept 2007
Exelon Generation	Undeclared, TX	Unspecified (1 unit)	November 2008
Amarillo Power	Undeclared, TX	EPR (2 units)	4 th Qtr 2008
TXU	Comanche Peak, TX	US-APWR (2 units)	July 2008

New nuclear plant status (continued)

Utility	Site/State	Technology	COLA Submission Expected Date
Florida Power & Light	Undeclared, FL	Unspecified	2009
UniStar	Calvert Cliffs, MD Nine Mile Point, NY	US-EPR (1 unit) US-EPR (1 unit)	March 2008 4 th Qtr. 2008
Progress Energy	Harris, NC Levy County, FL	AP1000 (2 units) AP1000 (2 units)	January 2008 July 2008
SCE&G	Summer, SC	AP1000 (2 units)	November 2007
Ameren UE	Callaway, MO	US-EPR (1 unit)	3 rd Qtr. 2008
Detroit Edison	Fermi, OH	Unspecified (1 unit)	October 2008
PPL	Susquehanna, PA	US-EPR (1 unit)	Late 2008
Duke	William Lee, SC	AP1000 (2 units)	October 2007
Alternate Energy Holdings	Bruneau, ID	Unspecified	2009