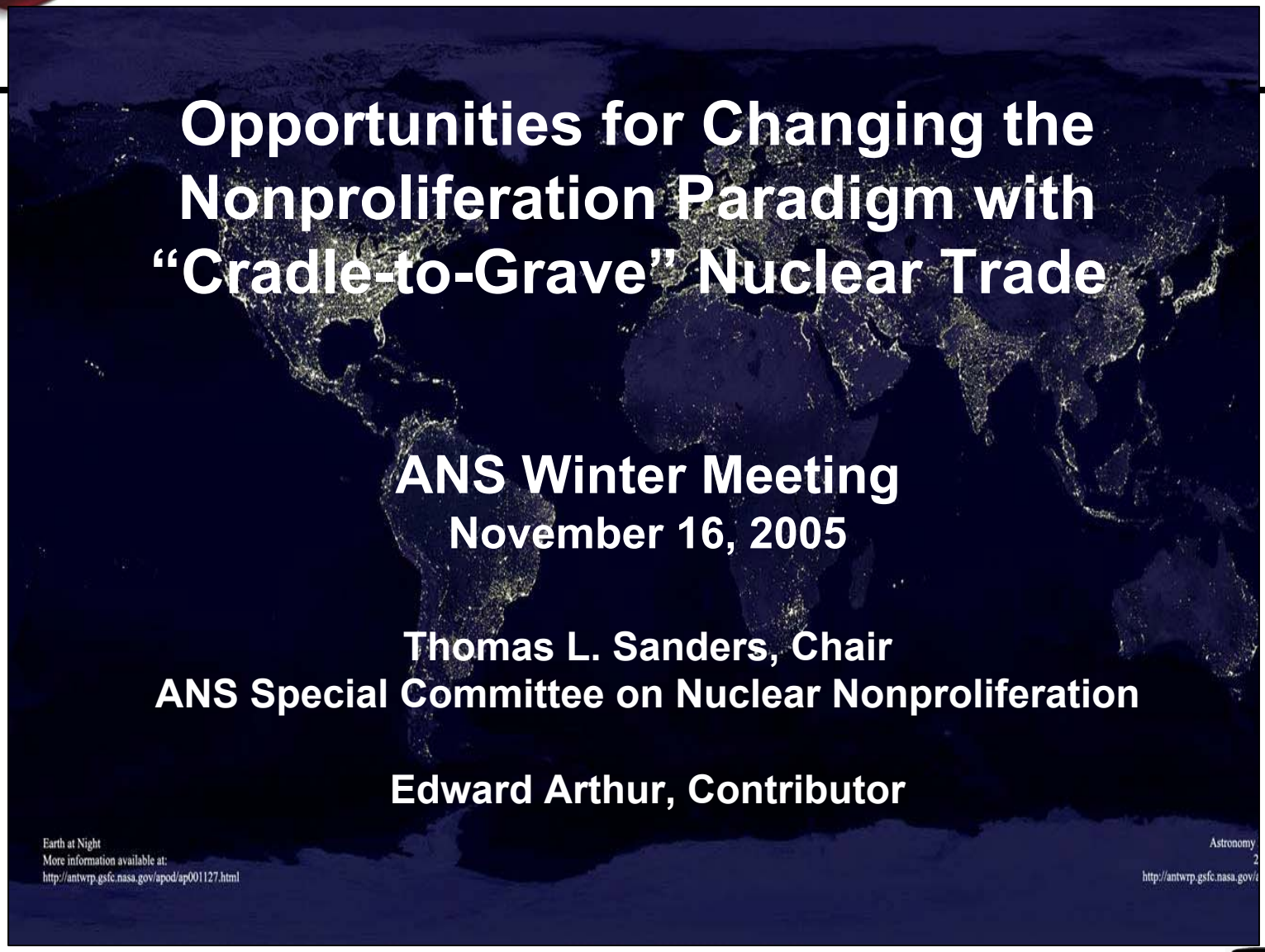
SAND2005-7238C



Opportunities for Changing the Nonproliferation Paradigm with "Cradle-to-Grave" Nuclear Trade

ANS Winter Meeting
November 16, 2005

Thomas L. Sanders, Chair
ANS Special Committee on Nuclear Nonproliferation

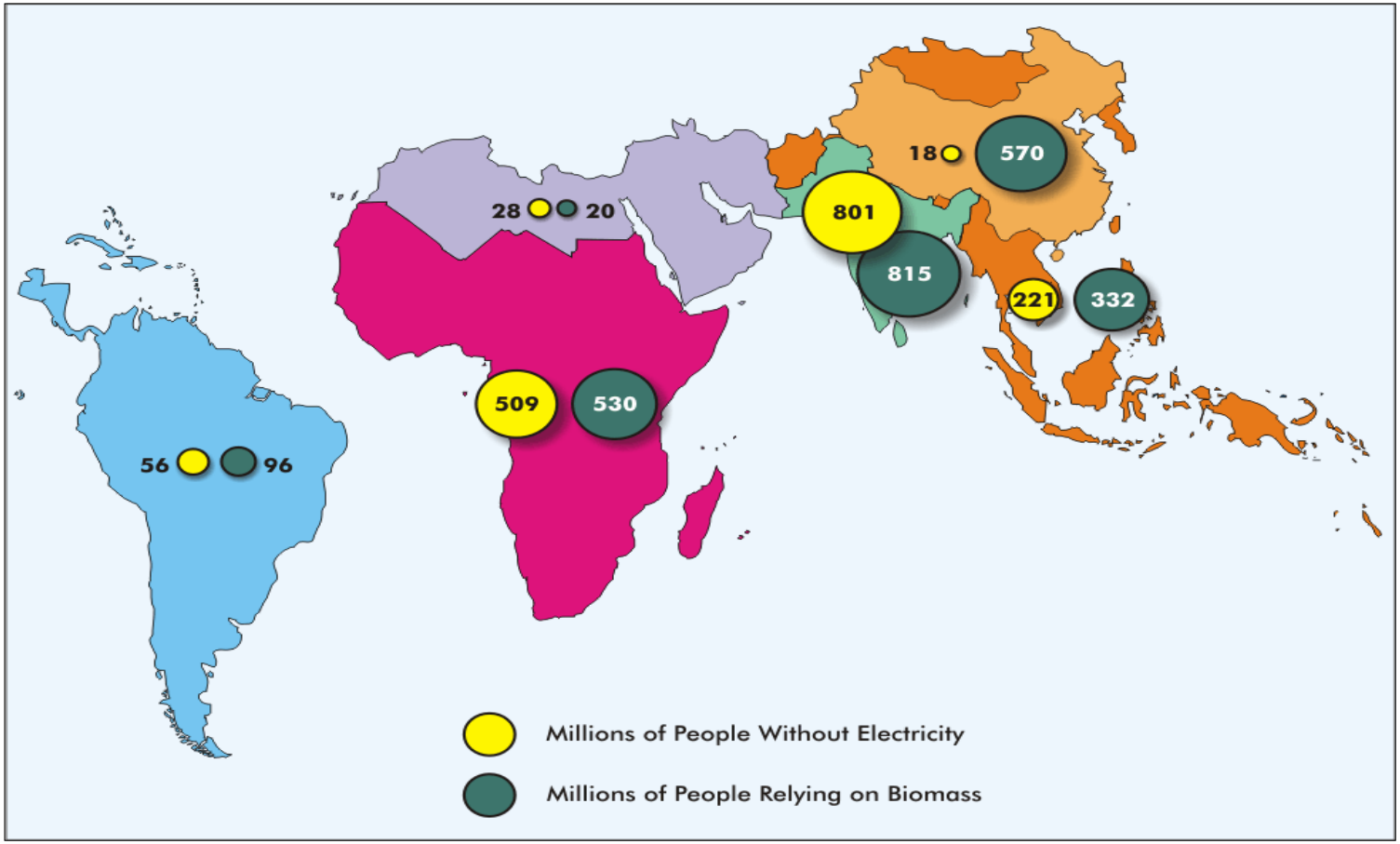
Edward Arthur, Contributor

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

Sandia National Laboratories

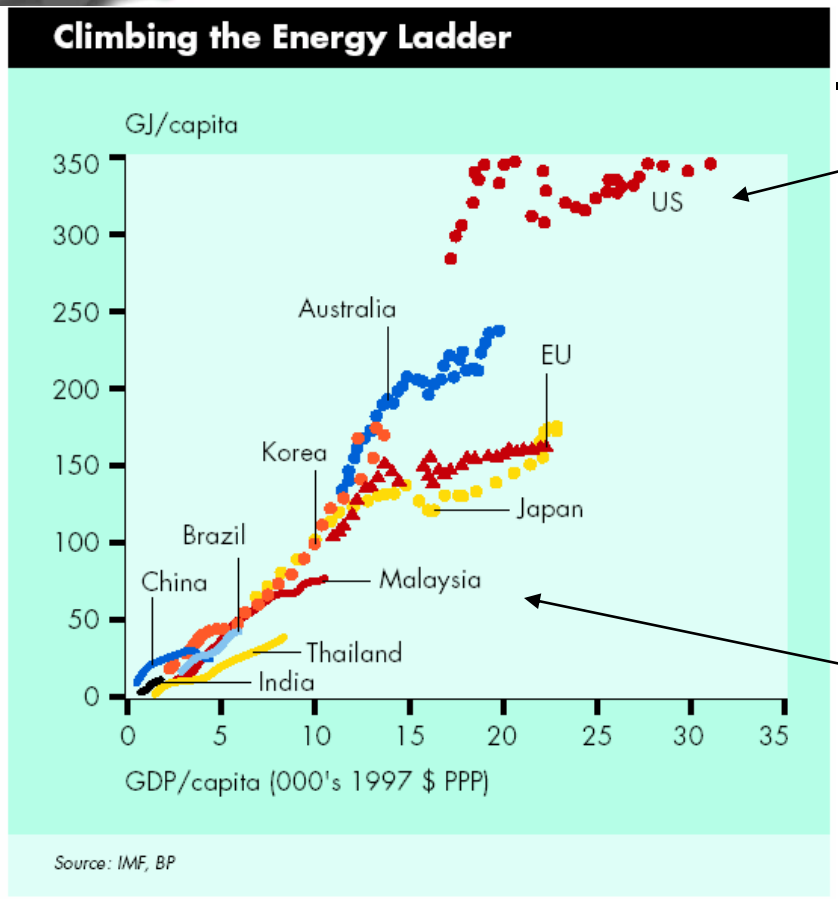
Today 1.6 billion People Have No Access to Electricity

and Rely on Biomass (Burning) to Meet Their Energy Needs



Sandia National Laboratories

National Security, Energy Security, Economic Prosperity, & Environmental Quality are essential ingredients of Global Peace & Prosperity



- Sustained U.S. prosperity is not possible with our current energy posture
  - We are 6% of world population using 30% of its resources
  - We import 2/3 oil from unstable regions
  - Natural gas is being used unnecessarily for electricity generation at the expense of other industry sectors
  - Environmental insults continue as a result of current fossil energy production technologies
  - Nuclear and coal are the only significant domestic resources
- We must sustain our own prosperity while reducing the resource gap,
  - Globally, an order of magnitude increase in today's energy consumption would be needed to achieve a minimum standard of living near that of Malaysia's, by 2050
  - There is a huge potential for conflict over access to energy resources

Nuclear Energy is playing a dominant and increasing role in global economic expansion.

President Dwight D. Eisenhower
Atoms for Peace - 1953

Serve the peaceful pursuits of mankind . . .

. . . provide abundant electrical energy in power starved areas of the world

. . . encourage world-wide investigations with the most effective peacetime uses of fissionable material

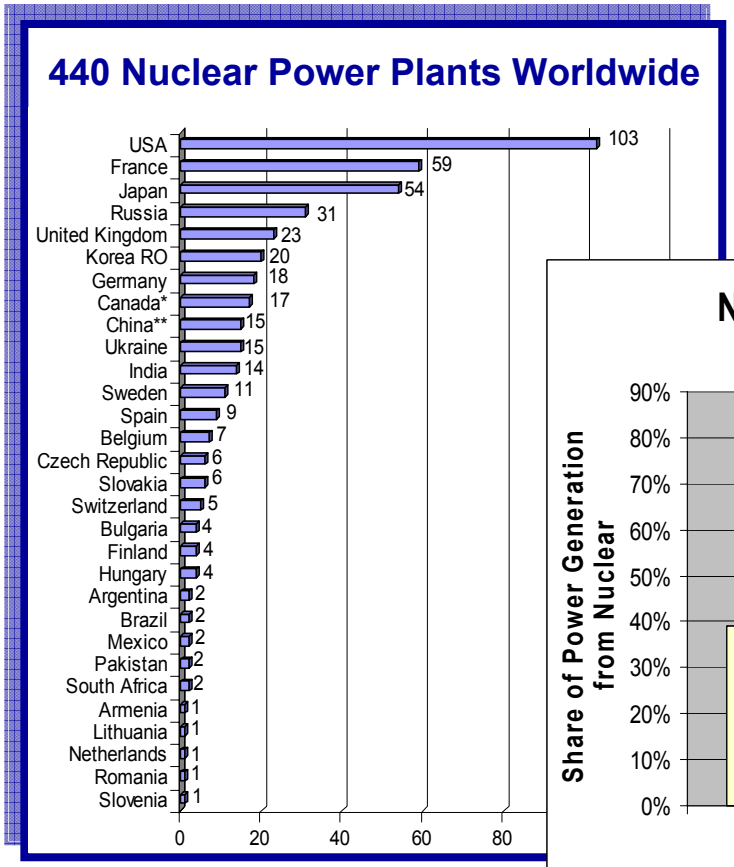
Create international controls to prevent proliferation (IAEA)

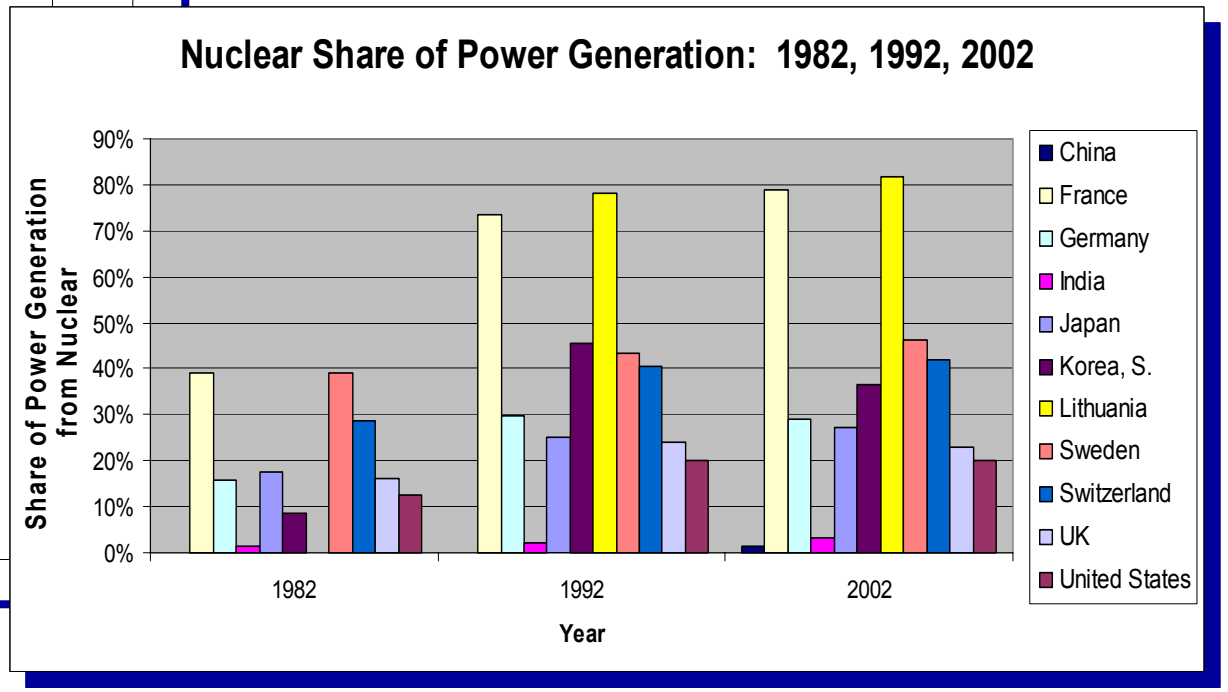
"Peaceful power from atomic energy is no dream of the future. That capability, already proved, is here now - today."

President Eisenhower,
" Atoms for Peace," - December 8, 1953

Sandia National Laboratories

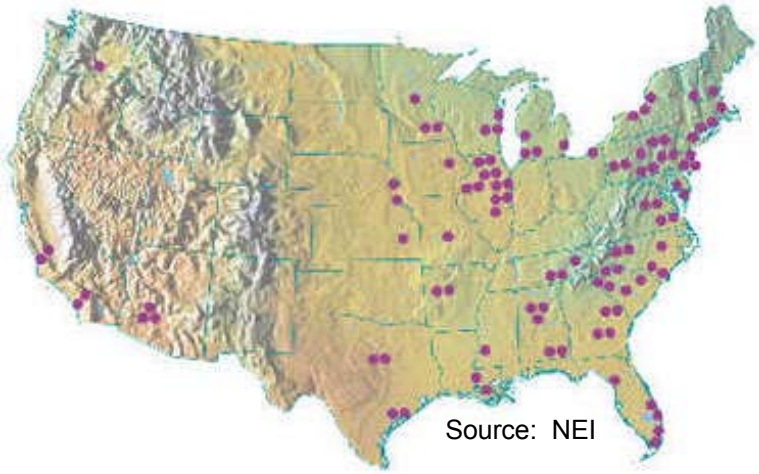
Nuclear is an Important Contributor to Power Generation in Many Countries





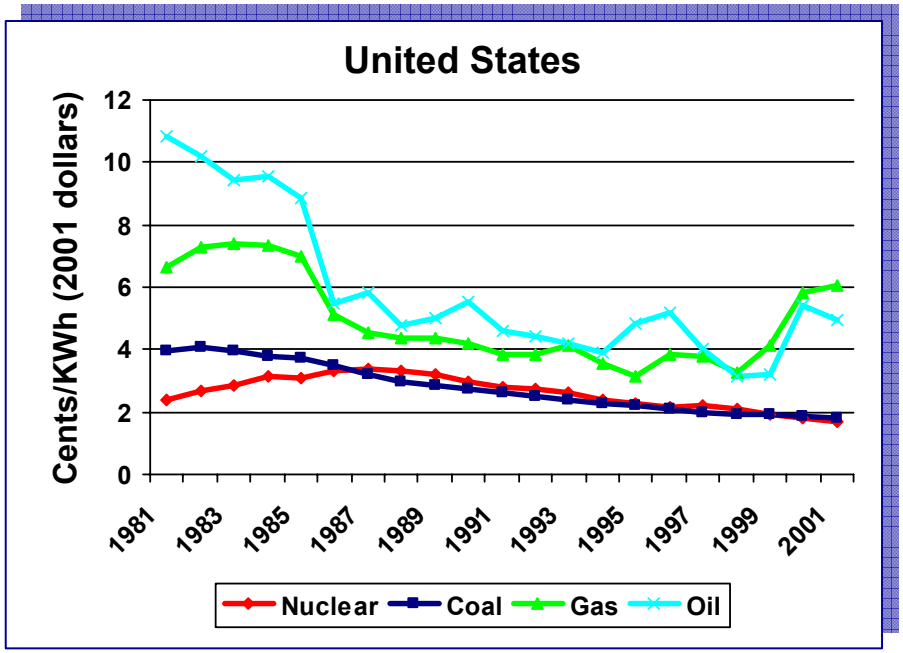
Sandia National Laboratories

Nuclear Energy in the US Has Performed Very Well


Source: NEI

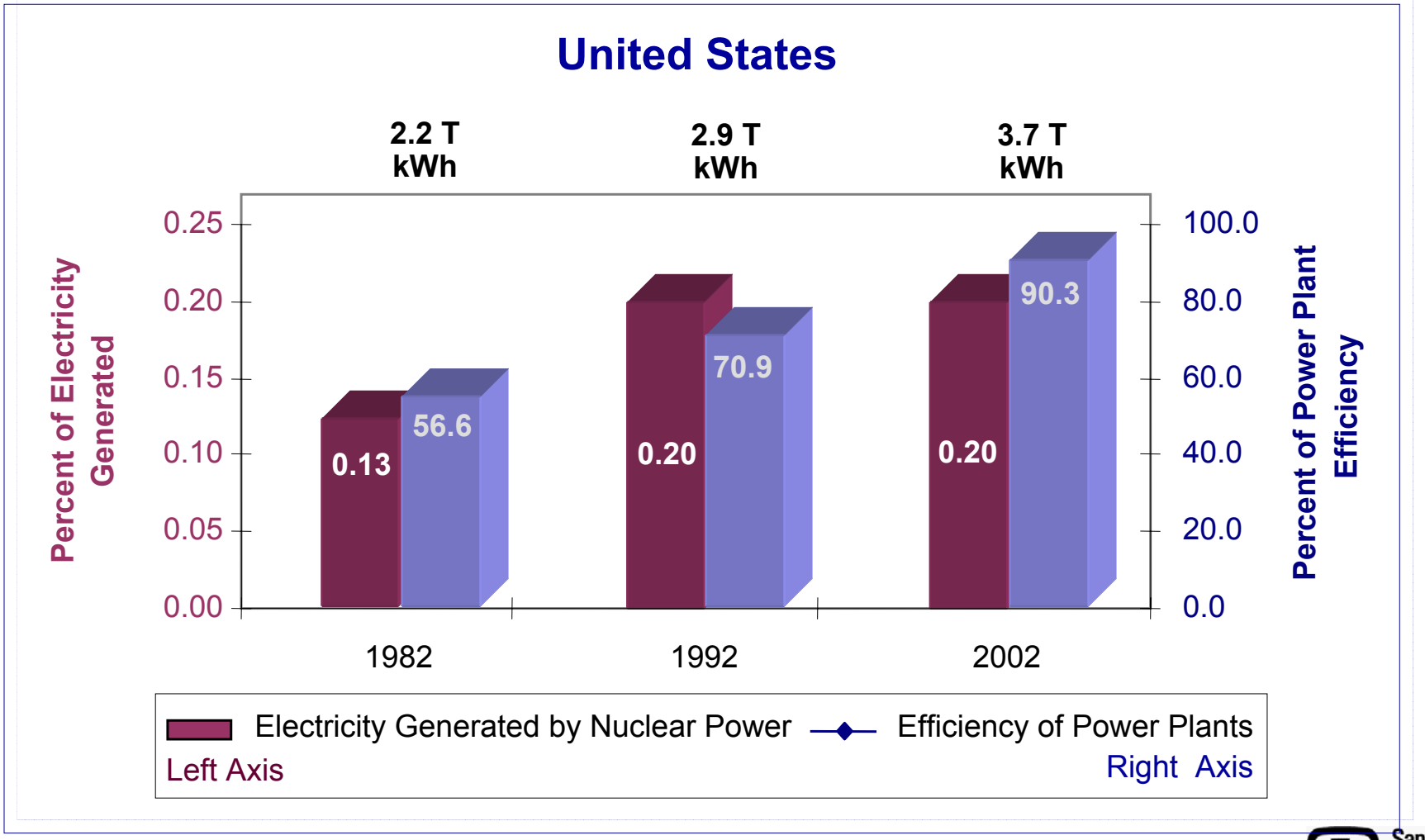
- They are, on average, 24 years old and licensed to operate for 40 years with an option to renew for an additional 20
- Over 2/3 of the United States' nuclear power plants have:
  - Renewed their licenses **(32 reactors)**
  - Filed for license renewal with the Nuclear Regulatory Commission (NRC) **(16 reactors)**
  - Officially informed NRC of expectations to apply for license renewal over the next six years **(22 reactors)**

- 103 commercial nuclear power plants producing electricity in the United States today
- Located at 64 sites in 31 states



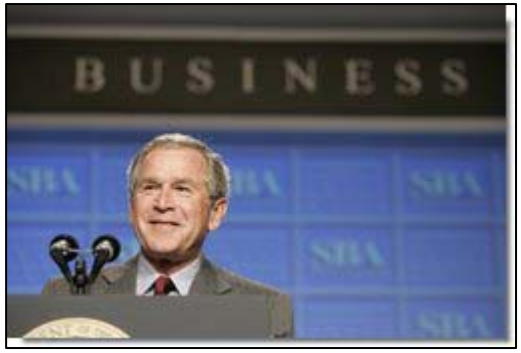
Sandia National Laboratories

U.S. Nuclear Electricity and Operating Efficiency



Sandia National Laboratories

President Bush Sees New Nuclear Plants Essential to U.S. Energy Independence



"The first essential step toward greater energy independence is to apply technology to increase domestic production from existing energy resources. **And one of the most promising sources of energy is nuclear power. Today's technology has made nuclear power safer, cleaner, and more efficient than ever before. . . "**

George W. Bush
April 27, 2005

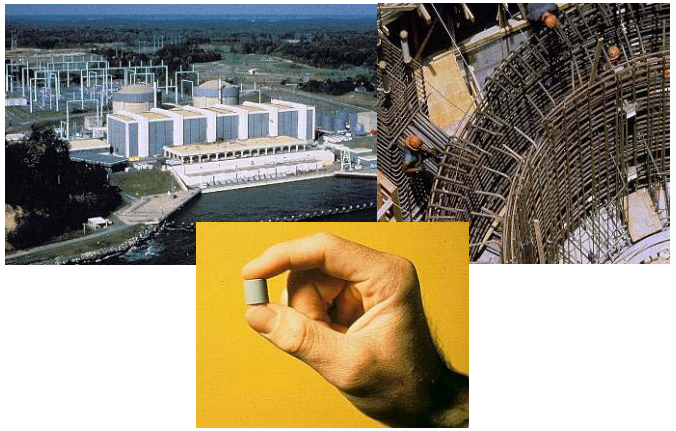
Nuclear Power 2010 Initiative

- Seven-year, $1.1B effort by Government and Industry to start building nuclear power plants by the end of this decade.

Sandia National Laboratories

The Peaceful Use of Nuclear Energy is Key to a Sustainable and Prosperous Future

- Nuclear plants are highly reliable and economic.
- Nuclear energy creates no airborne emissions.
- World nuclear fuel supplies can last a thousand years or more.



But Challenges Remain

- Highest levels of safety, efficiency, and operability must be achieved - everywhere.
- Nuclear materials and technology must be controlled to prevent weapons proliferation.
- A solution to the nuclear waste management issue must be achieved

US National Lab Directors Recommended a Strong Nuclear Energy Program

Nuclear Energy Action Plan (2002)

Nuclear Energy: Power for the 21st Century An Action Plan

Energy is vital to human civilization. It underpins national security, economic prosperity, and global stability. As the world's most powerful and prosperous nation, the U.S. must lead the way in developing a diverse energy system that can meet rapidly growing world energy demand in a way that promotes peace, prosperity, and environmental quality. This diverse energy system must include a growing component of nuclear energy.

In July 2002, the Directors of six U.S. Department of Energy (DOE) National Laboratories wrote to the Secretary of Energy to urge DOE to "implement a comprehensive and integrated plan to further the development of nuclear energy and the management of nuclear materials." Such a plan can help achieve the Laboratory Directors' vision:

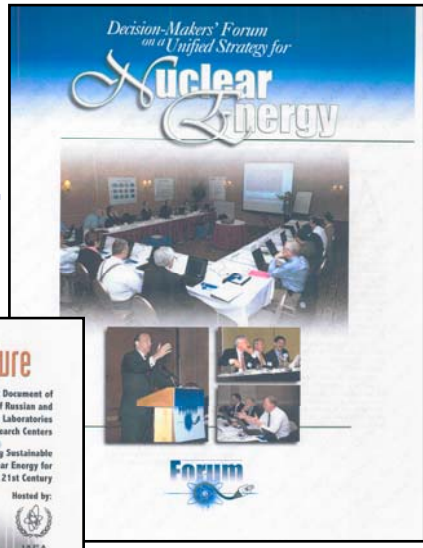
Vision:
Sustainable peace, prosperity, and environmental quality, enabled through immediate U.S. leadership in the global expansion of nuclear energy systems.

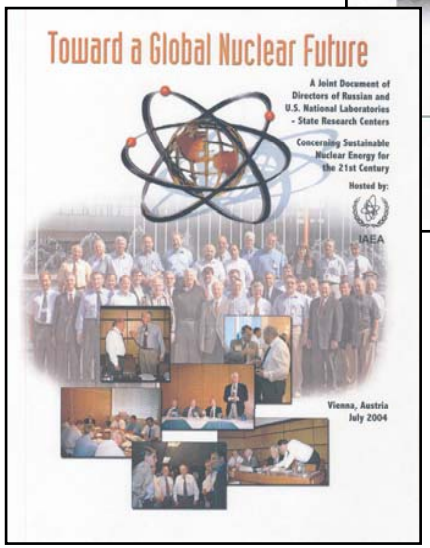
Goal #1: Improve Air Quality – Reduce Carbon Emissions, and Increase Energy Security

Goal #2: Reduce Waste by 90%

Goal #3: Reduce Proliferation Risk

Decision-Makers Forum in Washington, D.C. (2004)





Met With Russian Counterparts to Discuss Principles in Common (2004)

Sandia National Laboratories

In *2004*, President Bush Announced New Measures to Counter the Threat of Weapons of Mass Destruction

- **Called for changes in the global nuclear future**
  - ***Proliferation Security Initiative (interdiction of illegal trade).***
  - ***Expand "Nunn-Lugar" to other parts of the world.***
  - ***Implement cradle-to-grave nuclear supply concept between receiving and supplying nations.***
  - ***Implement the IAEA's Additional Protocol.***

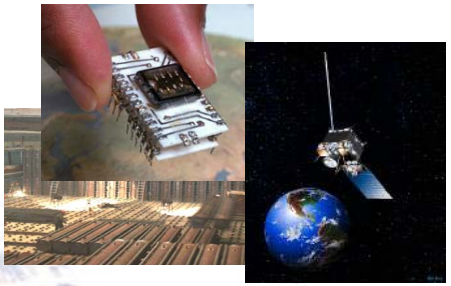
Overarching Recommendation

Concurrent with its Deployment of New Commercial Reactors, the United States Must Move Forward Rapidly With:

Safeguards

- **Advanced reactor technology for:**
  - Efficient production of electricity and hydrogen
  - Management and utilization of proliferable nuclear material
  - Global market penetration
  - Reactors for specific export markets

Advanced Proliferation Prevention

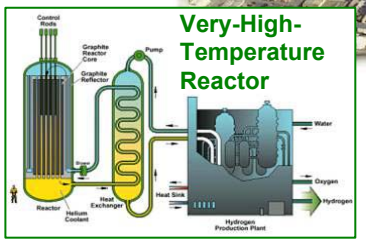


- **Advanced fuel separation and recycle technology for:**
  - Nuclear material resource optimization and management for proliferation resistance
  - Minimized burden on waste repository
  - Global market engagement

Advanced Reactor Technology

Advanced Fuel Separation

- **Advanced proliferation prevention technologies and approaches for:**
  - Process transparency through smart process controls
  - Real-time diversion prevention, detection and response
  - Comprehensive fuel cycle information management and integration

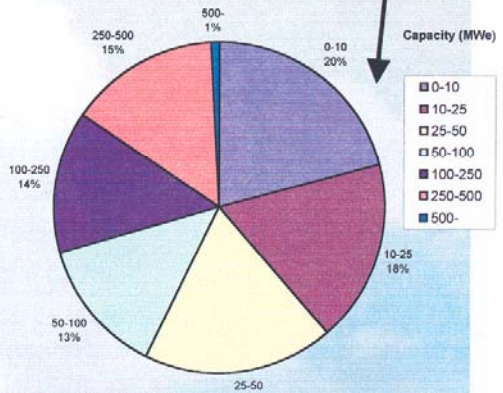


Sandia National Laboratories

Large-Scale Development of Secure Exportable Rectors—Key Premises

- *Exploit nuclear energy's million fold increase in energy intensity (vs fossil) and its transportability (no loss of energy content over 1000's of miles)*
- *Build secure,highly proliferation-resistant exportable reactors that require no refueling for up to 30 years*
- *Expand nuclear-based energy services to developing countries and produce hydrogen, drinking water, in addition to electricity*
- *Size economical nuclear power to developing country energy grids*

Today's reactors and targets for tomorrow



Example Mexico - 99% of power plants have less than 500 MW_E capacity)

Sandia National Laboratories

Several Nations are Pursuing Design and Technology Development

US -
LWR technology
Na cooled fast reactor
Pb cooled fast reactor

(Argonne, Sandia, Idaho, Los Alamos, Livermore, MIT, UC Berkeley, Texas A&M

Brazil -
H_2O cooled thermal reactor

France - *Na cooled fast reactor*

Russia -
H_2O cooled thermal reactor
Ice breaker (H_2O)
LWR technology
Na cooled fast reactor
Particle Fuel
Pb or Pb-Bi cooled

Japan -
H_2O cooled thermal reactor
LWR technology
Na cooled fast reactor
Pb or Pb-Bi cooled fast reactor

India- *Pb- cooled fast reactor*

Indonesia- *Pb-Bi- cooled fast reactor*

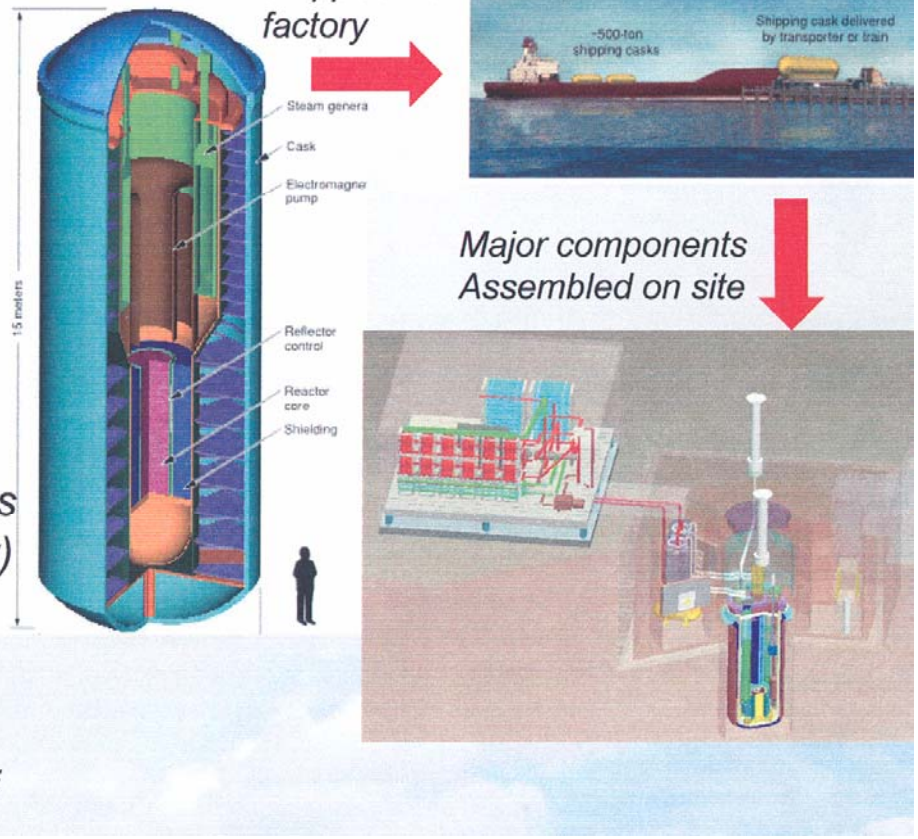
South Africa- *Particle fuel*

Long-Lived Exportable Reactor Concepts employ multiple approaches to

- ***coolants (H_2O, Na, Pb, Pb-Bi),***
- ***spectrum characteristics (thermal, epithermal, fast),***
- ***fuels (metal, particle, nitride),***
- ***power outputs (1 to 300 MW_E)***
- ***applications (electricity, hydrogen production, district heating, desalination)***

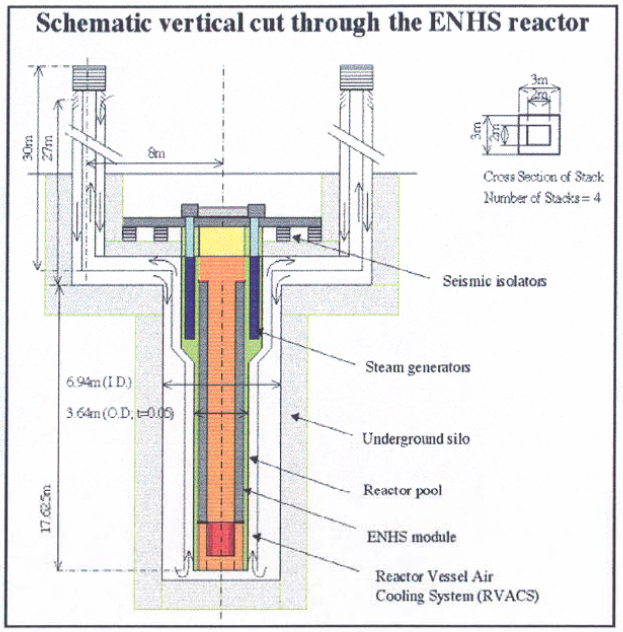
Secure Exportable Reactor Features

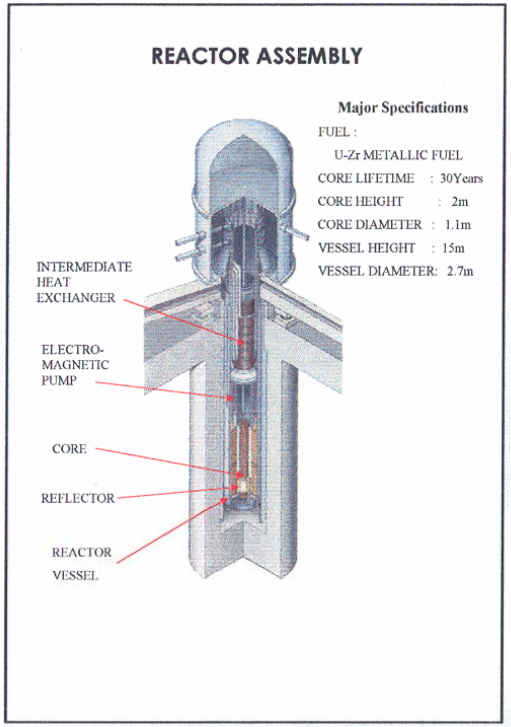
- ***Factory produced, fueled, sealed***
- ***Long fuel lifetime*** *(up to 30 years, no need for on-site fueling)*
- ***Inherently safe***
- ***High efficiency***
- ***Transportable*** *(components shipped to site for assembly)*
- ***Remotely monitored***
- ***Capacity - 100 to 300 MW_E***

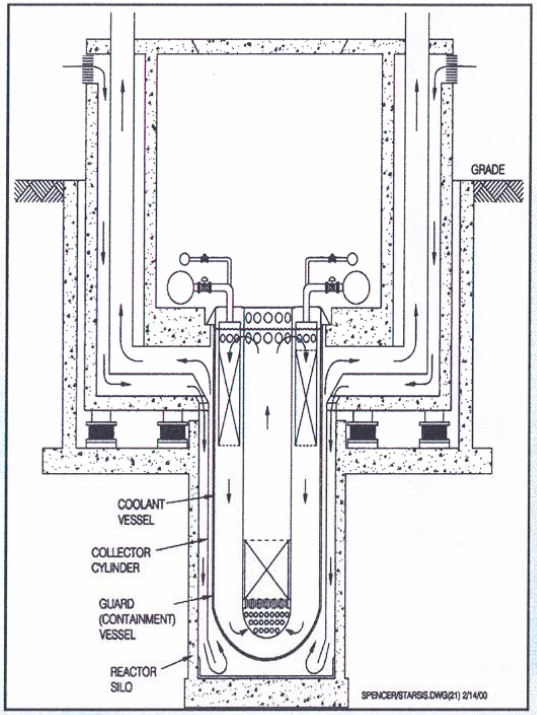


Sandia National Laboratories

Several Innovative Reactor Concepts are Being Studied







US - - UC Berkeley
- *Pb - Bi cooled*
- *Unattended operation*
- *Weld-sealed delivery*
- *U or U-Pu fuel*

Japan - Toshiba
- *Robust safety (fully passive)*
- *Na cooled*
- *U-Zr fuel*
- *Galena Alaska application?*

US - Argonne
- *Natural circulation*
- *Na cooled*
- *Metallic fuel*

Sandia National Laboratories

The U.S. must become a major supplier in the global nuclear expansion, within a new "user-supplier" international paradigm.

- **Enables the President's non-proliferation policy to be implemented through U.S. leadership-by-example.**
- **Accomplishes our major goals in all 3 key areas:**
  - **National Security**
  - **Energy Security**
  - **Economic Competitiveness**
- **Requires a major policy shift to enable the return and recycle of spent fuel and the minimization of high level wastes.**
- **The "exportable" reactor for smaller markets is key.**

Building a Global Nuclear Future

"Global Challenges – National Needs"

Focus on the Future

- Enable the emerging world to access clean, reliable energy supplies to fuel their economies
- Create a global nuclear services supply system that provides the benefits of nuclear energy to nations while discouraging materials production of nuclear proliferation concern
- Create partnerships among nuclear power states to establish a new paradigm for incorporating advanced manufacturing and infrastructure technologies to improve safety, reliability and security of fuel cycle systems
- Provide a longer term foundation for creating nuclear systems that are twice as efficient, create 90% less waste and enable the cradle to grave export of small long-lived reactors to developing markets in the world
- Pursue a multi-national repository that provides significant safety, security, economic and non-proliferation advantages.

The U.S. Must Become a Preferred Supplier in the Global Nuclear Expansion

National Security

- The "user-supplier" paradigm addresses a major potential proliferation concern with expanded use of nuclear power.
- Developing a comprehensive reactor and supply/return fuel cycle service capability:
  - Provides market systems that will define how nuclear trade in the 21st century will evolve.
  - Eliminates the need for smaller customers to have enrichment and reprocessing capabilities.
  - Helps the developing world acquire the energy resources necessary for achieving a prosperous future and for globally controlling environmental impacts.
  - Reduces potential for future conflict over access to energy resources.

Enables the President's non-proliferation policy to be implemented through U.S. leadership-by-example.