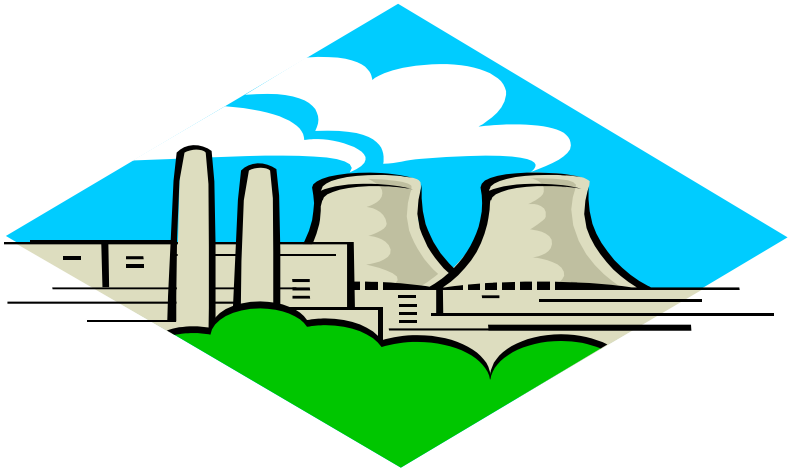
Nuclear Power - an Environmental Friendly, Clean, Reliable and Safe Electrical Power Source for Today and for the Future



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AEP INDIANA MICHIGAN POWER®

A unit of American Electric Power

Just the Facts

- **Throughout the nuclear fuel cycle, the small volume of waste by-products actually created is carefully contained, packaged, and safely stored. As a result, the nuclear energy industry is the only industry established since the industrial revolution that has managed and accounted for all of its waste, preventing adverse impacts to the environment**

- **The energy in one uranium fuel pellet – about the size of the tip of your little finger – is the equivalent of 17,000 cubic feet of natural gas, 1,780 pounds of coal or 149 gallons of oil.**

- **In 2004, U.S. nuclear power plants prevented 3.43 million tons of sulfur dioxide, 1.11 million tons of nitrogen oxide and 696.6 million metric tons of carbon dioxide from entering the earth's atmosphere.**

- **If you lived next door to a nuclear power plant, you'd still get less radiation each year than you'd get in just one flight from New York to Los Angeles.**

- **About 85% of the radiation humans receive comes from natural sources such as cosmic rays from space, granite and even our food. The remainder of our annual radiation dose comes from artificial sources such as medical x-rays. Less than 0.1% comes from the nuclear industry.**

- **Worldwide, 31 countries are operating 434 nuclear plants for electricity generation. In 14 countries, 36 new nuclear power plants are under construction.**

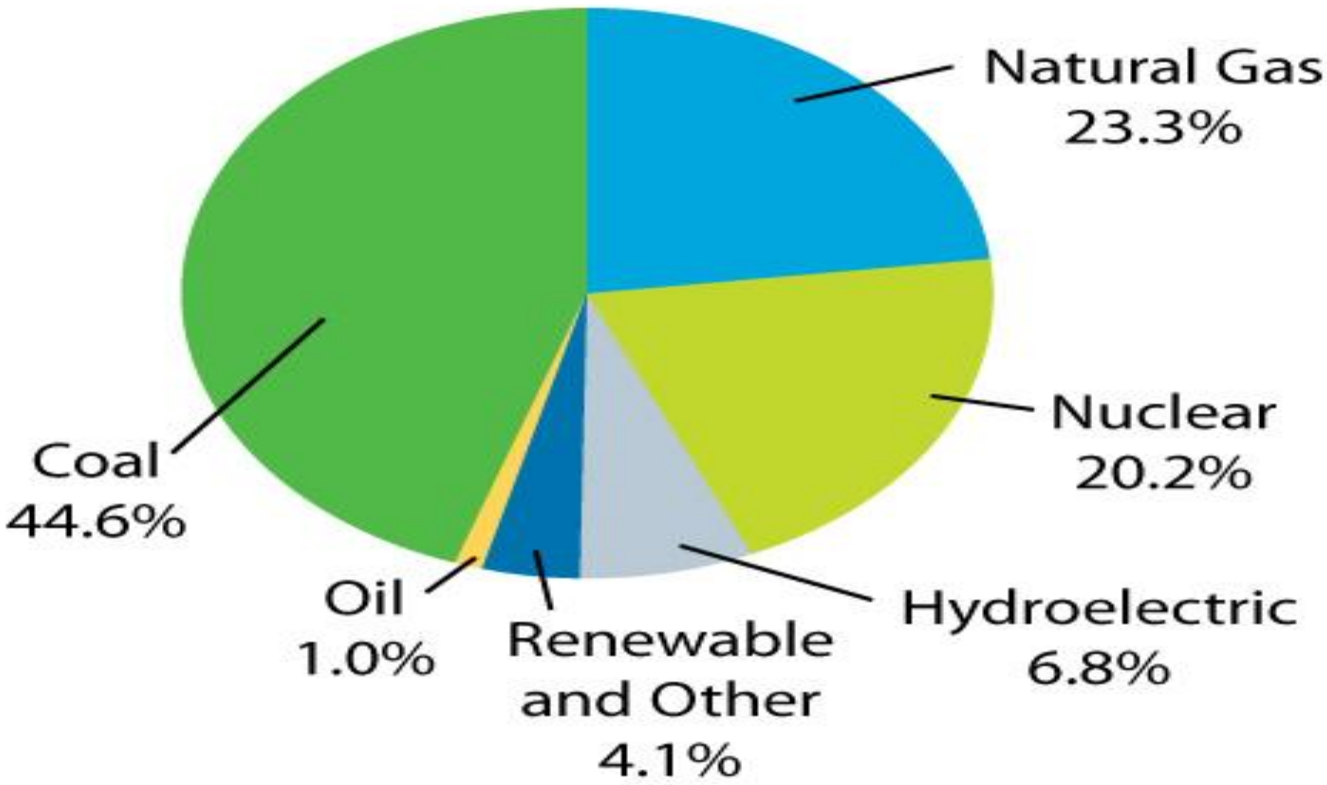
- **Nuclear power plants in the United States supply about 20 percent of the nation's electricity each year.**

- **Nuclear energy is the world’s largest source of emission-free energy. Nuclear power plants produce no controlled air pollutants, such as sulfur and particulates, or greenhouse gases.**

- **The use of nuclear energy in place of other energy sources helps keep the air clean, preserve the earth's climate, avoid ground-level ozone formation, and prevent acid rain.**

America’s 104 nuclear power plants generate over 20 percent of the nation’s electricity, while emitting no carbon dioxide or controlled pollutants. Nuclear energy provides nearly three-fourths of America's emission-free electricity.

U.S. Electricity Generation Fuel Shares 2009



Source: U.S. Energy Information Administration

Nuclear Safety

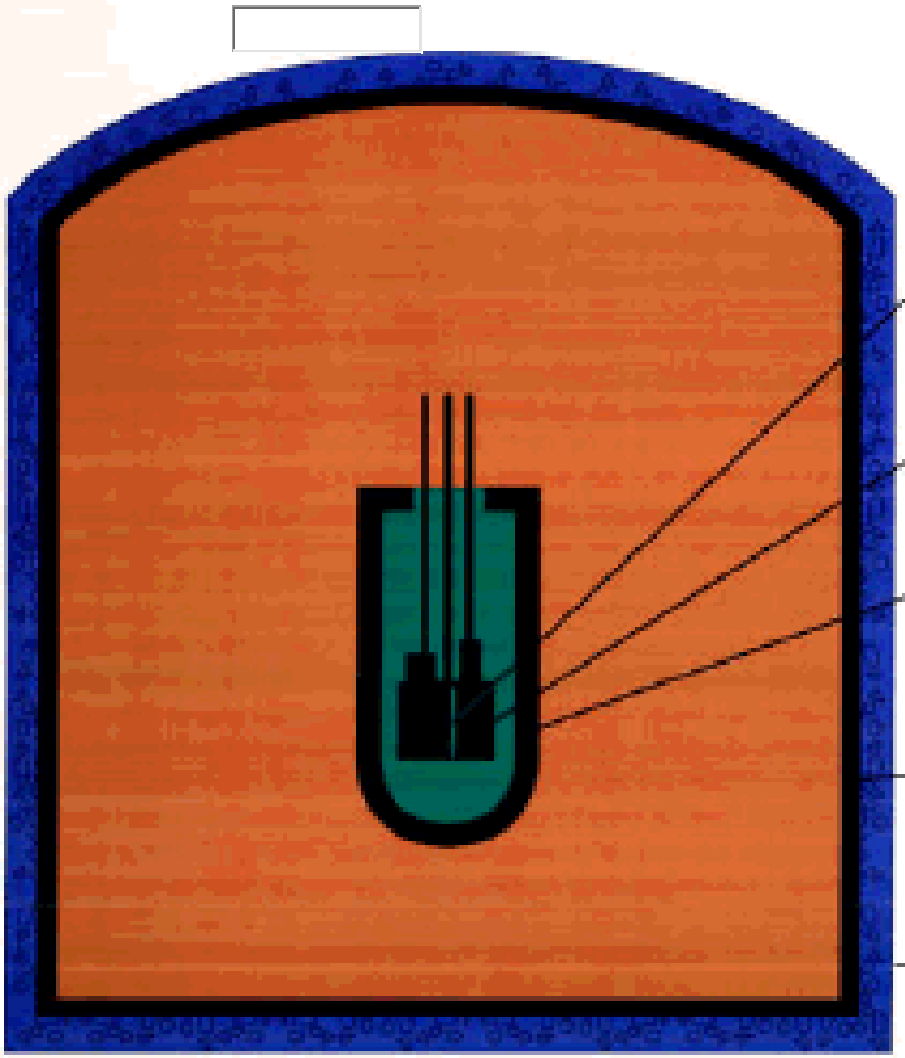
- The notion of nuclear safety covers all the conditions required to ensure that a nuclear facility is operated without having a harmful effect on the health of individuals and the environment.

- In a nuclear power plant, this objective assumes that three basic technical rules are followed:

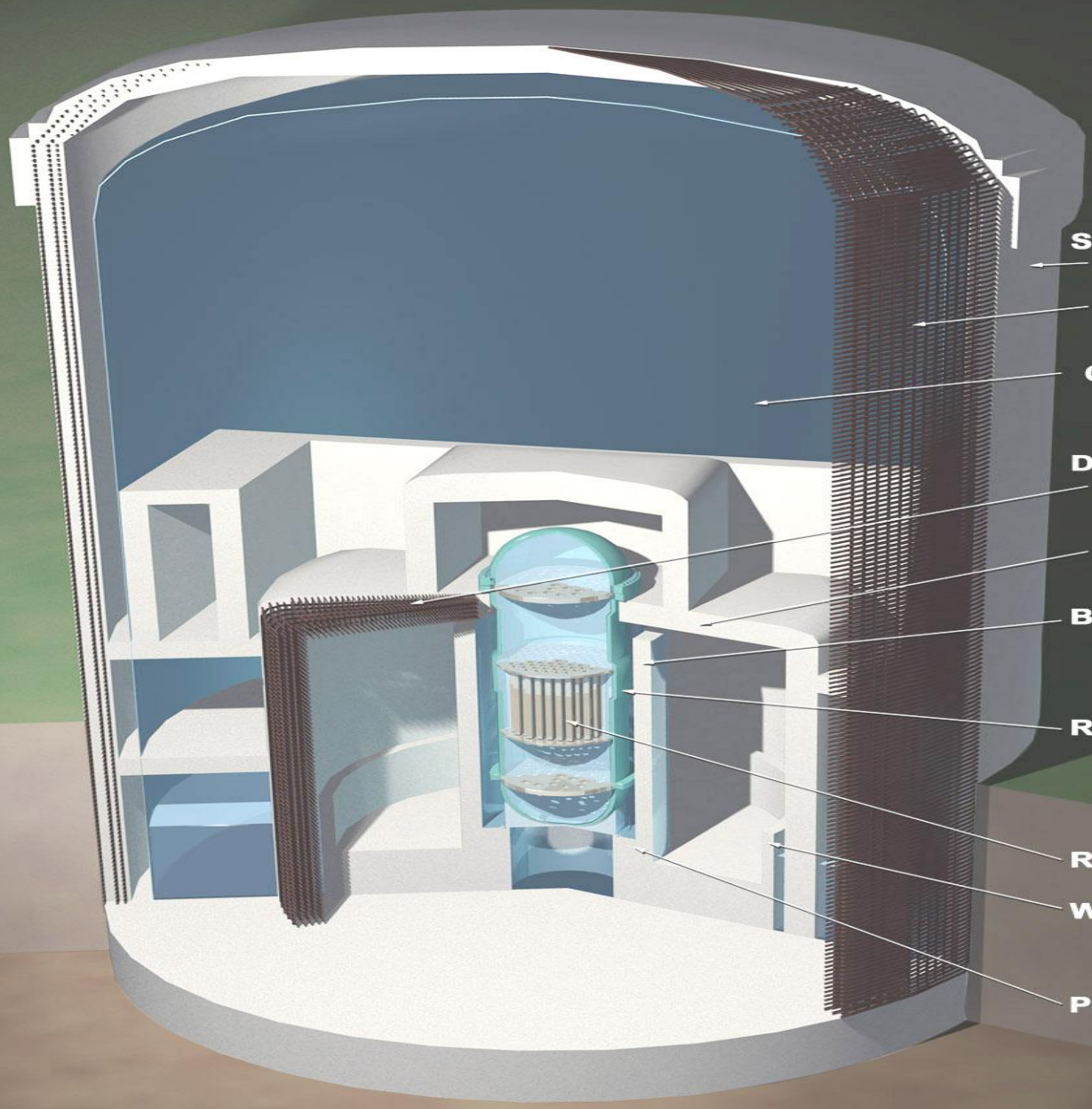
  - **the prevention of the spread to the outside of excessive quantities of radioactive products;**
  - **the control under all circumstances of the chain reaction and the power to stop it at any time;**
  - **the removal of heat generated in the reactor core by nuclear reactions.**

- In order to satisfy these requirements, the safety program is based on successive levels of protection which are applied at various points: facility design; operation; incident or accident phase. This combination of levels of defense is called in-depth defense.

Multiple barriers for safety



Multiple Layers of Safety at Nuclear Power Plants



Shield Building Wall
- Three-foot thick reinforced concrete metal reinforcement
- 2.5-inch diameter steel rods spaced one foot apart

Containment Vessel
- 1.5-inch steel cylinder
- 182 feet tall

Dry Well Wall
- Metal reinforcement
- 2.5-inch diameter steel rods spaced one foot apart
- Five-foot thick reinforced concrete

Bio Shield
- Four-foot thick leaded concrete with one-inch thick interior and exterior steel lining

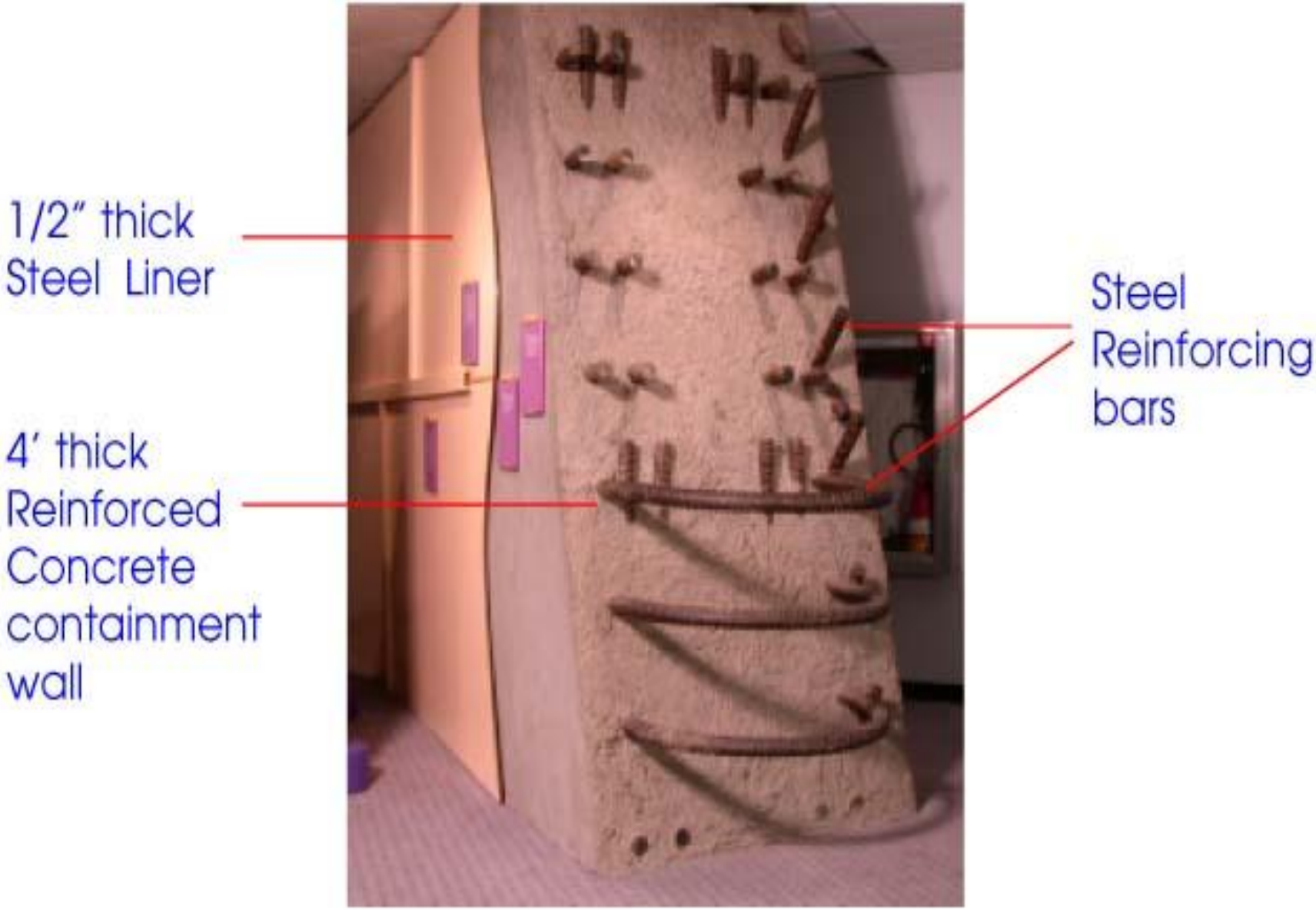
Reactor Vessel
- 70 feet tall
- 21 feet in diameter
- High Tensile Steel four to eight inches thick

Reactor Fuel

Weir Wall
- 1.5-foot thick concrete
- 24 feet tall

Pedestal
- Six-foot thick concrete with one-inch thick interior and exterior steel lining

Boiling Water Reactor



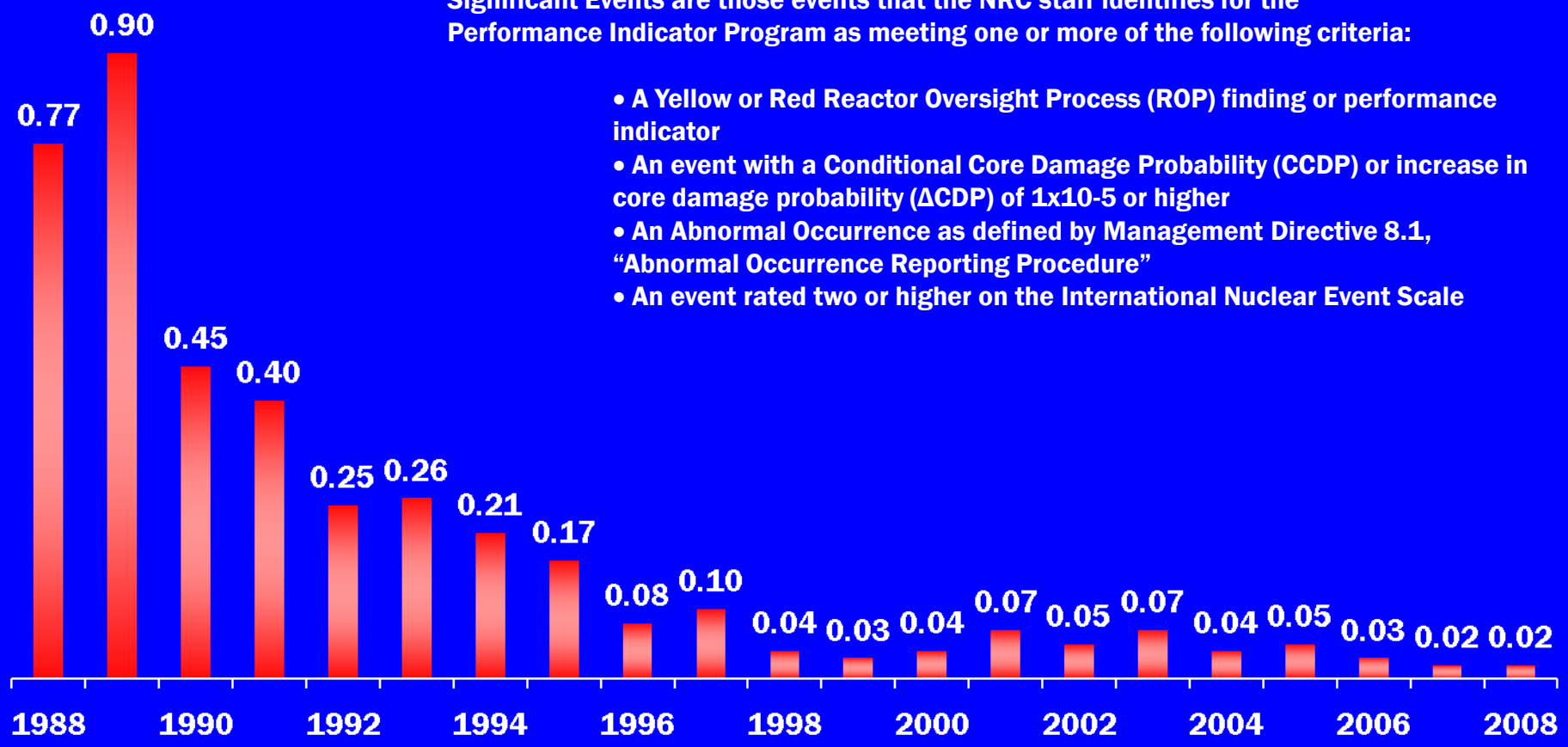
Construction of Containment Wall

Significant Events at U.S. Nuclear Plants:

Annual Industry Average, Fiscal Year 1988-2008

Significant Events are those events that the NRC staff identifies for the Performance Indicator Program as meeting one or more of the following criteria:

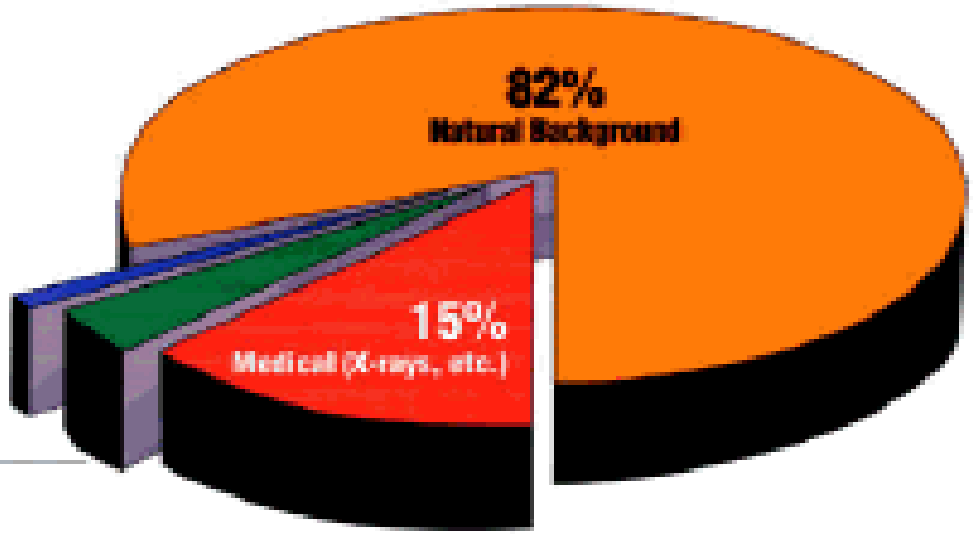
- A Yellow or Red Reactor Oversight Process (ROP) finding or performance indicator
- An event with a Conditional Core Damage Probability (CCDP) or increase in core damage probability (ΔCDP) of 1x10-5 or higher
- An Abnormal Occurrence as defined by Management Directive 8.1, "Abnormal Occurrence Reporting Procedure"
- An event rated two or higher on the International Nuclear Event Scale



Source: NRC Information Digest, 1988 is the earliest year data is available.
Updated: 4/10

Sources of Radiation

Natural Background (Soil, sunlight, etc.)	82%
Medical (X-rays, etc.)	15%
Consumer Products (T.V., smoke detectors, etc.)	3%
Nuclear Power Plants	Less than 1%



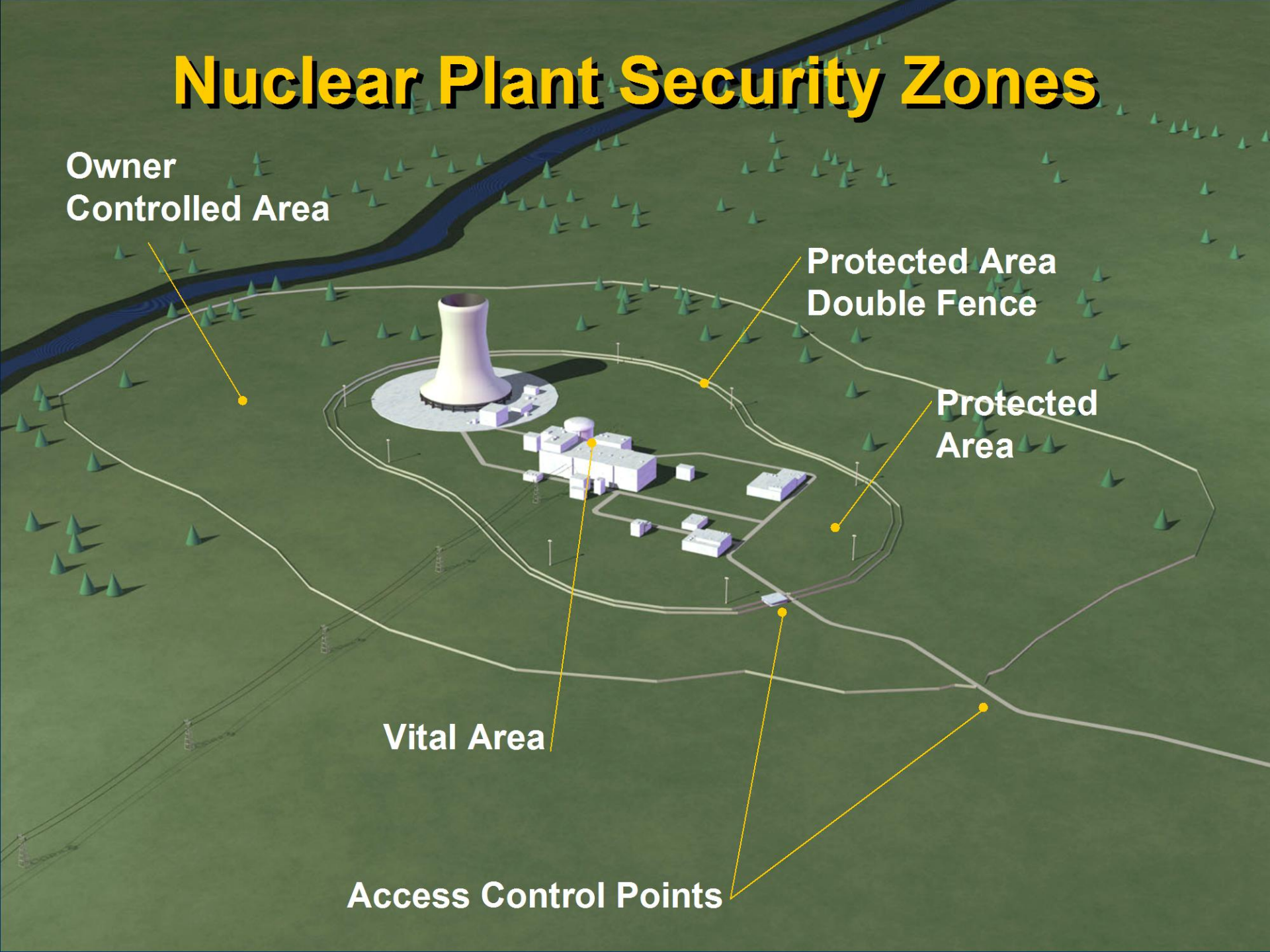
Source: National Council on Radiation Protection Measurements

Nuclear Safety

Nuclear Safety Depends on

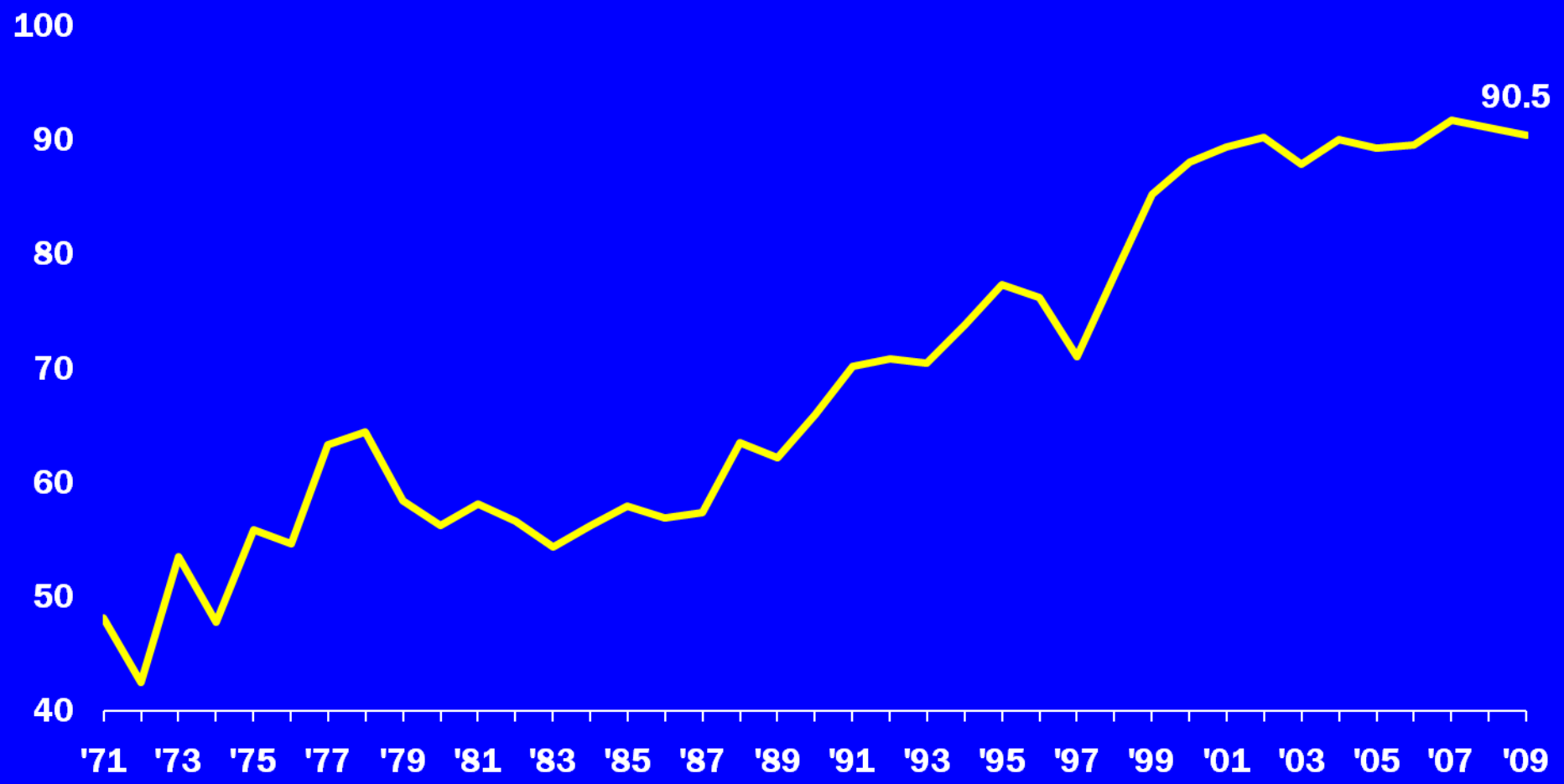
- Plant and equipment design
- Equipment health and reliability
- Procedures and processes
- People who engineer, operate, and maintain the facility

Nuclear Plant Security Zones



U.S. Nuclear Industry Capacity Factors

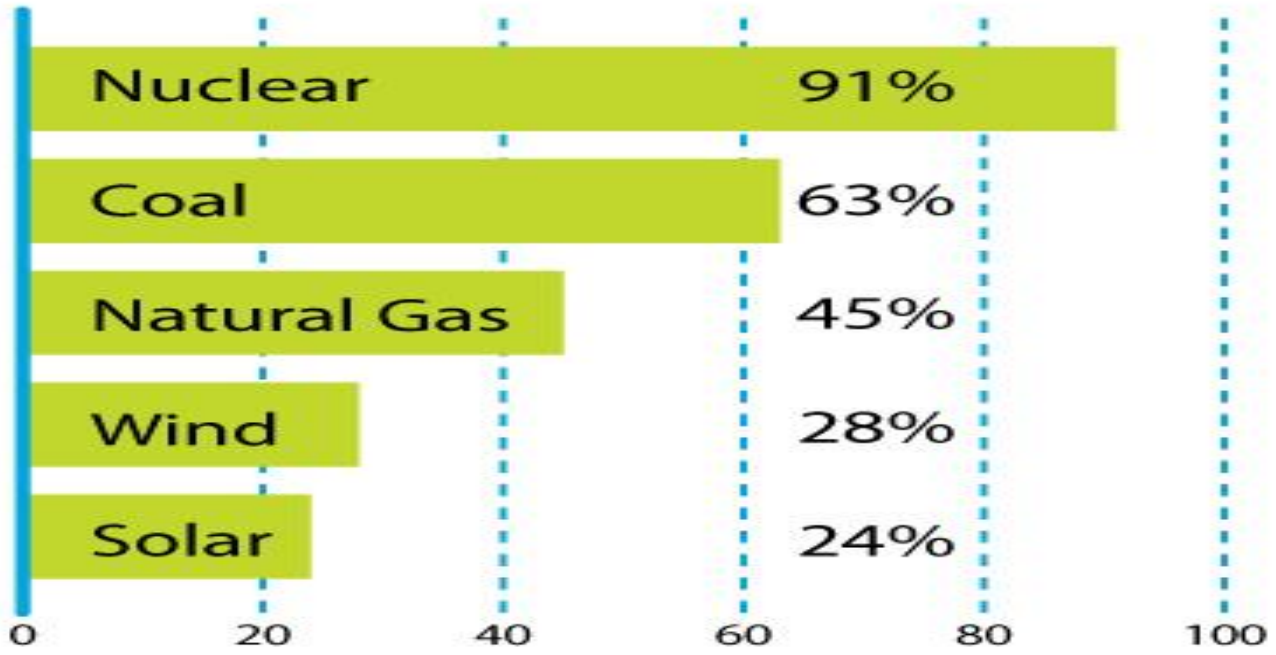
1971 – 2009, Percent



Source: Energy Information Administration

Updated: 5/10

Average Operating Efficiency* by Source of Electricity, 2009

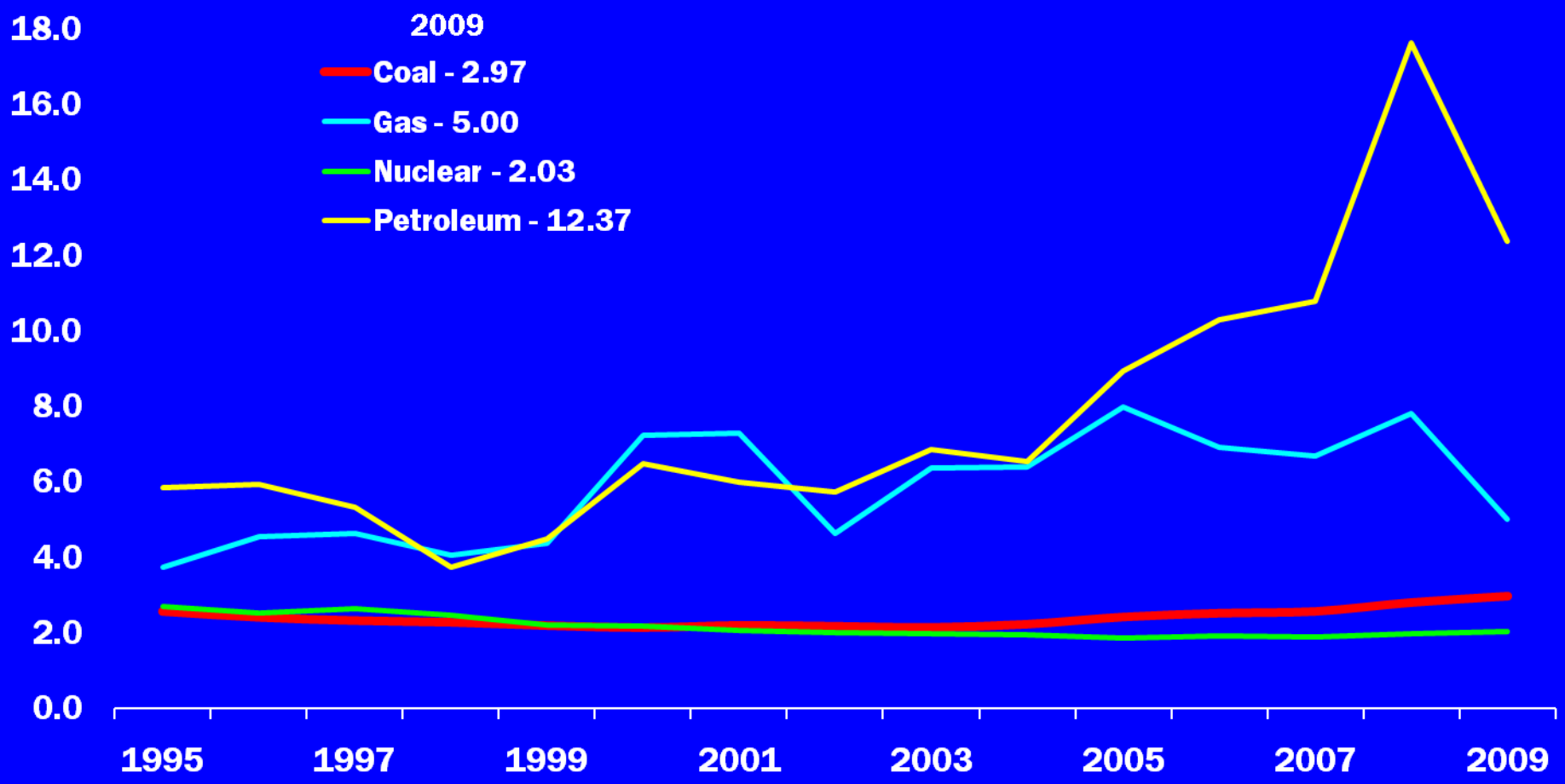


Source: Ventyx / U.S. Energy Information Administration

**Operating efficiency is measured by capacity factor, the ratio of the amount of electricity produced by a plant to the amount of eletricity that could have been produced if the plant operated all year at full power.*

U.S. Electricity Production Costs

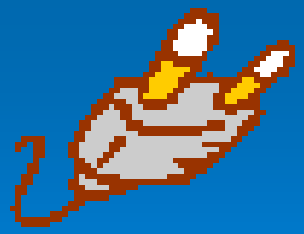
1995-2009, *In 2009 cents per kilowatt-hour*



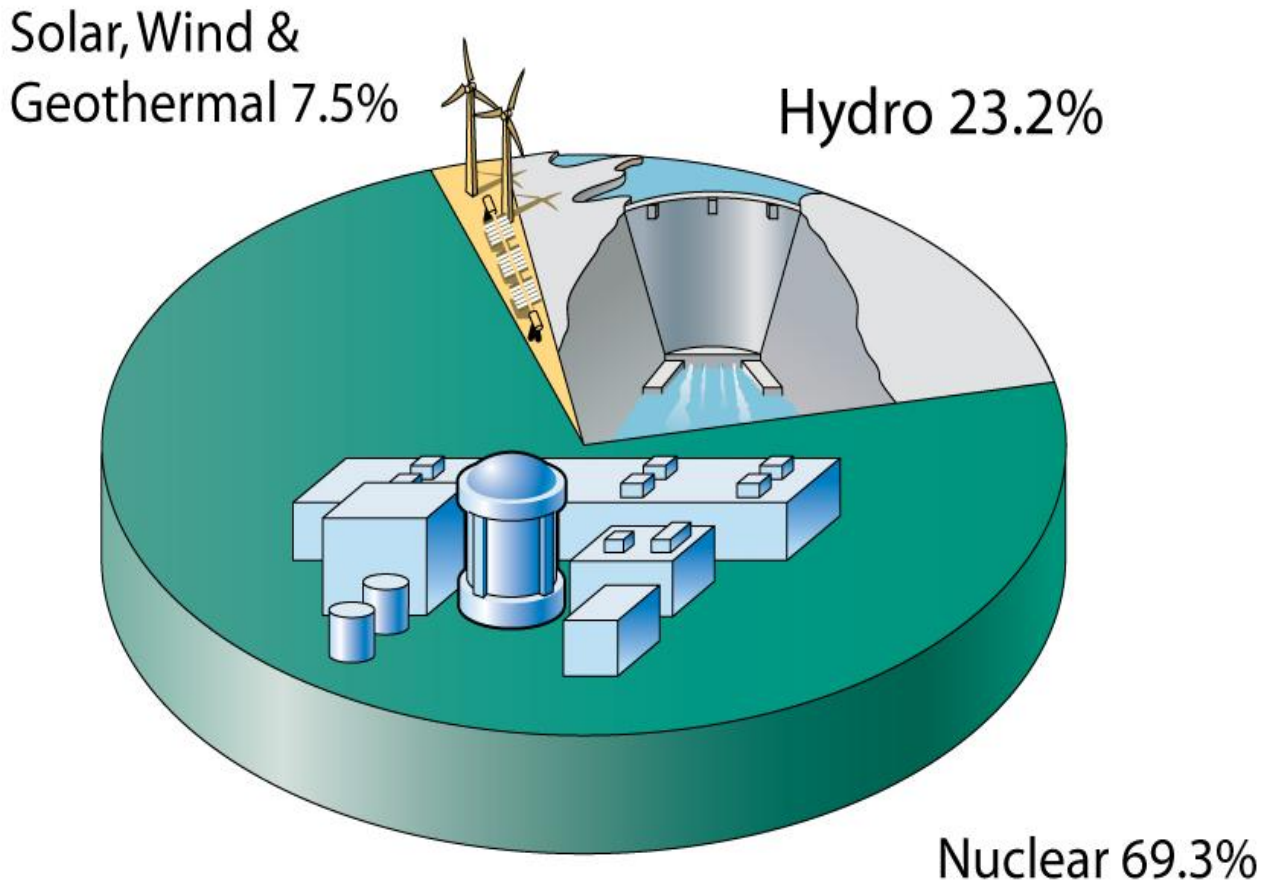
Production Costs = Operations and Maintenance Costs + Fuel Costs. Production costs do not include indirect costs and are based on FERC Form 1 filings submitted by regulated utilities. Production costs are modeled for utilities that are not regulated.

Source: Ventyx Velocity Suite
Updated: 5/10

Nuclear plants are the lowest-cost producer of base load electricity. The average production cost of 2.03 cents per kilowatt-hour includes the costs of operating and maintaining the plant, purchasing fuel and paying for the management of used fuel.



Sources of Emission-Free Electricity 2009



Environmental Facts

- **Nuclear power plants generate about 20 percent of U.S. electricity. They do not burn anything, so they do not produce any combustion byproducts.**

- **By substituting for other fuels in electricity production, nuclear energy has significantly reduced U.S. emissions of nitrogen oxides, sulfur dioxide and carbon dioxide.**

- **Only 27 percent of America's electricity comes from clean-air sources, including nuclear power plants, hydro-electric plants, wind farms and solar energy facilities.**

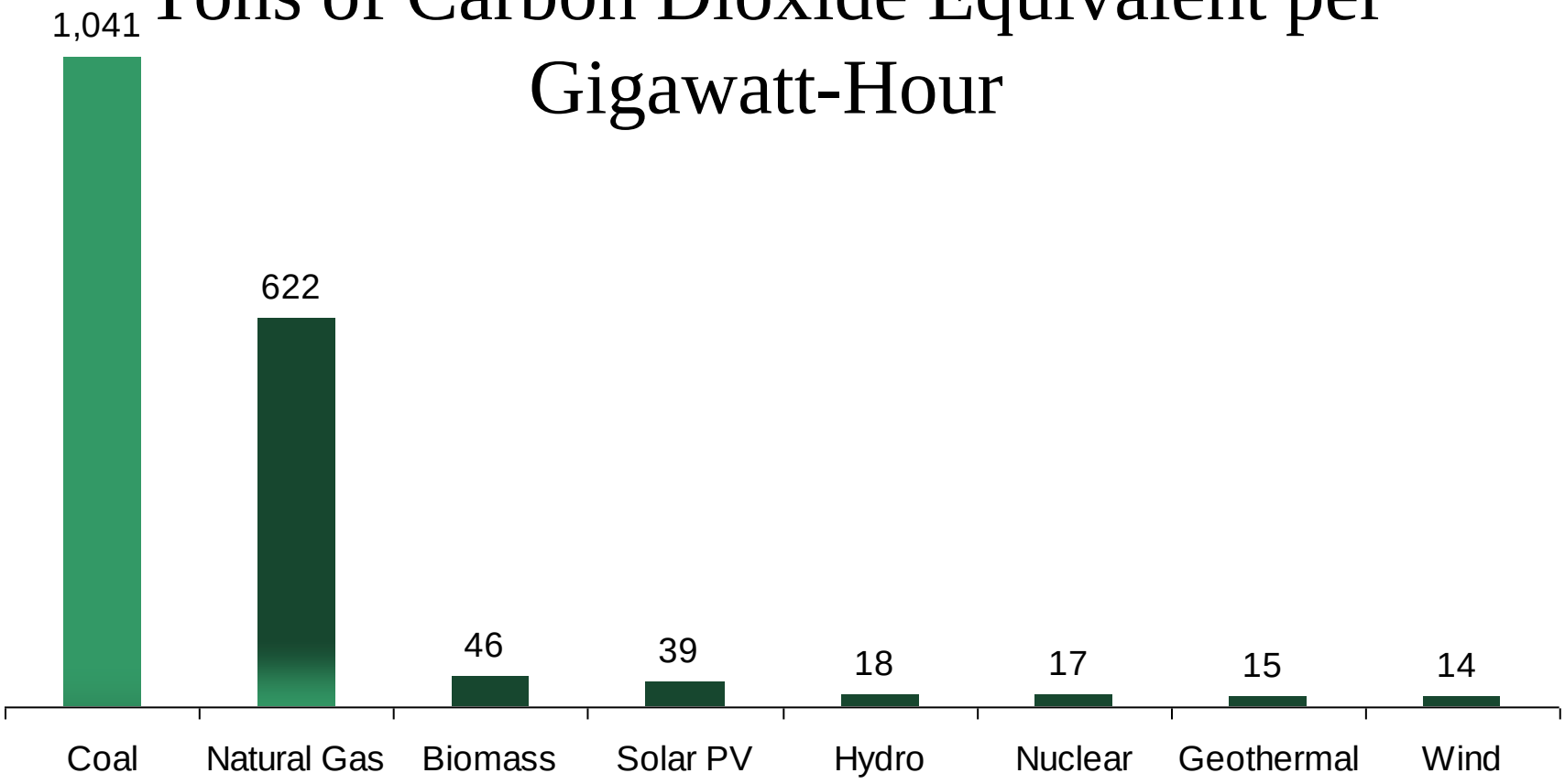
- **Nuclear energy accounts for almost 70 percent of the nation's clean-air electricity generation.**

- **In 2005, U.S. nuclear power plants reduced emissions of nitrogen oxides and sulfur dioxide—pollutants controlled under the Clean Air Act—by 1.1 million short tons and 3.3 million short tons, respectively. The amount of nitrogen oxide emissions that nuclear plants prevent annually is the equivalent of taking nearly 55 million passenger cars off the road.**

- **Also in 2005, U.S. nuclear plants prevented the discharge of 682 million metric tons of carbon dioxide into the atmosphere. This is nearly as much carbon dioxide as is released from all U.S. passenger cars.**

Comparison of Life-Cycle Emissions

Tons of Carbon Dioxide Equivalent per Gigawatt-Hour



Source: "Life-Cycle Assessment of Electricity Generation Systems and Applications for Climate Change Policy Analysis," Paul J. Meier, University of Wisconsin-Madison, August 2002.

Emissions Produced by 1 Kilowatt-hour of Electricity Based on Life-Cycle Analysis

Generation Option	Greenhouse gas emissions gram equiv. (in CO2/kWh)	Sulfur dioxide emissions (in milligrams/kWh)	Nitrogen oxide emissions (in milligrams/kWh)	NMVOC (in milligrams /kWh**)	Particulate matter (in milligrams /kWh)
Hydropower	2 – 48	5 – 60	3 – 42	0	5
Nuclear	2 – 59	3 – 50	2 – 100	0	2
Wind	7 – 124	21 – 87	14 – 50	0	5 – 35
Solar photovoltaic	13 – 731	24 – 490	16 – 340	70	12 – 190
Biomass forestry waste combustion	15 – 101	12 – 140	701 – 1,950	0	217 – 320
Natural gas (combined cycle)	389 – 511	4 – 15,000[*]	13 – 1,500	72 – 164	1 – 10
Coal – modern plant	790 – 1,182	700 – 32,321	700 – 5,273	18 – 29	30 – 663

[*] The sulfur content of natural gas when it comes out of the ground can have a wide range of values. When the hydrogen sulfide content is more that 1 percent, the gas is usually known as "sour gas." Normally, almost all of the sulfur is removed from the gas and sequestered as solid sulfur before the gas is used to generate electricity. Only in the exceptional case when the hydrogen sulfide is burned would the high values of sulfur dioxide emissions occur.

** NMVOC means non-methane volatile organic compounds.

Source: "Hydropower-Internalized Costs and Externalized Benefits," Frans H. Koch, International Energy Agency (IEA)-Implementing Agreement for Hydropower Technologies and Programs, Ottawa, Canada, 2000.

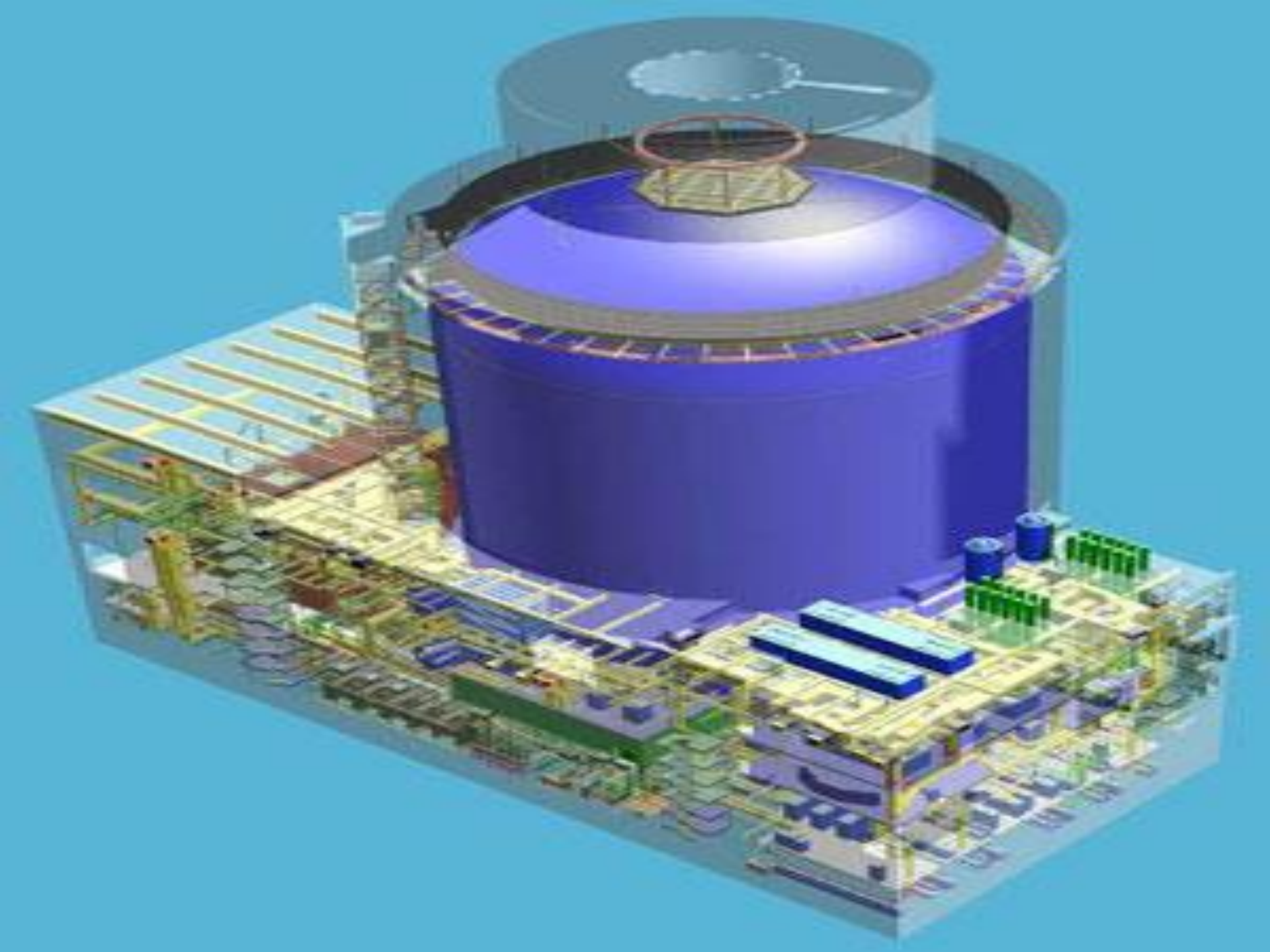
The Future of Nuclear Power

Nuclear Future

- **The U.S. energy industry is using standardized designs for future nuclear electric generating plants.**
- **The new designs will incorporate the latest technologies and more advanced safety features than today's plants, which already have achieved record levels of safety**
- **Simplicity in all aspects of nuclear plant operations, including safety, maintenance, training and spare parts procurement.**

Features of third-generation reactors include:

- a standardized design for each type to expedite licensing, reduce capital cost and reduce construction time;
- a simpler and safer design, making them easier to operate;
- higher availability and longer operating life;
- minimal effect on the environment; and
- more efficiencies in fuel consumption that will result in lower fuel costs.
- Standardization means that reactors will be built in families of the same design, except for a limited number of site-specific differences. Standardization will reduce construction and operating costs, and lead to greater efficiencies

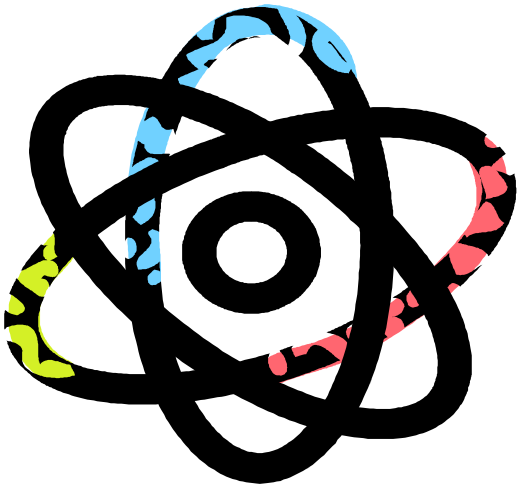


Nuclear Power - Worldwide Electric Power Option

- Nuclear power contributed about 15% to the total world electricity generation in 2009 with an installed capacity of 373GW.
- There are currently 436 nuclear reactors in operation in 30 countries worldwide.
- The US is the largest producer of nuclear power generating 31% of the total global nuclear generation followed by France, Japan and Russia.
- Nuclear power is an important source of power for countries such as Lithuania which generated 76.2% of its electricity through nuclear followed by France whose nuclear share in electricity generation stood at 75.2% in 2009.
- Sixteen countries generate more than 25% of their electricity through nuclear power and four countries more than 50% including Slovakia and Belgium.
- There is a continuing expansion of nuclear power throughout the world into areas such as the United Arab Empires. Also the Chinese nuclear power program is undergoing rapid expansion and growth.

Long Term Storage of Spent Nuclear Fuel

- Onsite storage (dry cask and spent fuel pools)
- Interim storage options
- Long term repository
- Reprocessing option



Yucca Mountain
Monitored Spent Fuel Repository

Located 100 miles northwest of Las Vegas

Yucca Mountain Repository

Nuclear Power – Ecologists Changing Views

- “I have been a committed environmentalist for many years. It is because of this commitment and the graveness of the consequences of global warming for the planet that I have now come to the conclusion that the solution is to make more use of nuclear energy.”

  — **Rev. Hugh Montefiore -** Former chairman and trustee for Friends of the Earth - The Tablet (U.K.), Oct. 23, 2004

- “Global warming is the environmental issue of our generation. Clearly, to solve this problem we need to have all technologies on the table. Therefore, nuclear energy ... needs to be considered.”

  — **Bill Chameides -** Chief scientist, Environmental Defense - USA Today, March 22, 2007

- “A more diverse mix of voices are taking a positive second look at nuclear energy—environmentalists, scientists, the media, prominent Republicans and Democrats and progressive think tanks. They are all coming to a similar conclusion: If we are to meet the growing electricity needs in this country and also address global climate change, nuclear energy has a crucial role to play.”

  —**Patrick Moore -** Clean and Safe Energy Coalition co-chair Greenpeace co-founder - Kiplinger’s Business Resource Center, September 2007

- “There’s no question that [nuclear energy] is a clean way to generate huge amounts of electricity. There are no emissions, no pollution, and I think it is a very positive development.”

  —**Max Schulz -** Senior fellow, Manhattan Institute - CNBC’s “Power Lunch,” April 11, 2007

- "If all the electricity you used in your lifetime was nuclear, the amount of waste that would be added up would fit in a Coke can."

  —**Stewart Brand -** Noted environmentalist and founder, publisher and editor of The Whole Earth Catalog – TED.com, June 2009

- "Unless we embrace something like nuclear it's going to be very hard to see how we get to a place where we have 24-7 reliable, affordable power that doesn't degrade the environment."

  —**Christine Todd Whitman -** CASEnergy co-chair, Former EPA administrator and New Jersey governor - Forbes.com, Jan. 13, 2010

Questions ???