Nuclear Energy: Statistics

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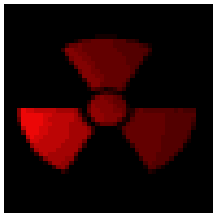
Civil Engineering

Today's Motivation

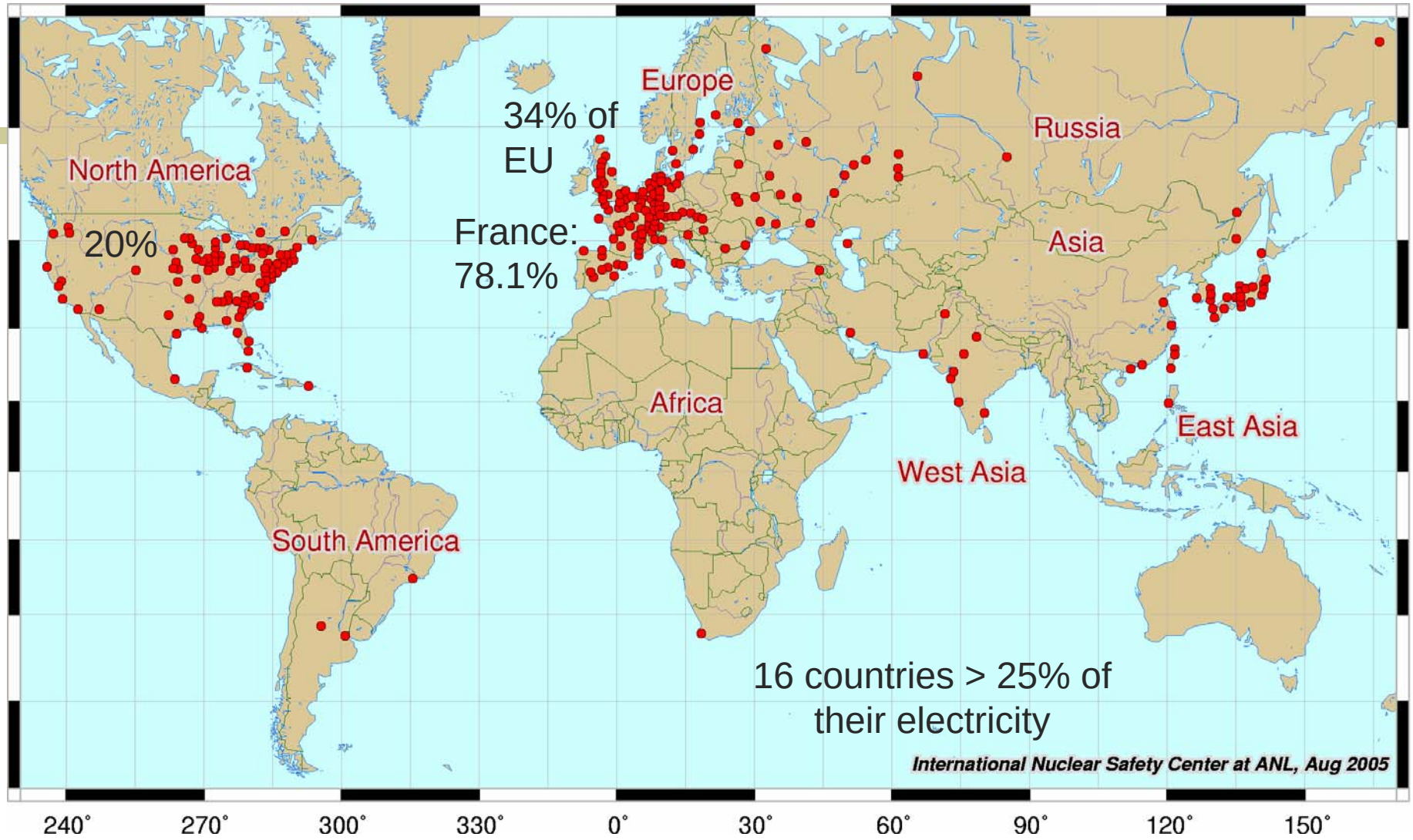
- The more people learn about nuclear power, the more supportive they are of it
  - 73% positive in Clean and Safe Energy Coalition survey in 2006.
- Nuclear power plants produce no controlled air pollutants, such as sulfur and particulates, or greenhouse gases.
  - The use of nuclear energy helps keep the air clean, preserve the earth's climate, avoid ground-level ozone formation, and prevent acid rain.
- One of the few growing markets
  - Jobs, capital…
  - 2006: 36 new plants under construction in 14 countries, 223 proposed.



Worried about Nuclear Power Plants? Dirty Bombs? Radon?

- U.S. civilian nuclear reactor program: 0 deaths
- Each year, 100 coal miners and 100 coal transporters are killed; 33,134 total from 1931 to 1995.
- Aviation deaths since 1938: 54,000
- “That’s hot.”
  - Coal-fired plant releases 100 times more radiation than equivalent nuclear reactor
  - Three Mile Island released 1/6 of the radiation of a chest x-ray
  - Despite major human mistakes, 56 Chernobyl deaths

Nuclear power plants: 15.2% of the world's electricity production in 2006.



31 countries worldwide operating 439 nuclear reactors for electricity generation.

U.S. Nuclear

- There are 104 commercial nuclear power plants in the United States. They are located at 64 sites in 31 states.
  - 35 boiling water reactors
  - 69 pressurized water reactors
  - 0 next generation reactors
- Nuclear already provides 20 percent of the United State's electricity, or 787.2 billion kilowatt-hours (bkWh)
- Electricity demands expected to increase 30% nationally by 2030.

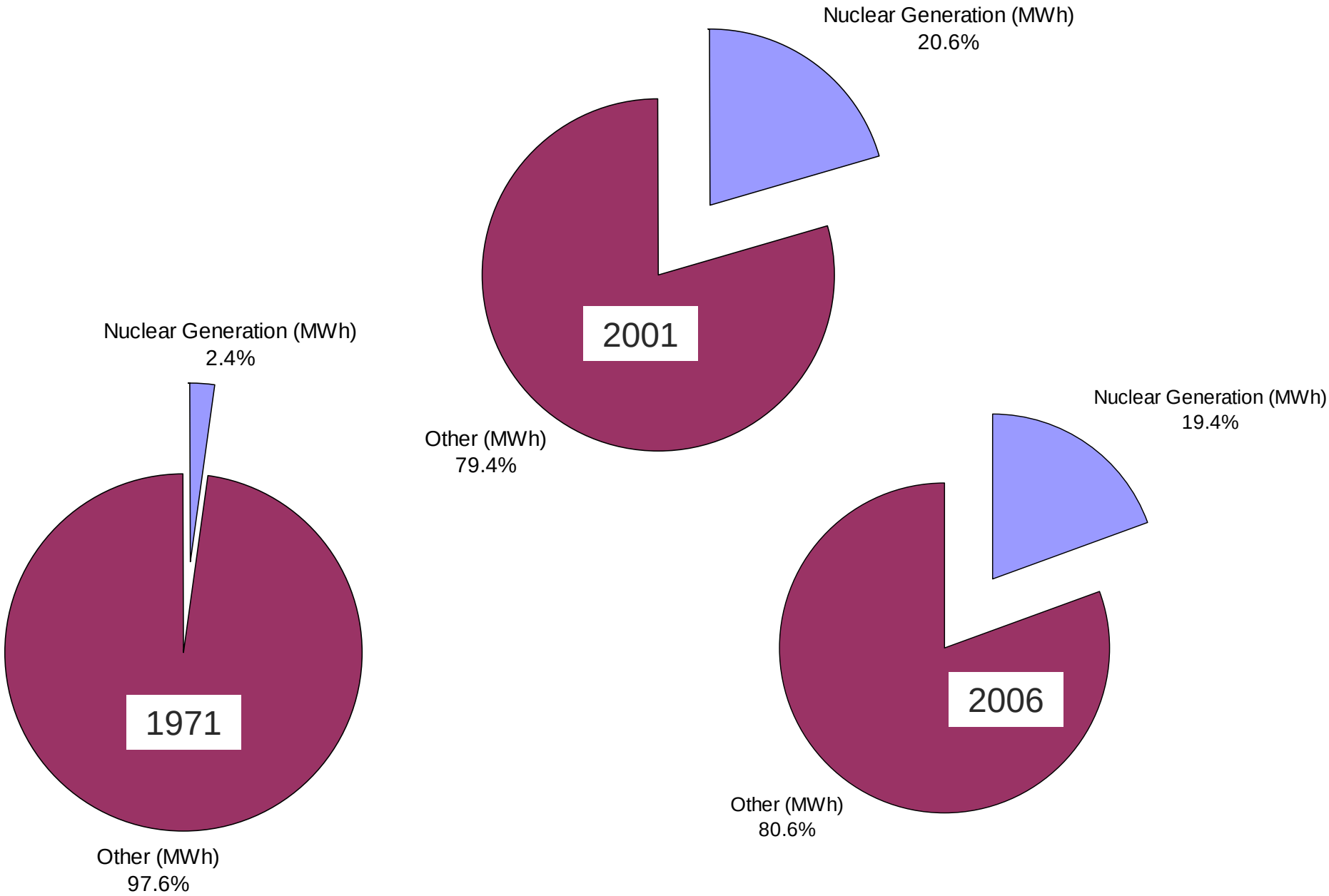
U. S. Nuclear Cont.

- 32 companies licensed to operate nuclear reactors; 4 manufacturers
- In seven states for 2006, nuclear makes up the largest percentage of their electricity generated:
- A 1,000-megawatt power plant can meet the needs of a city the size of Boston or Seattle.
- Largest U.S. nuclear plant:
  Palo Verde (Arizona): 3 reactors at 1,311 / 1,314 / 1,247 megawatts (MW) each for a total of 3,872 MW

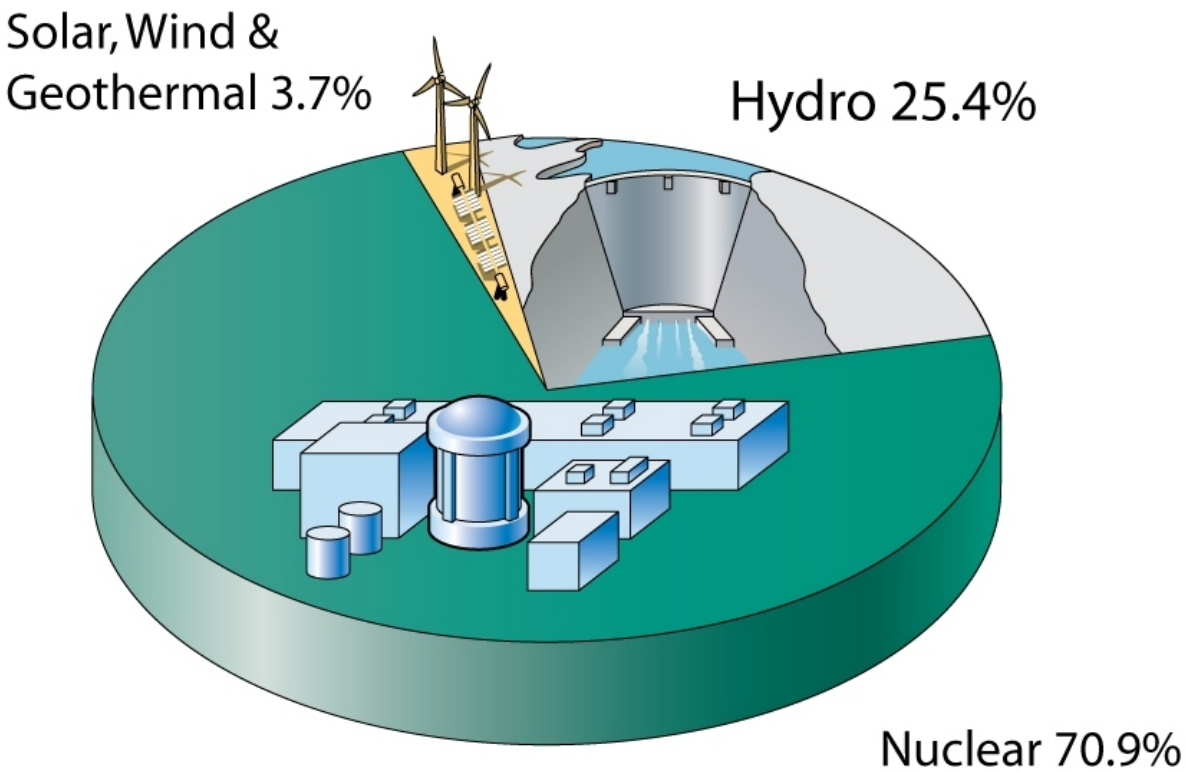
  Smallest U.S. nuclear plant:
  Ft. Calhoun (Neb.): 1 reactor at 478 MW

  Oldest U.S. nuclear plant:
  Oyster Creek, New Jersey, April 1969

State	Percent
Vermont	75.1
New Jersey	53.2
South Carolina	52.1
Illinois	48.8
Connecticut	48.4
New Hampshire	41.7
New York	30.1


Nuclear Generation (MWh)
20.6%
2001
Other (MWh)
79.4%
Nuclear Generation (MWh)
2.4%
1971
Other (MWh)
97.6%
Nuclear Generation (MWh)
19.4%
2006
Other (MWh)
80.6%

Sources of Emission-Free Electricity 2006



Of the U.S.'s 27% clean-air energy sources

U.S. Attitudes
(Clean and Safe Energy Coalition, 2006)

- 76% of Americans do not believe enough is being done to increase affordable electricity supplies for the future
- 69%of Americans do not believe enough is being done to reduce greenhouse gas emissions and air pollution associated with electricity production

→ However, industry operating at 89.6% of capacity

Nuclear Energy in Mississippi

July 2007

Mississippi's Electricity Generation

Nuclear	22.6%
Coal	39.4%
Oil	0.9%
Gas	33.8%
Hydro	0.0%
Renewable and Other	3.4%

Source: Energy Information Administration, 2006

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Nuclear Power Plants in the State

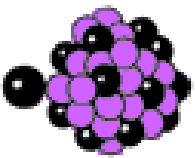
	City	Capacity (MW)	2006 Generation (MWh)	2004-2006 3-year Average Capacity Factor (%)
Grand Gulf 1	**Port Gibson**	1,266	10,418,586	92.2

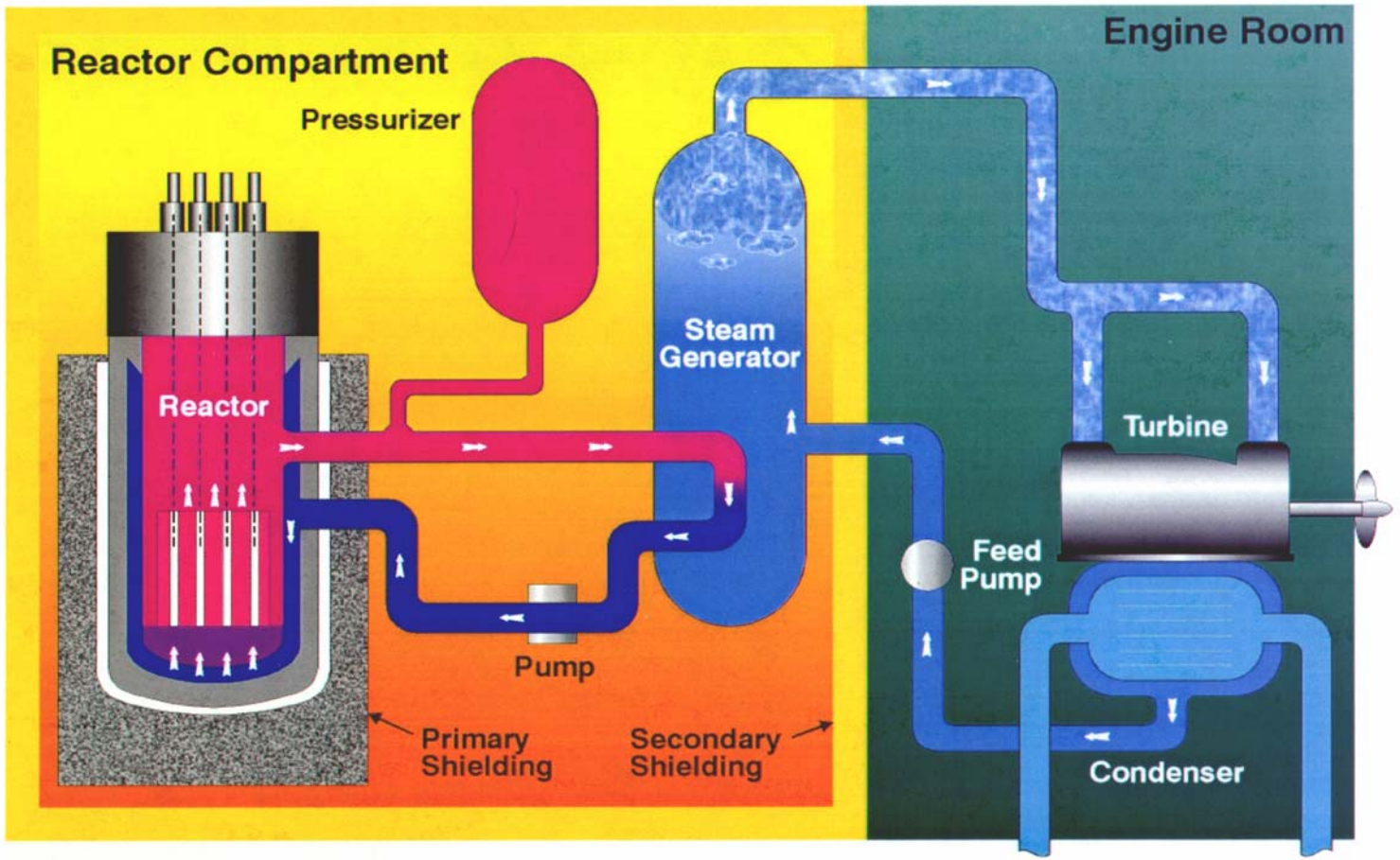
How Nuclear Power Plants Work

- http://www.southerncompany.com/southernnuclear/how.asp

http://www.southerncompany.com/learningpower/howplants.asp

Basic
Fission: Atom splitting





A Cost Effective Option

- Economically competitive
- Nuclear Power: 1.82 cents per kWh
- Coal: 2.13 cents per kWh
- Natural gas: 3.69 cents per kWh

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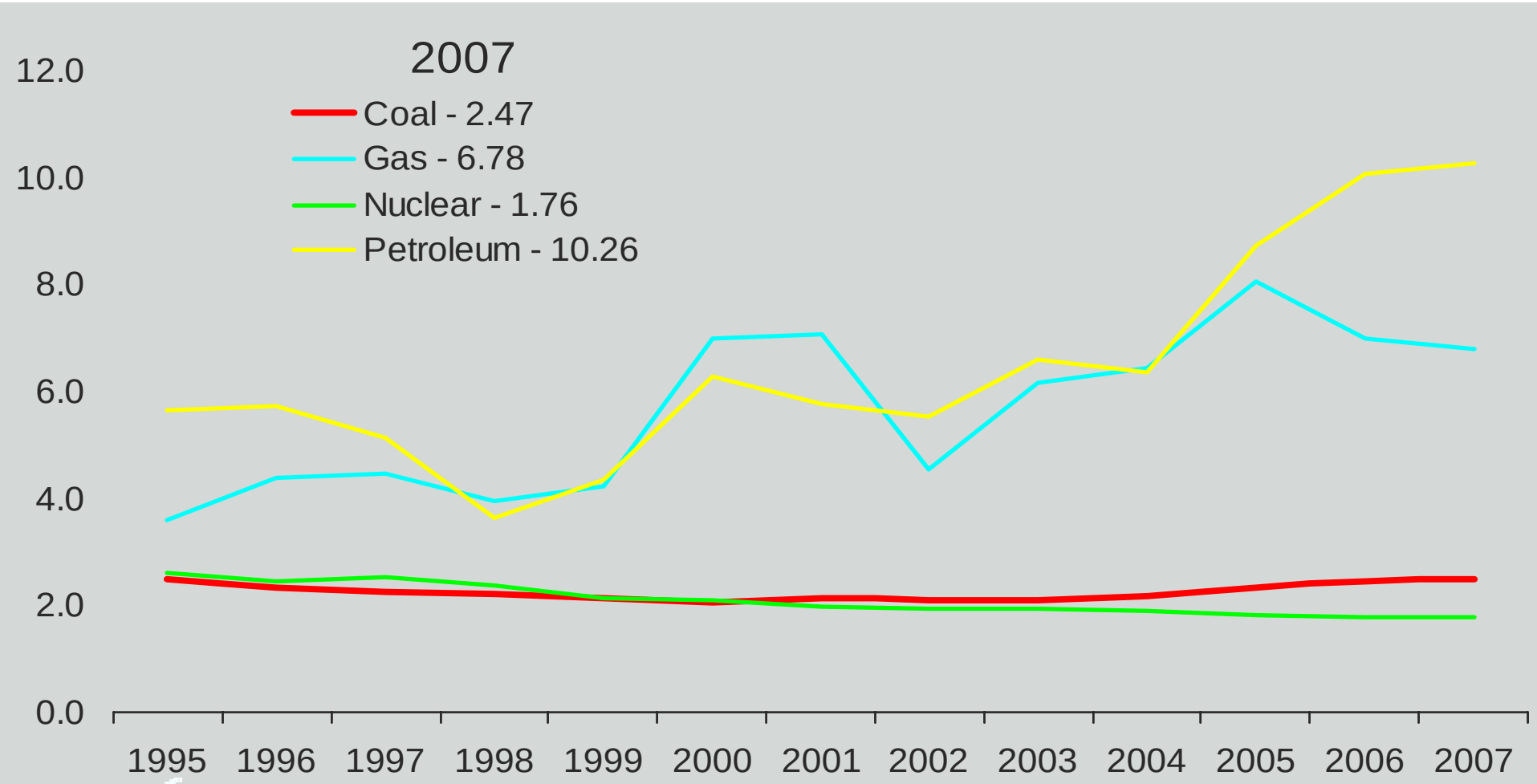
U.S. Electricity Production Costs

1995-2007, *In 2007 cents per kilowatt-hour*



Production Costs = Operations and Maintenance Costs + Fuel Costs

Source: Global Energy Decisions
Updated: 5/08

NEI
NUCLEAR ENERGY INSTITUTE

Energy Production Comparison

- Amount of electricity generated by a 1,000-MWe reactor at 90% capacity factor in one year:
  7.9 billion KWh
  - 740,000 households
- If generated by other fuel sources, it would require:
  - Oil: 13.7 million barrels – 1 barrel yields 576 KWh
  - Coal: 3.4 million short tons – 1 ton yields 2,297 KWh
  - Natural Gas: 65.8 billion cubic feet – 100 cubic feet yields 12 KWh

(Energy Information Administration)

Clean Energy Production Comparison

- Nuclear power plants require little land vs. 1000MWe solar plant consisting of 60 square miles of glass
- Biomass: ethanol takes 10 Iowas for 1000MWe and potentially more smog.
- 5400 windmills for 1000MWe (chopping birds)

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No Greenhouse Gases

- Nuclear power does not burn anything to generate electricity, saving 2.6 billion metric tons of CO_2 / year
- In 2004, the use of nuclear power to generate electricity avoided emissions of nearly as much carbon dioxide as is released from all U.S. passenger cars combined, 681 million metric tons.
  - 134 of 136 million passenger cars would have to be eliminated to keep U.S. carbon dioxide emissions from increasing.
  - 51 million passenger cars would have to be eliminated to save the same amount of nitrogen oxide emissions.
- Nuclear energy accounts for 90% of all electric utility savings in carbon dioxide emissions since 1973.
  - Nuclear power reduces worldwide CO_2 emissions by more than 2 billion metric tons per year.
- In 2006, nuclear plants avoided the emission of 3.1 million short tons of sulfur dioxide

Carbon Dioxide Comparison

Generating 1 million kilowatt-hours of electricity produces:

- 996 metric tons of carbon dioxide from a coal-fired plant
- 809 metric tons of carbon dioxide from an oil-fired plant
- 476 metric tons of carbon dioxide from a natural gas-fired plant
- None from a nuclear power plant.

Interim Dry Used Fuel Storage

- As of December 2004, more than 690 containers have been loaded at 30 nuclear sites.
- About 20 reactors at 16 commercial nuclear sites will need additional storage space by 2010, and at least 22 more reactors will need additional storage by the end of 2015.

Vertical Storage

Horizontal Storage

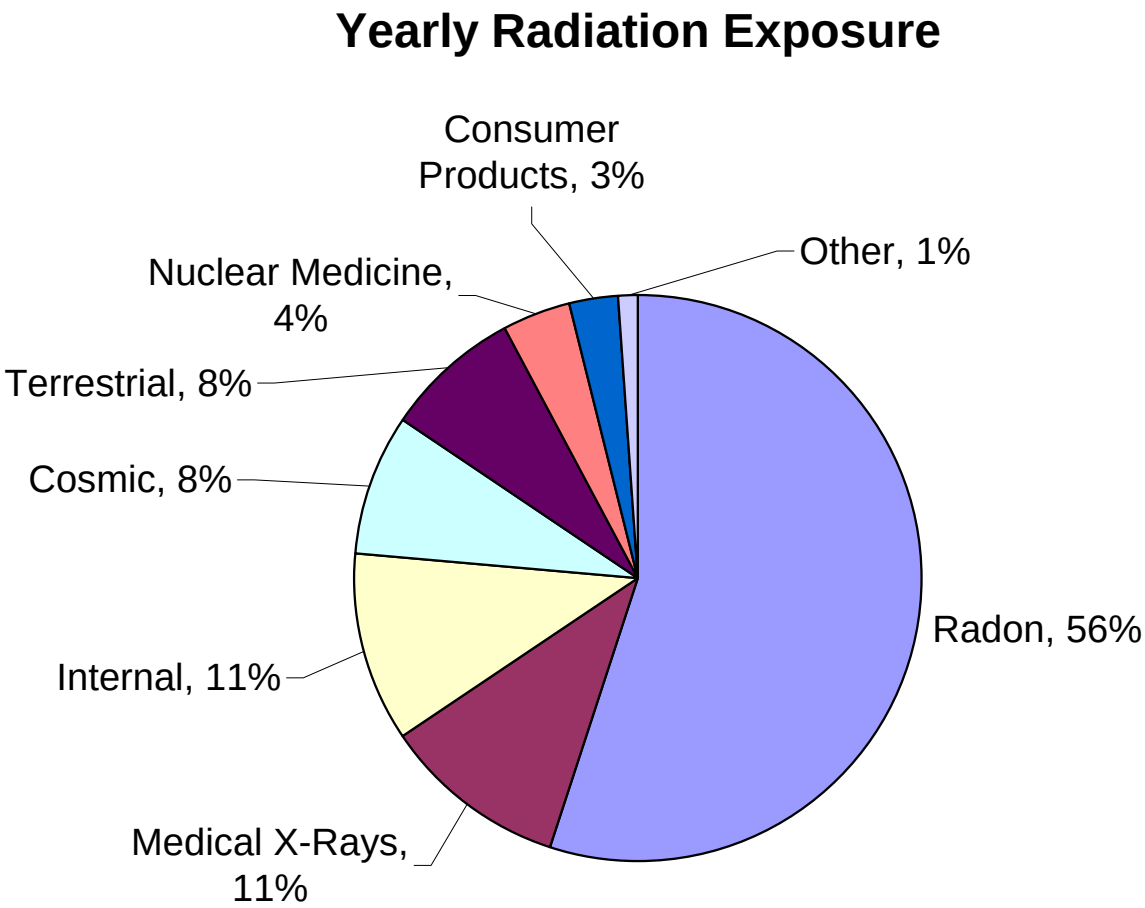
Low-Level Radioactive Waste (LLRW)

- LLRW consists of items that have come in contact with radioactive materials, such as personal protective clothing.
- Its radioactivity decays to background radioactivity levels in less than 500 years: 95% decays to background levels within 100 years.

Amount of low-level radioactive waste generated per year by plant/industry:

- 1998 Average Reactor Volume – 742 cubic feet (21 cubic meters) for PWRs; 2,790 cubic feet (79 cubic meters) for BWRs
- 1998 Industry Volume – 135,394.71 cubic feet (3,834 cubic meters)
- Decreased since 1998

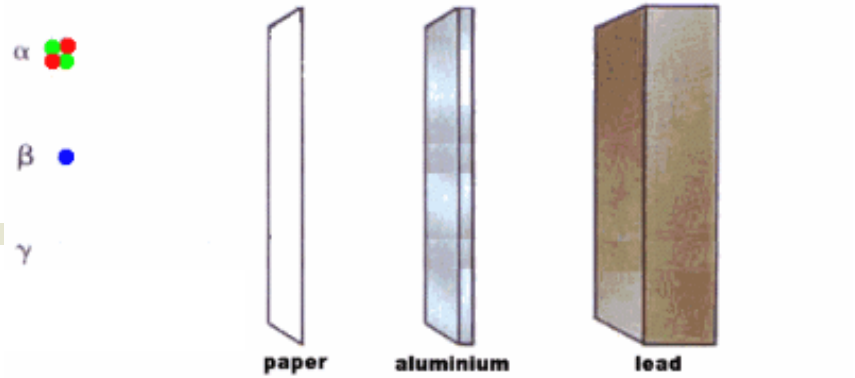
Health Physics



- Even 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.
- You would have to live near a nuclear power plant for over 2,000 years to get the same amount of radiation exposure that you get from a single diagnostic medical x-ray.

Natural Radioactivity

Fruits have the least natural radioactivity, so if fruits = 1…



Brazil nuts	14000
Lima bean	5160
Bananas	3910
Carrots	3780
White potatoes	3780
Cereals	600
Beer	430
Teas	400
Red meat	330
Liver and kidney	150
Flours	140
Peanuts	120
Chocolates	80
Biscuits	20
Evaporated Milk	15
Fish	15
Cheese and eggs	9
Vegetables	7
Fruits	1

Fission Facts: Southern Nuclear Company

- In December 1951, an experimental reactor produced the first electric power from the atom, lighting four light bulbs.
- All SNC plants are certified by the Wildlife Habitat Council to enhance and protect wildlife resources, and habitats around the plant sites.
- Water discharged from a nuclear power plant contains no harmful pollutants and even meet regulatory standards for temperature.
- Radiation is used to sterilize baby powder, bandages, contact lens solution, false eyelashes, mascara…
- Uranium is a relatively abundant element that occurs naturally in the earth's crust. Uranium oxide is more abundant than gold and silver, and as common as tin.

Other Facts About Nuclear Energy

- Supplies electricity each year to serve 60 million homes.
- Nuclear energy has one of the lowest environmental impacts of any electricity source.
  - A wind farm would need 235 square miles to produce the same amount of electricity as a 1,000-megawatt nuclear power plant.
- One uranium fuel pellet is equivalent to 17,000 cubic feet of natural gas, 1,780 pounds of coal, or 149 gallons of oil.
  (uses 5 pounds of uranium or 2 inch cube / day)

- The economic activity of a U.S. nuclear plant generates on average around $40 million in state and local tax revenues.
- There are nearly 100 different nuclear medicine imaging procedures available today. An estimated 10 to 12 million nuclear medicine imaging and therapeutic procedures are performed each year in the United States.

The future…

NEW MULTI-DISCIPLINARY TECHNICAL ELECTIVE
FALL 2009

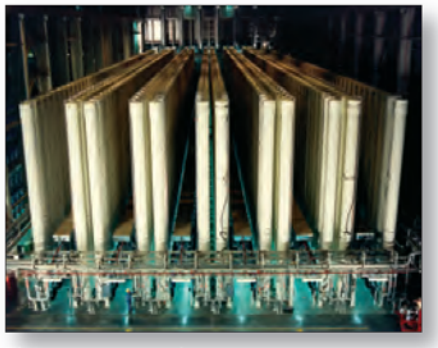
INTRODUCTION TO NUCLEAR ENGINEERING

CE497-1 CE Project / ENGR597-21 Special Projects II
E. K. Ervin, Civil Engineering; eke@olemiss.edu
MW 4pm-5:15pm
Anderson Auditorium 21

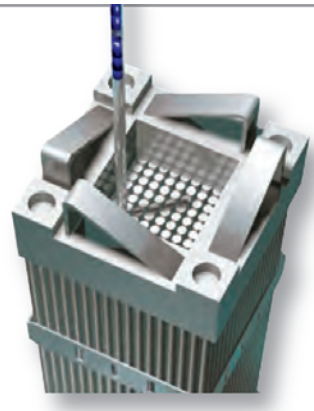
OPEN TO ALL MAJORS with consent of instructor.

- Nuclear Regulatory Commission Curriculum Education Grant Program

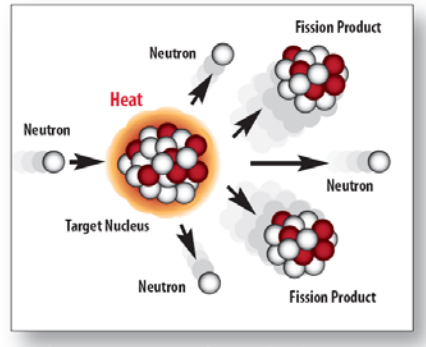
After mining, uranium is milled and processed to create **uranium oxide** or **yellowcake**.



The conversion plant removes impurities and chemically converts the material. **Enrichment** makes the uranium usable as a fuel.

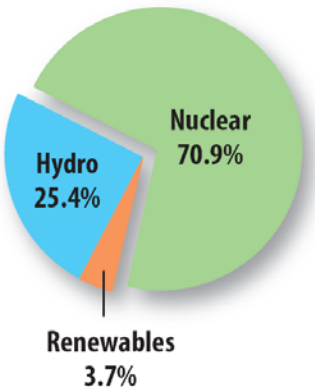


A fuel fabricator presses the uranium into solid, ceramic **pellets** and inserts them into rods making a **fuel assembly**. Assemblies are then transported to the nuclear plant and loaded into the **reactor**.



In the reactor, **nuclear fission** produces energy to heat water and create steam that powers generators to produce electricity.

Emission-Free Power



Nuclear energy is by far the largest source of **carbon-free** generation and provides 20 percent of U.S. electricity. By using nuclear power instead of fossil fuel-based plants, the industry prevents the emission of millions of tons of carbon dioxide and other greenhouse gases every year.

Fuel Pellet

A nuclear reactor generates reliable electricity around the clock without producing **greenhouse gases**.

Building new nuclear plants is critical to meeting U.S. **environmental and energy** goals.

With 400 to 700 permanent jobs at a nuclear power plant, it provides significant **economic benefits** to local communities.

After a cooling period, nuclear power plants store used fuel **safely** and **securely** on site in steel and concrete vaults.

Used fuel containers will travel by **trains, trucks** and **barges** to a permanent repository or a recycling facility.

Development of advanced **fuel-cycle technologies** improves efficiency and reduces waste but does not preclude the need for a federal repository.

A deep geologic repository is considered the best method of managing used nuclear fuel and recycling byproducts. The U.S. government is developing a repository at Yucca Mountain, Nev.