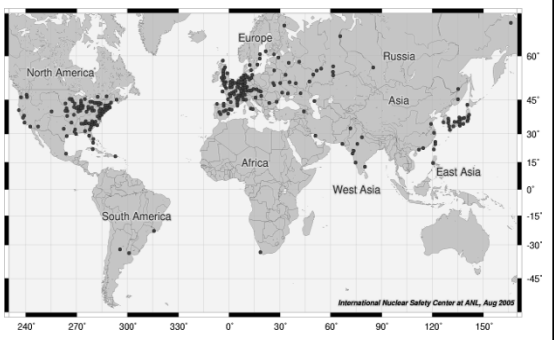
## Lec #22: Nuclear Power. I.

Today: Begin Nuclear Power (Chaps 13-15)

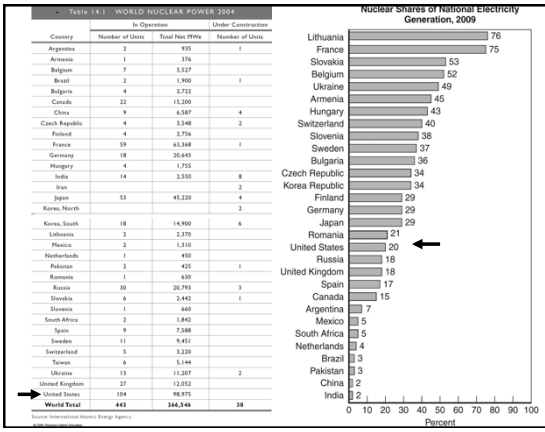
## Nuclear Power Today

- Worldwide:
  - 33 countries, 443 power plants, 367 GW capacity
  - 38 under construction
  - 18 countries have higher reliance on nuclear than US
  - France gets over 80% of electricity from nuclear
- In US:
  - 104 power plants; 99 GW total capacity
  - 20% of US electrical generation capacity
- South Carolina:
  - 7 nuclear plants
  - Savannah River Site

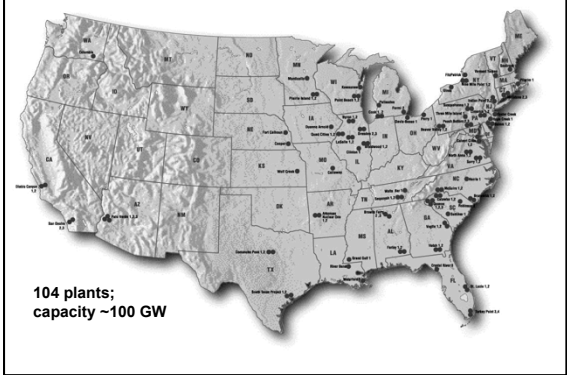
**World Nuclear Energy Facilities**




**Over 440 commercial nuclear power reactors operating in 30 countries**



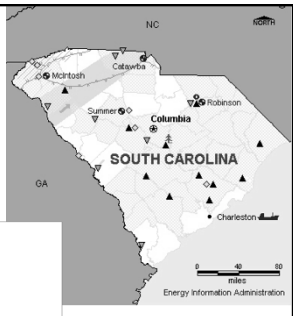

**US Nuclear Energy Facilities**

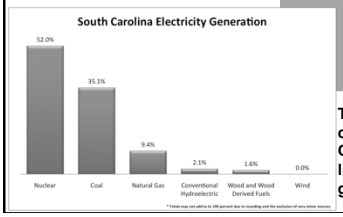


**104 plants; capacity ~100 GW**

**Nuclear Energy Facilities in South Carolina**

**South Carolina's four nuclear power plants typically supply about one-half of the State's electricity generation**

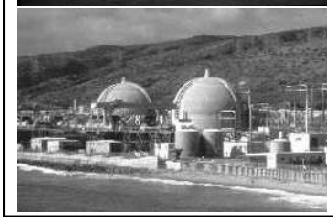



**Two new nuclear reactors could come online in South Carolina by 2016, if licensing and construction go as planned.**

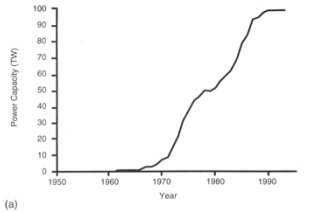
Oconee

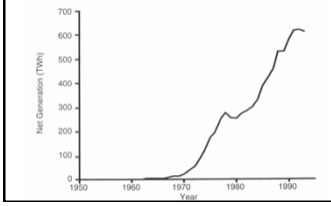
(near Clemson, SC)



San Onofre

(near Camp Pendelton)




TRENDS:

rapid buildup of nuclear power plants in 70's and 80's

no new plants ordered after 1979 (until very recently)

few under construction

many getting old

capacity has leveled off

Three Mile Island (near Harrisburg, PA)

## Nuclear v. Fossil Fuels

- No combustion byproducts!
  - no air pollution
  - no greenhouse gases
- Tiny solid waste stream!
  - coal: 100 train cars each day in; up to 10 cars of waste out
  - nuclear: 1 train car enough fuel for 3 years (in and out)
- Nuclear is proven technology
  - large scale electrical power plants
  - smaller scale for ship propulsion
- Fuel can be **reprocessed** until all fissile material is used
- Some reactors can "**breed**" more fuel than they use!

Average Operating Expense of Electricity Generation for Major U.S. Investor-Owned Electric Utilities, 2002-2006
In Cents Per Kilowatt Hour

| Year | Nuclear | Fossil Steam | Hydroelectric | Gas Turbine |
|---|---|---|---|---|
| 2002 | 1.82 | 2.13 | 0.87 | 3.69 |
| 2003 | 1.87 | 2.26 | 0.75 | 4.89 |
| 2004 | 1.83 | 2.39 | 0.87 | 5.01 |
| 2005 | 1.82 | 2.77 | 0.89 | 5.89 |
| 2006 | 1.95 | 2.96 | 0.85 | 5.78 |

Note: Excludes capital costs, a major expense for nuclear electricity.
*Source: U.S. Energy Information Administration.*

**PROS**
**•Emit relatively low amounts of carbon dioxide ($CO_2$).**
**•Large amount of electrical energy can be generated in one single plant.**

**CONS**
**•Pollution during mining and processing. Radioactive waste.**
**•Safety Issues. Although considered safe, accidents can still happen.**
**•Uranium is scarce, its supply is estimated to last only for about 50 years**
**•Nuclear Terrorism**

## Some Disadvantages

- Still relies on mining and "consuming" natural resources, but the impact is far less than coal and the geopolitics is not as unfavorable as petroleum.
- Uranium ore is a finite resource; maybe only ~50 years!
  - but it can go a long way with reprocessing a/o breeding
  - there might be more; we never really got serious
- Initial processing of fuel is very expensive and energy intensive (but infrastructure is already developed)
- Some radioactive waste release to environment is inevitable (though it's less than that from coal burning)
- High-level radioactive waste must be dealt with
  - spent fuel
  - power plant itself

# Fundamentals of Nuclear Physics

A. NUCLEAR STRUCTURE

1. Atoms
   - nucleus positively charged, massive, compact
   - electrons small, negatively charged, occupy "large" volume
   - chemical properties determined by electron # & excitation
   - neutral atom if # electrons = # protons
   - 92 natural "stable" elements

2. Common energy units: eV (electron-Volt) or MeV ($10^6$ eV)

   Chemical reactions in atoms = few eV

   Nuclear reactions = few to hundreds of MeV

   1 eV = (1.6E-19 C) times (1 J/C)

   = 1.6E-19 Joules