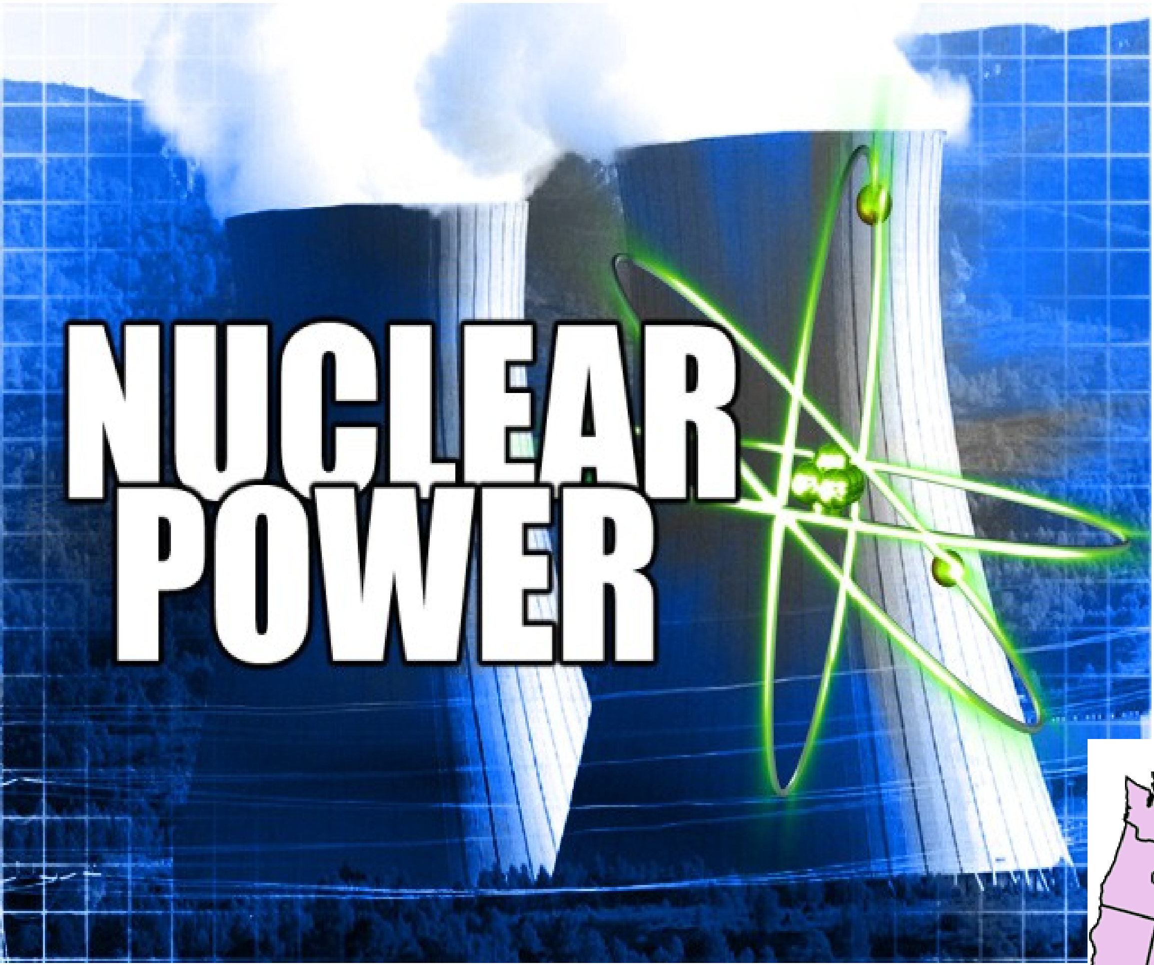
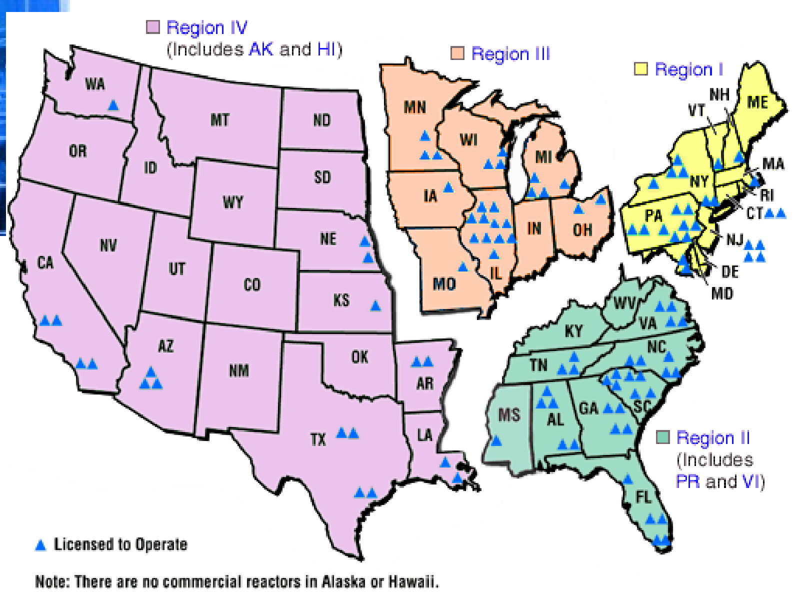
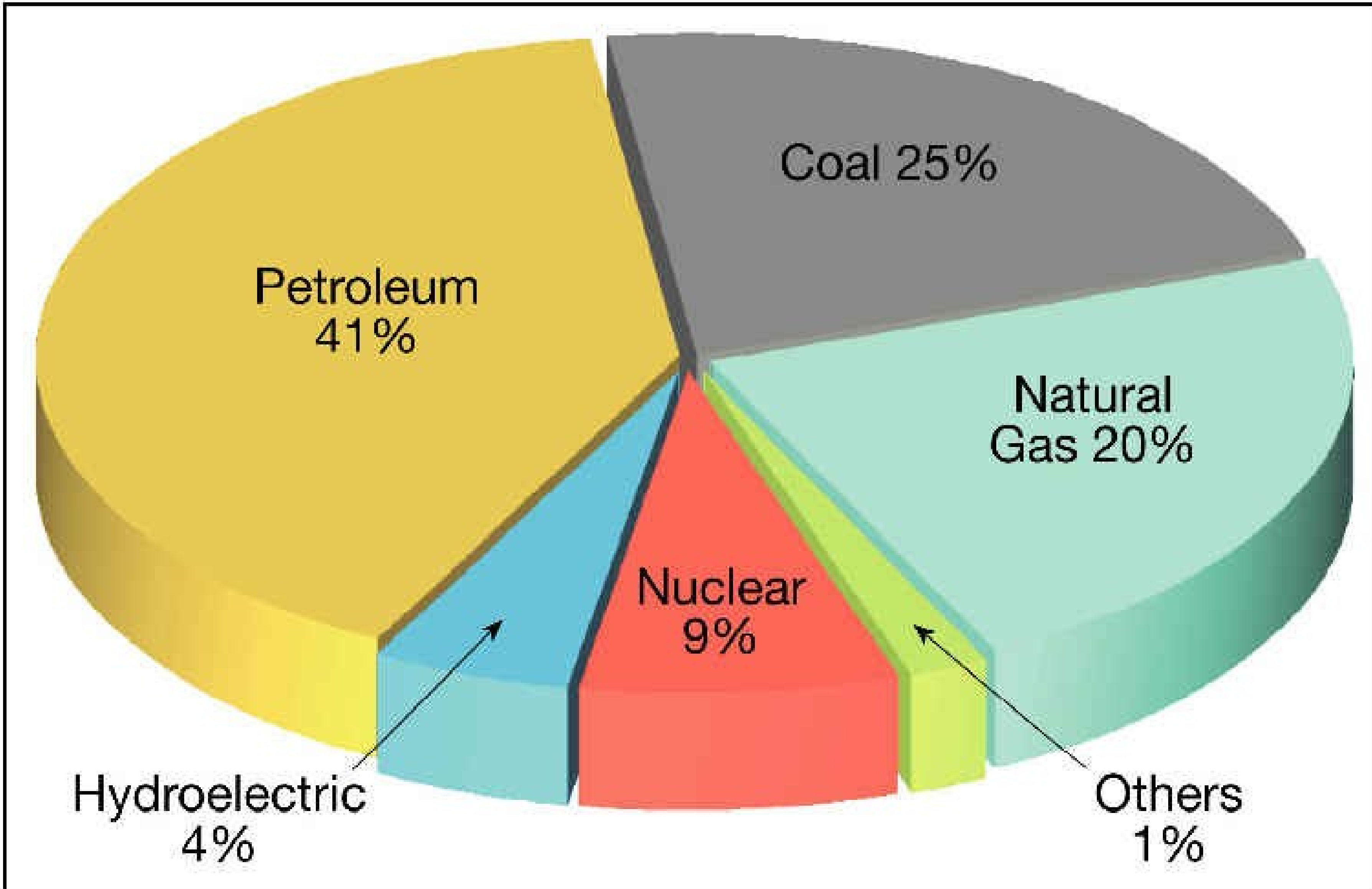


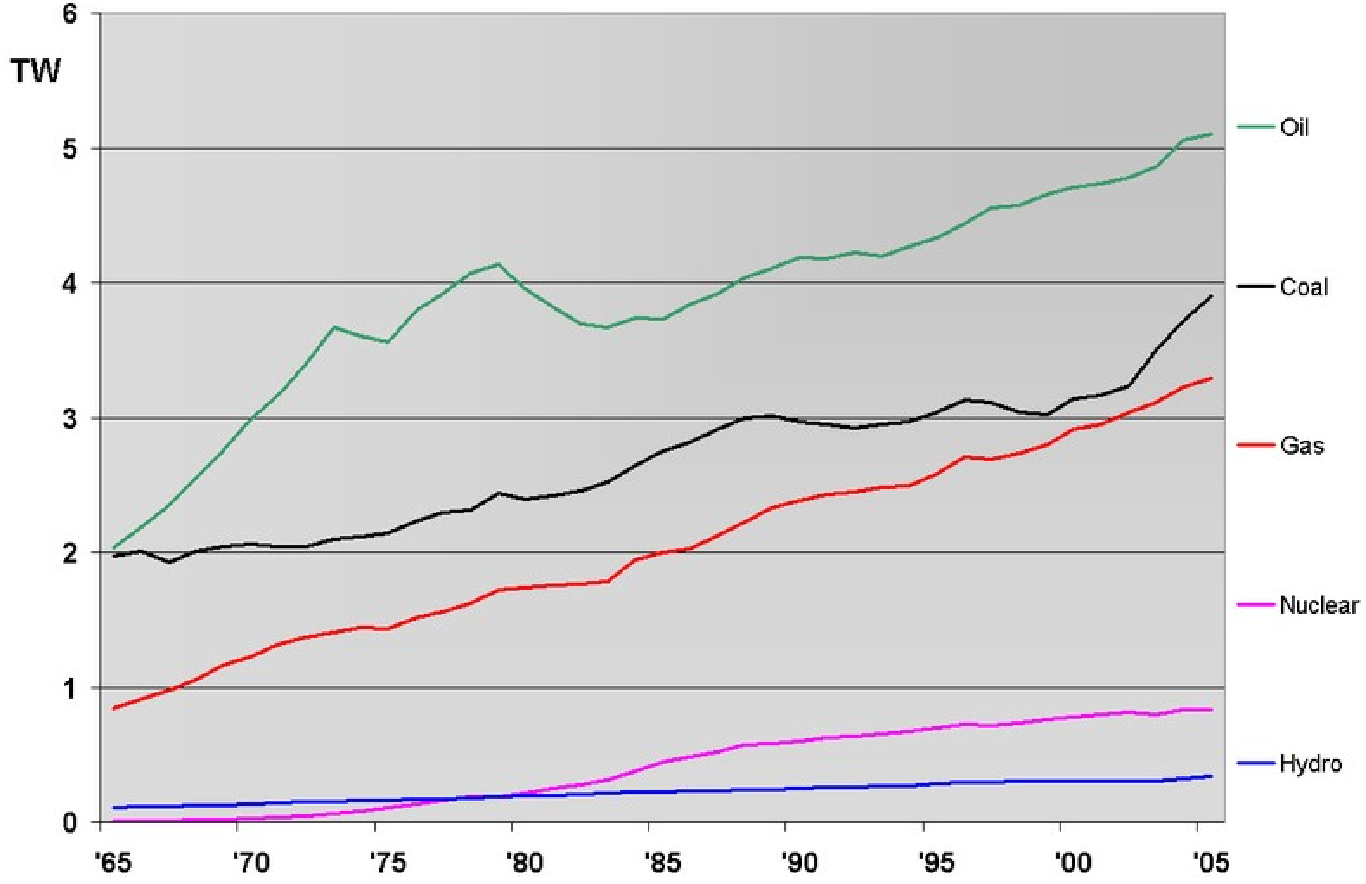
Approx 9% US energy from NP

104 Nuclear Reactors in US

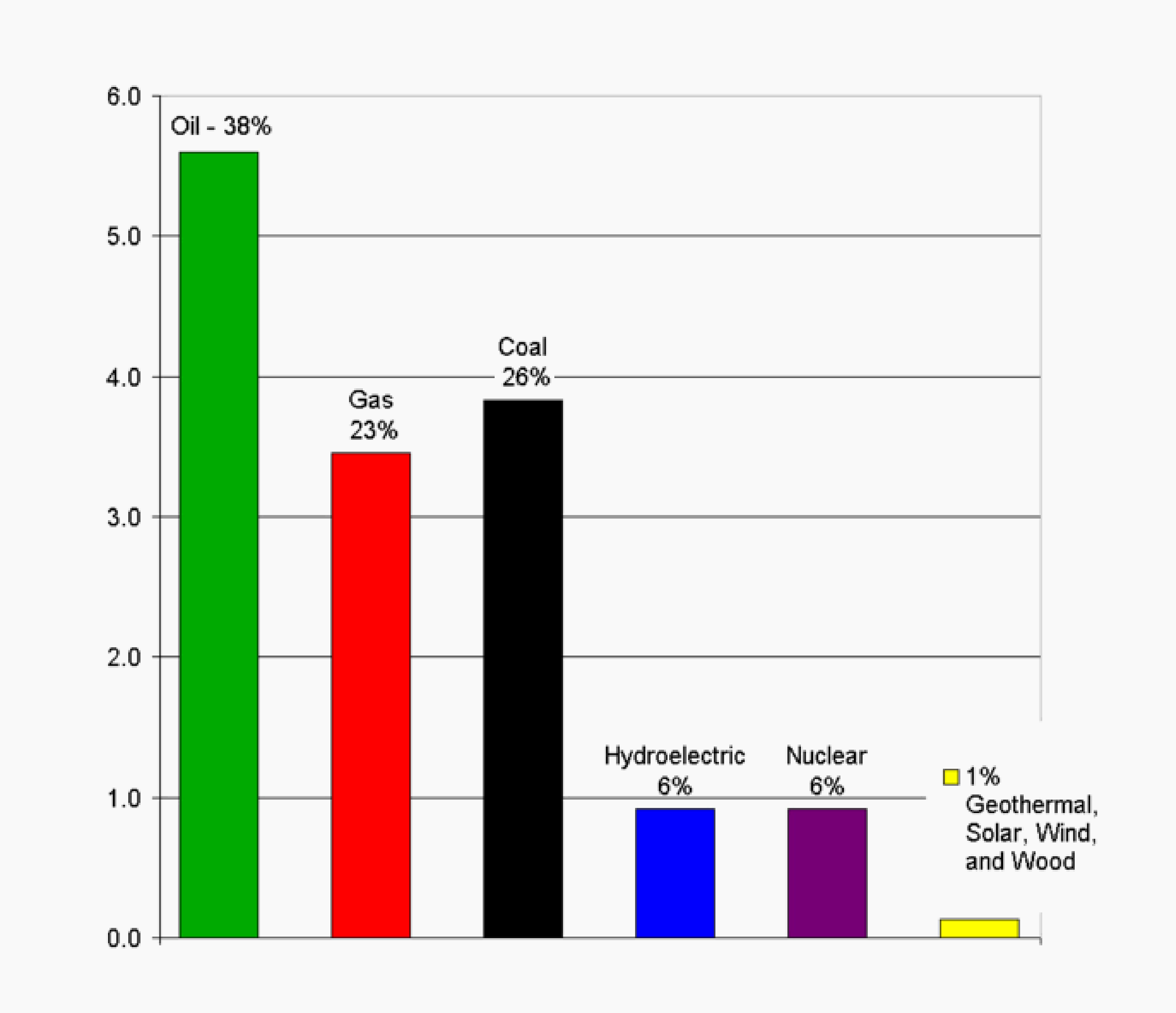


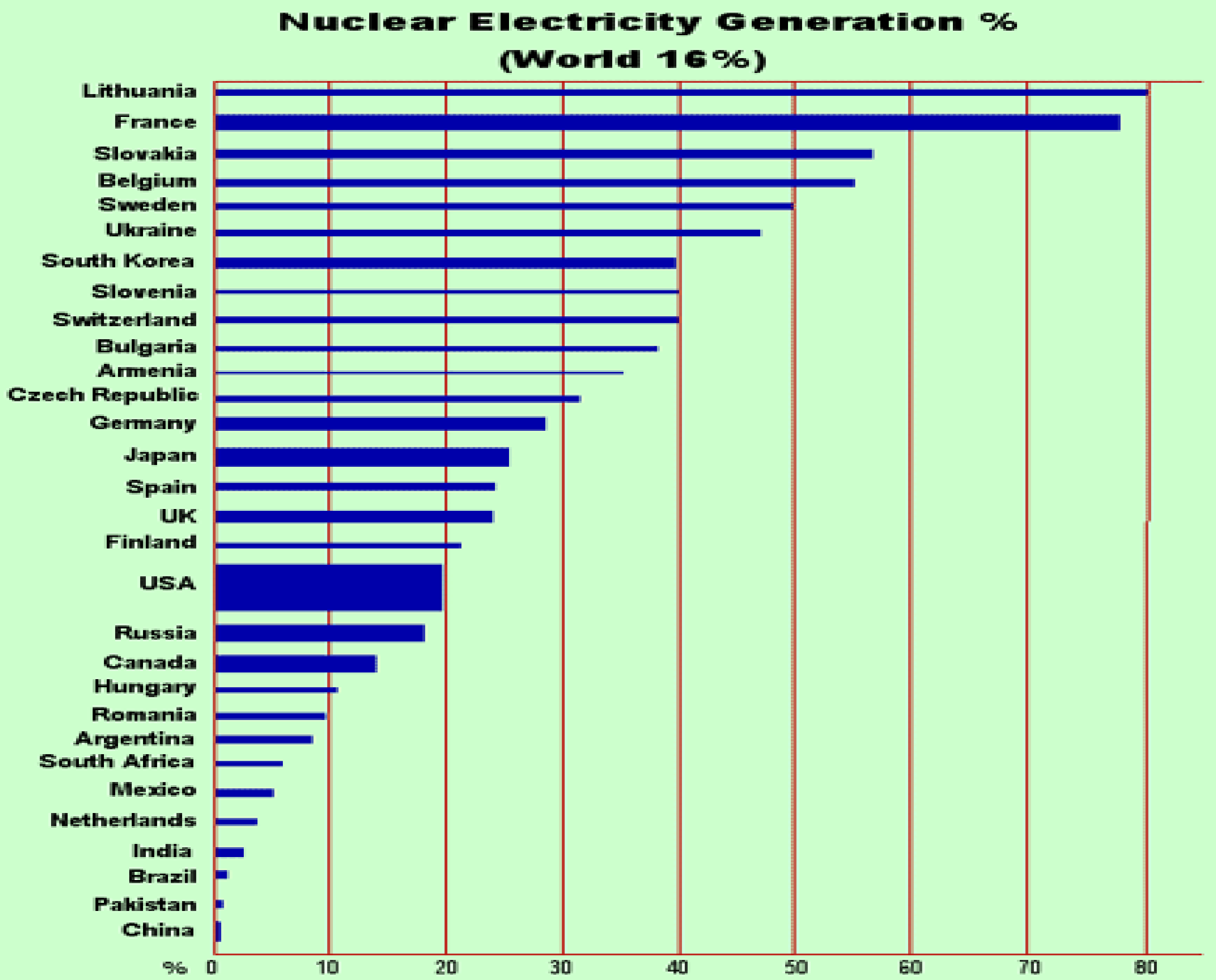

Coal 25%
Petroleum
41%
Natural
Gas 20%
Nuclear
9%
Hydroelectric
4%
Others
1%

World Energy Consumption



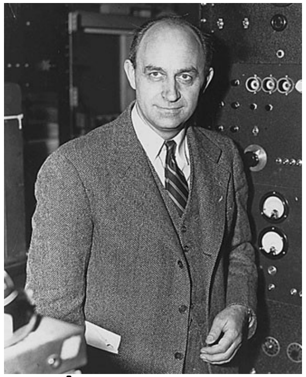
Terawatts


6.0
5.0
4.0
3.0
2.0
1.0
0.0
Oil - 38%
Gas
23%
Coal
26%
Hydroelectric
6%
Nuclear
6%
1%
Geothermal,
Solar, Wind,
and Wood

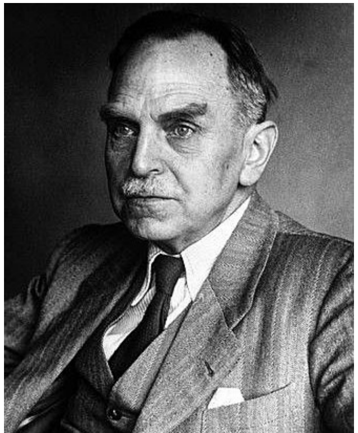


Nuclear Electricity Generation %
(World 16%)
Lithuania
France
Slovakia
Belgium
Sweden
Ukraine
South Korea
Slovenia
Switzerland
Bulgaria
Armenia
Czech Republic
Germany
Japan
Spain
UK
Finland
USA
Russia
Canada
Hungary
Romania
Argentina
South Africa
Mexico
Netherlands
India
Brazil
Pakistan
China
%
0
10
20
30
40
50
60
70
80

History of Nuclear Power



- 1934 – Enrico Fermi experimentally achieved nuclear fission showering Uranium with neutrons
- 1938- German chemists Otto Hahn, Fritz Strassmann, with Austrian physicists Lise Mietner, and Otto Frisch experimented on the product of neutron bombarded Uranium
  - They concluded the neutron split the nucleus of the Uranium atoms into two equal pieces



History of Nuclear Power

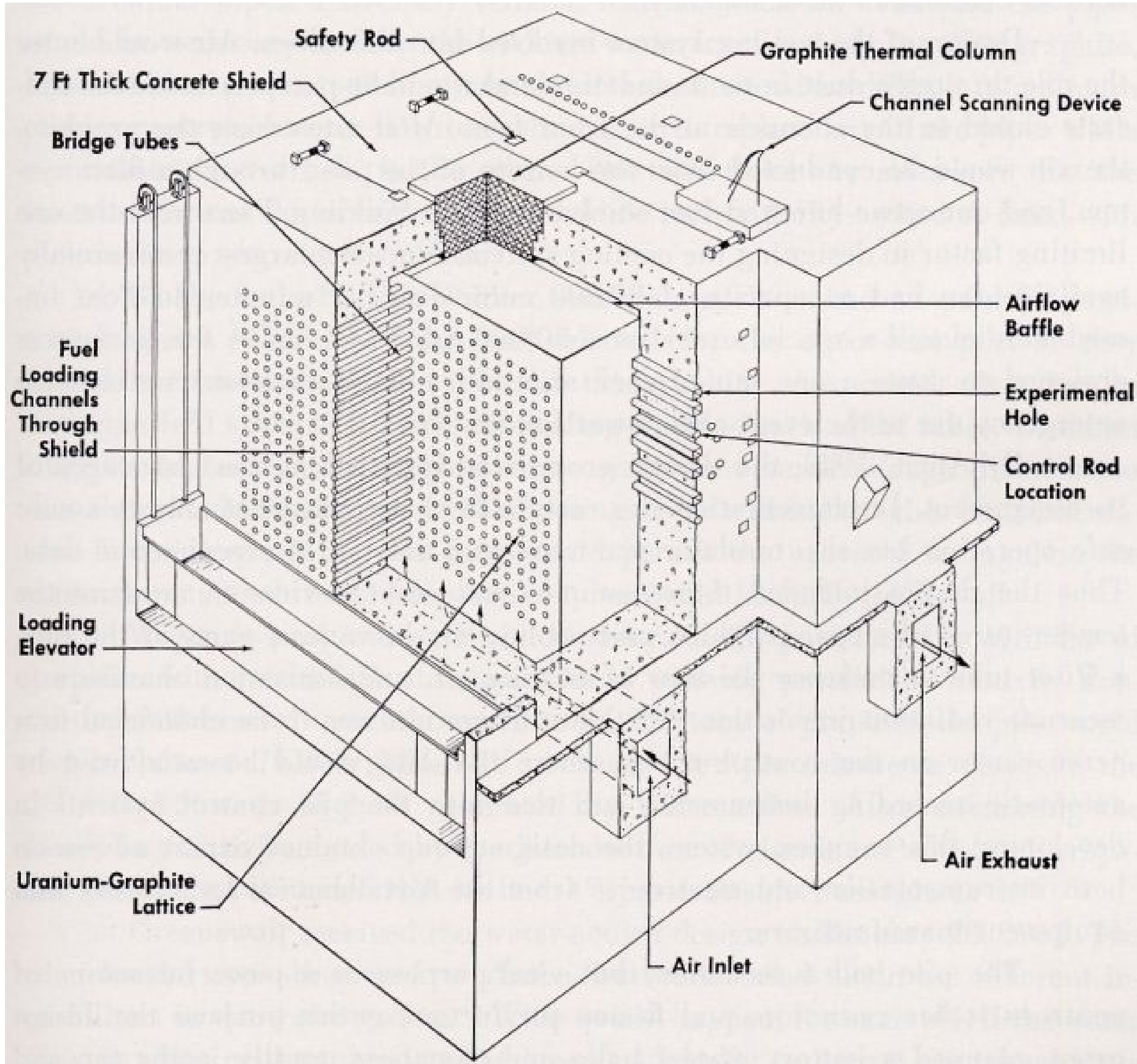
- Leo Szilard recognized that if fission reactions released additional neutrons, a self-sustaining nuclear chain reaction would result
- At this point numerous countries began petitioning their governments for funding nuclear fission research
  - U.S, U.K, France, Germany, Soviet Union
- In the U.S, Where Szilard and Fermi had migrated, the first man made reactor was created
  - Chicago Pile 1- which achieved criticality on December 2, 1942
- Manhattan Project- built large reactors at the Hanford site
  - Here plutonium was breed for use in nuclear weapons
  - A parallel uranium enrichment effort was pursued also

Chicago Pile 1

Pile = reactor
-wanted to turn Uranium into Plutonium

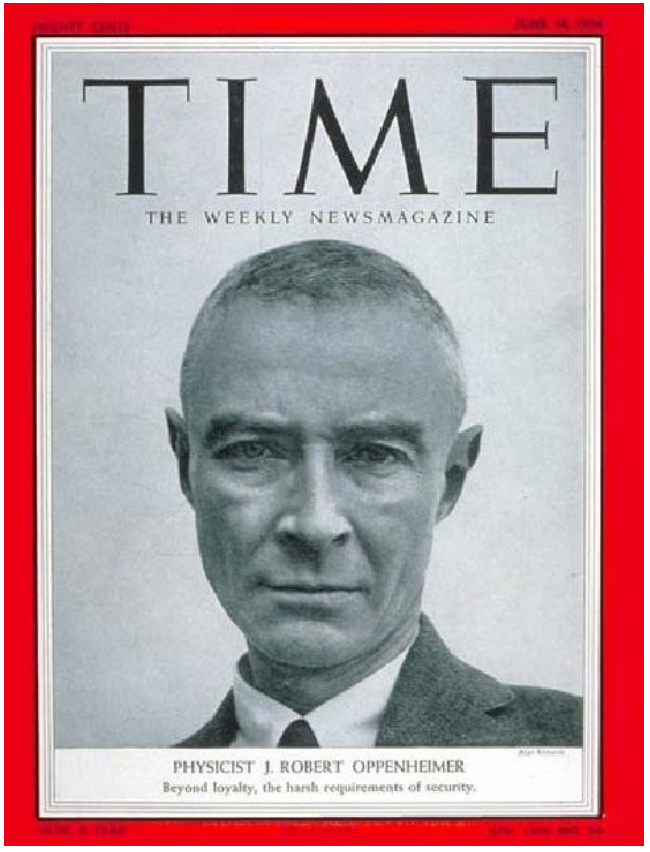
-built in the basement of U Chicago

December 1942
-the first self sustaining Nuclear chain rxn.



Manhattan Project

- Taking the knowledge of nuclear fission achieved on Chicago Pile 1, the Manhattan Project, headed by physicist Robert Oppenheimer, took the information from Chicago and designed the first nuclear weapon.



History of Nuclear Power

- U.S Navy was the first organization to develop nuclear power
  - Propel submarines and aircraft carriers
  - first nuclear-powered submarine, USS Nautilus, was put to sea in December 1954
  - Symbol of modern nuclear power

History of Nuclear Power- Cold War Race

- December 20, 1951- Electricity was generated for the first time by a nuclear reactor
  - A the EBR-I experimental station near Arco, Idaho
  - initially produced about 100 kW
- June 27, 1954- USSR's Obninsk Nuclear Power Plant became the world's first nuclear power plant to generate electricity for a power grid
  - produced around 5 megawatts electric power
- 1956 - world's first commercial nuclear power station in Sellafield, England
  - initial capacity of 50 MW (later 200 MW)
- December, 1957- The first commercial nuclear generator to become operational in the United States was the Shippingport Reactor in Pennsylvania

History Overview

-The science of atomic radiation, atomic change and nuclear fission was developed from 1895 to 1945, much of it in the last six of those years.

-Over 1939-45, most development was focused on the atomic bomb, weapons grade plutonium → enrichment of 235U.

-From 1945 attention was given to harnessing this energy in a controlled fashion for naval propulsion and for making electricity.

Nuclear Power Begins post WWII

-Since 1956 the prime focus has been on the technological evolution of reliable nuclear power plants.

Nuclear Fission

-most commonly used form of NP

-U235 is a special Isotope of the normal (inactive) U231

-Neutron collides with atom of U235

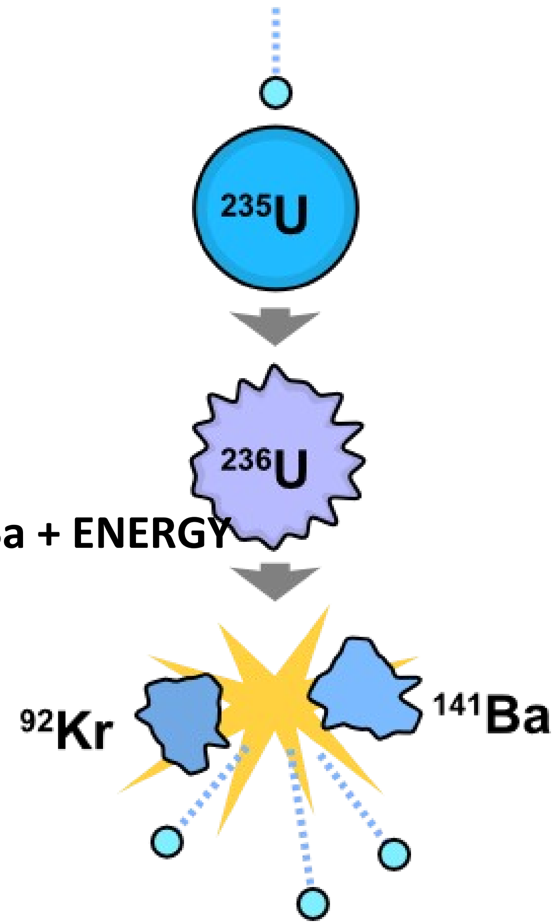
-atom splits into Krypton and Barium
plus ENERGY

235U + 1 neutron →→ 2 neutrons + 92Kr + 142Ba + ENERGY

-fission of one U235 atom yields Seven million times the energy of Exploding one TNT molecule

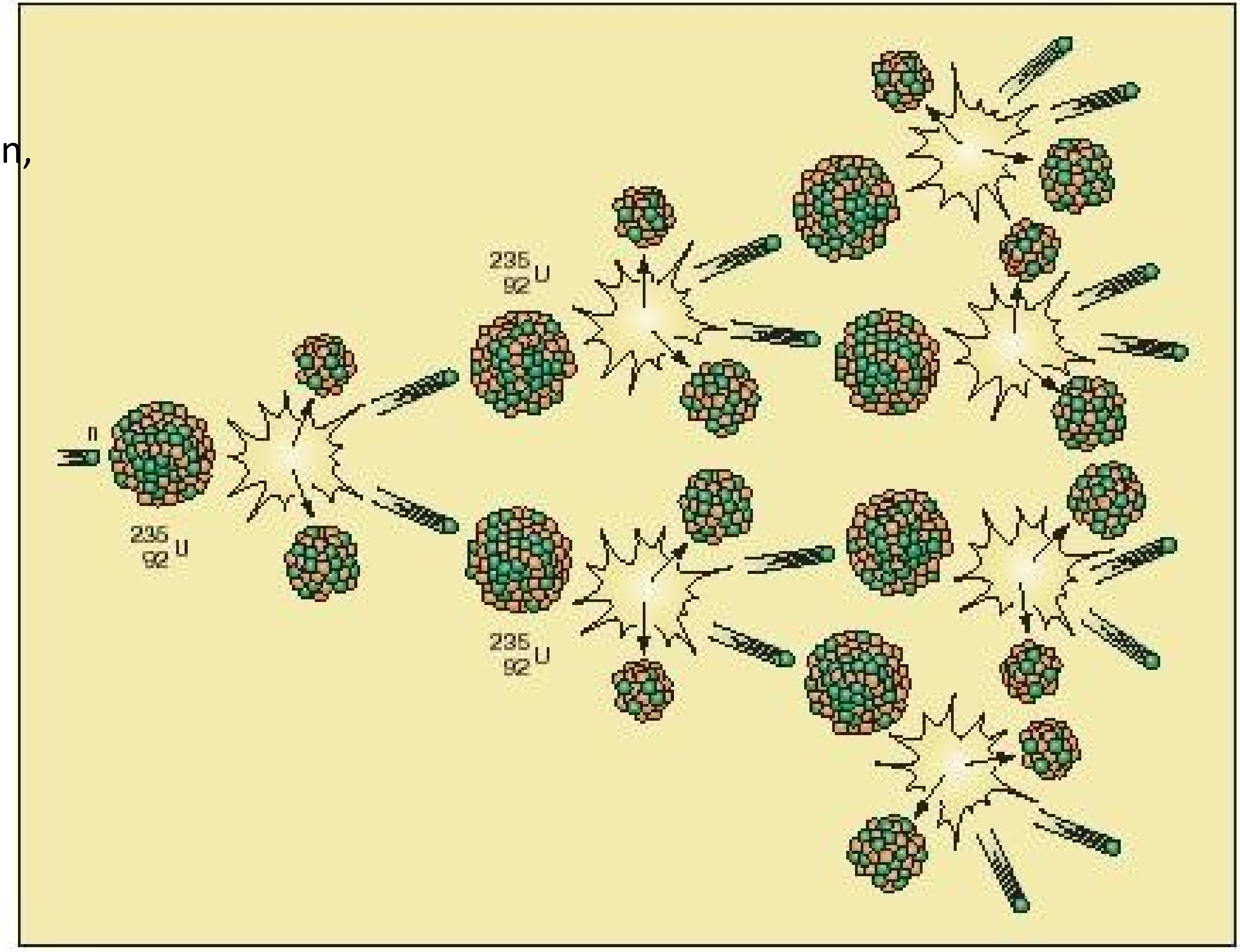
-control rods absorb neutrons
-controlling the rxn

-Supercritical rxn- resulting # neutrons > 1
-the rxn builds up

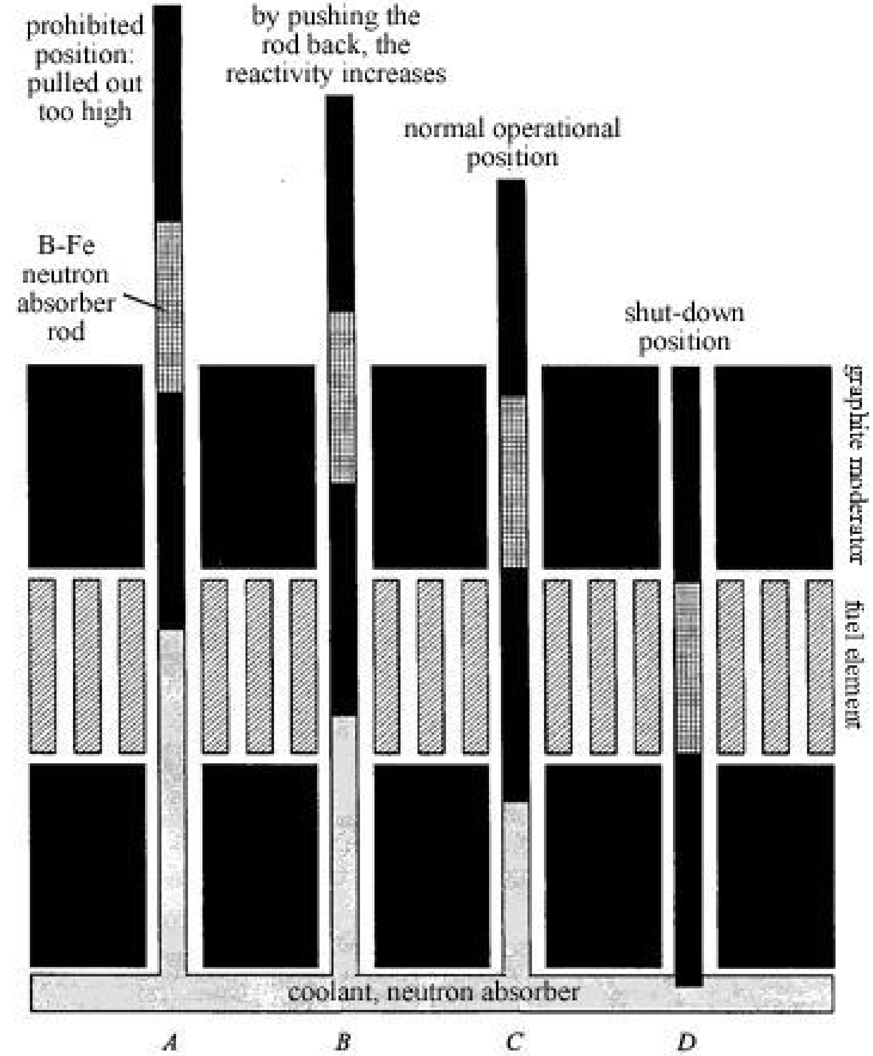


Supercritical Reaction

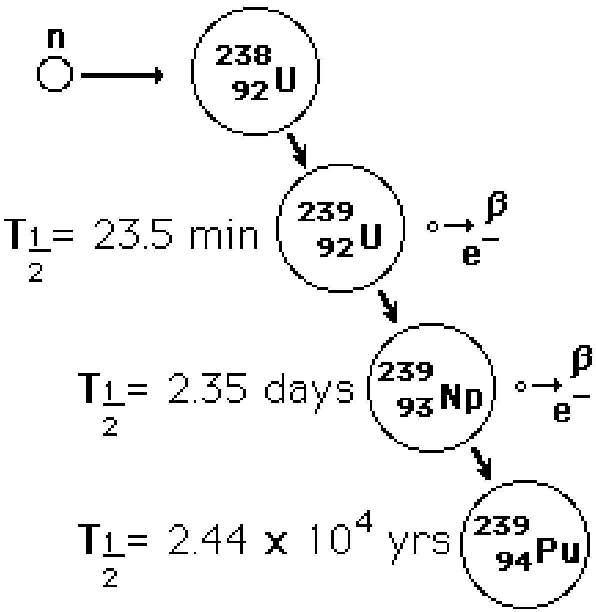
Additional Neutrons create a chain reaction, which is controlled by the control rods



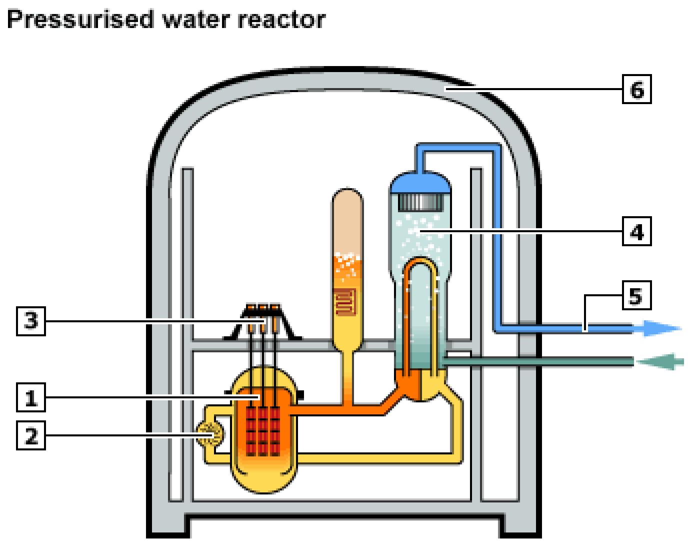
Control Rods



Breeder Reactors



-BR- also fission rxn, but using different fuel. Instead of fissioning U235, BR manipulates U238 into Pu239



-The Breeder Rxn produces fissionable (weapons grade) Plutonium239 from unfissionable U238
-U239 becomes Neptunium
-Neptunium becomes Plutonium239 that is available for fission with Exposure to neutron

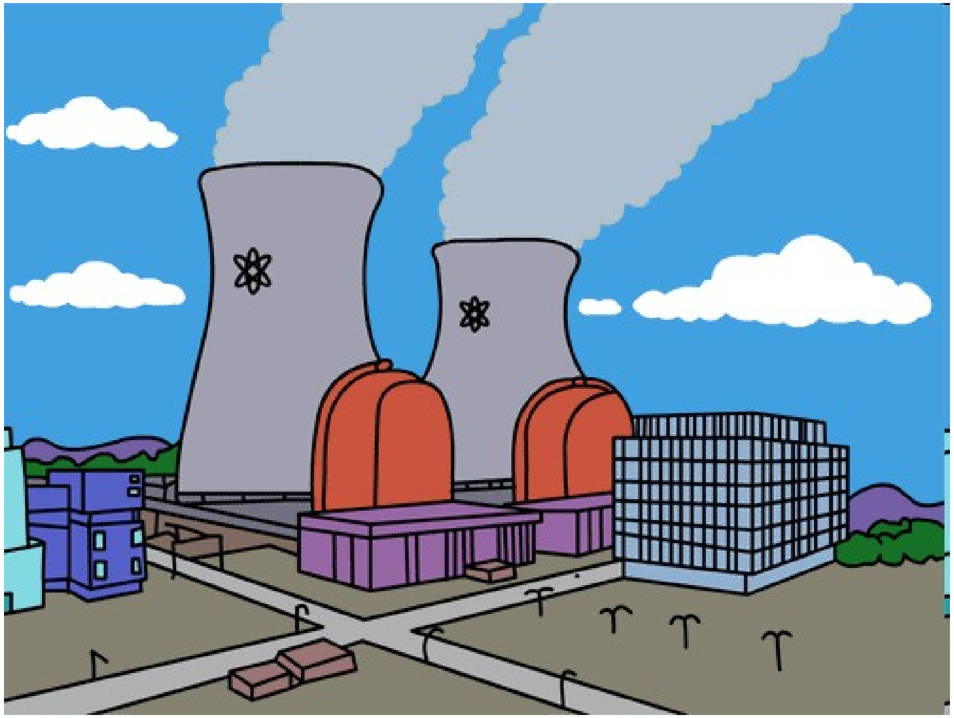
1. Reactor core
2. Coolant pump
3. Fuel rods

Nuclear Power:

A Survey View of
Reactor Technology

The Basics

- Powered by fission (primarily uranium-235)
- Fission heats water to steam
- Steam spins turbine, using dynamo effect to generate electricity
- Steam circulated through cooling container; waste water from cooling container exhausted into rivers



A little more detail…

- Fission rate controlled by (control) rods called **moderators** or **nuclear poisons**
- Moderators absorb or slow neutrons and thus mediate reaction
- Moderators can be used to stop all fission, if necessary (replace fuel or in case of danger)
- Some reactors use either a liquid metal (sodium, potassium) or gas (carbon dioxide, helium) as heat exchange element.

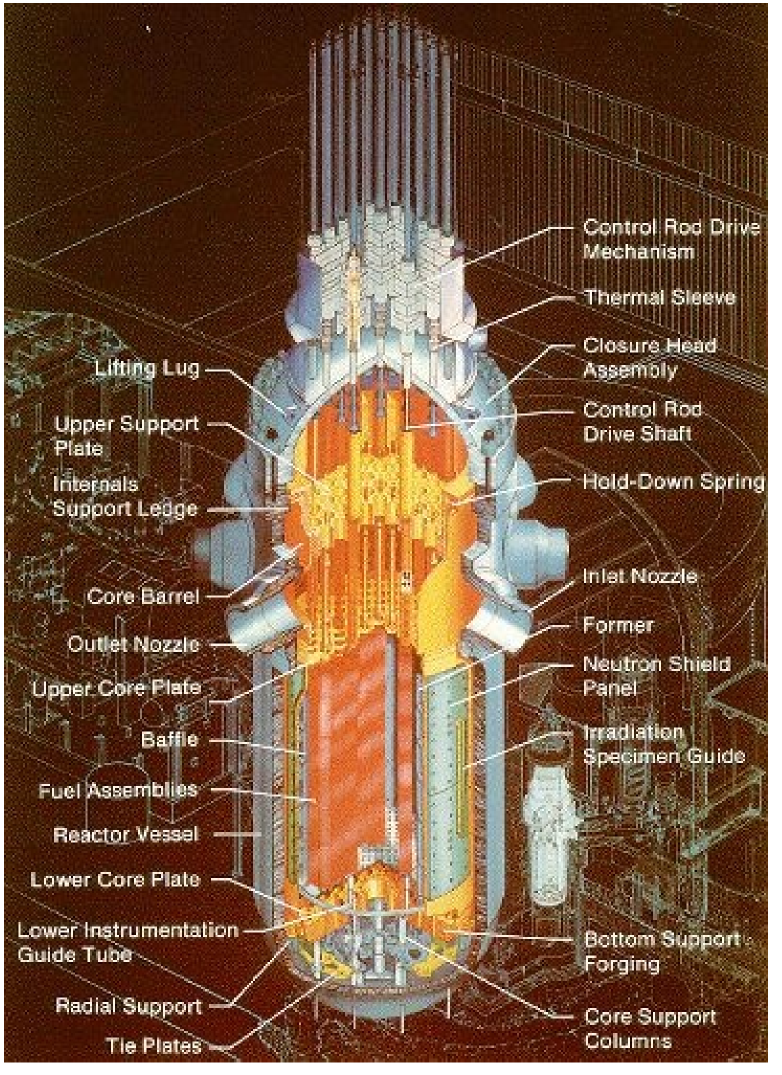
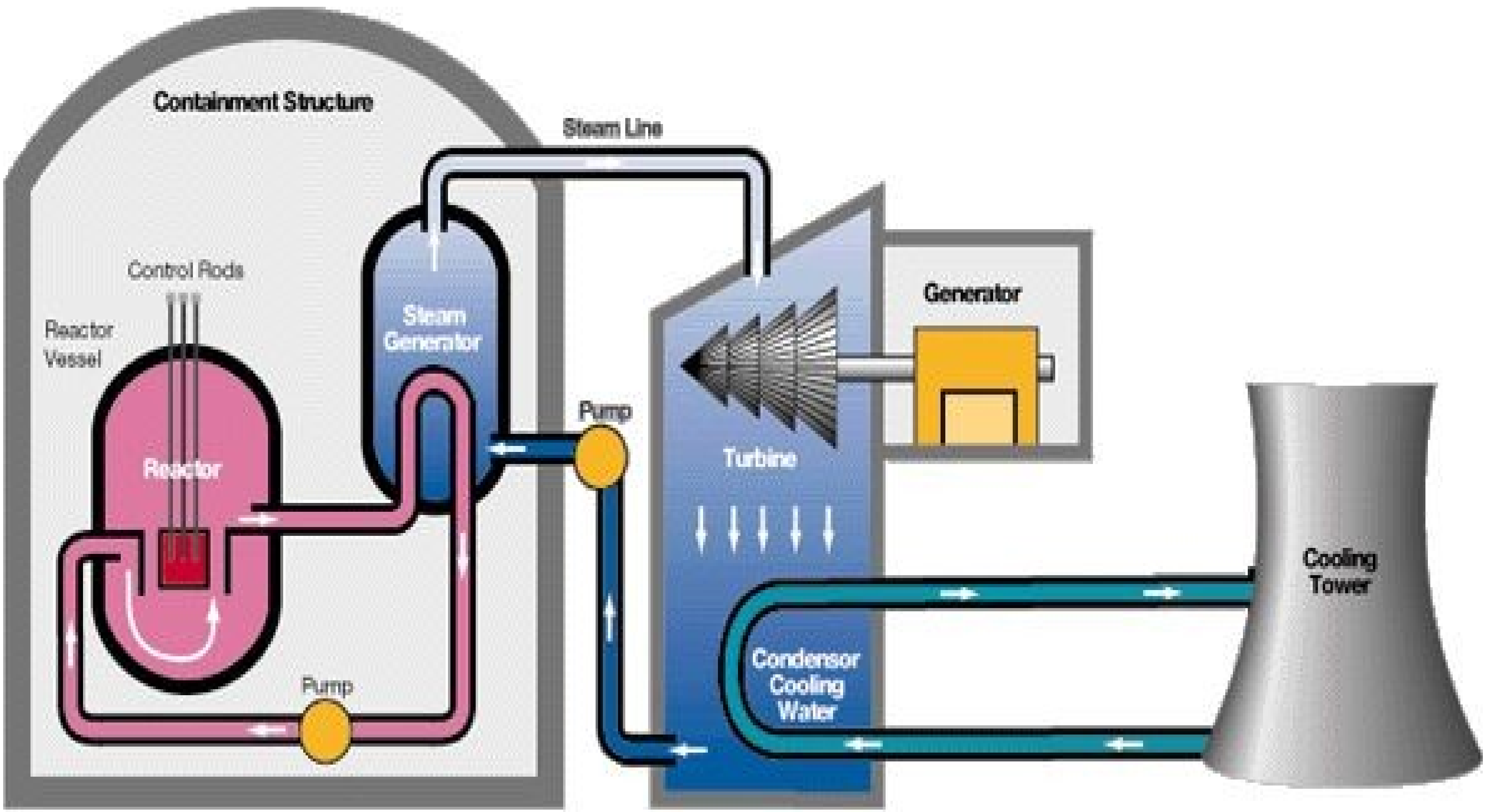


Diagram of Nuclear Plant



Reactor types

- Classified by use, fuel state, coolant, and moderator material
- Use is the broadest – least technical - category

- Uses:
  - Electricity
  - Propulsion
  - Desalination
  - Transmutation (“breeding”)
  - Research

Pros and Cons of Nuclear Power

Pros:

- Environmentally, nuclear power has very little impact:

  *does not depend on fossil fuels→ the carbon dioxide emission is minimal.

  *Coal and natural gas power plants emit large amounts of carbon dioxide into the atmosphere which contributes to ozone problems, acid rain, and global warming.

- Relatively inexpensive:

  *Uranium is less expensive than oil, natural gas, or coal.

  *Leads to lower energy cost for the consumer

- Because it does not depend on fossil fuels, fluctuations in oil and gas prices do not affect its supply.
- Reliability:

  *Nuclear power plants produce large amount of power on a consistent basis

Pros and Cons Cont.

Cons:

- Waste:

  *Each nuclear power plant generates, on average, 20 metric tons of high-level radioactive waste which takes tens of thousands of years to decay to safe radioactive levels. Plants also produce low level radioactive waste which still takes thousands of years to decay.

- Costs:

  *Expensive to store, monitor, and guard the large amounts of waste so that it doesn't fall into the wrong hands, as waste may be used in the production of nuclear weapons.

- The more power plants that are built, the higher the probability that some sort of breakdown in security would occur somewhere in the world.
- Nuclear power is not a renewable energy resource. The energy source of nuclear power is Uranium, which is scarce, as its supply is estimated to only last for the next 30-60 years depending on demand.

Waste Disposal
Low Level Radioactive Nuclear Waste

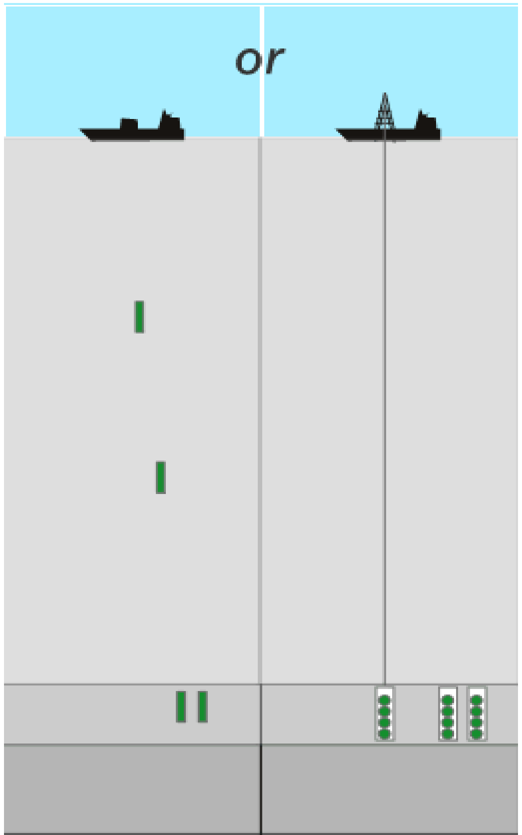
- Industrial and Medical Waste
- Half Life of 10-50 Years
- Stored in metal canisters
  - Sometimes in concrete bunkers
- Can be disposed of after life normal waste

High Level Radioactive Nuclear Waste

- Waste produced from nuclear reactors/fissioning process
- Very long Half Life- 100,000 years or more
- Disposed of in ocean, underground and mountain caverns, and recycling (though not a mainstream technique currently used)

Deep Ocean Disposal

- The waste is placed in borosilicate glass containers
- These containers are made to be unbreakable – dumped into the deepest and darkest places on earth



Deep Geological Burial

- Waste is buried in caverns
- Away from water sources (under and above ground)
- Far from people or other living organisms
- Dry climate- not prone to harsh weather conditions
- Yucca Mountain, Nevada


AP / Rick Gunn, File

Three Mile Island

- In 1979 TMI-2 which is a pressurized water reactor suffered a partial meltdown
  - Nuclear meltdown: term for a severe nuclear reactor accident
  - 3 Mile- losing the ability to either cool or control reactor core functions
    - Leads to melting of radioactive material

- The incident did not harm or kill any people, but nearly 43,000 curies of radioactive krypton were released into the air
- Results- no one harmed
- Regulations on plant construction, tr plant operation

Radioactive particles got into the water used for cooling and seeped into the basement.
-difficult and costly to clean
Particles released into the air

Chernobyl

- On April 26, 1986 Ukraine- reactor number four at the Chernobyl plant exploded
- The resulting fire sent a plume of highly radioactive smoke into the atmosphere
  - Four hundred times more fallout than had been released by the atomic bomb Hiroshima
  - Nearly 500,000 people needed to resettle
- 237 people suffered from acute radiation sickness, of whom 31 died within the first three months. Most of these were fire and rescue workers trying to bring the accident under control, who were not fully aware of how dangerous the radiation exposure (from the smoke) was (for a discussion of the more important isotopes in fallout
- Ecological effects- Bioaccumulation in the water system, fish and animals, and humans

  -People were affected all across much of Eastern Europe- the fallout was taken by the winds and swept across a much larger area.