Week 11, Lecture 1 – Reactors

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Nuclear Power, Nuclear Reactors

-- Overview

--- Reactor types

--- Reactors in Michigan

--- Reactors in France

-- Nuclear Fission process

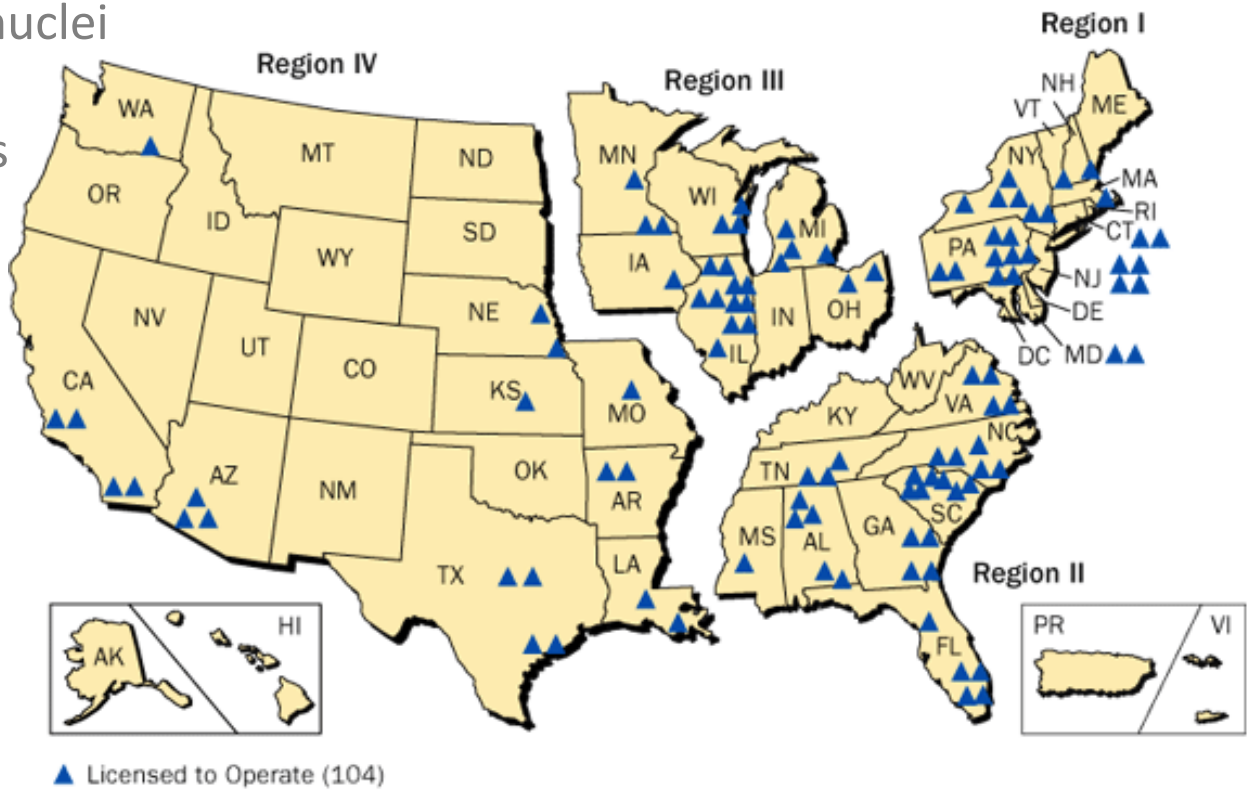
--- fission energetics, fissile nuclei

--- dynamical process

-- Nuclear Fission Operations

--- control and reactivity

http://www.nrc.gov/info-finder/reactor/



US Total Energy Consumption

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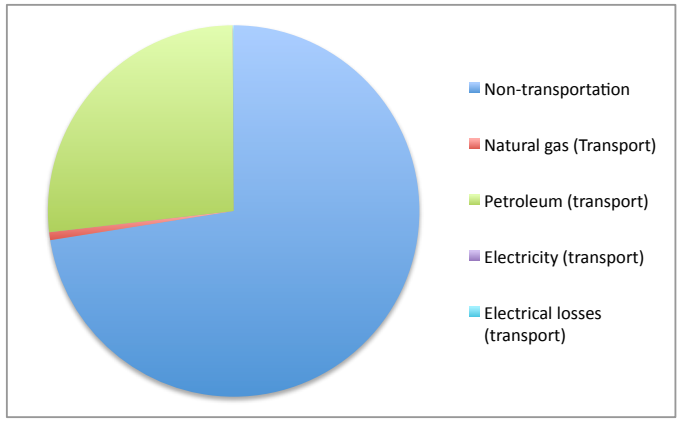
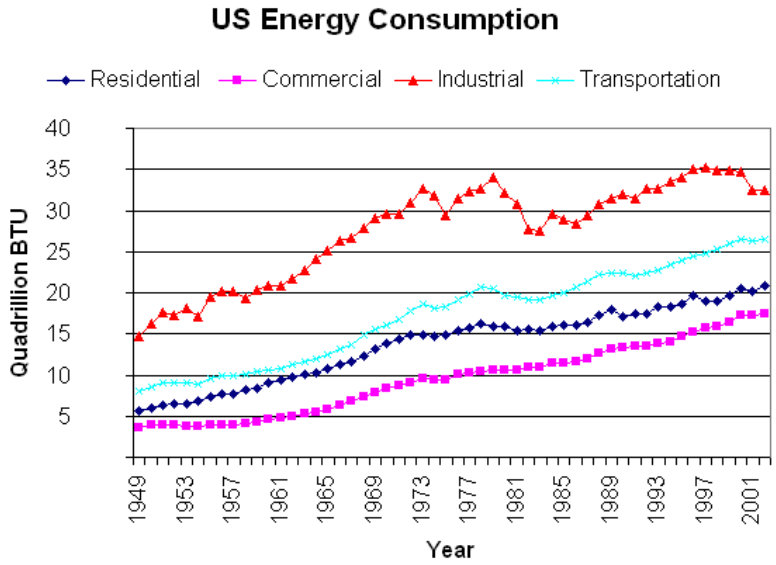
US Energy Consumption 2oo8, 99.3 Quads





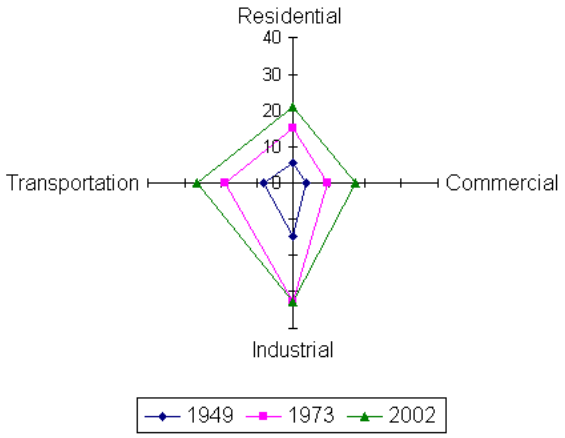
Q: What's a Quad in SI?

1 Quad = 1 Quadtrillion BTU

10^{15} BTU * 1055. J/BTU ~ $1x10^{18}$ J

(BTU = ΔE for 1 lb of water, 1^{o} F)

Power = 99.3 $x10^{18}$ J/ $3.15x10^{7}$ s = $3.15x10^{12}$ W



Power, what's possible in US?

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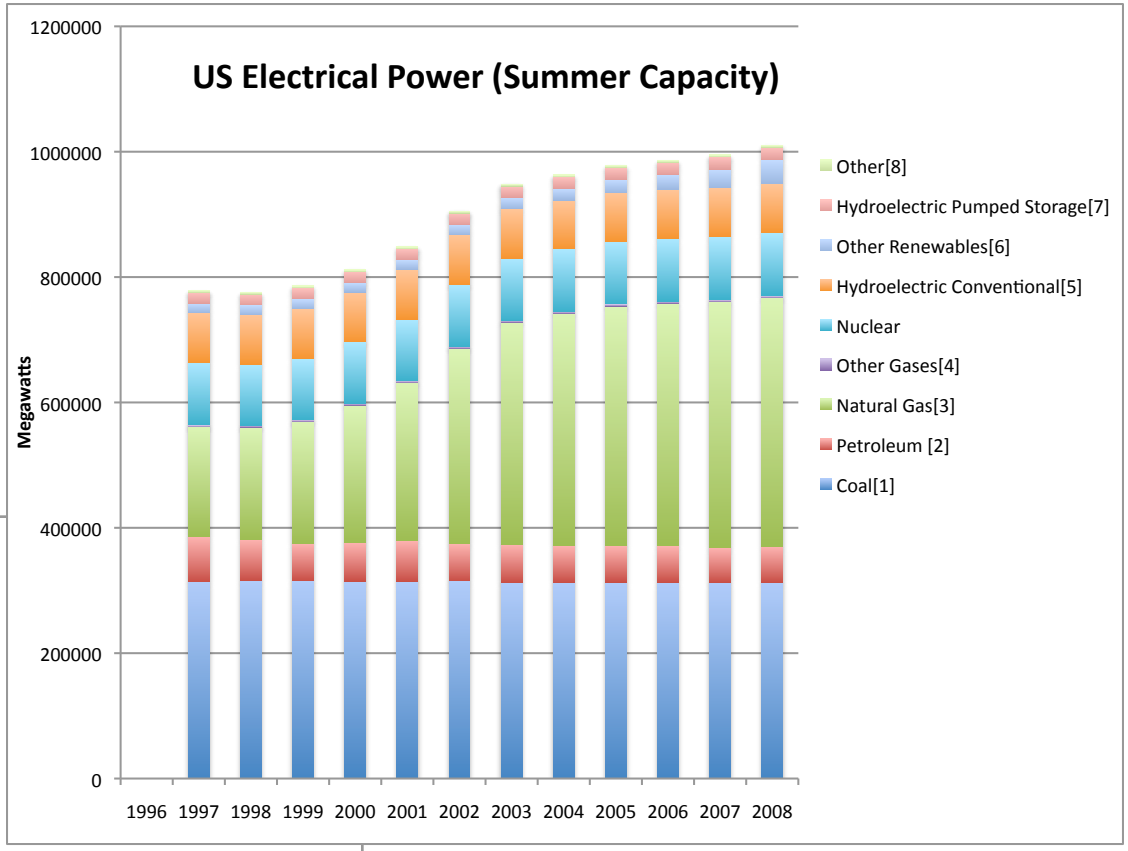
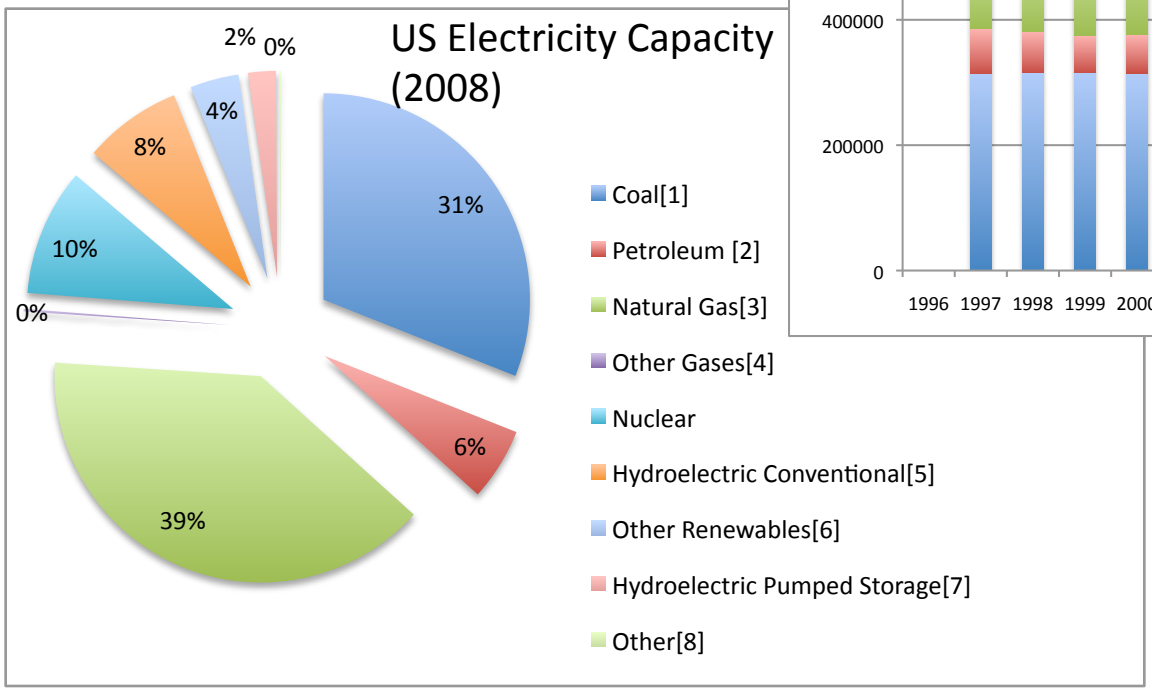
http://www.eia.doe.gov/cneaf/electricity/epa/epat1p1.html

"Capacity" is a measure of how much power could be theoretically delivered to customers.

Nuclear power component has been constant, the increase in recent years was in gas-fired plants (i.e. not sustainable).





"Latest" statistics are only available for 2oo8.

Power delivered in US & MI

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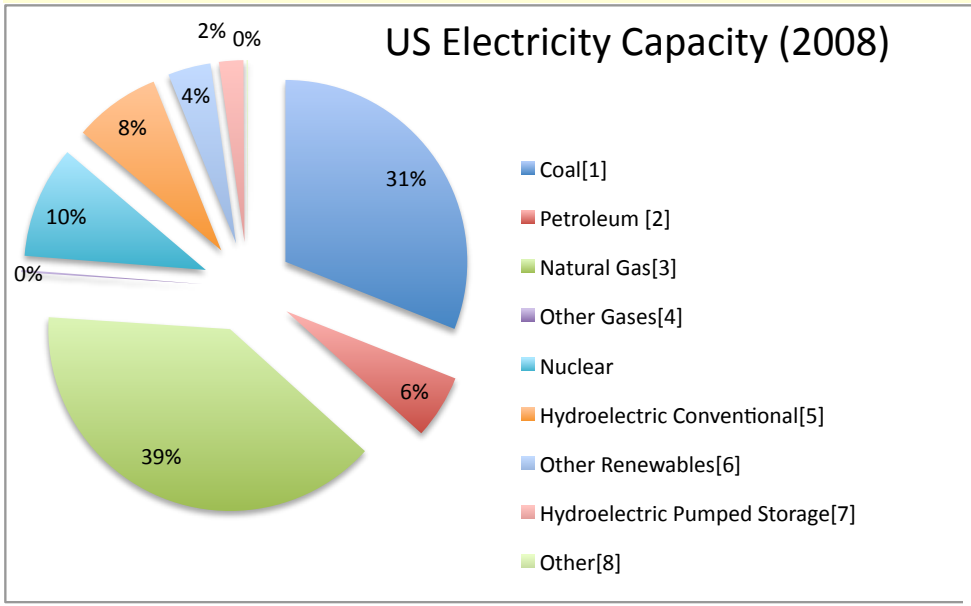
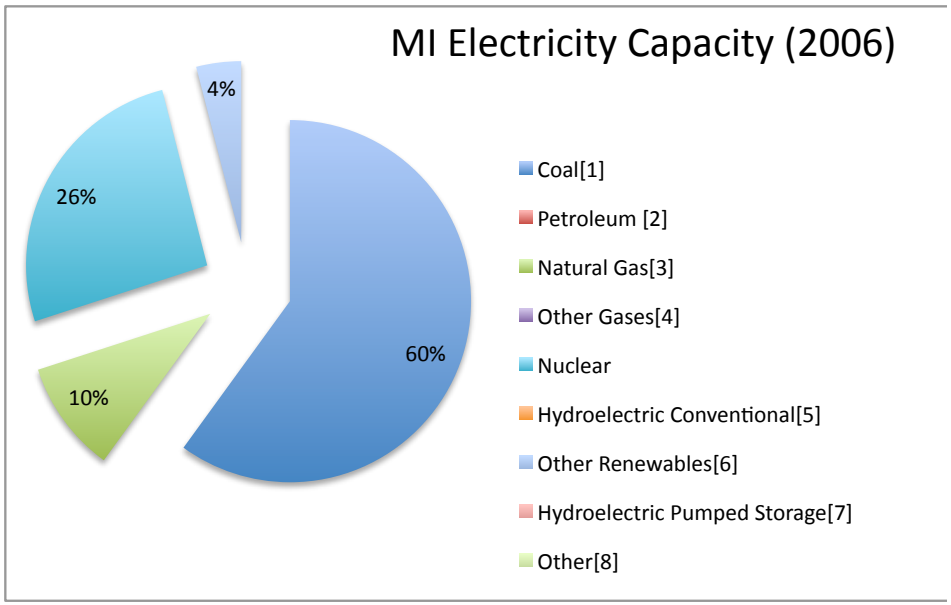
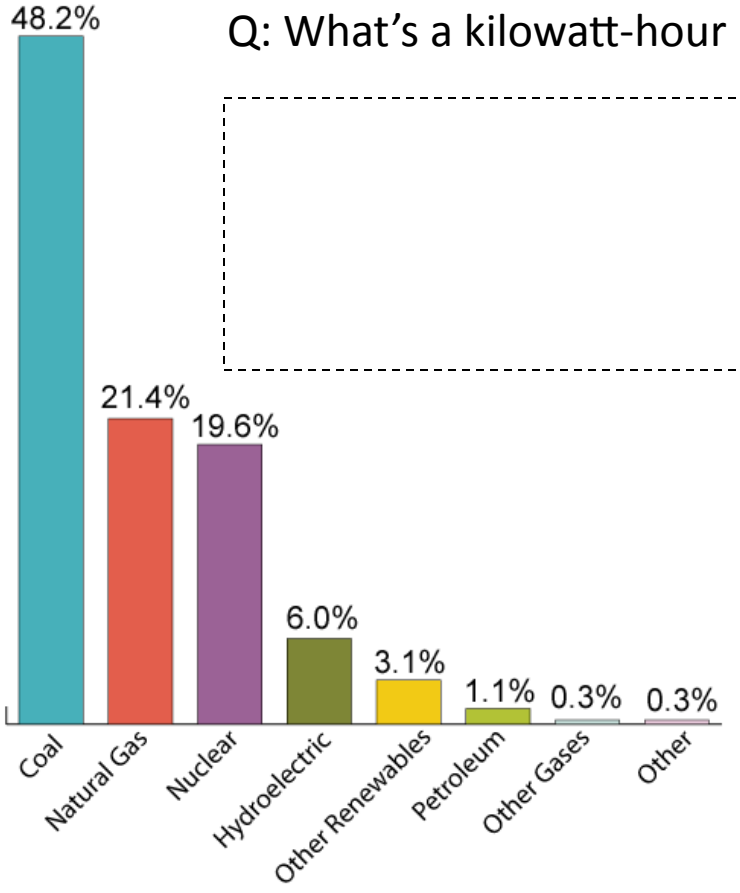




U.S. Electric Power Industry Net Generation, 2008

Total = 4,119 billion kilowatthours

Q: What's a kilowatt-hour in SI?



Source: U.S. Energy Information Administration, Form EIA-923, *Power Plant Operations Report*.

Michigan Nuclear Power Plants

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Two D.C.Cook Power plants in Benton Harbor are pressurized water reactors. The 1,048 net megawatt (MW) Unit 1 and 1,107 net MW

Fermi 2 plant in Monroe, is a boiling water reactor with 1122 net MWe

Palisades plant in South Haven, is a pressurized water reactor with 778 net MWe

Boiling Water Reactor (BWR)

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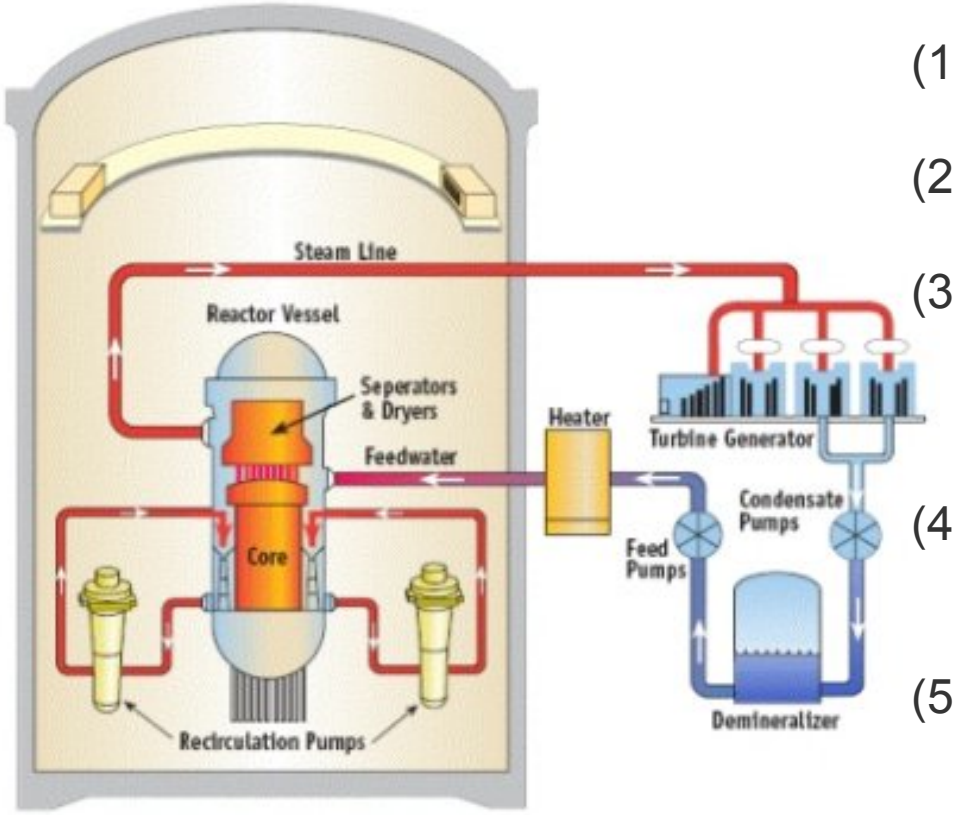

(1) the reactor core creates heat from nuclear fission
(2) a steam-water mixture is produced when water moves through the hot core
(3) the steam-water mixture leaves the top of the core and enters the two stages of moisture separation where water droplets are removed,
(4) the steam line directs the steam to the main turbine causing it to turn the turbine generator, which produces electricity.
(5) The reactor's core contains fuel assemblies which are cooled by water, which is force-circulated by electrically powered pumps. Emergency cooling water is supplied by other pumps which can be powered by onsite diesel generators.

Pressurized Water Reactor (PWR)

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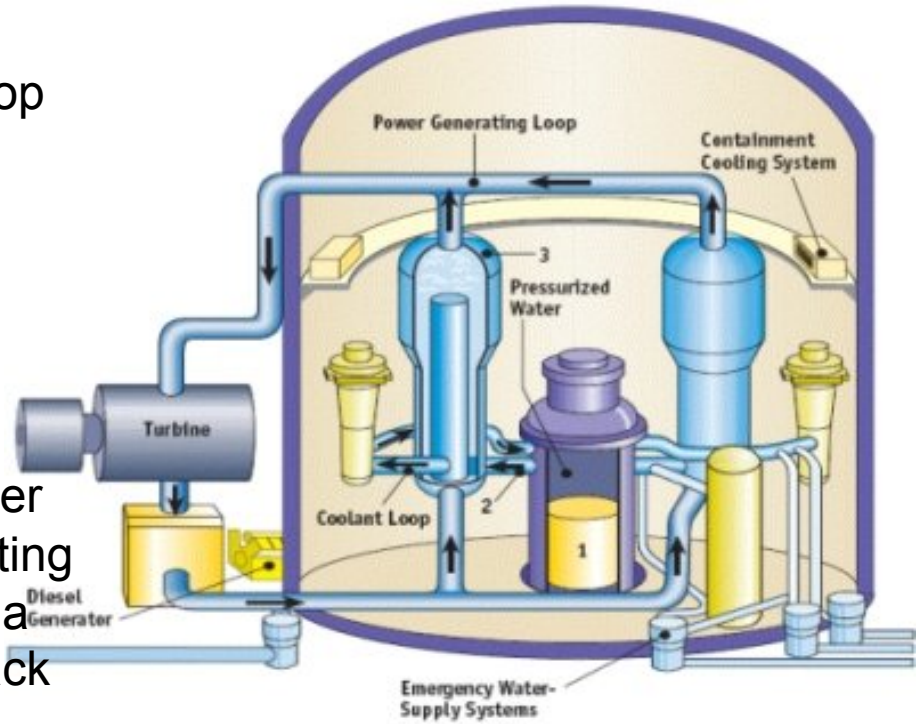
(1) the reactor core creates heat from nuclear fission
(2) pressurized-water in the primary coolant loop carries the heat to a steam generator
(3) the steam generator uses heat from the primary coolant loop to vaporize water in a secondary loop producing steam
(4) the steam turns the main turbine and generator, which produces electricity. The unused steam is exhausted to the condenser where it is condensed into water. The resulting water is pumped out of the condenser with a series of pumps, reheated, and pumped back to the steam generator.
(5) The reactor's core contains fuel assemblies which are cooled by water, which is force-circulated by electrically powered pumps. Emergency cooling water is supplied by other pumps which can be powered by onsite diesel generators.



Electrical Power in France

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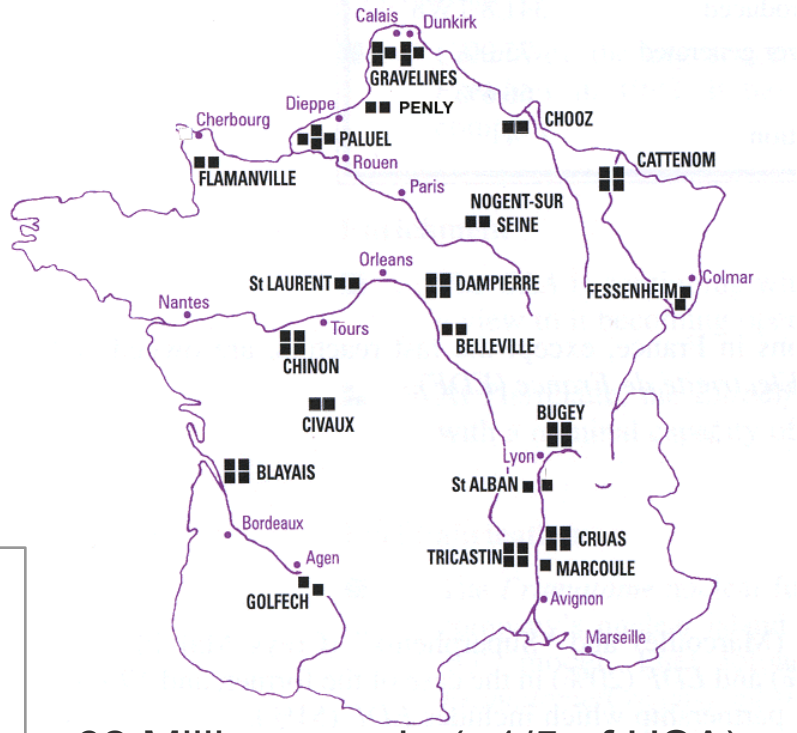
http://www.world-nuclear.org/info/inf40.html

•France derives over 75% of its electricity from nuclear energy with 59 reactors. This is due to a long-standing policy based on energy security.
•France is the world's largest net exporter of electricity due to its very low cost of generation.
•France has been very active in developing nuclear technology. Reactors, fuel products and fuel processing services are a major exports.



~62 Million people (~1/5 of USA)