ME/ENGR 2100 Fundamentals of Nuclear Engineering

Fission Reactor Basics:

Reactor Overview

Stephen R. Tritch Program in Nuclear Engineering
Swanson School of Engineering
University of Pittsburgh

Relevant Reading Assignments

- Sections 6.5 to 6.8 of "*Introduction to Nuclear Engineering*" by Lamarsh and Baratta, 3rd Edition.
- Chapter 3 of "*Nuclear Reactor Analysis*" by Duderstadt and Hamilton
- Page 100-120 of "*Nuclear Engineering: Theory and Technology of Commercial Nuclear Power*" by Knief, 2nd Edition.

Relevant Reading Assignments

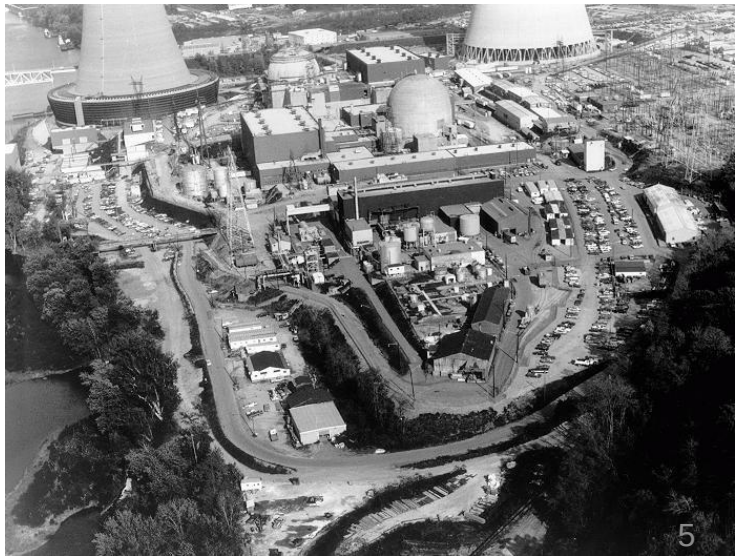
- "Secrecy, simultaneous discovery, and the theory of nuclear reactors" by Spencer Weart. American Journal of Physics, Vol. 45(11). November 1977

Learning Objectives

- Describe the identifying characteristics of a nuclear reactor

What is a nuclear reactor?

- Device to control a nuclear chain reaction
- First man-made reactor was Chicago Pile 1 in 1942
- Shippingport Atomic Power Station operational by 1957
- Many types of reactors have been built and many more designed

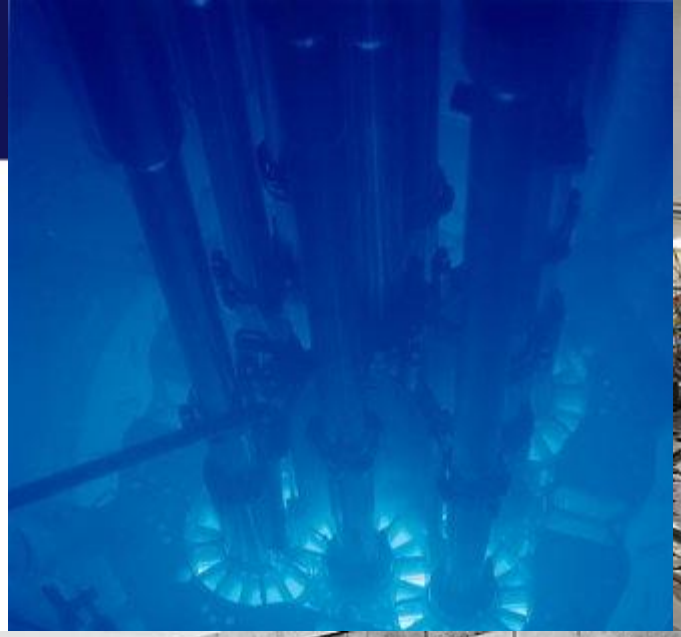


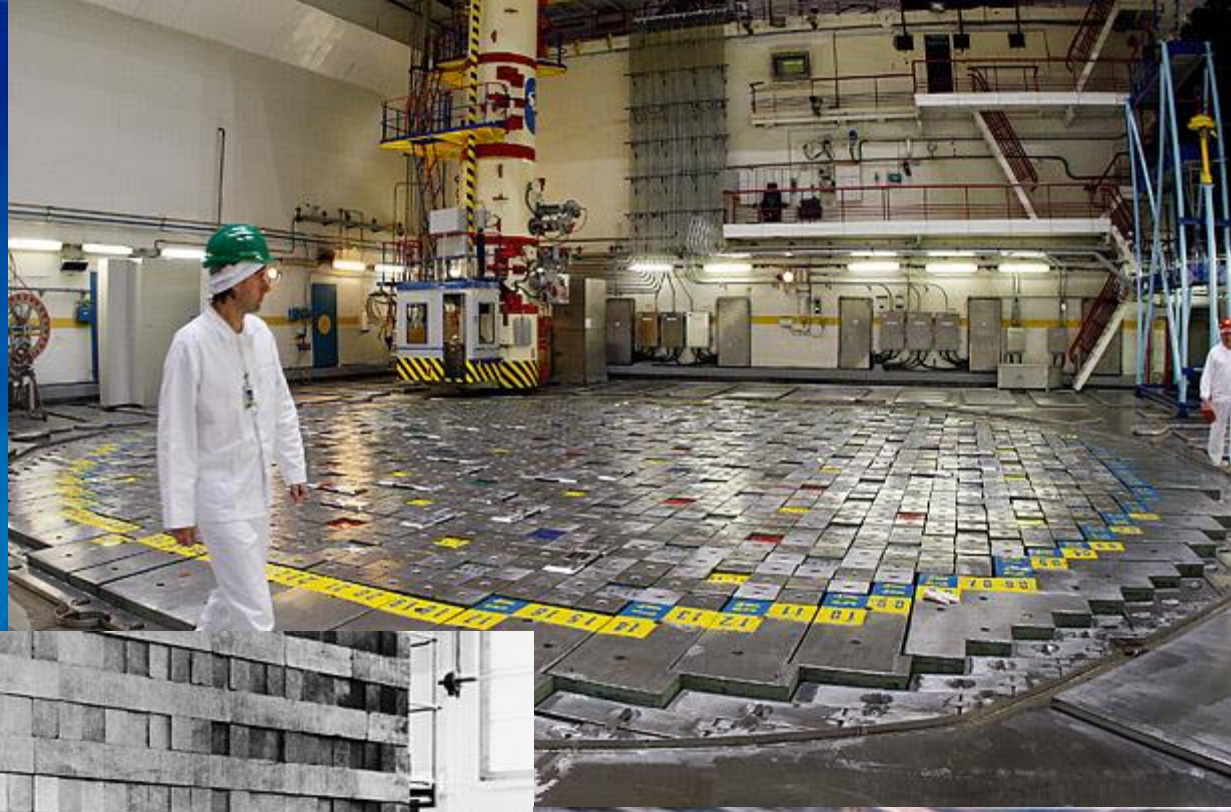
Classifying Reactors

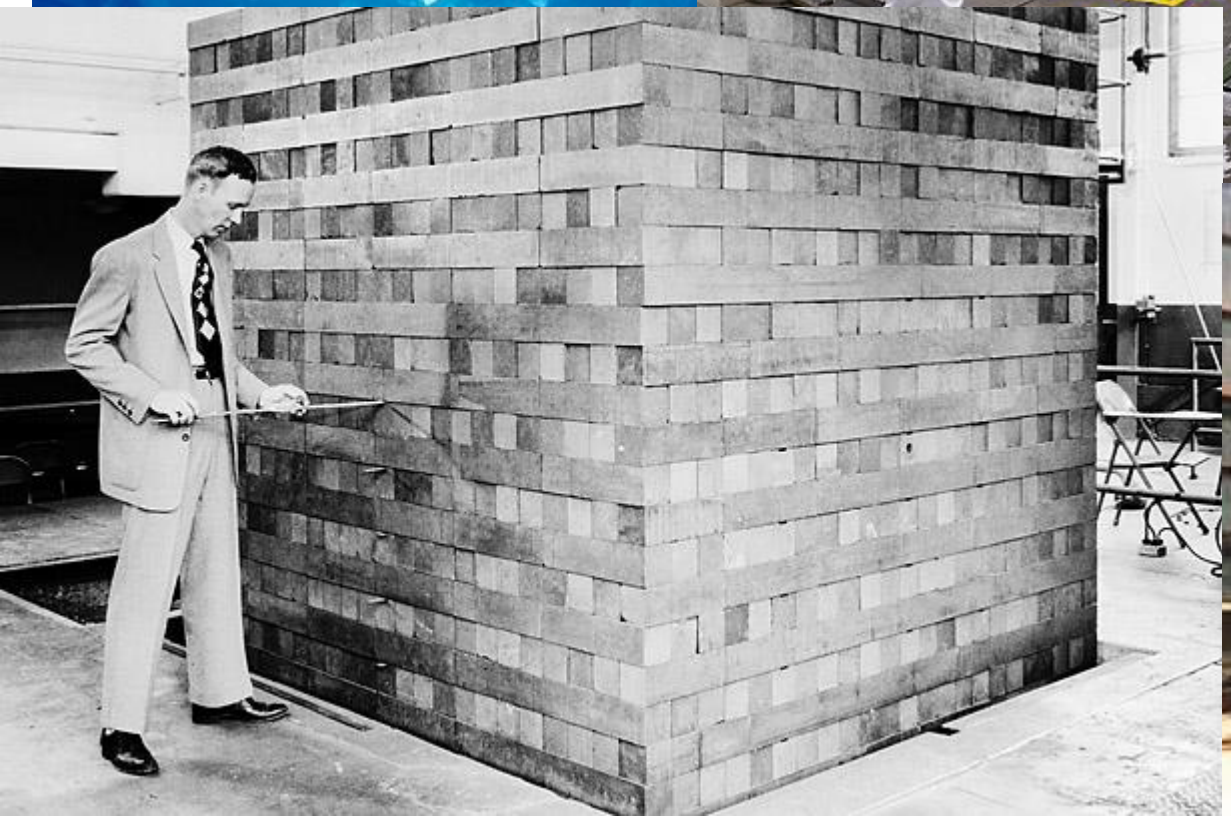
- By type of reaction
  - Fusion
  - Fission (fast neutrons, thermal neutrons)
- By moderator material (thermal reactors only)
  - Graphite
  - Water (heavy and light)
  - Light elements (Be, Li)
- By coolant
  - Water (PWR, Heavy Water PWR, BWR, Pool)
  - Liquid metal
  - Gas cooled
  - Molten salt

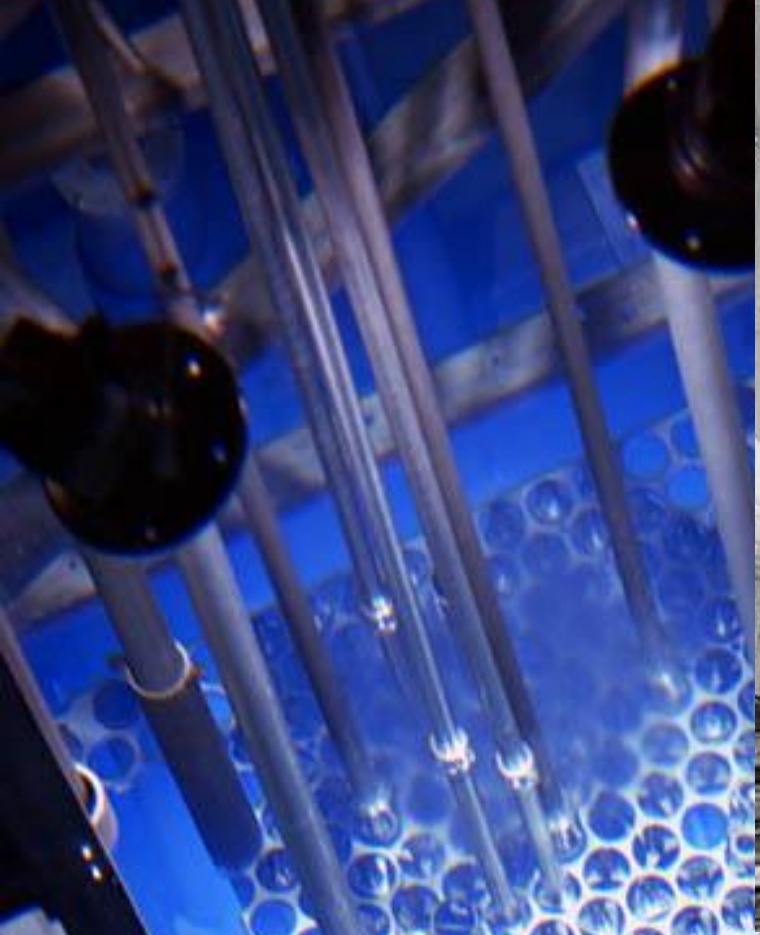
Classifying Reactors (II)

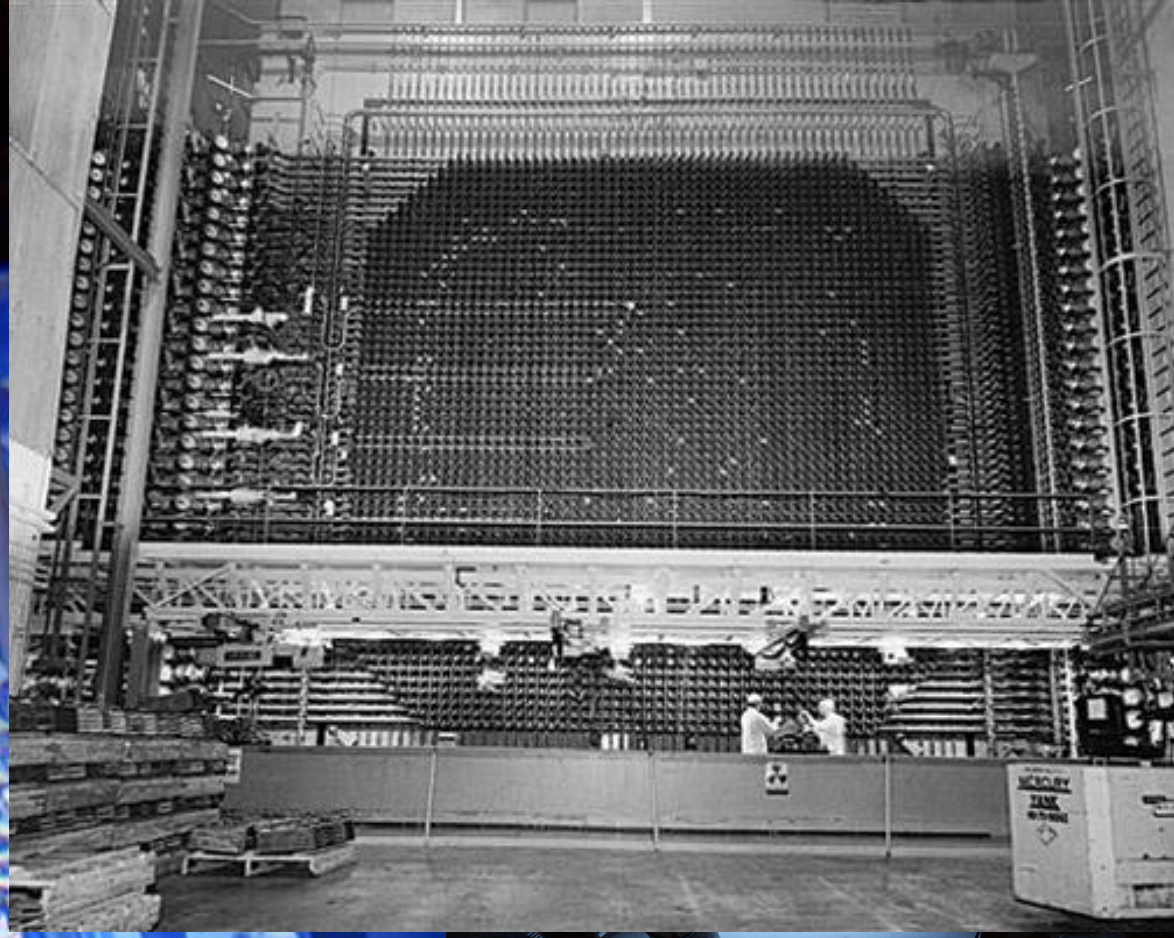
- By generation (I-IV)
- By use
  - Electricity (nuclear power plant)
  - Propulsion (marine propulsion)
  - Heat (desalination, domestic/industrial heating, hydrogen production)
  - Transmutation (breeding fuel, isotope production, weapons-grade material production)
  - Research (training, materials testing)

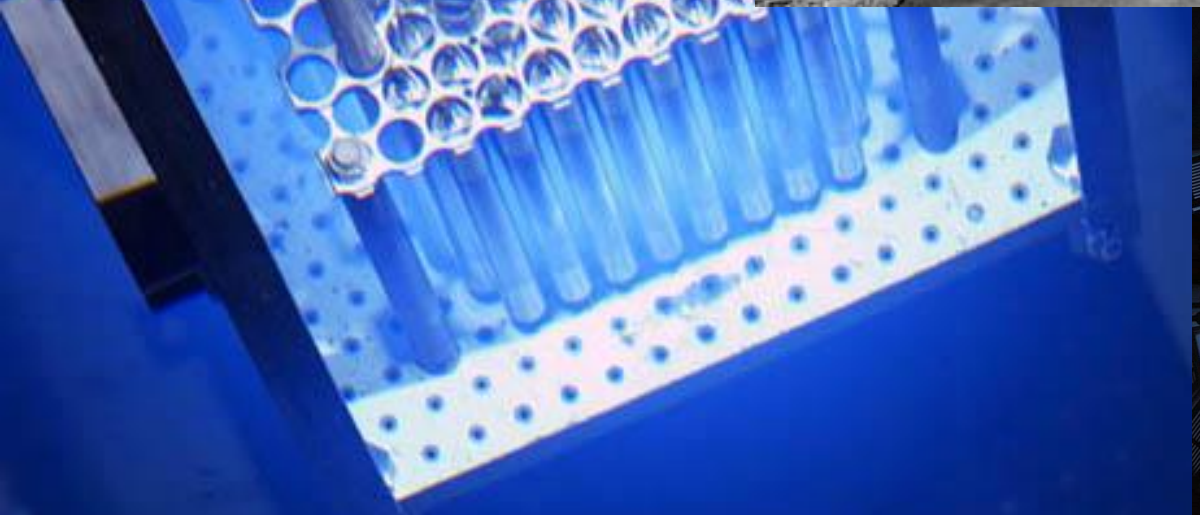


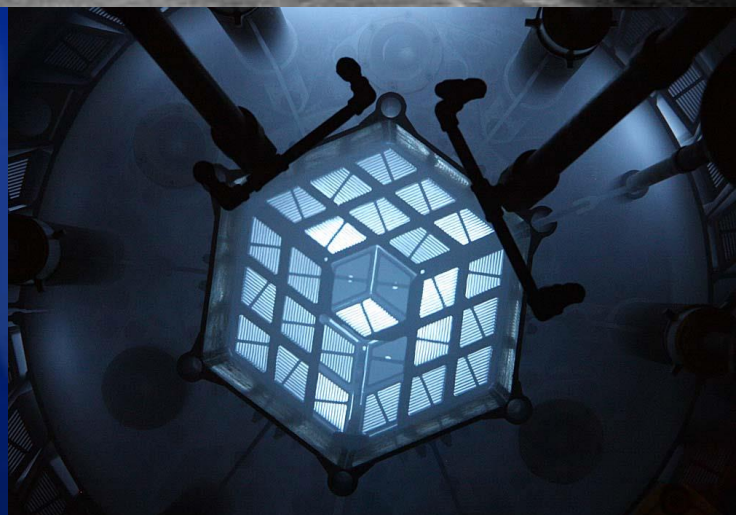








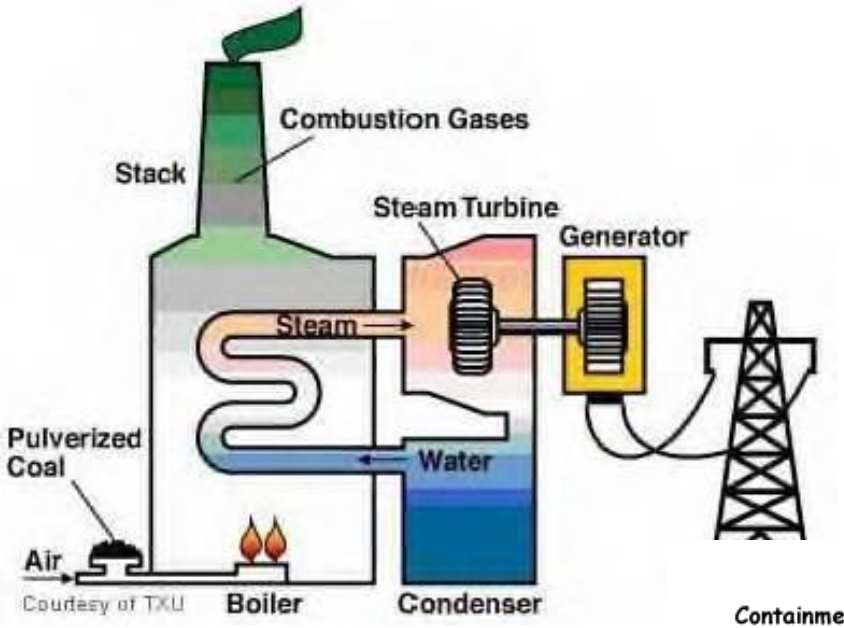




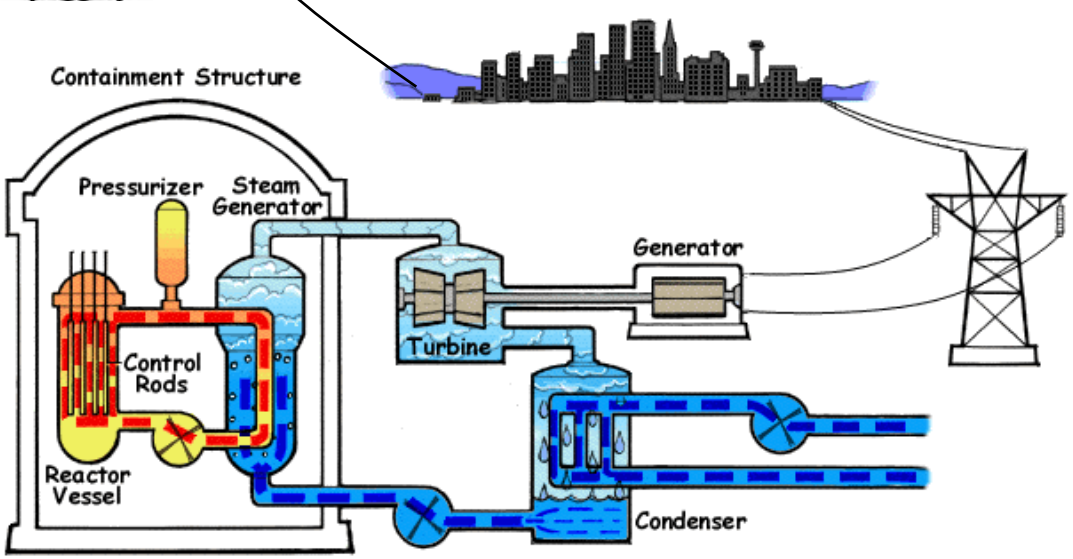
Reactor Properties

- Many types of reactors exist but they all share some important requirements
  - Nuclear fuel (fissile + fissionable)
  - Reactivity control mechanisms
  - Cooling capability
- Heat created through fission
  - Kinetic energy of fission products
  - Absorption of fission photons
  - Decay heat (radioactive decay)

Nuclear Power Plants



Coal Plant

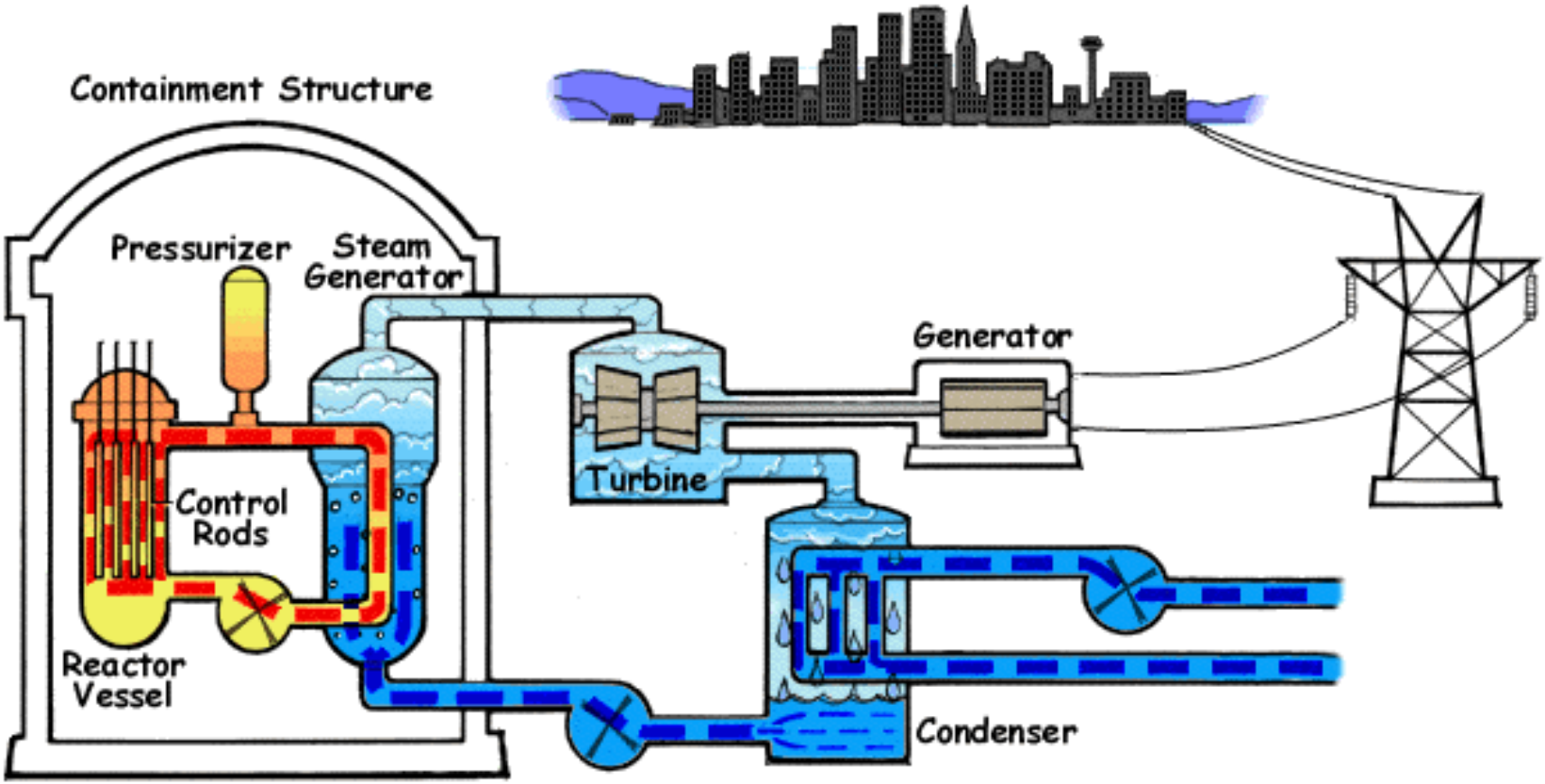


Nuclear Plant (PWR)

Nuclear Power Plants

- In this class we will focus on commercial power plants in US
  - Pressurized Water Reactors (PWR)
  - Boiling Water Reactors (BWR)
- Nuclear fuel (fissile)
  - Low enriched UO2 (BWR & PWR)
- Reactivity control mechanisms
  - Control rods (BWR & PWR)
  - Dissolved boron (PWR)
  - Flow rate (BWR)
- Cooling capability
  - Water (BWR and PWR)

Pressurized Water Reactor



Boiling Water Reactor