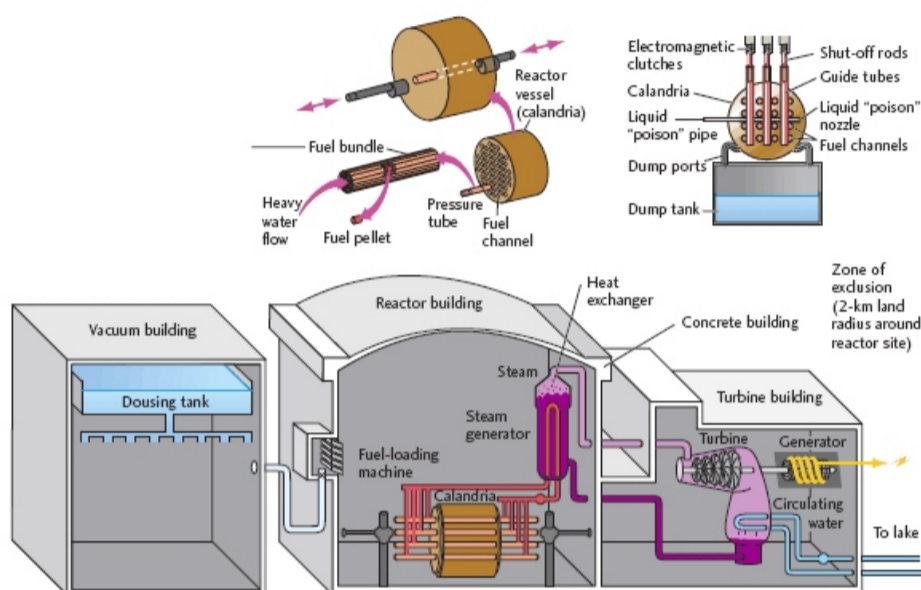




## Nuclear Energy and Reactors (18.6)

We have all heard of the enormous energy released from a nuclear fission bomb (A-bomb) or the even more destructive nuclear fusion bomb (H-bomb). However, through controlled reaction rates this energy can be harnessed in nuclear power reactors. Canada has built a world renowned reactor known as a CANDU reactor, **CAN**adian **D**euterium **U**ranium.

**The CANDU reactor** gets energy from the fission of Uranium which occurs in its many fuel bundles.



**Calandria** is the reactor core that contains a moderator, and the nuclear fuel to achieve nuclear fission.

**Nuclear fuel** ( natural uranium 235) is a material that can be consumed to derive nuclear energy

**Moderator** is a medium which reduces the velocity of fast neutrons,

**Deuterium** (Heavy water) is used as a modulator. Heavy water is chemically and physically identical to regular water, with the exception that the extra neutron in each atom of hydrogen makes it more dense.

**Control Rods** (shut off Rods) control the distribution of power in the reactor and can be used to shutdown the reactor.

Heavy water, containing Deuterium instead of normal hydrogen, is pumped through the core, or calandria, to act as a moderator and slow down the emitted neutrons so as to sustain the reactions.

The heavy water,  $D_2O$ , (at high pressure so as to not boil) also absorbs heat from the reaction and passes this heat onto ordinary water in a heat exchanger. The ordinary water becomes steam and is used to turn a turbine which is connected to an electromagnetic generator to produce electrical energy.

The fission reaction occurs in the fuel bundle. Heavy water, or deuterium oxide, is used to moderate the fast neutrons in the reactor. This water especially good at slowing down fast neutrons while being able to absorb the heat produced during the reaction. The heat is carried out of the reactor by water pumps to a heat exchanger, where it is passed on to an ordinary water supply loop to avoid the possibility of radioactive products leaving the reactor area. The hot ordinary water produces steam, which turns the steam turbine and the electromagnetic generator connected to it. The steam emerging from the turbine is cooled and condensed back to water by cooling water, usually supplied from a nearby body of water, such as a lake.

## CANDU Safety Systems

- 1) Moderator Dump - The heavy water moderator passes through the calandria by gravity. If no more heavy water is ‘poured’, the reactions stop because there is no moderator slowing down neutrons.
- 2) Cadmium Control Rods - Cadmium rods, which absorb neutrons, can be lowered into the core remotely to control the reactions. These rods are dropped from electromagnetic clutches and stop the reactions, if there is a power outage.
- 3) Moderator “Poison” - A neutron-absorbing solution can be injected into the moderator. This stops the chain reactions, while also cooling the core.

Known the pros and cons of nuclear power which are listed in Table 18.6.

<b>Issue</b>	<b>For Nuclear Energy</b>	<b>Against Nuclear Energy</b>
Demand for Electricity	The demand for electricity will keep increasing, so the way in which we generate electricity must be able to keep up	Energy conservation and efficiency improvements could reduce the growth rate for electricity demand while at the same creating jobs
Fuel Availability	Uranium, the fuel for nuclear fission, is indigenous to which frees us from depending on expensive importing of oil and natural gas.	Uranium mining in Canada disturbs buried radioactive material. Exposed radioactive material is called <b>radioactive tailings</b> . It leaches into the soil and groundwater, causing radioactive contamination of sensitive ecosystems
Safety	Everything we do involves risk , and there is certainly no way to generate the power that we need risk free. The safety of CANDU reactors has been proven and is a technology that is available now	Any safety record has been based on limited operational experience. Any health and environmental effects may take years to manifest themselves, when they do, the result is long term and catastrophic
The Environment	Compared to burning coal, CANDU reactors are much more environmentally friendly. The highly radioactive waste that is produced does not take up much volume	The nature of the effects of exposure to radioactive isotopes means that any negative health and environmental effects will not be realized for years. No permanent and safe methods for the disposal of long-lived high-level radioactive have been employed as of yet
Cost	High capital costs at the outset will be more than offset by a plenitude of safe and inexpensive power for years to come.	Nuclear power is very centralized and capital cost intensive. Quite often, the costs may be hidden due to various government subsidies

1. Which is classified as a nuclear fission reaction?
  - (A) A heavy nucleus splits into lighter atoms and energy is absorbed.
  - (B) A heavy nucleus splits into lighter atoms and energy is released.
  - (C) Smaller nuclei join and energy is absorbed.
  - (D) Smaller nuclei join and energy is released.
  
2. Which process involves making one helium atom from four hydrogen atoms?
  - (A) fission
  - (B) fusion
  - (C) gamma radiation
  - (D) radioactive dating
  
3. What is the function of the control rods in a fission reactor?
  - (A) absorbs slow neutrons
  - (B) increases the speed of neutrons
  - (C) prevents heat loss from the core
  - (D) transmits gamma rays
  
4. Which best describes nuclear fusion?
  - (A) It requires very high temperatures which are difficult to contain.
  - (B) It requires very high temperatures which are easy to contain.
  - (C) It requires very low temperatures which are difficult to contain.
  - (D) It requires very low temperatures which are easy to contain
  
5. What is the purpose of the moderator surrounding the fuel in a nuclear reactor?
  - (A) absorb neutrons
  - (B) decrease speed of neutrons
  - (C) increase speed of neutrons
  - (D) release neutrons
  
6. Which best refers to critical mass?
  - (A) The minimum mass of nuclear material required for an uncontrolled chain reaction.
  - (B) The minimum mass required to make a reactor economically viable.
  - (C) The total mass of uranium and plutonium in a reactor.
  - (D) The total mass on the verge of becoming radioactive.
  
7. In the Sun, a series of nuclear reactions have the net effect of making one helium atom from four hydrogen atoms. Which process does this describe?
  - (A) chain reaction
  - (B) fission
  - (C) fusion
  - (D) nuclear reactor

16. State two arguments to support, or two arguments to oppose, nuclear energy production June 2008

31. Use the graph below to determine the heaviest element likely to be produced from fusion. Explain your answer. AUGUST 2005

