

HOW DOES A NUCLEAR POWER PLANT WORK?



PUTTING OUR ENERGY TO GOOD USE

O n t a r i o P o w e r G e n e r a t i o n

ONTARIOPOWER
GENERATION



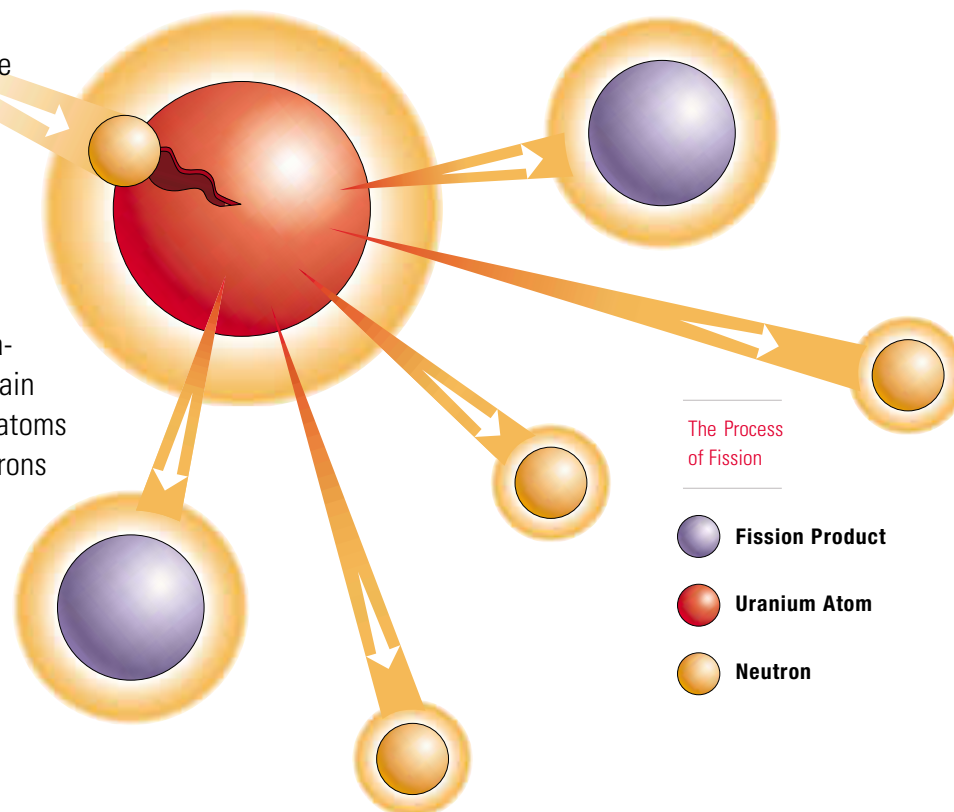
What a Nuclear Reactor Does

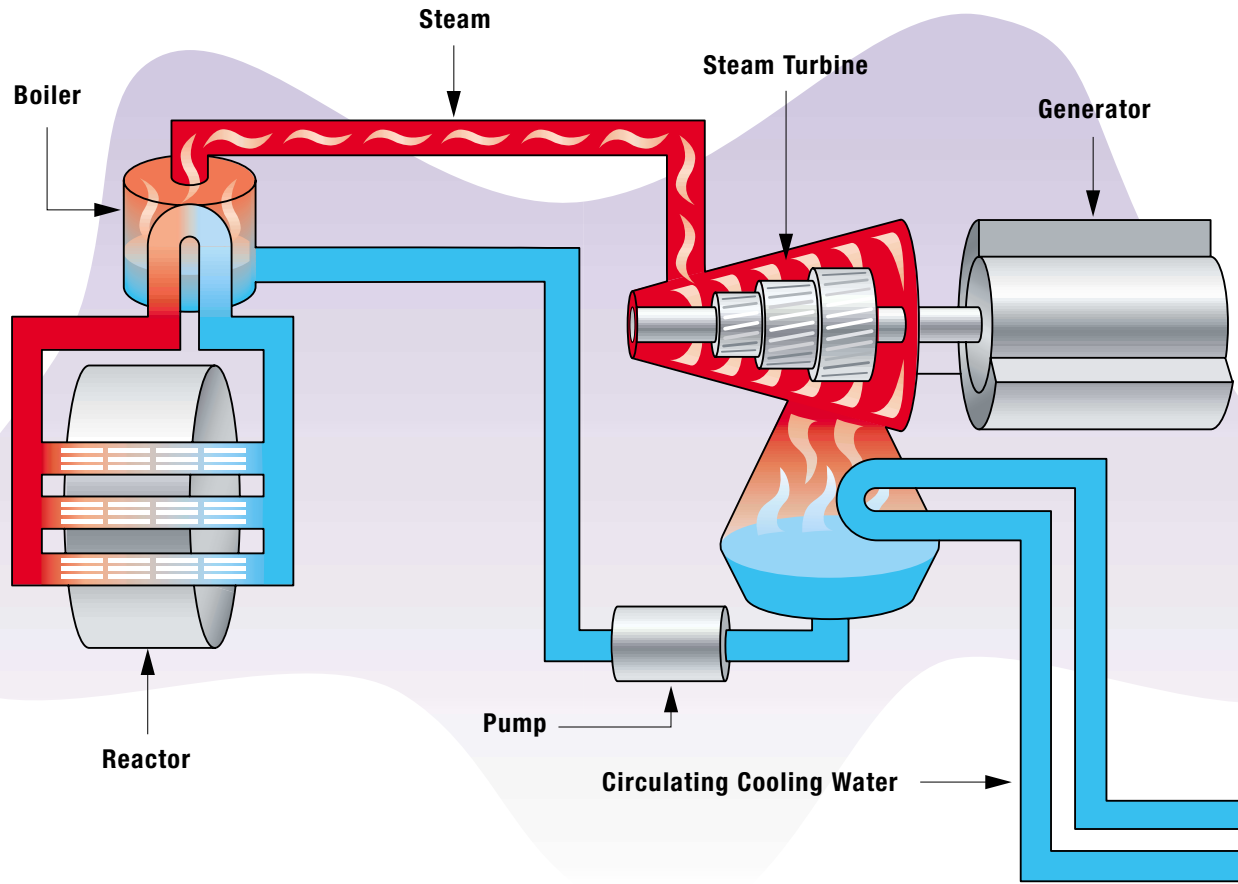
Nuclear reactors, which produce heat by splitting uranium atoms, do the same job as conventional power producing equipment in the generation of electricity – they produce heat to convert water into steam, which spins a turbine or generator to make electricity. Instead of coal, oil or natural gas, Canadian nuclear reactors use natural uranium for fuel. But the uranium is not burned. Uranium atoms make heat by splitting – the technical term is fissioning.

Fission makes Heat

When a neutron (a tiny sub-atomic particle that is one of the components of almost all atoms) strikes an atom of uranium, the uranium atom splits into two lighter atoms (which are called fission products) and releases heat at the same time. The fissioning process also releases from one to three more neutrons that can split other uranium atoms. This is the beginning of a "chain reaction" in which more and more uranium atoms are split, releasing more and more neutrons (and heat).

In a power reactor, the chain reaction is tightly controlled to produce only the amount of heat needed to generate a specific amount of electricity.





Heat makes Steam

The fission process generates a huge amount of heat. In order to be useful, the heat has to be moved to boilers to make steam. In a CANDU® reactor, heavy water does this job. It is pumped constantly through the fuel channels in the reactor and takes the heat from the fuel bundles up to boilers above the reactor. In the boilers the heated heavy water heats up ordinary water to make steam. The steam is piped out of the boilers and over to the turbine hall where it drives the huge turbines/generators that make the electricity we use.

Creating A Chain Reaction

Canadian reactors use fuel made of natural uranium. Like uranium in the ground, almost all of the uranium in CANDU® fuel is U-238. This is the common form of the element. The ore also contains tiny amounts (0.7%) of U-235, an unstable isotope of uranium that fissions spontaneously – that's why Geiger counters react to ore-carrying rock. The fact that U-235 atoms fission sponta-

neously makes it possible to get a controlled chain reaction going inside the mass of fuel in the reactor. But no chain reaction can take place in this fuel unless three conditions are all satisfied at the same time:

- several tons of fuel are present;
- the tubes containing the fuel are stacked in a special arrangement, neither too close together, nor too far apart; and,
- a material called a "moderator" surrounds the fuel.

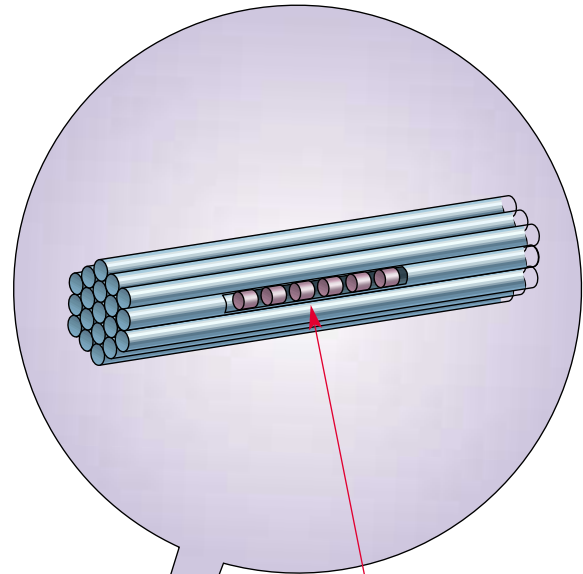
The moderator slows, or moderates, the speed of the neutrons resulting from the fission so they are more likely to collide with, and split, more uranium atoms. The moderator in Canadian reactors is heavy water which is very efficient at slowing down neutrons while not absorbing too many of them. Heavy water is 10% heavier than ordinary water because it incorporates a heavy form of hydrogen called deuterium.

Reactor Fuel

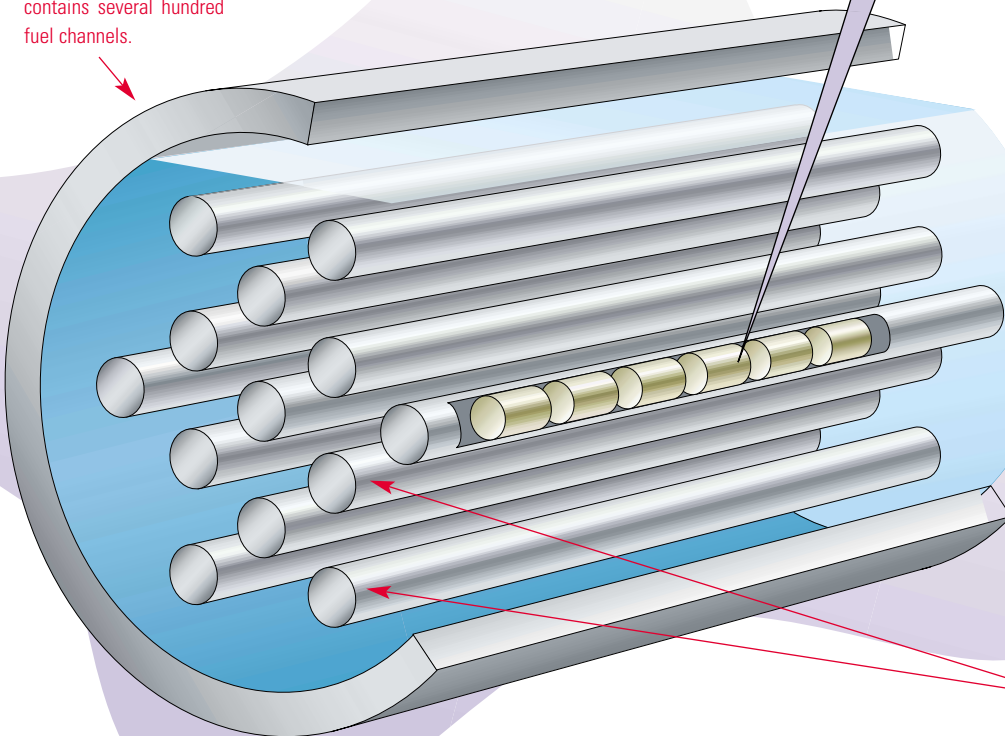
Natural uranium fuel for Ontario Power Generation's reactors is first formed into ceramic pellets and then sealed into metal tubes. The tubes are assembled into fuel bundles weighing about 22 kilograms each. One bundle produces the same amount of heat as 400 tonnes of coal.

The Calandria

The heart of an Ontario Power Generation reactor is a large cylindrical tank filled with the heavy water moderator. This tank, or calandria, is penetrated horizontally by several hundred fuel channels. Twelve or thirteen fuel bundles are placed end-to-end in each fuel channel as shown in the picture. Pressurized heavy water is pumped through the fuel channels where it is heated by the fuel to 300°C. It then travels to a boiler to boil ordinary water into high-pressure steam that drives the turbine/generator to produce electricity. Upon cooling the heavy water is returned to the reactor to pick up more heat and the ordinary water is recirculated to the boiler to be reheated.



The **calandria** is filled with heavy water and contains several hundred fuel channels.

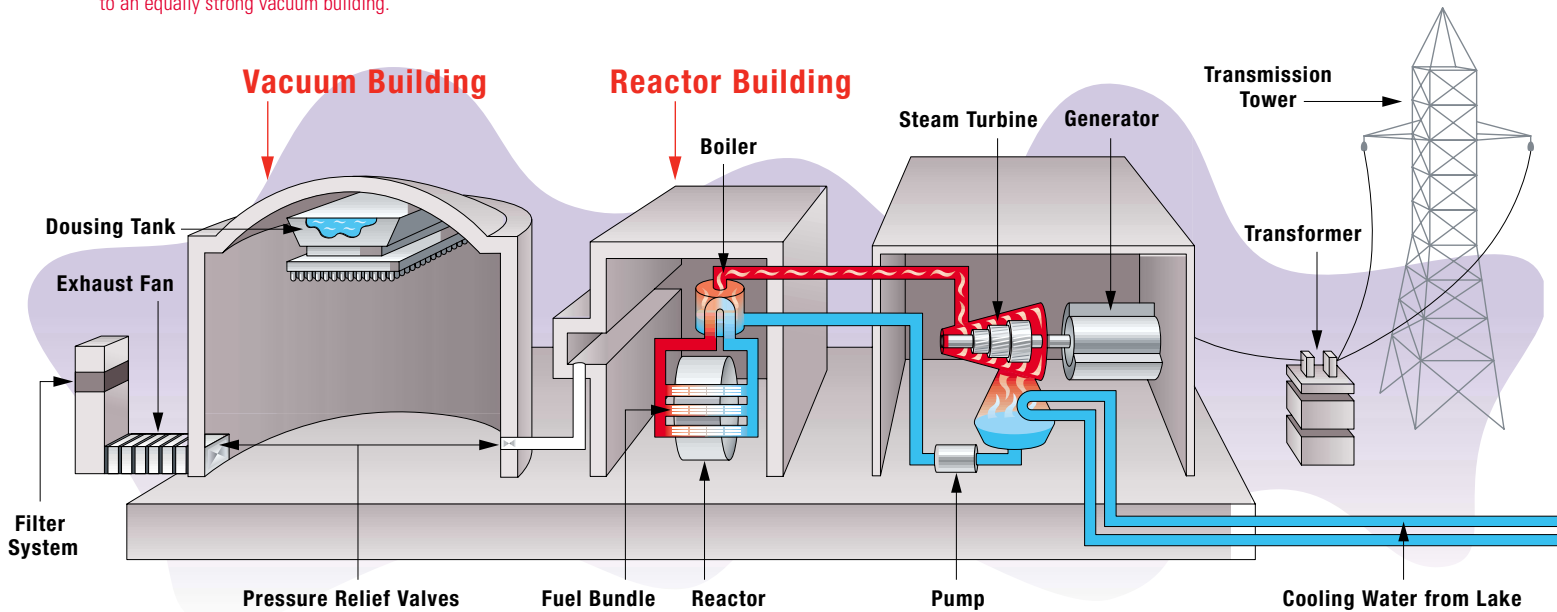


A **nuclear fuel bundle** is made up of several metal tubes, each housing uranium fuel in the form of **ceramic pellets**.

New fuel bundles are safe to hold in your hands - just as it is safe to hold a piece of uranium ore. It's the fission process inside the reactor that makes the used fuel more radioactive. One fuel bundle like the one you see above makes the same amount of electricity as burning 400 tonnes of coal.

The fuel bundles rest in tubes called **fuel channels** that run through a large tank of heavy water. Each fuel channel contains twelve or thirteen fuel bundles.

Each of Ontario Power Generation's reactors is enclosed in a steel reinforced, heavy concrete reactor building attached to an equally strong vacuum building.



Safety and Reactor Control

The reactor is automatically controlled to the required reactor power using liquid zone controllers and mechanical control absorbers. These specially designed tubes and control rods can be activated by the computer or manually controlled.

During routine operation, operators can shut down a reactor by completely inserting the control rods. In emergency situations, however, a separate set of neutron absorbing rods, called shut-off rods, will automatically drop into the reactor and shut it down.

In all Ontario Power Generation reactors, the safety systems are independent of the process systems and independent of each other. They do not function during normal operation of the reactor. They activate only if the process systems are unable to ensure the safe shut down or cooling of the unit.

Containment

Each of Ontario Power Generation's reactors are enclosed in a sealed reactor building with steel reinforced, concrete walls over a meter thick. The reactor building is connected by a large duct to the vacuum building, a large silo like structure which is maintained as a vacuum.

In the extremely unlikely event of a large leak in the reactor cooling system, steam and water would be released into the reactor building. The pressure would rise, opening large fast-acting valves connecting the vacuum building to the reactor building. The steam and any radioactive material would be vacuumed into the vacuum building to be condensed and cooled by water sprays from the dousing tank located at the top of the vacuum building.

The pressure inside the vacuum building and reactor building would stabilize at below atmospheric pressure. It would remain at that level for about a day or two, during which time short-lived radionuclides would decay, many radioactive particles would attach, or "plate" onto the vacuum building walls, and the accident would stabilize. Most importantly, there would be no airborne release of radioactive materials during this "hold-up" period, allowing ample time for any off-site emergency response, if required. Afterwards, a slight vacuum would be maintained by gradually pumping the contents of the vacuum building through high efficiency filters and charcoal absorbers to remove the most harmful radioactive materials. The filtered air would be vented outside the vacuum building through controlled releases and strict procedures.

More Information:

Ontario Power Generation is a major Ontario based generating company. The company's goal is to expand into new electricity markets while operating in a safe, open and environmentally responsible manner. We have more brochures and fact sheets on our nuclear stations and other facilities. To receive these please contact us at:

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