[FISSION]

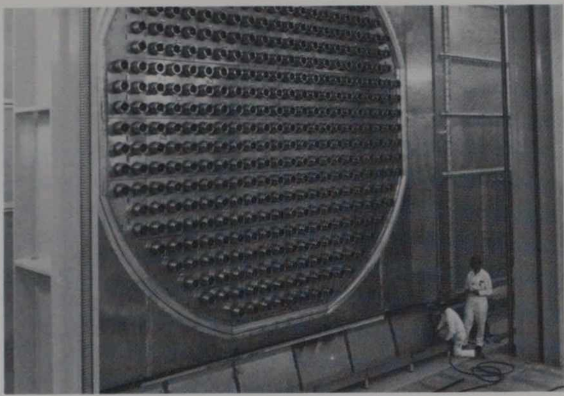
Canada's CANDU nuclear reactors use heavy water and natural, unenriched uranium.

The complex at Pickering, 32 kilometres from Toronto, has four units, each delivering 514 megawatts. Pickering has produced nearly 100 billion kilowatt-hours of electricity at a cost of $0.008 per kilowatt-hour, about half the cost of conventional electric power.

Each CANDU reactor has a horizontal tank filled with heavy water (deuterium oxide). Through the tank run several hundred identical tubes containing nuclear fuel (uranium oxide pellets). The pellets radiate neutrons to the heavy water, which is used both as a moderator and a coolant. As the first, it slows down the neutrons making fission possible; otherwise the neutrons released from the uranium-235 (U-235) isotopes would not fission other U-235 atoms. As the second, it transfers the heat of the nuclear reaction to ordinary water, which turns into steam used to drive a turbine generator that produces electricity.

Each reactor holds 4,680 fuel bundles, and several of those are used up each day. The spent bundles are replaced without interrupting the process, and the spent fuel is discharged into a spent-fuel storage bay.

The spent fuel—or nuclear waste—is a serious and much discussed problem. It contains numerous radioactive elements, some of which decay in seconds and others of which stay radioactive for as long as 24,400 years. At present the spent fuel is stored within the nuclear stations themselves,



The reactor faces at Pickering have 390 pressure tubes, each holding 12 fuel bundles.

and facilities exist there for many years' storage. It is estimated that the accumulated volume of spent CANDU fuel will total 565,000 cubic feet by the year 2000—enough to almost fill a room 60 feet by 100 feet by 100 feet.

The plan for long-term disposal of CANDU waste is to immobilize it in some insoluble solid and bury it in a mined cavity in the solid rock of the Canadian Shield. The disposal site is to be selected by 1983, and a demonstration mine is to be ready in the 1990s.

Nature's Way

Nature assembled the first nuclear reactor nearly two billion years ago in West Africa.

Scientists once assumed that natural uranium ore was always 99.3 per cent stable U-238 and 0.7 per cent volatile U-235. (The later isotope is the basic ingredient that is burned in the CANDU reactor.)

Then the French found uranium ore in Gabon that had only 0.4 per cent U-235. They concluded that the missing U-235 was burned up 1.7 billion years ago, long before the first physicist was born. The almost impossible had happened. A critical mass of ore, without such natural impurities as cadmium (which would have absorbed flying neutrons), had formed an accidental atomic pile underground, and a chain reaction had taken place.

[FUSION]

There is a second nuclear energy technique—fusion. It would have apparent advantages since its principal fuel, hydrogen isotopes, is in endless supply, and presumably it would produce a lower burden of radioactive waste.

The process requires extraordinary temperatures, about 100 million degrees centigrade, and the problem is how to construct hardware that can slam the atoms together and withstand the temperatures. Two approaches are being tried: one with laser beams, one with magnetic fields.

Fusion research is enormously expensive and only the United States, the Soviet Union and a combination of European countries could afford to finance it on full scale. Dr. Morrel Bachynski of Canada's National Research Council believes, however, that Canada can develop an auxiliary program. He thinks Canada could make a particular mark in the laser area. Experiments at INRS-Energie, a division of the Université du Québec, concern delivering laser energy to a target and developing materials that could be used for building fusion reactors. Dr. Bachynski told *Canadian Business*, "We do have some very good people. . . . We also have a unique opportunity in that we have a big electric power grid that's located just south of Montreal. . . . We could use large amounts of power in off-peak periods to do experiments for longer times."