natural uranium entirely in Canada. A wide range of tests in hot channels in the NRX and NRU reactors at heat ratings and energy yields in excess of those required has established that this oxide fuel is incomparably more dependable than the uranium metal fuel for which the NRX and NRU reactors were originally designed. No provision for reprocessing the irradiated fuel is involved, for, by careful attention in the reactor design to minimize any waste of neutrons, a yield of over 9,000 megawatt-days of heat is expected from a ton of uranium before it is discarded. This results in a prospective fuelling cost of about one mill (0.1 cent) per kilowatt-hour of electricity, to be compared with about three mills from coal at $8 a short ton.

Canada has access to such an abundance of coal, oil and natural gas that the competitive cost level for electric power is lower than in many other countries. Nuclear power plants of the types under construction in Britain and the United States were assessed as unable to reach a low enough cost level, at least until several successive plants have been built and operated to discover where economies are possible. Plants of the CANDU type do not promise to be significantly cheaper in total initial outlay, but the fuelling cost can be so much less that meeting the competitive target is a very real prospect.

The low fuelling cost derives as much from the details of the design proposed as from the general type of reactor chosen. Some of the important features seem worthy of mention. The first full-scale plant will generate 220 megawatts with a steam-cycle efficiency of 33.3 p.c., so that the reactor has to supply 660 thermal megawatts to the steam-raising plant. The reactor is essentially a tank of heavy water, 20 feet in diameter and 16.5 feet long, lying horizontally. It is penetrated by 306 fuel channels parallel to the axis on a 9-inch-square lattice. Each channel is a zirconium-alloy pressure tube of 3.25 in. inside diameter and about 0.16 in. thick. The fuel consists of bundles of 19 rods, 0.6 in. in diameter and 19.5 in. long, made of dense uranium dioxide in thin zirconium-alloy tubes. Heat is taken from the fuel directly by heavy water that passes at 560°F to the steam boiler, where normal water is raised to saturated steam at 483°F and 38 atmospheres. These details show that the design represents a very considerable advance over that originally conceived in 1956, and the improvement bears promise that continued progress will lead to costs well below the economic target. As examples of the advance, it may be noted that, for the same electric power output, the total heat production of the reactor has been brought down from 790 to 700 megawatts, the efficiency of the steam cycle itself has risen from 27.9 p.c. to 33.3 p.c., and the length of fuel rod has been reduced from 86 to 30 kilometers. The prospective fuelling cost has dropped from 1.85 mill/kwh. to 1.0 mill/kwh. On the other hand, no over-all reduction has been achieved in the capital cost estimates which remain in the range of $300 to $400 per electrical kilowatt for the whole plant. However, a reduction is expected now that manufacturing experience has been gained which can be used in future construction. Even greater reductions in unit power cost are in prospect from an increase in the capacity of the reactor to 500 megawatts of electricity and the incorporation of several such units in a large generating station.

An evaluation was completed in 1963 of the relative prospects of four types of large power reactor for which development work was well advanced. All are heavy water moderated and would not require any reprocessing of spent fuel. The fuel could be natural uranium or slightly enriched in the form of uranium dioxide or uranium carbide. The differences lie in the coolant and steam cycle. The four coolants are pressurized (perhaps partly boiling) heavy water (as in CANDU), fog or wet steam, ordinary boiling water, and an organic liquid. The fog and boiling water reactors would pass steam directly to the turbine; the heavy water and organic liquid would raise steam via a heat exchanger. Cost estimates were based on experience in the construction of CANDU and carried out by the