efficiency is then 29.1 per cent. 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 reactor power has been brought down from 790 to 700 megawatts and the length of fuel rod from 86 to 30 kilometres. The prospective fuelling cost has dropped from 1.85 mill/kWh to 1.0 mill/kWh. On the other hand, no wholesale reduction has been achieved in the capital-cost estimates, which remain in the range $300 to $400 an electrical kilowatt for the whole plant. No reduction is expected until manufacturing experience has been gained that can be used in future construction, but thereafter appreciable reductions should be possible.

The first plants seem to find economic application in Canada only in the Ontario system, where annual charges on capital are low and coal has to be imported and costs about $8 a short ton. Moreover, the demand for electricity in Ontario is growing at more than 200 megawatts capacity a year. To build reactors for lower powers saves little in the cost, so the cost a kilowatt rises and becomes uneconomical. Now that confidence has been gained from the early plants, higher powers seem possible and designs up to 750 electrical megawatts from one reactor are being studied.

Repair Problems

Operating experience with the NRX and NRU reactors at Chalk River and with the many other types throughout the world has served to emphasize the great difficulty and costliness of making even minor operating repairs in the presence of the extremely high levels of radiation that are encountered around reactors. Directly and indirectly, this is responsible for the current hesitation to construct a number of large plants that for economic power will cost no less than $40 million or $50 million each. With every new design it is necessary to acquire operating experience before the reliability and availability can be effectively estimated. Experience with defective fuel has been deliberately sought at Chalk River, because this is one of the difficulties most likely to be encountered. Appropriate techniques of locating the defective element, removing it and cleaning up the released radioactive fission products have been established and practised; at the same time, fuel designs and ratings that lead to least difficulty in these operations have been studied. Experience of mechanical failures of control rods has lent weight to reactor designs such as NPD, where control rods are not needed. Temperature changes are likely to provoke mechanical failures, so design is aimed at keeping the reactor at power for all essential operations, including refuelling and complete maintenance testing and readjustment of instruments and working parts of the control system.

A study is in progress of the relative merits of four types of large power reactor for which development work is active. 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. It is apparent that, in large sizes, construction costs would be comparable but the small differences may be significant. A larger difference is in prospect from fuel-fabrication costs. The cost of development of each type, although high, may be justifiable economically by the cost savings in appropriate circumstances. All appear competitive with conventional plants except locally, where fuel is abundant at low cost.