future rates of growth of total energy consumption are reduced, nuclear-electric usage will grow as rapidly as resources permit to conserve fossil fuels for uses for which they are irreplaceable, if for no other reason.

With a parliamentary appropriation for nuclear research and utilization of $89.4 million in 1973-74, the research and development activities of Atomic Energy of Canada Limited generate and support an atomic energy program that is comparable with that of the major nuclear powers. The development of CANDU (CANada-Deuterium-Uranium) power reactors provides a system which offers the prospect of abundant, low-cost electrical energy for the foreseeable future on a world-wide basis.

The unique feature of CANDU power reactors is the use of heavy water (deuterium oxide) as a moderator for slowing, or "moderating", the neutrons from nuclear fission to maintain the fission chain reaction. The high neutron economy obtained by using this moderator and employing neutron-transparent core materials (zirconium alloys) means that natural uranium may be used as fuel. The use of natural uranium in the CANDU system is incidental to the basic concept of neutron economy but its use at the moment has certain economical and political advantages and serves as a useful engineering design discipline. The user of a natural-uranium fuelled reactor system is not dependent on one of the few countries providing uranium enrichment services and is able, for a comparatively modest capital outlay, to establish a domestic fuel fabrication industry. This, together with the simplicity of the technology of the CANDU reactor, makes it a particularly good system for those countries wishing to establish an indigenous nuclear industry.

Ontario has a major nuclear power program, Quebec and New Brunswick are introducing nuclear units (see Chapter 13, Energy); all have selected CANDU systems. Other provinces are expected to follow in the 1980s as electricity demand grows and hydraulic sites become fully developed.

CANDU reactors are operating in India and Pakistan; Argentina and Korea have placed orders for 600-MW units; other countries, including Denmark, Iran and Romania, have indicated interest. Britain has selected the SGHWR concept, which is similar to CANDU, for its next generation nuclear stations and is considering technology exchange with Canada.

The main R&D centres are the Chalk River Nuclear Laboratories (CRNL) in Ontario and the Whiteshell Nuclear Research Establishment (WNRE) in Manitoba. Both sites contain research and applied science divisions and operate research reactors and other major facilities. Total staff of the two sites is about 3,100, of which about 650 are scientists or engineers. The following paragraphs outline the scope of R&D effort.

Radiation hazards control. The objective is to protect man and his environment from harmful effects due to nuclear power. Work covers the spectrum from environmental research through health physics to measurement and control of plant emissions. Waste management methods assume greater importance as the power program expands. Plutonium hazards and their control are of central importance to development of advanced fuel cycles.

Control and safety. Control strategies and safety systems are developed to meet operating requirements while assuring the safety of plant personnel and the public. Techniques such as direct computer control and independent multi-channel logic have been pioneered and applied.

Fuel development. Power reactor fuel is required to tolerate sustained operation at design rating, power cycling dictated by load following requirements and fuelling operations, and abnormal conditions that could result from system failures. The work includes applied research on behaviour of fuel and sheath materials in stress, temperature and radiation fields, the release and influences of fission product gases, heat transfer, sheath and bundle structural integrity, and vibration effects. Methods range from metallurgical research through irradiation tests of fuel bundles with sophisticated instrumentation in research reactors, to post-irradiation examination in shielded cells.

Heat transfer and fluid mechanics. This discipline is of basic importance to fuel development, system design and safety analysis. Conditions unique to nuclear plants are: high heat release rates and power densities in fuel channels, the enormous amounts of heat transferred through steam generator tubes from reactor coolant to turbine steam, and the requirement for precise