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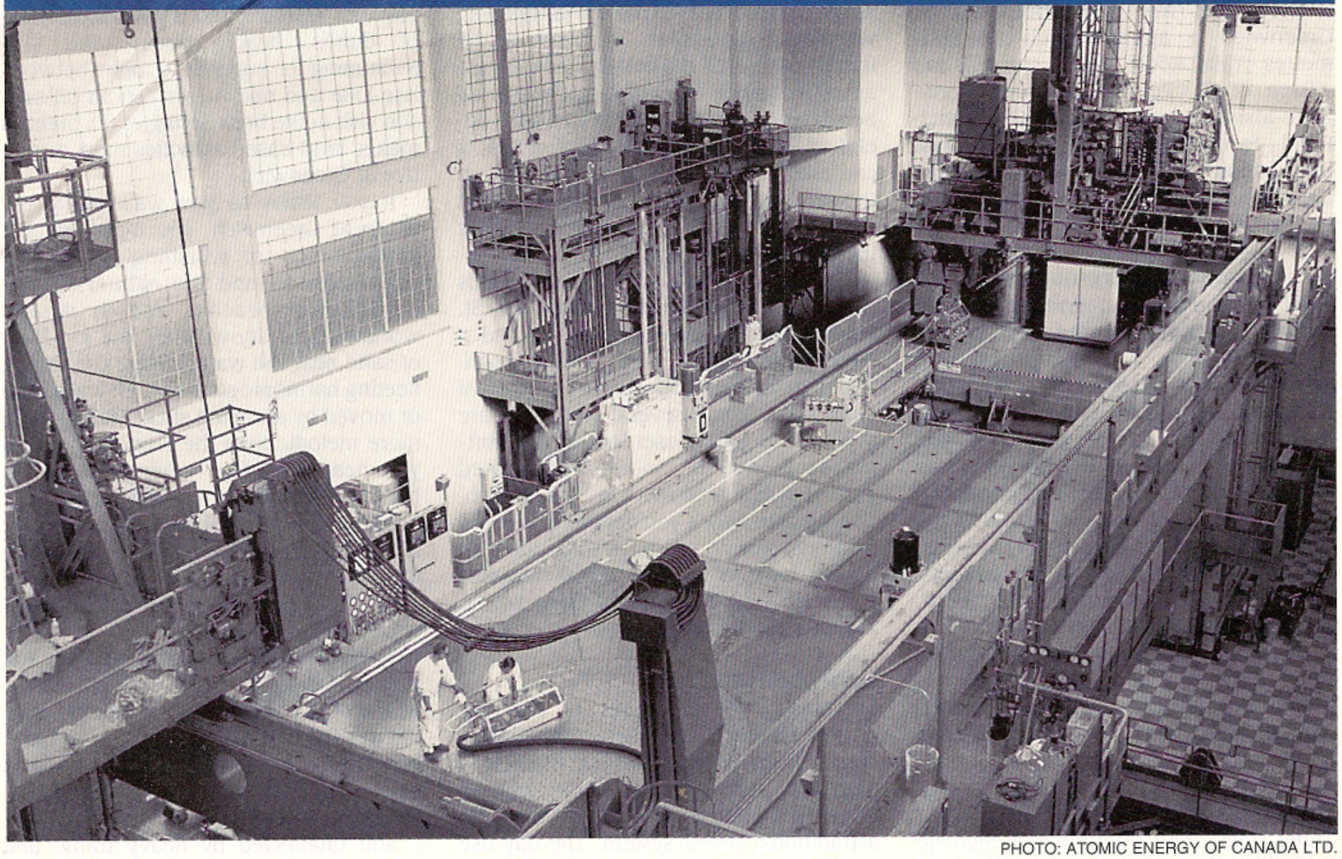
Canadian Reflections



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Entering The Nuclear Age

by Jeremy Whitlock

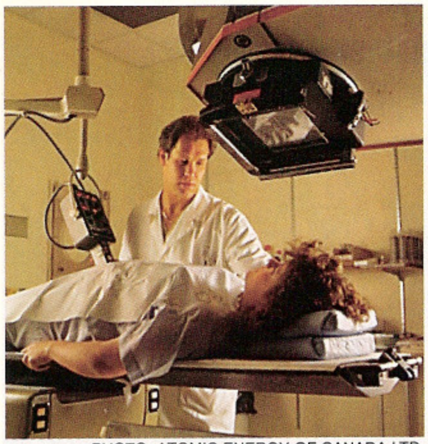

PHOTO: ATOMIC ENERGY OF CANADA LTD.

From top: Workers use radio-active cobalt created in the NRU reactor at Chalk River, Ont.; nuclear research has been a benefit to cancer therapy.

In September 1945, a month after the end of World War II, Canadians were still getting used to the idea that the Atomic Age had begun. Two American bombs of unimagined power had ended the hostilities, followed shortly by a statement from the Canadian government that Canada had proudly played an "intimate" role in their development.

Patriotism aside, it was true that Canada had participated in the Anglo-American atomic bomb program, and had, by accident of geology and geography, come out of the war with the world's second largest nuclear infrastructure. The time would soon come to decide what to do with it, but for now, a month after the war's biggest secret was out, the focus was still very much on getting the job done.

Here, in a clearing on the wooded Ontario shoreline of the Ottawa River about two hours west of Ottawa, Canada would become the second nation to construct a working nuclear reactor. It was Sept. 5, almost a month to the day after the Hiroshima bombing.

For Lew Kowarski it was a moment of personal closure. Five years earlier the burly Russian-born scientist had escaped France aboard a collier on the eve of Nazi occupation, with almost the world's entire supply of "heavy water"—about 200 litres in 26 cans. Three months before that the precious scientific cargo had been spirited out of Norway, just ahead of the German invasion of that country. Once safely on English soil, Kowarski and fellow refugee scientist Hans von Halban continued their experiments with uranium and heavy water that they had pioneered in France.

By an extraordinary convergence of

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public buildings between April 1 and Oct. 15. However, trained guide dogs are allowed.

The drive from Charlottetown to Greenwich is approximately 70 kilometres. Take Route 2 east through the village of St. Peters then onto Route 313—also known as the Greenwich Road—to the parking lot. For the latest information, call 902-961-2514 or visit the Web site http://www.parkscanada.gcc.ca/pei.

The Greenwich Interpretation Centre

Walk into the Interpretation Centre from the paved parking lot and walk onto a clear floor over a 3-D topographical model of the Greenwich Peninsula, St. Peters Bay and the surrounding area. This, of course, is the only way you should ever walk on the dunes! More than 20 exhibits cover the cultural and natural history of the region, including Time Line, which charts 10,000 years of habitation and displays on-site artifacts. Before leaving for the dunes and beach, stay and watch the 12-minute multimedia presentation on local human history called Wind, Sea and Sand, the Story of Greenwich and test your naturalist skills with the Shell Game, Shorebird Challenge and Dune Plant quizzes.

Exploring The Hiking Trails

Three trails, with interpretative signage explaining natural and cultural history, are available at Greenwich. The 4.5 km Greenwich Dunes Trail is rated at moderate difficulty. The 4.5 km Tlaqatik Trail and the 1.25-kilometre Havre Saint-Pierre Trail are rated 'easy', with the latter being wheelchair accessible. Because of the fragile nature of the dunes, visitors are asked to stay on the trails and designated beach access points and not trample vegetation. Park studies have shown that it can take as few as 10 footsteps through the same area to destroy protective plant cover which leads to erosion that scars the delicate dune habitat.

The Dunes Trail goes through fields with a view of the community of St. Peters, then an evergreen forest and a floating boardwalk over Bowley Pond. Walking further, you reach the coastal dune ridge where several side trails are available to get a closer look at the shifting sand system. Another designated pathway leads down to the beach. Chances are, when you get there, you will be alone. Nor do you have to be the outdoorsy type to see the dunes because paths are well marked and there are no arduous uphill climbs.

Day-Use Facilities

Sustainable development is the key design concept at Greenwich. Energy comes from wind, of which there is a plentiful supply, and solar power. Composting toilets eliminate the need for a traditional sewer system. The day-use area has washrooms and change rooms plus exterior showers, a picnic shelter and a wooden boardwalk to the beach. An observation tower with outside stair access rewards climbers with a cardiovascular workout and a panoramic view of dunes, beach, ocean and sky. Swimming is supervised only between late June and mid-August, so an off-season visit in the brisk spring or fall breezes makes land-based activities most attractive at Greenwich.

If you listen as you walk along the shore at Greenwich, you may hear the phenomenon of whistling or singing sand. Musical sand is a natural art that happens on beaches and in deserts worldwide. In dry weather, the top layer of sand near the water's edge can emit a fleeting harmonic sound when walked on or moved by a trailing stick. This is much more melodic than the crunching sound you hear underfoot when walking on hard, granular snow in very cold weather. Caused by the rubbing together of fairly smooth and uniform grains, the sands lose their singing voice as you move away from the shoreline to the upper wave limit of the beach.

Nature is the attraction of the Bays and Dunes Region of Kings County. Greenwich offers breathtaking views and uncrowded beaches removed from other busy Island attractions. The dunes provide an additional buffer that heightens the sense of serenity.

Still unaffected by heavy traffic and shoreline development, Greenwich sits in solitude. ■

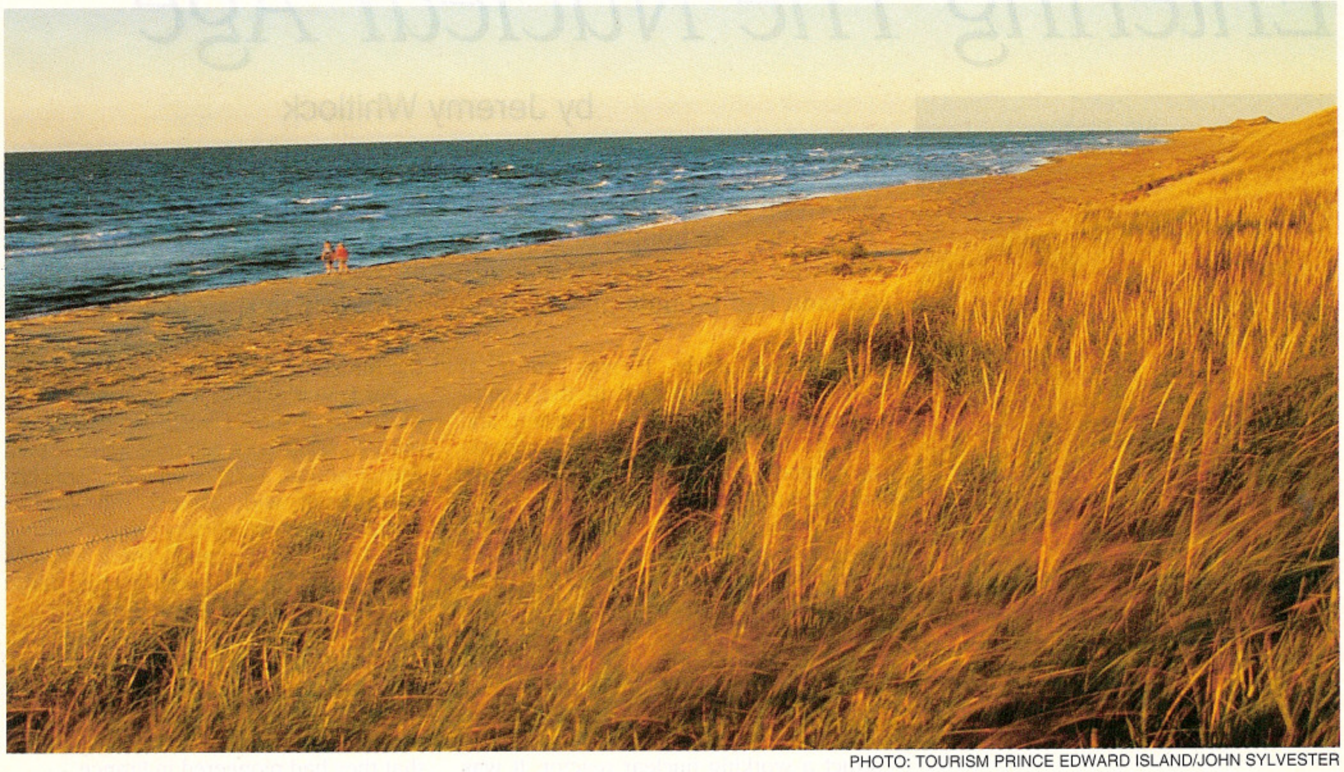

PHOTO: TOURISM PRINCE EDWARD ISLAND/JOHN SYLVESTER

A couple enjoys a quiet stroll along the beach at Greenwich.

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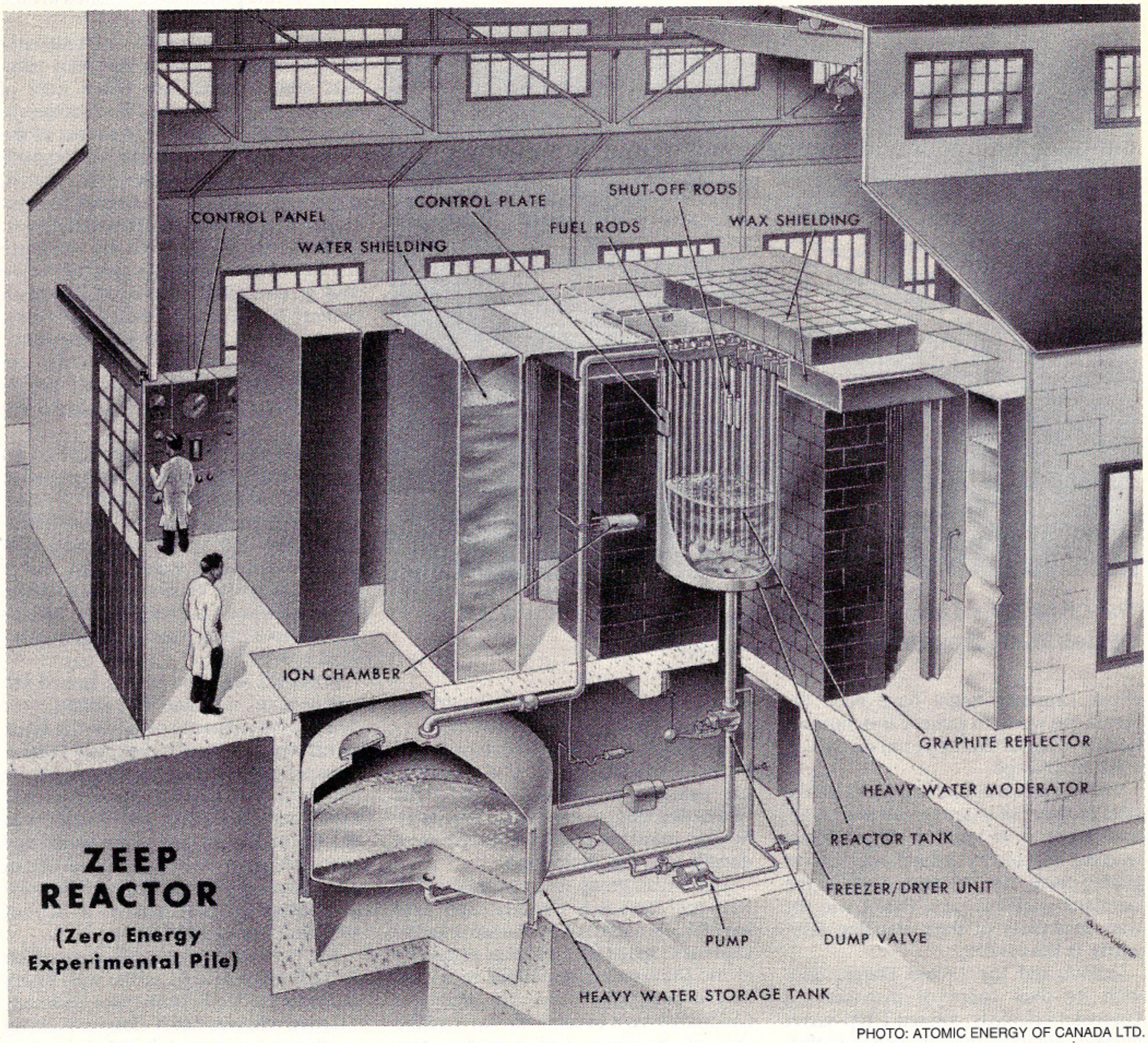

PHOTO: ATOMIC ENERGY OF CANADA LTD.

A cut-away drawing of the ZEEP reactor, Canada's first nuclear reactor and the first in the world to operate outside the United States. The reactor started up in September 1945.

history, the most spectacular scientific discovery of the century, the splitting of the atom (or fission), had been discovered just prior to the outbreak of the largest global conflict in history, and the discovery was made in Germany. Furthermore, many of the practical advances in studying this new energy source were made in France, and now all of that was in German hands.

All, that is, except Kowarski, Halban, and their heavy water. It was known that uranium fission could generate a lot of heat, and that heavy water (a rare form of regular water) could help achieve this. Increasingly, the British government became convinced that they possessed the energy source for a new weapon of immense destructive power, and if that were true, then so did the Nazis. One outcome of this suspicion was a 1943 commando raid on the Norwegian hydro plant that generated the heavy water.

Meanwhile, across the Atlantic in Ottawa, deep within the gothic laboratories of the National Research Council on Sussex Drive, Canadian scientist George Laurence closely followed Kowarski and Halban's work against the descending secrecy of WW II. By day, Laurence was responsible for teaching radiography to Canada's wartime aircraft industry, but in his spare time he worked towards building one of the world's first nuclear reactors.

Instead of heavy water, Laurence opted for carbon, a less efficient but cheaper and more available substitute. With 10 tonnes of the black, messy stuff (in the form of petroleum coke), and 450 kilograms of black uranium powder borrowed from Eldorado Gold Mines Ltd. in the Northwest Territories, Laurence conducted his experiments from 1940-42. In the summers he had help from Professor B.W. Sargent of Queen's University in Kingston, Ont.

The Holy Grail of this type of work was a self-sufficient nuclear reaction; that is, one in which uranium atoms continuously split each other in a chain reaction that requires no outside help. With purer materials and a full-time

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PHOTO: ATOMIC ENERGY OF CANADA LTD.

The Chalk River Laboratories was established during WW II on the Ottawa River, about two hours west of Ottawa.

effort, Laurence might have been the first in the world to achieve this, but that honour went to Enrico Fermi on Dec. 2, 1942, in Chicago.

The Americans had awoken to the grim prospect of a German atomic bomb, and were now putting their fullest wartime machinery behind the task of getting there first. All agreed that if the Germans won this race, they'd win the war, regardless of their standing elsewhere in the conflict.

Britain and the United States, each with its own cadre of dispossessed European scientists, formed a top-secret nuclear alliance that in demographic, scope and intent could only have been conceivable during WW II. The world's most brilliant minds were locked in a macabre race to build the perfect weapon.

But there was more to it. Nuclear fission was an energy source of almost unlimited potential, both good and bad. In a Faustian twist, the scientists were also building the energy source of a postwar industrial boom, or so many thought.

Developing concerns over security and industrial patents strained the Anglo-American relationship, and when the British offered to move their group to America to escape the European theatre of war, they were flatly refused. This is where Canada came in. A British colony with an abundance of both water and uranium, plus skilled workers, open space, natural resources, energy and (not least in importance) proximity to the American effort, the choice was clear.

A decision was made to host the British project in the fall of 1942. It was a defining moment for Canada, shaping the future direction of its science and technology infrastructure and thrusting it directly onto the world stage.

The British group was assigned to the National Research Council, and was joined by a number of Canadians led by Laurence. Space was found in a building at the University of Montreal, in a suitably cosmopolitan city. The Montreal Laboratory, as it became known, had the task of designing a pilot heavy-water nuclear reactor for producing plutonium. Prior to the war, plutonium had only existed in trace amounts. Now it held a place alongside uranium as the miracle fuel of the future. Interestingly, plutonium could only be created in great quantities within a nuclear reactor, one example of which was now the Montreal lab's focus.

The task had military significance, but the greatest concentration of scientific minds in Canadian history set about its task with an eye on the other edge of the sword: NRC President C.J. Mackenzie later commented that the deciding factor in taking on the Montreal lab was the obvious long-term social and economic significance of atomic energy. Canada was getting in "on the ground floor of a great technological process for the first time" in its history. Mackenzie never expected the project to be finished in time to contribute to the war.

Indeed, it was July 1944—a month after D-Day—when a site for the pilot plant was chosen about two hours west of Ottawa, seven kilometres north of the village of Chalk River on the shores of the Ottawa River. In utter secrecy a complete scientific lab was built from scratch, along with a town site—Deep River—for its workers a few kilometres to the west. Both sites were built by Defense Industries Ltd., with the familiar white and green colour scheme of Canadian military installations. Petawawa Works, as it was known during construction, looked like nothing more than an extension of nearby Canadian Forces Base Petawawa. This was, of course, the intention.

Chalk River Nuclear Laboratories was to host a 20-million-watt reactor called the NRX, for National Research X-Metal (X-Metal being the wartime code for uranium; later the name was changed to National Research Experimental, but it would always be known simply as NRX). First, however, a smaller test reactor needed to be built, and this assignment went to Kowarski.

Kowarski was one of the last of the British team to come to Canada, now lured by the chance to complete the quest he had begun five years before in France: construction of a heavy-water reactor. He named his reactor ZEEP, for Zero Energy Experimental Pile. The "zero energy" was due to the reactor producing barely any heat; "pile" was the jargon for reactors in those days, after Fermi built the first one in Chicago literally out of a pile of graphite (carbon) blocks.

The construction of ZEEP dragged on through the final days of the war, which ended in Europe in May 1945. Germany, it turned out, was never close to building an atomic bomb. In July the Americans had made enough plutonium of their own to secretly test the world's first atomic bomb in New Mexico. The world's second and third atomic bombs were dropped, less secretly, on Hiroshima and Nagasaki in August 1945, and that ended the hostilities with Japan.

Canada's first reactor, and the first one outside the U.S., started up a month later. Born out of military expediency within a larger American context, Canada's nuclear lab was suddenly a leftover wartime gift, fully staffed and ready to go.

On the books was the NRX reactor, already under construction. Never designed solely as a plutonium-producing reactor, the NRX came fully equipped for scientific experiments, including a number of "beam tubes" that permit streams of subatomic particles to leave the reactor and impinge on test materials.

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When completed in 1947, NRX was the most powerful research reactor in the world. Canadian nuclear science defined the forefront of the art, and the little Canadian Pacific Rail station in Chalk River welcomed the world's greatest scientists and other VIPs to the heart of the Canadian Shield.

Significantly, Canada did not pursue the development of atomic weaponry, despite being one of the three countries on Earth at the close of WW II with the know-how to do so. Canadian research reactors at Chalk River did turn out a relatively small amount of plutonium for the American market until well into the Cold War, but the broader foresight of NRX's designers, and the scientific vision of the National Research Council, put Canada soundly on a path to peaceful nuclear research and development.

One thing the NRX could do better than any other reactor was make radioisotopes; that is, materials that give off radiation for industrial, medical, or scientific purposes. In 1949, Dr. Harold Johns of the University of Saskatchewan asked the NRC to make some radioactive cobalt for use in cancer therapy. The idea was novel at the time, and Johns led the field: the powerful energy from radioactive cobalt could be harnessed to kill cancerous cells, without unduly affecting the surrounding non-cancerous tissue. Elsewhere in Canada, Roy Errington of Eldorado Mining & Refining Ltd., made a similar request to the NRC at about the same time. The race for the "cobalt bomb" (as the media dubbed it) was on.

It was a slow race, since even the most powerful reactor in the world took a full two years to make sufficiently potent radioactive cobalt. The media was nevertheless intrigued. In 1951, the cobalt for both parties was extracted from NRX, but the Eldorado therapy unit was the first to be ready for clinical use. On Oct. 27, 1951, Dr. Ivan Smith's cancer clinic at Victoria Hospital in London, Ont., was the first in the world to treat a patient with radiation, using the Eldorado unit. The Saskatchewan team followed with its first treatment 12 days later (the Saskatchewan unit had an illustrious career, treating almost 7,000 patients over the next 21 years).

From those humble beginnings, Canada became a world leader in the production of medical radioisotopes and radiation therapy devices. Today, Canada—through a private supplier—is responsible for 80 per cent of the world's radioactive cobalt for industrial and medical use, as well as a majority of the market for other important medical isotopes.

By 1952 the operations at Chalk River had outstripped the NRC's original mandate, and a new crown corporation, Atomic Energy of Canada Ltd., AECL, was created with the sole purpose of pursuing peaceful applications of Canadian nuclear research and development. At the time of transfer from NRC to AECL, a much more powerful research reactor was under construction, to be known as National Research Universal or simply NRU. NRU started operation five years later in 1957, and continues today as the workhorse for Canadian nuclear research and radioisotope production.

Also at the time of the handover to AECL, talks were under way regarding a Canadian electricity-producing reactor. Since the end of the war, electricity demand was skyrocketing in lock-step with the economy. Factories were springing up, inner cities were becoming increasingly electrified, and people were moving to larger homes in sprawling subdivisions.

Utilities like Ontario Hydro were keeping pace for the time being with new hydraulic developments, but soon all the large rivers would be used up. A fleet of new fossil-fuelled stations was planned, but for Ontario this meant buying expensive U.S. coal and choking its urban centres with smog. Although nuclear fission was new and largely untested as an electricity-producing energy source, it held the promise of an abundant, domestic fuel supply, and no air emissions. Not surprisingly, Ontario Hydro was interested in the wunderkind technology and became a corporate partner in its development right from the start.

When it came time to decide on a type of power reactor, Canada naturally turned to its unique heavy-water reactor expertise. August 1951 saw the formal publication of An Atomic Power Proposal by W.B. Lewis of Chalk River Laboratories, followed by high-level meetings and a series of feasibility studies involving the Ontario and federal governments, Ontario Hydro, and the NRC.

In 1954 the Nuclear Power Group was established at Chalk River Laboratories, bringing together representatives from utilities, engineering companies, manufacturers, and AECL's scientists to design a prototype heavy-water power reactor that could compete with coal-fired plants.

Although "made-in-Canada" was the overlying goal of this enterprise, "made-in-Ontario" largely resulted by default. Ontario not only provided the industrial base for much of the manufacturing, but was also the seat of Canada's nuclear engineering and scientific expertise, as well as uranium production.

In March 1955, Canada General Electric in Peterborough, Ont., was selected from seven bids as the prime contractor for the Nuclear Power Demonstration, NPD, project. General Electric would provide the design work, as well as $2 million in funding. Ontario Hydro would provide the plant site and all conventional (non-nuclear) equipment, plus operate the plant. AECL would provide the balance of funding and own the nuclear side of the plant.

The site was on the Ottawa River, just downstream from Ontario Hydro's massive Des Joachims hydro-electric power station at Rolphton.

These were heady days, where design and development proceeded in parallel, and key late-breaking design decisions became the blueprint for future Candu designs, as the technology became known as. The most significant of these decisions was made in 1957, when the team redesigned the entire reactor to better reflect the thinking on future Candu designs. Instead of having one large pressure vessel, as in American designs then being developed, NPD would assume the horizontal, pressure-tube arrangement characteristic of all Candu reactors to this day.

This would make NPD the first commercial power reactor to have a completely replaceable core, and the first to refuel while operating at full power: both remain signature Candu traits.

This decision also ensured that the manufacturing phase would approach 100 per cent Canadian content, since the specifications now more closely matched domestic industrial capabilities at the time. More importantly, it meant that international experience would be largely irrelevant to the Canadian nuclear program: the bold decision to be unique also meant self-reliance.

Construction continued, and as hurdles and delays were gradually overcome, an operations group, assembled under Lorne McConnell of Ontario Hydro, prepared to take over and bring Canada into the Nuclear Power Age.

NPD began supplying its first electricity to the Ontario grid on June 4, 1962, and reached full power (about 20 megawatts, enough for 10,000 homes) on June 28. Ontario Hydro would continue to operate the plant for the next 25 years, even as much larger Candu versions came on-stream in Southern Ontario, dwarfing NPD's meagre contribution.

Today, Ontario is one of the largest nuclear-powered jurisdictions in the world, and Canada is a world leader in both the power reactor and medical radioisotope market. This is a remarkable achievement for a largely empty country with a largely resource-based economy, and equally remarkable is its lineage to a single decision of wartime expediency. ■