

On Wednesday, September 27, 2006 at 2 p.m., the Ontario Heritage Trust and the Canadian Nuclear Society unveiled a provincial plaque at the Bruce Power Visitors' Centre north of Tiverton, Ontario to commemorate the Douglas Point Nuclear Power Plant.

The bilingual plaque reads as follows:

DOUGLAS POINT NUCLEAR POWER PLANT

The Douglas Point Nuclear Power Plant began generating electricity in 1967 and continued until 1984. This joint project between Atomic Energy of Canada Ltd. and Ontario Hydro was the first commercial-scale Canada Deuterium Uranium (CANDU) reactor. The Nuclear Power Demonstration (NPD) reactor in Rolphton, Ontario had proven the CANDU concept in 1962 and the 200-megawatt Douglas Point plant, ten times larger than NPD, demonstrated that a CANDU nuclear power plant could be scaled up for commercial power generation. The advances made at Douglas Point provided the province with a growing and reliable energy supply and contributed to the success of larger CANDU plants in Canada and abroad.

CENTRALE NUCLÉAIRE DE DOUGLAS POINT

La Centrale nucléaire de Douglas Point a commencé à produire de l'électricité en 1967 et ce, jusqu'en 1984. Ce projet conjoint d'Énergie atomique du Canada limitée et d'Ontario Hydro a été le premier réacteur nucléaire commercial CANDU (Canada Deutérium Uranium). Le réacteur nucléaire de démonstration (réacteur NPD) de Rolphton, en Ontario, a validé le concept CANDU en 1962 et la centrale de Douglas Point de 200 mégawatts, dont le réacteur était dix fois plus puissant que celui de Rolphton, a prouvé qu'une centrale nucléaire CANDU pouvait être aménagée à des fins de production commerciale d'électricité. Les progrès accomplis à la centrale de Douglas Point ont permis d'offrir à la province une source croissante et fiable d'approvisionnement en énergie et ont contribué à assurer le succès de centrales nucléaires CANDU plus puissantes au Canada et à l'étranger.

Historical background

The Douglas Point Nuclear Power Plant – or Nuclear Generating Station – achieved the important first step of start-up or “criticality” on November 15, 1966 and first generated

electricity in January 1967. It entered full commercial operation on September 26, 1968 and continued to supply up to 220 megawatts of electrical power (MWe) to the Ontario grid until it was retired on May 5, 1984.

Creating a prototype

Atomic Energy of Canada Ltd. (AECL) clearly stated well in advance of the Douglas Point opening that “it is a prototype, it is not expected to produce electrical energy at competitive costs in its economic environment.”¹ It is as a prototype that the Douglas Point Nuclear Power Plant participated in the growth of Canada’s peacetime nuclear industry, and as a prototype that the plant has historical significance. The Douglas Point Nuclear Power Plant is best understood as a giant test bed or proving ground, the final step on the way to the first generation of industrial nuclear generating plants located at Pickering, Ontario. The descendants of Douglas Point – the large-scale nuclear power plants at Pickering, Darlington and Bruce Peninsula – now supply over 50 per cent of Ontario’s power.

At the end of the Second World War, Canada had the only nuclear reactor outside the United States, as well as the world’s second-largest nuclear infrastructure. Unlike the United States, Great Britain and other countries that had developed nuclear capability, Canada’s nuclear program was non-military. Early projects – such as the ZEEP, NRX and NRU² – had proven that Canada could build increasingly sophisticated, increasingly powerful nuclear reactors.

Due to the high cost of reactors and nuclear research, efforts were made to increase the societal benefits of the peaceful use of nuclear power in Canada. Early in the 1950s, Dr. George Laurence, Dr. W.B. Lewis and others began advocating using the heat from nuclear reactors to generate electricity in order to meet rapidly growing domestic, commercial and industrial demands for electricity. But such an ambitious undertaking needed an administrator. That came in 1952 with the establishment of a Crown corporation – Atomic Energy of Canada Ltd. (AECL) – that was charged with nuclear power development as one of its main responsibilities.

It was one thing to come up with the idea but another matter to build a workable nuclear power system to generate electricity through nuclear fission in a country with no military nuclear program. Canada needed a proof-of-concept project. AECL, Canadian General Electric and Ontario Hydro jointly provided the proof with the NPD (Nuclear Power Demonstration) plant at Rolphton, Ontario, which started to feed electricity into the grid on June 4, 1962 and operated until 1985. With an output of 20 MWe, the NPD plant proved that the Canadian technology worked, but gauging the prospects of commercial success would demand a much larger-scale – a commercial-scale – prototype. That would be the task of the 200 MWe Douglas

¹ Atomic Energy of Canada Limited, *Douglas Point Nuclear Generating Station*, Internal report AECL-1596.

² Zero Emissions Experimental Pile (1945), National Research Experimental (1947), National Research Universal (1957).

Point nuclear power generating plant, a plant with 10 times the output of the proof-of-concept NPD plant.

In 1959, well before the completion of NPD, the federal government (through AECL's newly-created Nuclear Power Plant Division in Toronto) and Ontario Hydro agreed to proceed with the design, development, construction and operation of a 200-MWe nuclear power plant. Work on a commercial-scale prototype started before the proof-of-concept plant was in operation because of the pressing need for power that resulted from post-war growth and industrial development. And, with the United States, Britain and France working to create their own nuclear reactors, speed was of the essence if Canada was to gain a commercial foothold in the emerging world of nuclear power generation.

When design work started on Douglas Point, the projected size of nuclear reactors was increasing rapidly. Similar growth had occurred during the early years of hydroelectric power, when the output of turbines and generators rose dramatically in the course of a few years. The growth was exciting as well as potentially profitable, but scaling up also brought uncertainty and delay.³ Countries that were developing nuclear generating stations had to consider whether proof-of-concept designs could be scaled up enough to become commercially viable. The projected 200-MWe Douglas Point unit had 10 times the power output of the NPD unit, but Douglas Point was expected to be surpassed by subsequent nuclear power plants. Each project built on the knowledge gained from the one before and influenced those that followed. NPD and Douglas Point were intended to provide much-needed design details as well as engineering, construction and operating experience for even larger reactors.

Research is illuminating, but can provide unpleasant surprises in the short term. This was the case when it was discovered that the NPD pressure vessel intended to house the reactor core, fuel, moderator and coolant could not be scaled up to the size required for use in future reactors. In order to put NPD back on a scalable track rather than a dead-end development path, the reactor design was significantly changed. The pressure vessel was eliminated and replaced by horizontal pressure tubes to contain the pressurized heavy water coolant and the fuel. The reactor was redesigned to be refueled while under full power. These courageous mid-project design changes created the fully developed CANDU system which has proven itself in Canada and internationally.

Douglas Point was the first reactor designed from the start as a full CANDU (**CAN**ada **D**euterium **U**ranium) system reactor, with its characteristic features of horizontal pressure tubes, its reliance on naturally occurring uranium oxide fuel rather than either enriched

³ For an introduction to the uncertainty and delay associated with the early years of scaling up hydroelectric generating at Niagara Falls, see Norman R. Ball, *The Canadian Niagara Power Company Story*. Erin, Ontario: The Boston Mills Press, 2005.

uranium or uranium metal, and the use of heavy water as both a moderator and coolant – or heat transfer medium – with only the coolant water at high pressure. Most importantly, in terms of continuous reliable power supply, the design allowed for refuelling while the reactor was running and producing power; other systems had to be shut down for refuelling.

The Douglas Point Nuclear Power Plant offered the world a prototype for an economic source of long-term electrical power. Many technical details had to be resolved quickly in a short period of time. Just as design had started on Douglas Point before the NPD reactor was complete, plans were proceeding for the first generation of industrial-scale reactors at Pickering before Douglas Point was finished. Nonetheless, many of the lessons and features of Douglas Point were incorporated into the Pickering A Plant. The Douglas Point Nuclear Power Plant commercial prototype prepared the way for the industrial scale installations that followed.

Douglas Point's most significant contribution to the Canadian nuclear industry was the cross-fertilization or transfer of technology from the Douglas Point commercial-scale prototype to Ontario Hydro's first two industrial or large-scale reactors at Pickering, each of which had more than double the capacity of Douglas Point. "All sorts of lessons were learned by all sorts of people. The reason Pickering 'A' worked so well is that the right people got their hands dirty at Douglas Point and learned the right lessons."⁴

Technical contributions

Of the many technical contributions of Douglas Point, the following are most historically significant. In the CANDU reactors, heavy water plays a crucial role as both moderator and coolant or heat transfer medium. But with tons of heavy water costing \$20.50 per pound, losses had to be kept very low through a combination of "low heavy-water leakage and efficient recovery of this leakage."⁵ This was not easy to achieve. Bob Hart writes that "making arrangements for design, construction and operation of prototype CANDU stations was only the start of the work involved in industrializing CANDU technology. That station is made up of a myriad of pumps, valves, pipes, heat exchangers, seals, fittings, instruments, all of which had to be made to a quality that was essentially foreign to Canadian manufacturers and critical components such as fuel, pressure tubes and calandria tubes had to be made from materials Canadian manufacturers had never even seen."⁶ All parties contributed. Industry learned to work to higher engineering and manufacturing standards and AECL did much of the research in

⁴ Atomic Energy of Canada Limited CANDU Operations, *The Douglas Point Story. Power Projections, Special Edition, June 1984*, p. 22. Available online at <http://www.cns-snc.ca/history/DouglasPoint/DouglasPoint.html>.

⁵ H.K. Rae, "Heat Transport System" in D.G. Hurst, ed., *Canada Enters the Nuclear Age. A Technical History of Atomic Energy of Canada Limited*. Montreal: McGill-Queen's University Press for Atomic Energy of Canada Limited, 1997, p. 282. The full article is on pp. 276-293.

⁶ R. G. Hart, "Business Development, Revenue Generation and the Impact of Change" in D.G. Hurst, ed., *Canada Enters the Nuclear Age. A Technical History of Atomic Energy of Canada Limited*. Montreal: McGill-Queen's University Press for Atomic Energy of Canada Limited, 1997, p. 395. The full article is on pp. 391-406.

areas such as better valve stem design, which allowed manufactures to make better designed products.⁷

Douglas Point also showed AECL the need to be very careful about design assumptions. The design of Douglas Point was based on the premise “that the HTS [Heat Transfer System] could be made leak-tight and kept in that condition. This proved to be much too optimistic, at least with the components selected for its construction.”⁸ It was a costly assumption, but prototypes – no matter how big and how costly – are intended to provide learning through experience, and “this experience at NPD and Douglas Point led to various measures to reduce heavy-water upkeep costs that were applied in the design of Pickering and later reactors. Heavy-water and ordinary-water systems were segregated as far as possible, and light-water valves, joints, pumps and other leak-prone equipment were excluded from heavy-water areas.”⁹

The Douglas Point plant was innovative in reducing the complexity and number of components required to run its machinery. In subsequent CANDU power plants, “The number of mechanical joints and valves was drastically reduced – e.g., there were 2,000 packed valves in heavy-water service at Douglas Point and only 170 per reactor at Pickering – and those selected were of high quality. Welded joints were used extensively, even if it meant cutting pipes in future to replace or repair components.”¹⁰ In addition, “Pump shaft seals, heat exchanger flanges and large valve stems [at Douglas Point] were fitted with two seals, so that heavy-water leakage into the interspace between the seals could be recovered in a closed heavy-water collection system for direct return to the HTS.”¹¹

AECL’s earliest challenges had been getting reactors to work safely and efficiently. NPD introduced a new component – the generation of electricity. At 10 times the size of NPD, Douglas Point taught “AECL to expand its R&D efforts to take an in-depth look at many out-reactor components (for example, pump seals, valves, steam generators and heat exchangers), and to develop more rigorous specifications for them.”¹² Douglas Point illustrated the need to incorporate ideas from many areas of research – not surprisingly, since a nuclear generating plant is one of the world’s most complex engineering systems.

⁷ For information on the research for and redesign of valve stems to reduce leakage, see H.K. Rae, “Heat Transport System” in Hurst, ed., *Canada Enters the Nuclear Age*, pp. 283-4.

⁸ H.K. Rae, “Heat Transport System” in Hurst, ed., *Canada Enters the Nuclear Age*, p. 283.

⁹ H.K. Rae, “Heat Transport System” in Hurst, ed., *Canada Enters the Nuclear Age*, p. 283.

¹⁰ H.K. Rae, “Heat Transport System” in Hurst, ed., *Canada Enters the Nuclear Age*, p. 283.

¹¹ H.K. Rae, “Heat Transport System” in Hurst, ed., *Canada Enters the Nuclear Age* p. 282.

¹² H.K. Rae, “CANDU and Its Evolution” in D.G. Hurst, ed., *Canada Enters the Nuclear Age. A Technical History of Atomic Energy of Canada Limited*. Montreal: McGill-Queen’s University Press for Atomic Energy of Canada Limited, 1997, p. 199. The full article is on pp. 191-214.

While the detailed improvements are significant in themselves, the most important legacy of Douglas Point is that “these expensive lessons were learned in time to apply them to large commercial reactor stations being built in the late sixties and early seventies.”¹³ A specific example of this was the research done by AECL in response to serious heavy water leakage problems at Douglas Point. When the new technology was applied “in Pickering in 1973, leakage past packing [leakage at valve stems] was greatly reduced, but more importantly, valve maintenance time was cut by a factor of more than one hundred. An annual savings in maintenance costs at Pickering of \$1 million was achieved. This technology was transferred to industry and used at all subsequent CANDU stations.”¹⁴

Douglas Point also demonstrated much about the need to think in terms of ongoing maintenance while still at the design stage. A well-intentioned effort to save money by reducing the hold-up of heavy water backfired – referred to as a “revenge effect”¹⁵ by historian and author Edward Tenner – because pumps and valves were so difficult to get at and work on, resulted in repairs that took too long or required too large a work crew. Any money saved in heavy water was more than taken up by increased maintenance costs.

Computers are now such an integral part of the nuclear industry that it is easy to overlook some of the pioneering efforts made in this area. Here too, the Douglas Point Nuclear Power Plant is historically significant. Computers are a particularly important component in reactor safety. Douglas Point’s 306 fuel channels, compared with NPD’s 132, meant that monitoring the fuel bundles and controlling the reaction by changing the heavy water levels in the calandria was a much more demanding task. Prior to Douglas Point, AECL had paid more attention to automating reactor controls than did other countries. Douglas Point represented a major innovation with its “use of extensive computer data processing.”¹⁶ More significantly, “Douglas Point was the first reactor in the world in which a reactivity-control element was positioned by a stored-program digital computer.”¹⁷ With the world’s first use of a digital computer to control a power reactor, Douglas Point dramatically extended AECL’s lead in automating reactor controls. As a result of the strides made at Douglas Point, Pickering became the first nuclear power plant in the world with full computer control – a feature in all CANDUs built since that time.

¹³ H.K. Rae, “CANDU and Its Evolution” in Hurst, *Canada Enters the Nuclear Age*, p.200

¹⁴ H.K. Rae, “Heat Transport System” in Hurst, *Canada Enters the Nuclear Age*, p. 285.

¹⁵ Edward Tenner, *Why Things Bite Back: Technology and the Revenge of Unintended Consequences*, New York: Knopf, 1996.

¹⁶ H.K. Rae, “CANDU and Its Evolution” in D.G. Hurst, ed., *Canada Enters the Nuclear Age*, p. 199.

¹⁷ H.K. Rae, “CANDU and Its Evolution” in D.G. Hurst, ed., *Canada Enters the Nuclear Age*, p.199. For additional information on computer applications see M.F. Duret and H.K. Rae, “Reactor Physics and Control” in D.G. Hurst, ed., *Canada Enters the Nuclear Age. A Technical History of Atomic Energy of Canada Limited*. Montreal: McGill-Queen’s University Press for Atomic Energy of Canada Limited, 1997, pp. 215-232. There is a brief section on Computer Control, p. 231.

Conclusion

The Douglas Point Nuclear Power Plant is one of Canada's most historically significant nuclear power projects. It was a successful commercial-scale prototype and a critical link in the development of the CANDU reactor. The successes at Douglas Point were a vital step toward supplying Ontario with over 50 per cent of its electrical energy through nuclear plants. These successes also reduced the province's dependence upon less environmentally sound methods of power generation. The advances and knowledge gained from the Douglas Point Nuclear Power Plant provided Ontario with a growing and reliable energy supply and assisted in the growth of high-tech industries in Ontario and elsewhere across Canada.

The Ontario Heritage Trust gratefully acknowledges the research of Dr. Norman Ball in preparing this paper.



© [Ontario Heritage Trust](#), 2006