NUCLEAR POWER | BY PAUL WEBSTER

# No can-do?

Six decades and $15 billion later, it's make-or-break time for Canada's government-supported nuclear reactor–building program. Once considered the country's paramount scientific achievement, the Canada Deuterium Uranium (CANDU) reactor—uniquely able to burn natural uranium fuel that can be replaced while the reactor is running—has suffered a bitterly bruising decade of safety controversies. Most recently, the government of Canada's most populous province, Ontario, announced plans to mothball, rather than refurbish, two CANDU reactors at the Pickering Nuclear Station near Toronto, more than a decade before their projected retirement date.

Amid the failures, the government-owned Atomic Energy of Canada Limited (AECL), which developed the CANDU technology, is aiming for nothing less than a wholesale rebirth. In 2000, AECL requisitioned hundreds of millions of dollars and gathered a team of 380 engineers to entirely rethink the reactor. The result was a new design, the Advanced CANDU, which AECL has begun shopping around. The reactor's success in the marketplace could foretell the fate of the CANDU technology.

Unlike previous generations of CANDUs, which relied on expensive, hard-to-handle heavy water coolant, the new design will be cooled with light water, making it roughly $200 million cheaper to build. AECL says that fueling the new design with low-enriched fuel rather than natural uranium, which fueled all previous CANDUs, will add significant operational savings. Most important of all, the new CANDU design aims to overcome the Achilles' heel of earlier designs: the complex system of hundreds of degradation-prone, tough-to-fix radioactive fuel tubes and coolant pipes running into the reactor core.

By switching the thickness of the metal used in the reactor's massive phalanx of radioactive piping, AECL claims the new fuel system will run trouble-free for 30 years. To help it guarantee the lifetime of the new design's cooling system for 60 years, AECL changed the alloys used in the coolant pipes. "We've learned our lessons," says Pat Tighe, AECL's vice president for sales. "We've dealt with the premature-aging issue." Whether the new design booms or busts depends in large part on whether Tighe's words convince new clients.

Control room: The CANDU plant simulator in Qinshan, China.

CAE INC./ MICHAEL CHATLANI

The signs so far have been discouraging. With global nuclear energy capacity expected to grow dramatically in the coming decades, AECL has been pushing for Advanced CANDU sales in the United States, Britain, and China. But earlier this year both Chinese and U.S. nuclear executives decided not to pursue the new CANDU. In the United States, AECL's partner, Virginia-based Dominion Resources, said the licensing process for the Advanced CANDU seemed too slow. In China, despite the recent completion of two CANDUs near Shanghai, officials say more CANDUs won't fit well with the country's already heavy dependence on pressurized water reactors (PWRs). (Chinese reluctance is particularly discouraging because growth in China's nuclear market is expected to be substantial, with officials planning to build 30 new reactors by 2020.)

As for Britain, AECL is still in the running for a new wave of nuclear construction, but AECL Vice President Ken Hedges says that the British "seem to have turned away" from the Advanced CANDU. This leaves the Ontario market as the most promising. But even in Ontario—where politicians want new nuclear plants, and AECL has always had a monopoly—the prospects for the new CANDU appear mixed.

The province's nuclear history has been severely punishing. Ontario's 20 CANDUs were all purchased by the provincial government during a nuclear buying spree in the 1960s and 1970s. By the time the newest CANDU went on-line in 1989, the government's nuclear program had racked up $25 billion in debt, almost all of which remains unpaid. As for the reactors themselves, the first set of machines began wearing out in 1984, after little more than a decade in use. By 1997, with questions about the safety and reliability of the CANDU system growing, eight reactors were laid up. Repair tabs for six of the reactors have averaged about $1 billion each.

Not surprisingly, Ontario officials aren't ruling out breaking AECL's monopoly in its home market and purchasing foreign reactors. The potential for new competitive contracts has attracted French and U.S. reactor makers, who have dropped lots of visiting cards around the province in recent months.

AECL's Tighe argues that the Advanced CANDU is the right choice for Ontario, citing internal studies indicating that despite their late-adolescent breakdowns, CANDUs are cheaper to operate and maintain than U.S. and French PWRs. "[The] reactors are maintained with continuous refurbishments, which is expensive," he says. "But if you take the cost of a CANDU shutdown for refurbishment and you discount it back for 25 years, it's almost nothing." (The publicly owned AECL denied requests to see its cost studies on the grounds of competitive confidentiality.)

Despite AECL's enthusiasm for the Advanced CANDU, some reactor experts doubt whether the new design will deliver as promised. Frank Greening, a recently retired senior CANDU inspector for the Ontario government and likely the top expert on CANDU piping outside of the manufacturer, questions claims that the Advanced CANDU will overcome its predecessors' aging problems. He notes that AECL has come up with a stream of new fuel tube and coolant pipe designs in the past, all of which have failed. "The story goes on and on and on," Greening says.

He is particularly skeptical about AECL's claim that the reactor's new stainless steel coolant pipes "will operate maintenance-free for the full 60-year life of the plant," arguing instead that the CANDU's aging problems stem not from the choice of materials but from the reactor's basic design. "Advanced CANDU is still CANDU, which means a large array of horizontal pressure tubes," he says. "It's like having a car with over 300 coolant lines going in and out of the engine. Every single coolant line has to be leak-tight and requires complex 'plumbing' to allow for on-line refueling. . . . It's not worth the effort."

The decision to switch from natural uranium fuel, which is plentiful in Canada, to enriched uranium, which is not produced in Canada, may also prove problematic. Canadian operators would have to use fuel enriched at plants in the United States or other countries. But they may be reluctant to go offshore for fuel, according to Bill Garland, a nuclear physicist at McMaster University in Hamilton, Ontario, and a former CANDU designer. "I don't know if the penny has dropped yet about that in Canada," he says.

Having been shut out of Chinese and U.S. markets, and facing a struggle in Ontario, AECL is bucking decades of precedent and clearing the way to peddle its new reactor to India. The Indian market has been off-limits to AECL since the 1970s, when plutonium extracted from CANDU spent fuel was used to build India's first nuclear devices. In September, with momentum growing for new Indian reactor construction—and U.S. reactor manufacturers poised to jump into the market after Washington decided to loosen export restrictions last July—the Canadian government quietly ended its moratorium on nuclear sales to India, instituted after India's first bomb tests in the 1970s.

Canadian disarmament experts, including Lloyd Axworthy, the former foreign minister who successfully championed the international landmine ban, say the Canadian decision undermines global nonproliferation efforts. With an eye on a potentially large market for CANDU reactors, however, the Canadian government's decision was well calculated, says Reid Morden, a former AECL president. "I think they finally decided that for good and sufficient self-interest we should do this." ⚛

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