Over budget, overdue and, perhaps, overdesigned

They have become an enduring Canadian mystery. They were originally scheduled to become operational in November 2000, providing Canada with a long-term secure supply of medical isotopes.

Yet, years later, the once highly lauded Multipurpose Applied Physics Lattice Experiment (MAPLE) reactors are still in limbo because of technical difficulties, and Canada's 50-year-old National Research Universal reactor is being pressed into service well beyond its original projected lifetime.

The MAPLEs were to have been the first reactors in the world dedicated exclusively to the production of medical isotopes, which are used for diagnostics and the destruction of tumours or cancerous cells through gamma rays or manufactured drugs

The reactors were said to have the capacity to supply double the worldwide demand, yet with their future so uncertain, it's unclear when, or if, they'll ever serve as a secure source of supply in Canada, let alone the world.

Isotope supplier MDS Nordion when the had originally hired the crown corporation Atomic Energy of Canada Ltd. (AECL) to design and construct 2 MAPLE reactors and a processing facility in Chalk River, Ontario, in 1996. Aided by an interest-free loan from the federal government, the firm agreed to pony up $140 million for construction of the reactors. Radioisotope production had historically been vested with AECL but the government moved to private it in the late 1980s and eventually found a willing buyer, in 1991, in the form of MDS Health Group Inc., for $165 million.

In a 2005 renegotiation of the contract between MDS Nordion and AECL, ownership of the Dedicated Isotope Facility was transferred to AECL in exchange for $68 million in cash and promissory notes, as well as a 40-year commitment to supply Nordion with isotopes, the value of which was pegged at $344 million. MDS Nordion promptly wrote off a $345 million loss.

Chris Wattie / Reuters

The control room at the AECL Chalk River nuclear facility.

Under the agreement, AECL absorbed all remaining MAPLE development, construction and operational costs. In AECL's 2006/2007 Summary Corporate Plan, the projected cost of completing the project was estimated at $130 million.

More current numbers have not been publicly disclosed, although a Sept. 5, 2007, report from the Office of the Auditor General indicated AECL forecasts the cost of overhauling its Chalk River infrastructure, including MAPLEs, at $600 million over the next 5 years and $850 million over 10 years. The federal government's Feb. 26th budget shovelled $300 million towards that effort.

According to some nuclear experts, the additional outlays and extended timeline are no guarantee that the facilities will be ready by the current target deadline of Oct. 2008.

Among the skeptical are Fred Boyd, who spent more than 50 years in the nuclear industry working with AECL, its regulator the Atomic Energy Control Board (now the Canadian Nuclear Safety Commission), the Department of Energy Mines and Resources (now Natural Resources Canada), and who remains a regular contributor to the Canadian Nuclear Society Bulletin.

Boyd fears that fundamental design flaws and testing requirements will continue to delay the project. "I think the most optimistic would be at least a year and I guess I am sufficiently pessimistic at the moment that it would be longer than that."

The issue that has continuously perplexed designers of the MAPLE reactors has been their positive power coefficient reactivity (Box 1).

For safety reasons, the reactors were designed to have a negative power coefficient reactivity value. It was expected to be −0.12 mk/MW. In June 2003, it was measured at +0.28 mk/MW.

Since then, AECL has tested and retested its predictions and results. Experts from around the world have been recruited to help solve the riddle. Argentina's Investigacion Aplicada was hired, along with a bevy of American contractors. To date, their reviews have confirmed that all AECL measurements

Box 1: The lowdown on meltdowns and other matters nuclear

Criticality:
The point at which a nuclear chain reaction becomes self-sustaining. During nuclear fission, some neutrons are ejected and interact with the surrounding material. If that material includes fissile fuel, some of those neutrons are absorbed, causing more fissions in essentially a self-perpetuating cycle.
Reactivity:
A measure of the degree of change in the production of neutrons within a reactor's core. Operating a reactor basically involves keeping a balance in the number of neutrons in the core. If there are too few, the chain reaction stops. If there are too many and they aren't stopped within a few seconds, it can spiral out of control, which can lead to destruction of the reactor core and, potentially, a breach in containment.
Power coefficient of reactivity:
Reactivity is affected by many factors including the temperature and density of both the fuel and surrounding coolant. The coefficient, or rate, is directly related to a tendency of the core to change its power level. If the rate is positive, the core power increases and if it's negative, the core power decreases. If it's zero, the core power is stable. A negative coefficient is considered to have a higher safety margin.
Consequences:
MAPLE reactors were designed to generate 10 MW of heat and medical isotopes, instead of electricity, while having a negative power coefficient. That is considered inherently safe because if the power in the reactor ever rose, for any reason, such as breaking of a coolant pipe (as was the case with Ontario's Pickering reactor) the population of neutrons in the reactor would decrease. Essentially, there would be a negative feedback loop in which the neutrons would peter out, thus preventing a run-away nuclear reaction. A positive power coefficient is considered riskier because if the reactor, for example, had a power pulse, there's a possibility that a runaway reaction would occur. It's argued that a series of "control rods" can be inserted to essentially put brakes on the reaction. The problem is that, in the case of Chernobyl, the insertion of such control rods actually caused the reaction to escalate. In all preliminary tests to date, the MAPLEs have not been "self-braking." Rather, even a small increase in power has caused an acceleration of the reaction.

and data analyses were done correctly.

Yet, no amount of analysis, fiddling or technological repair has resolved the deviation from original design. Tests in 2007 achieved the exact same +0.28 mk/MW measurement.

But AECL Director of Corporate Communications Dale Coffin insists that "we have made some progress."

Coffin says the next tests will be completed this spring, again under the watchful eye of the Canadian Nuclear Safety Commission, and will determine the direction for future AECL action as the MAPLES start-up date looms.

It begs the question: Is it even possible that the problems will be resolved by the fall?

The answer to that, it seems, is to alter the nature of the inquiry.

Boyd and other experts argue that because the reactor is only slightly positive and because there are potential shutdown mechanisms and precautionary measures, it should be possible to to simply steam forward. "The actual risk is quite small," Boyd says.

You can never eliminate all risk, he muses, adding that while not desirable, it makes sense to move forward with licensing and operation activities without fully understanding the problem.

The process has been overly cautious, Boyd argues. "The desire has been and this has been a tendency throughout the world the last 10 or 20 years, prompted by the one bad accident at Chernobyl, that people in the nuclear business have been leaning over backwards to try and make things more inherently safe."

AECL has flashed indications that it is moving towards a similar conclusion. Coffin, for example, stresses that the actual results of the power coefficient reactivity are "so close to being negative."

The crown-owned company has also told safety regulators that it may want to move forward with licensing, even if the problem isn't resolved. In a public hearing in September 2007, AECL submitted a plan that deemed "low or negative" power coefficient reactivity as acceptable, even though that was contrary to the original design.

Safety commission staff initially maintained that AECL should be working towards a negative value, in order to support the original safety case. But even the regulator seems to be warming to the notion of licensing positive value reactors.

Spokesman Aurèle Gervais confirmed in an email interview that AECL can submit a safety case with the issue unresolved. But it hasn't yet made such a submission and hasn't indicated a timeframe in which it might do so.

Commission "staff does not prescribe the 'sign or magnitude' of the [power coefficient reactivity], but makes recommendations to the Commission on the basis of acceptability of risk," wrote Gervais. "Staff recommended the original MAPLE's operating licence based, among other design/physics characteristics, on the inherent safety provided by a negative [power coefficient reactivity]."

Yet, even if the crown-owned company and the regulator all agree to move forward in spite of the positive power coefficient reactivity, problems remain.

According to Boyd, designers still haven't resolved how to process the isotopes that are produced by the reactors.

There are problems surrounding the extraction of the molybdenum isotope while separating it from the uranium, Boyd says.

"There have been difficulties at the processing facility extracting the molybdenum isotope, which is the most valuable one, out of the samples. I have been told there are still some significant problems with the process so my understanding is that is likely to be the greater impediment for early startup. So in other words, it will take longer to solve that one than to solve the MAPLE problems. I don't have any details on that. That is strictly second and third hand, but from people that I trust and who know something about what's going on." — Ben Magnus, Ottawa, Ont.

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