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The Canadian Nuclear Industry: Status and Prospects

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Addressing International Governance Challenges

Summary

Canada was one of the first countries to adopt nuclear energy. It is the world's largest supplier of natural uranium and a supplier of nuclear technology and expertise. However, recent announcements such as the Ontario government's plans to postpone indefinitely the construction of two nuclear reactors at its Darlington facility, and the federal government's intention to privatize Atomic Energy of Canada Limited (AECL), the nuclear science and engineering company, raise questions about nuclear energy in Canada.

This paper provides an analysis of the future of nuclear energy in Canada and the likely parameters of any revival. Findings include:

- Canada has lost the domestic political consensus that made possible the original development of the CANDU reactor technology;
- The Ontario decision to delay indefinitely its plans for the construction of new nuclear reactors is emblematic of this loss and indicative of the obstacles confronting the Canadian nuclear industry;
- Fragmented federal-provincial energy policy jurisdictions and political gamesmanship result in domestic market inertia effectively thwarting any prospects for a Canadian nuclear revival;
- Without a revival in the domestic market for nuclear energy, AECL is unlikely to be successful marketing and selling reactors internationally;
- Privatization of AECL will do little to improve the company's prospects and will mean the end of the CANDU reactor technology.

Canadian Centre for Treaty Compliance

CIGI's Nuclear Energy Futures Project is being conducted in partnership with the Centre for Treaty Compliance at the Norman Paterson School of International Affairs, Carleton University, Ottawa.

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Letter from the Executive Director

On behalf of The Centre for International Governance Innovation (CIGI), it is my pleasure to introduce the Nuclear Energy Futures Papers Series. CIGI is a non-partisan think tank that addresses international governance challenges and provides informed advice to decision makers on multilateral governance issues. CIGI supports research initiatives by recognized experts and promising academics; forms networks that link world-class minds across disciplines; informs and shapes dialogue among scholars, opinion leaders, key policy makers and the concerned public; and builds capacity by supporting excellence in policy-related scholarship.

CIGI's Nuclear Energy Futures Project is chaired by CIGI distinguished fellow Louise Fréchette and directed by CIGI Senior Fellow Trevor Findlay, Director of the Canadian Centre for Treaty Compliance at the Norman Paterson School of International Affairs, Carleton University, Ottawa. The project is researching the scope of the purported nuclear energy revival around the globe over the coming two decades and its implications for nuclear safety, security and non-proliferation. A major report to be published in early 2010 will advance recommendations for strengthening global governance in the nuclear field for consideration by Canada and the international community. This series of papers presents research commissioned by the project from experts in nuclear energy or nuclear global governance. The resulting research will be used as intellectual ballast for the project report.

We encourage your analysis and commentary and welcome your thoughts. Please visit us online at www.cigionline.org to learn more about the Nuclear Energy Futures Project and CIGI's other research programs.

John English
Executive Director

List of Acronyms

ACR	Advanced CANDU Reactor
AECB	Atomic Energy Control Board
AECL	Atomic Energy of Canada Limited
CANDU	CANada Deuterium Uranium
CNSC	Canadian Nuclear Safety Commission
EPR	Evolutionary Pressurized Reactor
FOAK	first-of-a-kind
NAOP	Nuclear Asset Optimization Plan
NPCIL	Nuclear Power Corporation of India Limited
NPD	Nuclear Power Demonstration Reactor
NRX	National Research Experimental Reactor
OCAA	Ontario Clean Air Alliance
OPG	Ontario Power Generation
PHWR	pressurized heavy water reactor
PUB	Public Utilities Board
ZEEP	Zero Energy Experimental Pile

Introduction

A putative Canadian nuclear energy revival came to an abrupt halt on June 29, 2009, when the Government of Ontario announced the indefinite postponement of its plans to build two new nuclear reactors at its existing Darlington facility. Coming almost exactly a month after an announcement of the federal government's intention to privatize Atomic Energy of Canada Limited (AECL), the Canadian government-owned nuclear science and engineering company, the Ontario announcement capped a period of remarkable developments in the Canadian nuclear industry.

Around the globe, predictions of inexorable growth in electricity demand together with concerns over energy security and the climate impact of greenhouse gas emissions from fossil-fuelled power plants have combined to prompt renewed interest in nuclear energy.

Just what does such a revival mean for Canada? As the world's largest supplier of natural uranium, Canada will inevitably play a pivotal role in meeting any increased demand for nuclear energy – fulfilling the country's traditional resource-supplier role. But Canada is also a supplier of reactor technology and nuclear expertise to the world market. Are there specific opportunities to be had, good jobs to be chased in an increasingly competitive global economy?

And what about the domestic use of nuclear energy? What do the recent provincial and federal announcements mean for the prospects of the Canadian industry? Canada was one of the world's first adopters of nuclear power and the atom continues to play a prominent role in supplying electricity to Canadian homes and businesses. Is there still substance to all of the talk about a resurgence of the domestic market for nuclear energy?

This paper is an analysis of the future of nuclear energy in Canada and the likely parameters of any revival. It is not a discussion of whether nuclear power should be promoted, but rather, in a Canadian context, whether it can succeed. The history, infrastructure and policies governing the Canadian civil nuclear industry give clues

Author Biography

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as to the shape and direction of its future. The decisions shaping that future are inevitably bound to the character of the Canadian federation: federal-provincial squabbles over who pays and who benefits will constrain indefinitely any prospect of a substantive expansion of nuclear energy in Canada.

Canada's Nuclear History

Canada's nuclear history began during World War II when the country joined the United States and Britain in the Manhattan Project. Canada was a full partner and signatory to the 1943 Quebec Agreement which bound the three often fractious parties together to collaborate and share the detailed information and technology of nuclear weapons development (USDOS, 1970). Canadian facilities hosted many British experts; Canadian mines and mining companies supplied vital material; and Canadian scientists and engineers played an integral role in the ultra-secret race to produce the world's first atomic bomb. This experience was swiftly turned towards the peaceful use of atomic energy when, in 1945, a team of Canadian, American and British researchers started up Canada's first nuclear reactor. The experimental Zero Energy Experimental Pile or ZEEP, at Chalk River, Ontario, was the first reactor to be operated outside of the United States.

Immediately following the war, the Chalk River facilities were put under the authority of the Atomic Energy Control Board (AECB), the predecessor of today's Canadian Nuclear Safety Commission (CNSC). The AECB was created under the Atomic Energy Control Act of August 1946. It was charged under the Act with making "…provision for the control and supervision of development, application and use of atomic energy and to enable Canada to participate effectively in measures of international control of atomic energy." In 1951, the AECB established AECL as a Crown corporation to take over the operational and management responsibilities for the development of nuclear energy from the National Research Council, which held wartime responsibility. As a result, AECL's mandate is not defined in an Act of Parliament, but is rather derived from this transition between war and peace and the parallel shift of emphasis from nuclear weapons development to energy production.

The success of the ZEEP reactor was quickly followed by the completion of the larger National Research Experimental Reactor (NRX), also built at Chalk River and brought online in 1947. It was these developments that laid the groundwork for the design of a pressurized heavy water reactor (PHWR) specifically for electrical power generation. The prospect of harnessing the awe-

AECL — The Crown Corporation

As with any Canadian Crown corporation, AECL has both a commercial and a public policy role. In a recent review of AECL, the Office of the Auditor General of Canada (2007: 1-2) described its public policy role as follows:

> "AECL operates in a complex environment. As a Crown corporation, it has not only commercial objectives but also a public policy role, which includes sustaining and enhancing nuclear technology to safely and securely support Canada's nuclear energy supply — CANDU reactors supply about 16 percent of Canada's electricity. AECL's research also supports nuclear non-proliferation, nuclear medicine, environmental initiatives, and basic scientific research in various industries including agriculture and non-destructive testing. In addition, AECL is a major producer of medical isotopes for the diagnosis and treatment of disease.[1] The Corporation is also responsible for managing the federal government's nuclear wastes and legacy obligations."

In its commercial role, AECL is a nuclear technology and engineering company providing comprehensive services from facility design to nuclear waste management and decommissioning. In addition, AECL supports CANDU reactor facilities through their operating life cycle with power plant life extensions, upgrades and refurbishment engineering services.

As a federal Crown corporation, AECL is unable to borrow money on the commercial market and instead funds its operations through the revenues it generates and an annual taxpayer subsidy called a "parliamentary appropriation." Responsible to the minister of natural resources, AECL must submit an annual corporate plan to the government for approval and obtain Government of Canada consent for all key financing decisions, such as investments in capital assets or any decisions that commit government funding. This also means that the corporation's liabilities are liabilities of the Crown (in effect, the Canadian taxpayer) and that any losses, operating deficits or other extraordinary charges become the responsibility of the government. Moreover, as an agency of the Canadian government working in a highly regulated and high-profile nuclear industry, AECL must be especially mindful of its compliance with both domestic and international standards and regulations; any lapses, however minor, have the potential to embarrass the government of the day (Office of the Auditor General of Canada, 2007).

[1] Problems with aging reactor facilities and the failure of a major modernization project caused the federal government to reassess the corporation's role in the production of medical isotopes and prompted a recent declaration that AECL would ultimately end its activity in this field.

some power of the atom for generating electricity was critical; it provided the rationale for continued Canadian involvement in nuclear science and engineering in the absence of a Canadian policy to develop nuclear weapons. It was on the basis of this potential for power generation that AECL was quickly mandated to build a 22MWe prototype Nuclear Power Demonstration (NPD) reactor. Completed in 1962, the NPD was the first CANDU (CANada Deuterium Uranium) reactor and it, in turn, paved the way for the much larger 200MWe prototype built at Douglas Point, Ontario. Built and owned by AECL, Douglas Point was operated by Ontario Hydro and the station remained in service from 1968 to 1984 – though not without frequent and costly maintenance outages.

CANDU Commercial Power Reactor Development

Douglas Point proved the technical feasibility of the CANDU design as a production reactor and became the basis of the Indian Rawatbhata 1 reactor, which was completed in 1973 as a collaborative venture by AECL and the Nuclear Power Corporation of India Ltd (NPCIL).[2] During the same period, the experimental 250MWe Gentilly-1 reactor came online near Bécancour, Quebec. An attempt to simplify the complexity of the original CANDU design and thus reduce its cost, the Gentilly-1 was a novel engineering prototype but an unmitigated operational failure. It produced power for only 180 days over seven years before it was permanently decommissioned (Hurst et al, 1997: 203-4).

Notwithstanding this setback, AECL, with continued federal government support, developed into a full-fledged nuclear technology and engineering company devoted to designing and marketing the CANDU reactor. Pressure soon mounted to develop an export market as a means both of demonstrating the credibility of the Canadian technology and leveraging the tremendous research and development costs, in the hope of lowering domestic user costs and making the industry more economically sustainable (Bratt, 2006: 16-30, 90-1). Of course, exporting reactors also helped encourage the wider use of nuclear power, which conveniently served to expand the market for Canadian uranium mines (Bratt, 2006: 17). Today, there are 29 CANDU reactors in service around the world and another 13 CANDU-derivatives built by India based on the Rawatbhata design.

Figure 1: CANDU Power Reactors Outside Canada

Unit	Location	In-Service	Output
Rawatbhata I	India	December 16, 1973 (shutdown since 2004)	
Rawatbhata II	India	April 1, 1981 (construction started by AECL but completed by India)	187 MWe
KANUPP	Pakistan	1972	137 MWe
Wolseong 1	South Korea	April 22, 1983	679 MWe
Embalse	Argentina	January. 20, 1984	648 MWe
Cernavoda 1	Romania	December 2, 1996	706 MWe
Cernavoda 2	Romania	October 5, 2007	706 MWe
Wolseong 2	South Korea	July 1, 1997	715 MWe
Wolseong 3	South Korea	July 1, 1998	715 MWe
Wolseong 4	South Korea	October 1, 1999	715 MWe
Qinshan 1	China	December 31, 2002	728 MWe
Qinshan 2	China	July 24, 2003	728 MWe

Source: This table was compiled from data taken from AECL's website (2009), the International Atomic Energy Agency and the World Nuclear Association.

The Ontario Experience

The Province of Ontario has been the major commercial user of the CANDU technology. After Douglas Point, Ontario's first electricity generation reactor came online at Pickering in 1971 and, in less than two decades thereafter, the province built another 19 reactors, contributing roughly half of the province's annual electricity supply.

However, Ontario has had a love-hate relationship with its CANDU reactor fleet (Wells, 1997; Swift, 2004). Though by far the largest contributor of electricity to the province's grid of any generating source, the price of nuclear power has been both financially and politically high. Cost-overruns and schedule delays plagued Ontario's nuclear construction efforts, the worst case being the Darlington facility, built in phases between 1981 and 1993. Originally approved in 1978 at an estimated cost of $2.5 billion, construction hold ups, technical problems and project management issues were exponentially compounded by political interference and indecisiveness. All of these factors combined to delay completion by a decade. This pushed the final cost of the four-reactor project to over $14 billion (Ontario Clean Air Alliance, 2004) and created a crippling debt load for Ontario Hydro, the province's hydro utility. Indeed, the Darlington fiasco so compromised the utility's financial position that the provincial government was ultimately forced to step

[2] Canada's collaboration with India was short-lived, coming to an abrupt halt after India used a research reactor provided by Canada to produce the plutonium for its 1974 "peaceful nuclear explosion." Canada immediately halted construction of India's second CANDU Power reactor, RAPP II. The project was ultimately completed by India without Canadian participation and India went on to build an additional 13 reactors based on the CANDU design.

Figure 2: Canadian CANDU Power Reactor Installations

Facility	MWe Net	Date Operational	Planned Close	Status
ONTARIO Ontario Power Generation Pickering A				
UNIT 1	515 MWe	1971	2022	Shut down in 1997 – restarted November 2005
UNIT 2	515 MWe	1971	–	Shut down in 1997 and deemed “Uneconomic to restart”
UNIT 3	515 MWe	1972	–	Shut down in 1997 and deemed “Uneconomic to restart”
UNIT 4	515 MWe	1973	2018	Shut down in 1997 – restarted September 2003
Ontario Power Generation Pickering B				
UNIT 5	516 MWe	1983	2014	
UNIT 6	516 MWe	1984	2015	
UNIT 7	516 MWe	1985	2016	
UNIT 8	516 MWe	1986	2017	
Ontario Power Generation Darlington				
UNIT 1	881 MWe	1992	2020	
UNIT 2	881 MWe	1989	2020	
UNIT 3	881 MWe	1993	2022	
UNIT 4	881 MWe	1993	2023	
Bruce Power Bruce A				
UNIT 1	750 MWe	1977/2009	2010/2035	Shut down in 1997 – under refurbishment, online scheduled 2009
UNIT 2	750 MWe	1977/2009	2015/2035	Shut down in 1997 –under refurbishment, online scheduled 2009
UNIT 3	750 MWe	1978	2036	Shut down in 1997 – restarted 2003
UNIT 4	750 MWe	1979	2036	Shut down in 1997 – restarted 2003
Bruce Power Bruce B (The Bruce B facility produces 40% of the world’s Cobalt-60, which is used for cancer radiotherapy, to sterilize medical equipment, and to irradiate foods)				
UNIT 5	806 MWe	1985	2014	
UNIT 6	822 MWe	1984	2014	
UNIT 7	806 MWe	1986	2016	
UNIT 8	790 MWe	1987	2017	
QUEBEC Hydro-Québec Gentilly Nuclear Generating Station				
UNIT 1	250 MWe	1971		Prototype – Shutdown in 1977
UNIT 2	635 MWe	1983/2011	2011/2040	Refurbishment decision made
NEW BRUNSWICK NB Power Point Lepreau Nuclear Generating Station				
UNIT 1	635 MWe	1983/2009	2011/2038	Shutdown for refurbishment 2008 expected online in 2009

Canadian installed reactors, rated capacity (net), in-service date and operational status (operational unless otherwise indicated)

Source: This table was compiled from data taken from the AECL, the CNSC and the respective reactor operators.

in and fundamentally restructure the company (Wells, 1997). Under the Ontario Electricity Act of 1998, Ontario Hydro was broken up into five component Crown corporations and its $38 billion debt was orphaned into an account, the repayment of which provincial electricity consumers see added to their utility bills to this day.

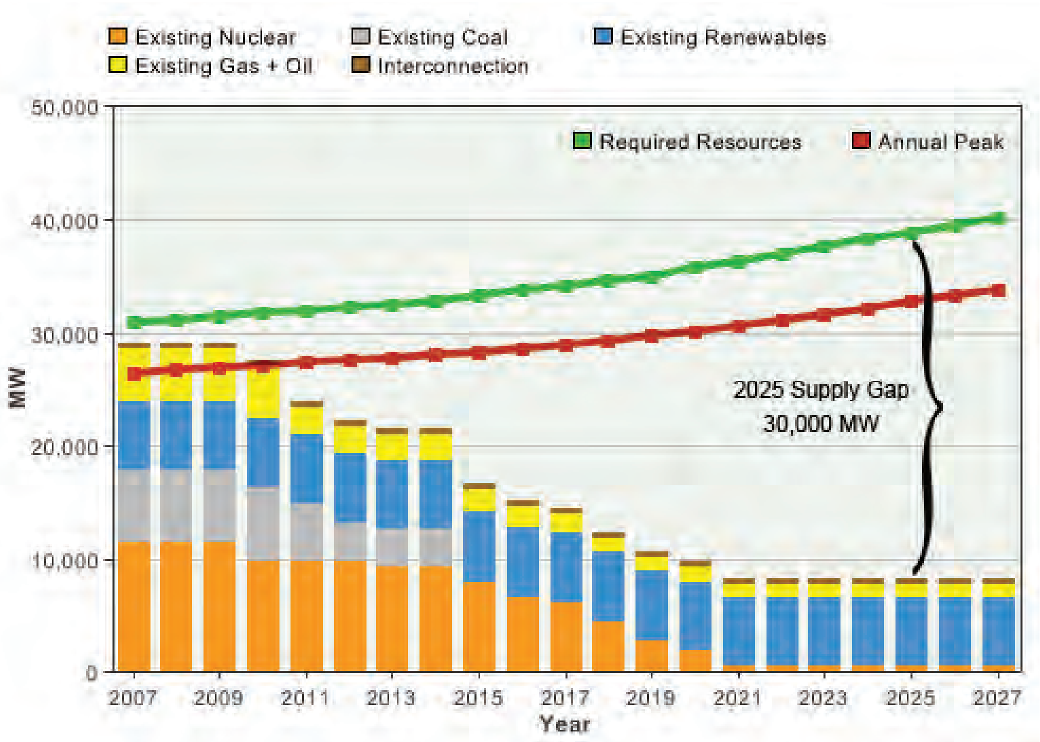
Though the Three-Mile Island accident in 1979 and the Chernobyl catastrophe in 1986 certainly deepened the nuclear chill, it was the Darlington experience, more than anything, which cast a pall over nuclear energy in Ontario and Canada more broadly. Moreover, while Darlington was the iconic “bad-nuke” experience, problems with nuclear technology more generally plagued the Ontario energy landscape. In 1983, a “loss of coolant accident” at Pickering A necessitated a costly rebuild of four reactors. By the mid-1990s, maintenance problems due in part to cost-cutting measures by the cash-strapped Ontario Hydro, forced the early shutdown of eight reactors. After a 1995 maintenance error forced the permanent shutdown of a Bruce reactor, the question of what to do with the province’s aging and expensive nuclear fleet became a hot political issue. The issue came to a head in 1997 when Canada’s nuclear regulator, the Atomic Energy Control Board (AECB), mandated the shut-down of the four Pickering A reactors until Ontario Hydro upgraded certain emergency shutdown systems. Though the utility committed to completing the upgrades, financial constraints caused long delays and further cost overruns (Pickering Review Panel, 2003). Following the recommendations of a group of American experts hired by Ontario Hydro to conduct an independent, external audit of its entire nuclear operation (Andognini, 1997), the utility prepared a Nuclear Asset Optimization Plan (NAOP). Three more reactors at Bruce were promptly shut down in early 1998 so scarce resources could be directed to upgrade the still-functional units at Bruce B, Pickering B and Darlington. Coal-fuelled generating plants were fired up as over 5,000 megawatts of nuclear generation capacity went offline and journalists proclaimed the “beginning of the end of nuclear power in Canada” (CBC, 1997).

A Canadian Revival

Ontario Reconsiders

It was the Ontario government’s 2003 decision to shut down those heavily-polluting, coal-fired generating facilities that first fanned the embers of a Canadian nuclear revival. Combined with broader concerns over climate change, fears that skyrocketing natural gas prices would push the cost of gas-fired generation beyond politically tolerable thresholds forced the nuclear option back into consideration.

Figure 3: The Ontario Energy "Supply Gap"



Source: Ontario Ministry of Energy and Infrastructure, 2009

However, the Canadian revival got off to a rocky start. The first refurbishment of a Pickering reactor, originally scheduled for completion in 2000, was not completed until 2003, at triple the original estimated cost. The troubled restart of the facility was not pushed forward again until the Ontario Power Generation Review Committee report was published in 2004. Though the refurbishment of the next reactor, Unit 1, was completed considerably more efficiently than its predecessor, coming back online on schedule in late 2005, and a mere 50 percent over its initial budget, the overall experience prompted the decision to retire the other two Pickering A reactors permanently. However, with these shut-downs, the expiration of the Pickering B reactor fleet license in mid-2013, and the rest of the nuclear fleet aging, the province was facing a serious potential shortfall in generating capacity (see Figure 3).[3]

The Ontario revival

The prospect of shortages in generating capacity prompted the Ontario Government to complete an agreement with Bruce Power in the fall of 2005 to proceed with the immediate refurbishment of two reactors (Units 1 and 2) at the Bruce facility[4] that had been laid-up in the 1997 shutdown. This was to be followed by the refurbishment of an additional two reactors (Units 3 and 4) once the first pair had come back online.

The refurbishment project is intended to extend the operational life of the reactors by at least 30 years and improve their generating efficiency to provide 3,000MWe of generating capacity (OPA, 2009). The total cost of the project was originally estimated at $4.25 billion to be financed by Bruce Power on the strength of a long-term electricity purchase commitment from the province, together with a suite of guarantees offsetting accident liabilities and

[3] This graph is reproduced from the Ontario Ministry of Energy and Infrastructure at: http://www.mei.gov.on.ca.wsd6.korax.net/english/energy/electricity/index.cfm? page=nuclear-electricity-supply. However, according to the province's Independent Electricity System Operator, Ontario's annual electricity consumption fell by almost six percent between its historic peak in 2005 and 2008. Forecast growth in demand has dropped significantly as a result of the economic downturn. Though the long-term peak consumption growth trend still drives provincial planning, the downturn has given the province some considerable "breathing room" in its near-term operations. In fact, the province has increasingly faced the problem of generating too much baseload power during off-peak hours (Hamilton, 2009), a problem which will be exacerbated when the two reactors being refurbished at Bruce (see below) come back online over the coming year.

[4] The eight-reactor Bruce complex is the largest (by generating capacity) nuclear power facility in North America and the second largest in the world. Bruce Power is the private-sector operator which took over responsibility for the complex in 2001 following the break-up of Ontario Hydro.

certain waste management expenses. As of early 2009, with the repair of the first two units roughly a year from completion, that estimate had climbed closer to $6 billion, though the increase was partly due to an expansion in the scope of some of the refurbishment activities.

The decision to proceed with the Bruce refurbishment was, in many ways, the real genesis of the Ontario and, by extension, Canadian nuclear revival. It was the first of a series of decisions by the provincial government to massively re-invest in the province's nuclear generation capacity. It was followed in June 2006 by the release of the Ministry of Energy's Integrated Power System Plan, which called for replacing and rebuilding nuclear generation capacity sufficient to supply 14,000MWe – roughly its peak existing capacity. This, in turn, triggered the decision by the minister of energy to instruct Ontario Power Generation (OPG), the provincially-owned electricity generation company, to begin the federal approvals process for constructing a new nuclear generating facility at the Darlington site.

Also in 2006, after a two-year feasibility study, Bruce Power, with the support of the province, applied to the CNSC for a licence to prepare its existing Tiverton site for up to four new reactors. Subject to regulatory and environmental approvals, the plan calls for the reactors to be constructed, optimistically, over a four-year period and to come online in the 2014-18 time frame. More controversially, Bruce also applied to the federal regulator for permission to construct a four-unit facility in the vicinity of the province's Nanticoke coal-fired site. This move has attracted a decidedly less-than-enthusiastic reaction from the provincial government, which prefers to keep new reactor construction within the precincts of existing nuclear facilities (World Nuclear News, 2008; Hamilton, 2008).

By 2008, the province was talking openly about investing as much as $40 billion to replace and refurbish its nuclear generating capacity (Marr, 2008). Bids to build a new, two-reactor facility at Darlington were accepted by the province in February 2009.

Better the Devil you Know?

The bidding process for Ontario's first new-build initiative since the troubled 1990s attracted three proposals. Among these, AECL and its Team CANDU partners represented the providers of the province's existing installed capacity and thus had the home-team advantage. Toshiba-owned Westinghouse Electric elected to bid only its reactor technology, choosing to rely on others for construction and commissioning, thereby sidestepping the thorny issue of liability for construction cost overruns at the cost of ignoring a key aspect of the bid criteria. AREVA Canada, part of the French government-owned, vertically-integrated, nuclear industry giant proposed that Ontario select its new, 1,650MWe Evolutionary Pressurized Reactor (EPR).[5] AREVA pushed the idea that Canada, and Ontario in particular, needs to diversify its nuclear industry away from its reliance on AECL and CANDU. AREVA tried to sweeten the pot by dangling the prospect that, by signing on with them, the province's considerable nuclear industry base could enjoy a much larger share in the worldwide revival than they might ever be in a position to reach through AECL. According to AREVA, a successful EPR build in Canada could be up to 70 percent Canadian-sourced.

In its decision, the Ontario government clearly rejected this line of reasoning and instead determined that AECL best fit the province's criteria. In its announcement at the end of June 2009, however, the Ontario government explained that while AECL's bid was the only one compliant with the requirement to accept a high margin of the risk for delays and cost overruns, the resulting bid price was more than the government was prepared to accept. Consequently, the provincial government decided to halt the procurement process indefinitely: "concern about pricing and uncertainty regarding the company's future prevented Ontario from continuing with the procurement at this time" (Government of Ontario, 2009). Elaborating on the announcement in a press conference, Energy Minister George Smitherman explained that AECL's proposal was judged superior to those of the other bidders in its overall conformance with the bid specifications and its approach to risk mitigation, but that the price was "billions" too high. He also pointed to "uncertainty" regarding AECL's future as a cause for significant provincial concern and concluded:

> "[t]he government of Canada needs to do the work that they're doing now to clarify the future ownership of AECL, and when they have clarified that, to sharpen their pencils substantially so that the people of the province of Ontario can renew their nuclear fleet with two new units from that company." (Howlett and McCarthy, 2009).

[5] The EPR enjoyed the distinct competitive advantage of being the most advanced in terms of the stage of its development and commercialization. AREVA has already sold five of these light-water reactors: one to Finland, two to France and two to China. Both of the Finnish and the first of the French reactors are under construction, though not without significant problems. However, though AREVA pressed this as an advantage (having the expenses of working out initial design and construction issues borne under an unrelated contract), the province was ultimately unconvinced.

AECL at the Precipice

There is a depressing irony to the Ontario decision, with Darlington once again symbolizing government prevarication in the management of a major nuclear build. Certainly, if Ontario selected a supplier other than AECL for its new build initiative, the impact on AECL's reputation and the effects on the company's business prospects more generally would have been catastrophic. More than any other jurisdiction, Ontario has invested heavily in nuclear power and operates more CANDU reactors than all other provinces and countries combined. AECL is headquartered in Ontario and some 4,000 members of its workforce are based in the province. Its major research and commercial facilities are located at Chalk River and Mississauga, Ontario. AECL was counting on the Darlington project to galvanize those resources to launch its new Advanced CANDU Reactor (ACR) design.

But what is the impact of this non-decision – announcing a winner, but no prize? Without the active support of its home province and largest customer, it is hard to imagine any other province, let alone an international customer, seriously considering the unproven ACR – especially given the high-risks of a first-of-a-kind (FOAK) build. A former Ontario deputy energy minister has argued that AECL's fate depends so entirely on an Ontario build that not proceeding would effectively "doom" the company and render any consideration of privatizing AECL moot (Purchase, 2009).

The Advanced CANDU Reactor (ACR-1000)

To its considerable credit, AECL's five most recent power reactor projects, based on its previous CANDU-6 design, were completed on-time and on-budget. These represent the last five of a total of eleven CANDU-6 reactors AECL has built, reinforcing the importance of being able to replicate a reactor design as a means of achieving the economies of scale necessary to control construction risks. However, the CANDU-6 design is now over 30 years old. AECL's ability to market reactors domestically and abroad now depends on the extent to which it can successfully fund and develop the ACR. Though AECL professes confidence in the new ACR, its development marks a significant departure from the traditional CANDU reactor design. It is still at the earliest stages of the design and regulatory certification processes, as evinced in the federal government's 2009 budget that provided AECL $135 million specifically for the continued development of the reactor.

Referred to in the nuclear industry as a Generation III+ reactor, the ACR is a 1,200MWe reactor designed for construction in pairs. It was developed from the CANDU-6, keeping many of its key features but with some fundamental design changes. Though still generically a heavy water reactor, its design incorporates some of the capital cost-saving features of light water cooling. Unlike the previous CANDU models, the ACR will run on low-enriched uranium (LEU), extending fuel life by almost three times and thus reducing high-level waste volumes. This fuel change, however, represents a significant departure for the CANDU family and detracts from what has been one of its most prominent attributes: the use of natural uranium, an attractive fuel from both a cost[6] and nuclear non-proliferation perspective.

AECL originally planned to develop a 700MWe version of the ACR for the US market, targeted for availability in 2011. However, that market failed to materialize for the company and, with signs of a nuclear revival in Ontario, the company sought to adapt the design to a 1,200MWe reactor more suitable for the Ontario and broader Canadian markets (Auditor General for Canada, 2007). The ACR-1000 received initial design approval from the CNSC in February 2009, certifying that the design met regulatory requirements and expectations for power reactors in Canada.

AECL has grand ambitions for the ACR; with a projected 60-year design life and claims of a staggeringly low, "overnight capital cost"[7] in the range of $1,000 per kilowatt of generating capacity (Canadian Nuclear Association, 2002), the ACR would indeed mark a radical advance in reactor technology. By using a design predicated on the assembly of prefabricated units employing standardized components, AECL predicts that construction times for the new reactors can be reduced to as little as three years for the fifth and subsequent builds – the point at which its aggressive overnight capital cost estimate becomes achievable.

Getting Beyond the Precipice

The challenge, of course, is to make the first sale, to have the chance to overcome the inevitable and myriad initial

[6] Natural uranium is considerably cheaper and more readily available than enriched uranium, though this advantage is largely offset for CANDU reactors by the high price of the heavy water used as a moderator.

[7] Overnight cost is a means of estimating the cost of long and complex engineering projects, netting out interest costs. It is an estimate of the present value of a project as if paid as a lump-sum up front. It is usually expressed in dollars per kilowatt of electrical generating capacity ($/kWe). Estimates of the overnight cost of existing and currently-planned nuclear facilities are in the $3,000 - $7,000 per kWe range, though some estimates range as low as $1,200/kWe. For a discussion of overnight costs, see The Economics of Nuclear Power: Current Debates and Issues for Future Consideration, by David McLellan.

design and construction problems. Only after that first build is it possible to achieve sufficient critical mass to actually reap the benefits of prefabrication and standardization, and so be able to realize those economies. The magnitude of this challenge is bluntly illustrated in the outcome of the Ontario bid. In its early planning, Ontario Power Generation (OPG) estimated the cost of its first pair of ACRs at slightly less than $2,500 per kilowatt (OPG, 2005: 7). By 2007, this figure had climbed to $3,000 (OPA 2007). At the same time, commercial credit rating agencies such as Standard & Poor's and Moody's were estimating the costs of new reactors at anywhere between $5,000 and $8,000 per kilowatt. In stark contrast, unconfirmed press reports (Hamilton, 2009) claim the AECL bid for the Darlington reactors was approximately $26 billion or the equivalent of roughly $10,800 per kilowatt and the AREVA bid, which apparently failed to satisfy the government's requirements for managing the risk of cost overruns, was reportedly in excess of $7,000 per kilowatt of generating capacity.

The price of AECL's Ontario bid was a direct result of the federal government's reluctance to underwrite potential cost overruns associated with AECL's Darlington bid, coupled with its broader insistence that the bid be made on a "commercially viable" basis. This essentially turns the tables on the original AECL commercialization strategy. Indeed, the federal government's definition of "commercially viable" seems to go so far as to encompass most, if not all of the costs (and risks) associated with the first-time build – rather as if the Apple Corporation expected the purchaser of the first iPhone to pay all of the costs associated with its development. This certainly appears to be the case in the Ontario bid and it is no wonder the Ontario government balked at the price tag on the AECL proposal. It means, in effect, that the onus for accepting the risk of building the FOAK ACR would lie on the Ontario electricity consumer and ultimately the Ontario taxpayer, effectively subsidizing future export sales. This is a clear reversal of the original policy concept wherein the CANDU export business was considered a means of containing domestic energy costs by leveraging R&D expenses (Bratt, 2006).

This policy change also points to the immensely complex balance between cost and financing in high-value, long-duration capital projects. AECL's inability to raise capital, due to its Crown corporation financing structure, and the federal government's refusal to continue investing in the ACR leave the company unable to amortize the costs of development over the anticipated product life. Instead, the full burden of these costs had to be borne in the Ontario bid and resulted in the astronomic price.

AECL Privatization

The other alternative to meeting AECL's funding requirements, and the one in which the federal government is now actively engaged, is the privatization of AECL.

At the end of May 2009, following a string of unintentional disclosures and embarrassing miscues, the federal government announced its intention to proceed with privatization; indeed the government appears to be signalling a wholesale retreat from involvement in the nuclear industry, having also communicated its intention to withdraw from the production of medical isotopes (Akin, 2009). Though the announcement came as no surprise, its timing appeared more forced by events than a considered step. As early as 2007, news reports had the Crown corporation all but sold off to US industrial giant General Electric Co. (Hamilton, 2007). In early 2008, the federal government commissioned a $1.5 million advisory report by National Bank Financial Inc. to determine a possible valuation of the Crown corporation and to make recommendations on the privatization of all or part of its business. After a prolonged delay – doubtless at least partly due to sensitivity over the imminent Ontario announcement of the results of the Darlington bid – a summary of the report was made public at the same time as the privatization announcement.

The report summary highlighted the potential benefits to AECL of privatization, specifically access to badly needed risk capital, the ability to make equity investments and the ability to create a strategic "market-focus" on commercial opportunities relieved of the weight of a public policy role (Natural Resources Canada, 2009). The report envisages splitting the AECL power reactor business off from the Chalk River research and development establishment, with the latter remaining in government hands under private-sector management. The reactor business and its attractive maintenance and refurbishment activities would then be offered for sale on either a majority or minority ownership basis. Unstated in the summary, but reported from previously leaked documents, is the more prosaic consideration of the various legacy obligations and liabilities associated with the corporation, particularly Chalk River. Amounting to as much as $7 billion, these are a serious impediment to any potential privatization and so will be retained by the federal government.

The privatization announcement effectively forced the Ontario government's hand. The province's premier, Dalton McGuinty, previously declared that "The Ontario government is unwilling to purchase new reactors from AECL unless it receives assurance that the federal government will remain the ultimate backer of AECL," signalling clearly that any move to privatize AECL would effectively sink its prospects for future business in Ontario (Frame, 2008). This was, by implication, an endorsement of the status quo – a federally "backed" AECL, the majority of whose economic and industrial benefits flow to Ontario.

This leaves Ontario and the federal government engaged in something of a dance of veils. Ontario has selected AECL, but has frozen the procurement. The federal government, meanwhile, sends out mixed signals, attempting, with one hand, to put increasing distance between itself and AECL by moving ahead with plans for privatization, while tirelessly globe-trotting to Asian and Eastern European capitals promoting AECL and CANDU with the other (Reuters, 2009a; Reuters, 2009b; Rennie, 2009). Adding to the confusion, a senior member of the prime minister's staff went on record characterizing AECL as "dysfunctional" and "one of the largest sinkholes of government money probably in the history of the government (sic) of Canada" (Cheadle, 2009). Such comments are unlikely to inspire confidence in AECL among potential foreign customers or improve its valuation in the eyes of possible investors.

Engineering physics professor and Canadian nuclear analyst David Jackson argues convincingly that the proposed restructuring of AECL is a tacit declaration of the federal government's unwillingness to underwrite the billions of dollars the ongoing research and development of the ACR will inevitably cost (Jackson, 2009). Jackson makes the point that by disaggregating the Chalk River R&D functions from the AECL reactor sales and maintenance business, the government is effectively starving the latter of any prospect for success by eliminating its capacity to innovate. His conclusion: "no potential purchaser would want to buy an ACR with no assured R&D backup and thus, in effect the restructuring is the end of the ACR" (Jackson, 2009). The current impasse in Ontario certainly seems to confirm this assessment.

New Brunswick

Ontario, however, is not the only province reconsidering nuclear power. The Point Lepreau plant in New Brunswick (NB) was built between 1975 and 1983 at a cost in excess of $1.4 billion ($1979). The first installation of the 635MWe CANDU-6 reactor in Canada, the plant was operated quite successfully for a period, and was ranked several times as the world leader for lifetime capacity factor (the standard measure of operational efficiency for nuclear power reactors). But by 1997, the reactor began to show signs of premature wear and aging, and its reliability began to degrade. When the refurbishment option, which would add 25-30 years to the plant's operating life, was first considered in 2000, cost estimates were in the range of $500 million. These estimates jumped to $845 million by the time the project was reviewed by the NB Public Utilities Board (PUB) in 2002 and that jump, combined with the perceived risk of further cost increases, prompted the Board to recommend against proceeding with the project. In 2005, the NB government rejected this recommendation and decided to proceed (New Brunswick, 2005), by which time the refurbishment estimate had climbed to $1.4 billion, including roughly a million dollars a day for replacement power while the reactor is offline. Engineering delays quickly pushed the schedule and budget aside. The reactor went offline in April 2008 and, by January 2009, the refurbishment project was "three to four months" behind schedule due to engineering difficulties with its FOAK feeder tube replacement. By the end of June 2009, those delays had stretched to seven months. The reactor was expected to be back online by late 2009 but, with the announcement of the latest delay, the utility is no longer forecasting a completion date (CBC News, 2009).

Part of the rationale for proceeding with the refurbishment, despite the cost uncertainty highlighted by the NB PUB, was the expectation that NB Power and AECL could profit from the experience as suppliers of technology and expertise to the operators of the other nine CANDU-6 reactors installed in Argentina, China, Korea and Romania; those reactors will reach the end of their respective service lives over the coming two decades. There is a certain dubious optimism to such an expectation; just how NB Power and AECL would insulate themselves from risk of liability for problems and overruns in those other jurisdictions is unclear.

In 2007, the provincial government also decided to launch a pair of studies into the potential construction of a second and possibly third reactor at the Point Lepreau facility. A feasibility study was conducted by the Team CANDU consortium to examine the business case for private sector investment, considering the prospective markets and potential environmental and socio-economic impacts of the project. The province also commissioned a "higher level study" to identify key issues affecting project viability and broader business case issues such as the domestic and export market for electricity, the economic benefits to the province and the overall economic viability of the project. Conceptually the project proponents see a largely private-sector, Team CANDU consortium financing and building a multi-billion dollar ACR facility on a "merchant-plant basis." The province's NB Hydro utility would become the plant operator, while the major market for the electricity from the new reactor would be the Maritime provinces and north-eastern US states. Though

Team CANDU – Nuclear Merchants

The Team CANDU consortium was formed in early 2006 by AECL and its principal nuclear power engineering and construction partners (Babcock & Wilcox Canada, GE Canada, Hitachi Canada and SNC-Lavalin Nuclear) in anticipation of the Ontario Darlington bid. The group is formed around a business model in which each of the partners takes on a share of project risk to deliver new CANDU power plants on a turnkey "merchant-plant" basis; it is on this basis that the New Brunswick proposal is going forward.

The merchant-plant model reverses the existing practice whereby nuclear facilities are publically financed and owned, though not always publically operated. Capital financing for plant construction is provided by a private sector proponent such as Team CANDU. In the US however, no new reactors have been constructed with private funding so far; nuclear merchant-plant arrangements have been limited to the acquisition and operation of existing plants selling power into the deregulated electricity market (Geesman, 2008). Merchant-plant arrangements for new builds in the Canadian context will never be wholly private-sector enterprises. First, any such arrangement would need to rely on some form of a long-term power purchasing agreement ultimately guaranteed by a public utility. Next, no private sector operator can assume the huge liability risk associated with the potential catastrophic failure of a nuclear plant. In Canada, this risk is offset by the federal Nuclear Liability Act, which, in effect, provides insurance for the nuclear industry. Moreover, because of the potential for regulatory-review delays during project execution, there would need to be contingency arrangements to transfer the costs of such delays away from the merchant-builder. Finally, expenses related to nuclear waste management and non-proliferation measures such as implementation of IAEA safeguards are also commonly assigned to the public sector – though waste management costs are factored into facility operating costs under the Canadian Nuclear Fuel Waste Act. All of these offsets are subsidies that mask the full cost of nuclear energy production; they essentially transfer costs and risks from the merchant-providers, and ultimately their utility rate-payers, to the general tax base at whichever level of government is providing support.

These and similar forms of subsidies and offsets are common features of nuclear power projects and are a frequent target of criticism by anti-nuclear and alternative supply advocates, who point to them as fundamentally market-distorting and disadvantageous to both alternative energy suppliers and demand-side (conservation) initiatives (OCAA Research Inc., 2008).

In addition, the complexities and uncertainties inherent in nuclear plant design, construction and commissioning make crafting risk-sharing arrangements extremely complex. Such complexities are multiplied many-fold in first-of-a-kind situations. Such has been the case in AREVA's current Olkiluoto 3 project in Finland. The flagship project for the new EPR design, the project is now running some two years behind schedule and is reportedly more than 50 percent over budget. As a result, members of the construction consortium and the purchaser are suing each other over the delays and over-runs.

There are rumours that disagreements between the Team CANDU partners are close to splitting the consortium apart over exactly these sorts of issues. Certainly the failure of Team CANDU to produce a bid that satisfied the Ontario government suggests the prospects for a merchant-plant arrangement for an ACR build in either New Brunswick, Saskatchewan or Alberta – all jurisdictions with considerably less invested in nuclear and with markedly smaller electricity markets – are dim at best. The Ontario non-decision is a definite negative signal to potential investors and would consequently add a large risk premium to invested capital, adding to the already considerable costs of a new build. Former investment banker and California Energy Commissioner John Geesman points to this kind of situation as the critical challenge facing prospective merchant-plant arrangements:

> "…the crux of nuclear's financial challenge: how can private investors be sure how much it will cost and how long it will take to complete construction of a new plant? Absent the extraordinary ratepayer guarantees that politically sank the industry before, or distasteful taxpayer absorption of cost-overruns, will this technology make it to the battlefield?" (Geesman, 2008).

the NB government is currently reviewing the studies, the "sticker-shock" that prompted Ontario's decision to freeze its new-build initiative and rumoured tensions within the Team CANDU consortium make it highly unlikely that New Brunswick could make a credible case to go it alone on an ACR build.

Québec Refurbishment

Québec is also planning to refurbish its Gentilly-2 CANDU-6 reactor, which has operated since 1983. Located in Bécancour on the south shore of the St. Lawrence River, the plant generates approximately three percent of the province's power, supplying mainly Montreal and Quebec City. Bécancour was hard-hit in 2007 when the world's largest magnesium production plant was abruptly shut down. The nearby town of Trois-Rivieres was similarly affected by slowdowns in the manufacturing and forestry sectors. In mid-2008, the Quebec government decided not to spend $1.6 billion to shut the Gentilly-2 plant down in 2011 when it would have reached the expected end of its operational life. Instead, the province decided to invest close to $2 billion to refurbish the reactor and construct a new radioactive waste facility, thereby extending the plant's projected operating life to 2040 and preserving the roughly $120 million annual benefit the plant's operation brings to the local economy (Hydro-Quebec, 2003, 2008). Though, on the one hand, this is a significant commitment to nuclear power from a province that enjoys an abundance of hydro-power, it was more obviously the political salience of regional development that swayed the decision.

Saskatchewan New Build

With provincial energy demand in Saskatchewan expected to climb by 1,200-1,750MWe by 2020, and with the province's strong uranium mining base contributing to a generally favourable public opinion of nuclear energy, Saskatchewan would seem a prime candidate to embrace the nuclear renaissance. Bruce Power is promoting the construction of a two-reactor, 2,200MWe plant, at an estimated cost of $8 to $10 billion, to be operational by 2020. Touting the prospect of 60 years of post-construction employment for 1,000 workers and an annual regional economic benefit of $240 million, Bruce is working actively with SaskPower, the province's electricity utility, to study the possibility of locating a plant in the region east of Lloydminster, near the Alberta border. The proponents argue a nuclear build would allow the province not only to meet its increased demand but also to reduce substantially its current reliance on coal-fired generation.

A report commissioned by the provincial government and released in April 2009 recommends the province pursue a common power-generation solution with neighbouring Alberta and that nuclear power be included in those plans, highlighting it as a potentially significant stimulus to the provincial economy with ongoing net benefit (Uranium Development Partnership, 2009). The report describes one scenario of a 3,000MWe nuclear power plant supplying Saskatchewan and Alberta, but cautions that improvements to Saskatchewan's power grid alone would likely cost approximately $1 billion. Public consultations on the report are now underway but, somewhat controversially given the ongoing nature of those hearings, provincial Premier Brad Wall has already made clear his ambition to see a reactor built in the province (White, 2009).

Wall, a firm proponent of expanding Saskatchewan's role in the nuclear industry, argues that it is crucial for the province's long-term prosperity to "add value" to its natural resource stream and to move beyond being hewers of potash and the drawers of uranium. Indeed, there is an inherent attraction to the idea that a province that is the source of so much of the world's uranium supply should leverage this natural advantage and extend the scope of its involvement in the industry to reap greater rewards from its resources. Hence the province's enthusiasm for a range of industrial development initiatives related to the resource, from proposals for developing a Canadian uranium enrichment capacity (rejected in the advisory report) to establishing a nuclear medicine capacity (supported in the advisory report) and the reactor build itself. The risk involved in such a strategy lies in the distortion effects that the required massive investments would have on the province's economy and the risk that the almost inevitable cost overruns and construction delays would overwhelm a provincial treasury reliant on a tax-base of barely one million citizens. Awareness of this reality likely explains why the premier has offered vocal support, but precious little public money. However, while the province might dream that the private sector could be enticed to carry the investment load, this is unlikely without huge concessions, risk offsets, liability waivers, loan guarantees and the like.

Alberta New Build

In early 2008, Bruce Power applied to the Canadian Nuclear Safety Commission for permission to prepare a 390-hectare site on Lac Cardinal, 30 kilometres west of Peace River, in anticipation of building an $8-10 billion, four reactor, 4,000MWe facility for completion by 2017. If completed, the facility would be the largest operating nuclear generating station in the world. The Alberta initiative is actively supported by Bruce Power's Calgary-based, one-third owner, TransCanada Corporation – the publicly traded, natural gas pipeline giant and power producer (Financial Post, 2007).

Though the Alberta government, in the interests of its dominant fossil-fuel-driven industrial and resource base, has long-eschewed nuclear energy, it recanted in mid-2008 and struck an expert panel to consider "…the factual issues pertinent to the use of nuclear power to supply electricity in Alberta" (Government of Alberta, 2009). This seeming shift in policy was at least partly driven by the possible use of nuclear energy to produce steam for extracting oil from the Alberta oil sands.

Nuclear in the Oil Patch

It takes roughly a thousand cubic feet (30 cubic metres) of natural gas to produce a single barrel of oil from the oil sands (National Energy Board, 2006). With some projections of future oil sands production levels ranging up to three million barrels a day by the middle of the next decade (National Energy Board, 2006), the substantial diversion of one valuable resource to produce another becomes increasingly problematic – even setting aside the issue of carbon emissions. Alberta accounts for roughly 80 percent of Canada's natural gas production, half of which is exported to the US; however, the province's natural gas production peaked in 2001 and is now gradually declining (Alberta Energy Resources Conservation Board, 2008). Thus, increased usage for one activity must come at the expense of others. Simple economics would predict that the price of Alberta's natural gas must rise in response, making oil sands production less economically competitive and significantly affecting the continental natural gas market.

Early discussions of using nuclear reactors to produce the steam and hydrogen necessary for extracting and refining oil from the oil sands began in 2003. An early proposal from Energy Alberta Corp., a private company formed in 2005 and acquired by Bruce Power in 2008, predicted that a single CANDU-6 reactor could support the production of up to 200,000 barrels of oil a day, reduce natural gas demand by up to 6 million cubic metres and reduce CO_2 emissions by some 3.3 million tonnes per year. A later proposal, which got as far as a site preparation application to the CNSC, envisaged a partnership with AECL to construct one or more, 2-reactor plants based on the new AECL ACR-1000 design in the vicinity of Lac Cardinal in the Peace River district. This application was subsequently withdrawn because Bruce Power is now considering a different location.

There are, however, considerable obstacles to using nuclear reactors in the oil sands (Nikiforuk, 2008: 129-138). The need for a large, secure and fixed location for a nuclear facility means that, even if ideally situated at the beginning of operations, extensive steam transmission lines are needed as the mining operation works its way further from the reactor site, significantly decreasing energy efficiency. The high capital cost of nuclear energy is also an impediment, making the nuclear option economically viable only at relatively high combined natural gas/oil prices. In March 2007, the federal government's House Standing Committee on Natural Resources recommended against using nuclear energy until its repercussions are better understood, pointing to the proliferation of reactors that would be required to meet the projected oil output (up to 20 by 2015). The report also suggested that greater consideration be given to smaller, 100MW-range reactors and, possibly, to semi-portable reactor facilities, adapted from those used for military applications, to compensate for the steam transmission problem. However, this suggestion is problematic as such small-scale reactor technologies are still in the early developmental stage and have serious safety, security and non-proliferation implications that the military does not have to consider.

The Alberta expert panel was specifically mandated not to make a definitive recommendation on the adoption of nuclear power; its report, released in March 2009, instead recommended that the province define a process, timeline and the possible parameters of the role the provincial government might play for a prospective nuclear build (Government of Alberta, 2009). It stressed the decision to proceed with a nuclear plant should be based on a private-sector-led business case that establishes economic viability based on market factors, as opposed to economic development factors. No mention is made of possible cooperation or even coordination with neighbouring Saskatchewan; however, similar to the situation in Saskatchewan, any use of nuclear generating capacity for electricity supply (as opposed to oil-extraction) would require a substantial and costly upgrade of the provincial electricity grid and related infrastructure that would inevitably involve significant public-sector financing.

Rating the Revival

What is required for a successful national nuclear enterprise? Writing in 1982, Bertrand Goldschmidt observed that:

> "Whenever a country's nuclear effort has been able to profit from continuity, with a technical and political consensus giving support to competent technical and executive teams, it has reaped benefits – as can be seen in the Canadian and French examples." (Goldschmidt, 1982: 469)

Quite clearly, the French still have this, and Canada has lost it. In particular, Canada lacks the political consensus on nuclear energy that characterized the development of the CANDU technology and its initial domestic deployment.

Unquestionably, the greatest obstacle to any substantive and sustained expansion of the nuclear energy industry in this country is the fragmented energy policy space that is Canada. Unlike AREVA in France, AECL cannot rely on a national power utility to drive demand for a sea-to-sea grid of nuclear power plants supporting Canadian base-load power generation and coordinated electricity exports to the US. Thus, while some politicians and proponents of Canadian nuclear power may yearn to see AECL become Canada's answer to AREVA, reality is considerably more banal.

Under Part 6 of the Canadian Constitution Act of 1982, jurisdiction over energy, electricity and natural resources is vested in the provinces (Mahler, 1987: 126-140). The federal government retains general jurisdiction over nuclear energy, international and interprovincial trade and commerce, and regulation of the safety and security of nuclear reactors. Responsibility for environmental matters associated with energy and electrical industries is shared by the federal and provincial governments.

This fragmentation is of profound consequence for the nuclear energy industry in Canada. As a result of these constitutional arrangements, energy and electrical industries and utilities are organized and focused largely along provincial lines, and are reflective of the fundamental variations in each province's physical and political environments (Blake, Cassels & Graydon LLP, 2008). In most provinces, the electricity supply is highly integrated, with the bulk of the generation, transmission and distribution functions provided by one or very few dominant utilities. Although some of these utilities are privately owned, most are provincial Crown corporations with some smaller investor-owned utilities, municipal utilities and industrial establishments. Inter-provincial coordination and cooperation, meanwhile, is fraught with all of the complexities that so dog the federation more generally – one need only consider the apparent lack of consultation and coordination between neighbouring Alberta and Saskatchewan in their respective nuclear planning to find a current and relevant example. Likewise, Ontario and New Brunswick appear to have engaged in little, if any, coordination in their respective nuclear ambitions. Also, tellingly, the Ontario/Quebec transmission interconnection, which could act as an effective means of handling Ontario's baseload generation surplus problem during non-peak hours and provide an additional source of supply during peak demand hours, is limited to about four percent of Ontario generating capacity (Ministry of Energy and Infrastructure, 2009; Ontario Clean Air Alliance Research Inc., 2009). By contrast, Quebec interconnections to the north-eastern US have more than double that capacity.

For capital-intensive mega-projects like nuclear power, this fragmentation spells inefficiency, overhead, expense and, consequently, risk. In a market relying on the individual provinces and their various utilities (public and private) to provide a domestic customer-base, the opportunities for sustained-build nuclear programs are minimal. This makes it difficult to reach the kinds of build volumes necessary to overcome FOAK risks and all of its attendant consequences. It similarly impedes optimization of construction methods and technology, making it virtually impossible to achieve the kinds of economies AECL foresaw when it mooted the $1,000 per megawatt price point for the ACR. Those provinces interested in pursuing the nuclear option are thus left looking for any means to offset that risk, which inevitably lands them on the doorstep of the federal government – as is amply demonstrated by the current Ontario-federal standoff.

The result is institutionalized domestic market inertia which effectively impedes the Canadian nuclear industry's ability to compete internationally; it simply cannot gain sufficient domestic momentum to make it truly competitive in the international marketplace. Consider, for instance, AECL's experience in China and South Korea where, despite the much-touted (by AECL and its partners at any rate) on-time and on-budget completion of the CANDU-6 reactors at Qinshan and Wolseong, both countries have politely bypassed AECL. They instead selected Westing-house and AREVA to construct their next nuclear plants (Webster, 2006). Thus, while individual Canadian suppliers may indeed prosper in a market increasingly constrained by material and skills shortages by finding a niche with the increasingly dominant global suppliers, Team CANDU faces an uphill battle as an integrated supplier. The Canadian industry/technology mix can find little traction without a strong domestic base and thus continues to look to the federal government for much of its export market development assistance as well as for R&D and technology support.

The provinces, meanwhile, use nuclear plants as regional economic development levers to try to pry open the federal tax base to support provincial industrial and infrastructure investments. With the partial exception of the current discussions in Alberta, every nuclear power project currently under consideration in Canada is featured by its host province as an engine for economic development in one form or another. As a result, examples of cross-cutting and often competing motives abound. An obvious recent case is Point Lepreau: the federal government under Paul

Martin refused a direct request from New Brunswick in 2005 for some $600 million to support the refurbishment. Subsequently, however, the federal government has underwritten a range of AECL expenditures that have directly supported the project, the latest being a 2009 federal budget allocation for various cost over-runs associated with the project. While AECL, as the general contractor for the project, faces contract penalties for scheduling delays, those penalties are in essence a shell game, shifting the cost overruns from the provincial utility to the federal government – from provincial taxpayers to federal taxpayers.

Not dissimilar is the case of Team CANDU's plea (McCarthy, 2008) for federal support for its Ontario bid in an effort to offset what were argued to be French government subsidies to AREVA. In effect, Team CANDU was asking federal taxpayers to subsidize a competitive bid in a domestic province or, stated more baldly, asking federal taxpayers to subsidize Ontario power consumption. Indeed, the very fact that the Ontario government decided to seek bids for the new Darlington build instead of simply directing the business to AECL (as had previously been the practice) can be seen as little more than an elaborate means of extracting a greater commitment from the federal treasury; the decision to halt the procurement represents an even more blatant demand. In this regard, the federal privatization announcement, notwithstanding the awkward circumstances of its timing, can be interpreted as pushing back or attempting to limit potential federal exposure in an Ontario build. Given the recent history of cost over-runs and the resulting federal liabilities associated with the Point Lepreau refurbishment, Bruce refurbishment and medical isotope reactors, such reluctance seems well-founded. The extent to which any potential private-sector buyer of AECL's reactor business might be prepared to assume this risk without some form of federal guarantee or risk-share arrangement, however, remains to be seen.

That there has been extensive federal support for the Canadian nuclear industry is unquestioned. The outspoken critic of AECL in the Prime Minister's Office pegged the total value of government support to the Crown corporation at some $30 billion (Cheadle, 2009). To date, the cornerstone of this support has been technology: for AECL and its CANDU reactor technology. This support has been provided in the belief that AECL and the industry that surrounds it is a net benefit to the country, that fostering and promoting expertise and domestic capability in nuclear science and engineering is sufficiently important to Canada as a whole to warrant an ongoing claim against the federal treasury. That this policy has been at least partially successful is demonstrated by the line-up of international nuclear giants – including the likes of AREVA, GE and Westinghouse – sniffing around the privatization, interested in snatching up AECL's stable of scientific and engineering expertise (Jackson, 2009) by aggressively recruiting individuals if not by actually acquiring pieces of the company. At the same time, the huge investment in AECL and its CANDU technology has exerted a kind of policy inertia attenuating efforts to both innovate and promote. This leaves the Crown corporation in a seemingly perpetual policy void without clear direction and, due to its financing limitations, lacking the resources to compete in an increasingly competitive international marketplace.

This inability to compete in turn raises the question as to whether, from a public policy perspective, it is better to continue public investment in nuclear energy. On-going commitments of financial and political capital are essential to sustain the technological and political consensus, and the competent technical and executive teams that Goldschmidt highlighted. Are there sufficient public policy benefits to justify continuing direct involvement in nuclear science and engineering, supporting the expensive and risky business of reactor development and heavily subsidizing CANDU technology both domestically and internationally?

With the announcement of its plans to privatize AECL's power reactor business, the current federal government has now clearly signalled its preference to let market forces be the judge. Though the shape and extent of future government support is uncertain, this move represents a choice by the government to put its stock in the broader nuclear industry from a business perspective rather than supporting continued technology development from a public policy perspective. Whether such a policy will succeed in making the Canadian nuclear industry more competitive in the international arena, and whether this will produce a net benefit to the country as a whole, remains to be seen. One thing is certainly clear: repackaging the Team CANDU proposal to Ontario for a prospective international client will command little interest when stacked against the likes of AREVA, Westinghouse and Hitachi, unless it is accompanied by massive federal export subsidies.

In the end, this leaves the domestic prospects for the Canadian nuclear energy industry in an uncertain space: cross-cutting federal and provincial priorities will inevitably constrain any sustained Canadian nuclear energy revival. The withdrawal of federal support from AECL's reactor business will leave those domestic jurisdictions considering nuclear power facing the prospect of massively higher costs. Interprovincial competition for economic development opportunities will restrain collaboration, while the distribution of constitutional authorities hinders broader efforts to coordinate. And as always, provincial efforts to mitigate risk will continue to be constrained by federal efforts to do the same; each party seeking advantage at the expense of the other's tax-base – the quintessential Canadian political two-step.

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The Centre for International Governance Innovation
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