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The Nuclear Option in Canada: Why it is Gaining Ground

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Introduction

Over the last five years, the nuclear option in Canada has gone from "off-the-radar" to an essential part of the energy debate. In Ontario, in particular, building new nuclear plants, along with life extension of existing plants, has been recommended by government commissions as one of the vital energy supply options to be pursued. Both life extension and introduction of new nuclear power plants are complicated by uncertainties in the energy market, and by changes in the organizational and policy environment. Public and policy maker recognition of the nuclear role are steadily growing, but commercial conditions to support nuclear projects are still difficult to define and obtain.

Overall, the Canadian perspective is towards increasing support for the nuclear option. Canada is poised to join the vanguard of the broadening nuclear power expansion:

- Canada, as a resource-rich but energy-intensive nation, is sensitive to the rapid price increases and supply security concerns regarding oil and gas.
- Just as fossil fuel demand is outstripping supply, for most of Canada, electricity demand is outstripping **affordable** supply (partly because of an aversion to building new capacity over the last 15 years).
- Conservation, energy efficiency and alternative energy sources, such as wind, are becoming recognized as making only a limited contribution to filling the energy demand-supply gap, despite being politically vote catching.
- Nuclear power's clean air, zero-GHG characteristics are recognized by decision makers. The wider public are slowly recognizing this value; in Canada's case, the impacts of global warming in the north are showing more quickly, more extensively, than in other regions of the world - global warming is starting to be seen as a threat to Canada's natural environment.

AECL views that there is high potential for nuclear to make a strongly increasing contribution to Canadian energy supply – nuclear power plants such as AECL's ACR-700 (Advanced CANDU Reactor) have the economic advantage over other new sources; AECL's successful track record with new power plant projects lends confidence to customers and stakeholders; and Canada's long nuclear tradition means that the infrastructure is ready to support plant life extension and new build.

This paper provides some further detail about the Canadian energy scene; discusses the case for nuclear; looks at the challenges to be overcome; and includes a final AECL perspective.

Development of Canada's energy market

Traditionally, the electricity market, and nuclear's role, have been considered rather separately from other energy markets. Increasingly, the interconnectedness of energy markets is a factor to be considered in policy making.

Growth in Canada's electricity demand has averaged about 1.3% per year over the last 10 years (Reference: Canadian Electrical Association), varying somewhat by region. Electricity demand as a fraction of total energy demand has increased, but electricity demand has grown more slowly than gross domestic product. This means that Canada is becoming more energy efficient per unit of GDP; and that one contribution to this trend is the move to increased electricity use.

During the last 15 years, very little new electricity capacity has been added. This has resulted in traditionally energy rich Ontario and Quebec becoming net importers of electricity. Ontario, in particular, has had an extreme shortage of electricity in the last two to three years, importing as much as 15% of its power through limited grid interconnections on the hottest summer days. This has strained internal reserve margins and internal capacity to the limit. Everyday users of electricity have finally become affected, with urgent requests to turn off air-conditioners and avoid using appliances.

Overall in North America, new supply has been overwhelmingly natural gas-fired generation. In fact, in the last ten years, 200GW of new gas generation has been either built or planned in the northeast of the continent alone.

However, what appears at first sight to be a large contribution to supply is simply a move of the bottleneck from generating capacity to fuel supply. At today's prices for natural gas, much of this new capacity sits idle, because to run is to operate at a loss. Alternatively, capacity addition still at the planning stage is deferred or cancelled.

Canada is a significant producer and consumer of natural gas. However, in Canada, as in North America overall, new supply is not being discovered in sufficient quantities to satisfy demand. Frontier gas from the Arctic will stave off this imbalance, provided massive pipeline investments are made, but only temporarily. The past regime of an abundant resource is coming to an end, and policy makers know it.

One resource is abundant in North America - coal. However, the air pollutant and greenhouse gas emissions from coal are now seen as a serious drawback. Ontario has pledged to close all of its coal plants this decade.

In this environment, nuclear offers an emissions-free supply option that offers security of supply. The supply gap is large enough, using Ontario as a prime example, that the need between now and 2020 is not just to start building new plants, but to plan and install a new fleet.

The greatest uncertainty comes from the development of the electricity markets in the various jurisdictions. Canada, like many other countries and the EU, has been moving towards deregulated, competitive markets for electricity, since the first opening of Alberta's market in 1998. There, results have been mixed. In both Alberta and Ontario, the opening up of the markets caused sharp spikes in spot prices at peak times, relative to the previous regulated prices. In both cases, public outcry caused the governments of the day, despite their commitment to the free market, to intervene. At present, the Ontario market is somewhere in the middle ground between regulated and deregulated. The current plan is to have an independent arm's length Ontario Power Authority carry out overall supply planning, including acting as a buyer arranging electricity supply contracts on behalf of most consumers. The OPA's prime role is to ensure secure, competitive supply. The government has recognized the generic obstacle to new build. No new capital-intensive plant can compete with existing, largely paid for assets. The plan is that electricity from these existing "heritage" assets will be regulated, including price, while the OPA will oversee a competitive market for remaining supply, and then calculate a "blended" price for the consumer. This policy framework is still being developed, with a draft bill issued for legislative review in July 2004.

The reaction of the electricity industry is cautious, knowing that "the devil is in the details". Negotiating appropriate rates for power purchase agreements will be the first test.

The case for nuclear – and the challenge

As noted above, the above energy environment is increasingly positive for the nuclear option. The case for nuclear, both for life extension of existing units and for new plants, is based on familiar themes:

- Economics
- The environment
- Balance of commercial risks
- Security of supply
- Infrastructure benefits

The challenge is to meet expectations in all of these areas, with a first nuclear project that meets the needs of all stakeholders – owner/operator; vendor; electricity consumers; governments; and financing institutions.

The case for life extending Canada's existing units is straightforward, provided careful planning and review of the scope of refurbishment required is completed.

Emphasis on this activity is an absolute essential if project costs are to be fully defined so that "discovery risk" is contained. If this is done, so that upfront costs and future plant performance can be committed with confidence, then the economic case is clear – if the costs enable a better electricity price than the alternative, then life extension will go ahead. The CANDU plants in Canada today were all originally designed for a 30-year life. The feasibility in principle of life extension to 50 years or beyond has been well established. For each plant owner, the decision whether to life extend is an economic one. For the earliest units, such as Pickering, which started operation in 1971, life extension is complicated by the need for extensive refits to upgrade the units to today's requirements. For example, the original turbine condenser tubes at Pickering were made of admiralty brass: to life extend, the plant has had to replace these with stainless steel condenser tubes, to minimize discharge of corrosion products.

For new nuclear units, the same elements of the business case exist, but the commercial challenge is broader – to create a project framework, which satisfies all parties, and delivers economical, reliable electricity.

We believe that the case for nuclear in Canada with regard to the environment, security of supply and infrastructure benefits is strong. After all, in areas such as Ontario where air pollution causes smog estimated to kill over 1800 citizens each year, the clean air benefits of nuclear are hard to refute. In reviewing some of the energy situation in Canada, above, it is easy to see the advantages of nuclear in fuel supply: fuel costs typically represent less than 5% of CANDU or ACR electricity costs, and Canada's domestic uranium resources could supply our existing fleet for centuries. Similarly the infrastructure benefits from high-tech jobs and from technology development in maintaining and expanding the nuclear fleet, are clear, based on successful experience in Canada. AECL has estimated that, by adding eight new ACR's, thousands of jobs would be created in Ontario alone, with a total of around C$20 billion of economic benefit to Ontario.

The principal challenges to the nuclear option are the commercial ones. Making the nuclear case on environmental, security or infrastructure is a necessary prerequisite to provide the context and confidence to policy-makers and stakeholders. But then these commercial challenges need to be addressed:

- Economics
- Risk mitigation
- Project structure
- Financing

Each of these challenges is interconnected. To a large extent, successfully meeting these challenges requires a known, stable framework for electricity supply that enables the potential economic advantage of the nuclear option to be recognized. The ultimate challenge in launching a new nuclear project (aside from the technical challenge of obtaining regulatory project approval through environmental assessment processes, etc.) is financing. Gaining the confidence of investors to commit funds itself requires attractive economics, measures to mitigate project commercial risks, and a well-established project structure with highly credible, committed participants.

Economics

In Canada, and in many jurisdictions, any new build must compete with existing already paid for assets. It is very difficult for new nuclear to compete with existing generation such as hydro dams and nuclear plants, where generating costs may be as low as 2¢ (US)/KWh. However, where jurisdictions enable all new generations to compete against each other, nuclear may be the cheapest new option. AECL has found that new ACR capital costs are similar to or better than state-of-the-art clean coal plants (before any credit for zero air emissions). The ACR delivers this with relatively low technology risk, because the ACR design is based on the standard CANDU 6 technology used in our recent projects, with a specific set of changes designed to enable a significant reduction in capital cost.

Overall, in Ontario, the Provincial Conservation and Supply Task Force found that nuclear new build with ACR units offered significantly lower lifetime electricity costs than natural gas, wind or other renewable options. This means that a nuclear project should be able to offer a more attractive power purchase agreement than new build alternatives.

Risk mitigation

Traditionally in most areas in Canada, regulated monopoly utilities supplied electricity, and as such took most risks of new projects: construction cost and schedule risk, and operating performance risk. They were able to do this because they could pass on any resulting costs to the electricity consumer – who bore any "market" or price risk. With the advent of deregulated and competitive markets, this model has had to change.

Overseas, AECL has built new units under a variety of contract risk models, including turnkey-like models. Most recently, AECL has completed a two-unit CANDU project at Qinshan, near Shanghai in China, based on the Turnkey model. AECL delivered the units under a firm-price fixed schedule contract.[1] AECL is ready to deliver Canadian projects using this model, adapted to include pain-share/gain-share elements, on construction. Plant operating performance risk is still the responsibility of the owner/operator. However, the operating performance of AECL's CANDU 6 units worldwide offers consistently high capacity factors with units varying in age, jurisdiction and location/owner. This offers strong support that operating risk can be effectively managed. Further, AECL is committed to providing strong, integrated operating support for refurbishment projects; AECL and partners are considering operating support contracts including gain-share/pain-share arrangements based on plant performance.

The remaining risk element is market, or price risk. Here, policy makers have recognized that without appropriate stable pricing frameworks, this risk cannot be mitigated sufficiently to allow major new build to be financed. The notion of Power Purchase Agreements to be negotiated between the future plant owner and

[1] Local Chinese companies were selected by the customer to carry out construction, and took cost risk on their scope. AECL took cost risk on all other elements, and took all schedule risk.

the electricity distribution organization, or market operator (or with individual large consumers), is seen to address this. Defining such agreements to appropriately reflect the role of project proponents, owners and electricity consumers will take work. However, if the economics are right, a win-win-win solution should be achievable.

Project structure

Traditionally in most of Canada, electricity generation projects have been managed by the utilities themselves, often taking on elements of the engineer/procure/construct role. With the change in electricity markets, utility or generating companies are also redefining their roles, to become more focussed on the operational side of their business. This is leading to increased preference for turnkey-like contracts, typically with a single prime contractor. AECL, either alone or with key partners, is ready to take on this role, similar to the project lead role for the recent Qinshan project in China. Such a vendor group could cover the full project scope, depending on the preferred role for the plant owner. Frequently, the owner may wish to participate in commissioning and start up activities, as this would contribute to both staff training and the owner oversight role.

The requirements for a successful vendor group include: nuclear project experience; direct expertise for role in the project; financial ability to support their role; and ability to function effectively as part of a project team. The Qinshan project team, consisting of AECL, Bechtel, Hitachi and selected Chinese organizations, certainly met all these requirements.

Financing

Of all the building blocks for a project, financing is the most fundamental, the most challenging, at least for the next round of nuclear plants and also the most significant in impact on electricity economics. Financing can be arranged for the project stage initially, with a view to refinancing for the operating stage, or can be arranged for both construction and operations together. Vendor, owner or governments can all play a role in financing. The prerequisite is a very well defined, fully planned project, with regulatory approval achieved to the maximum extent. Ultimately, the electricity price structure, such as power purchase agreement terms, needs to be well defined so as to provide the assured revenue required before financing can be completed. The cost of financing depends on the roles of the three groups involved, in particular on the levels of debt and equity and on the required returns. The activity of arranging financing ultimately represents a market test of the viability of a project.

Conclusions

In Canada, as in many OECD countries, the need to add to electricity infrastructure is becoming apparent. Life extension of existing nuclear units, and projects to build new units, are being planned. The key challenges, once energy policy issues have been addressed, are mainly commercial. Based on its successful experience with overseas projects such as Qinshan, and on its evolutionary approach to design of new advanced power plants, AECL is well placed to meet these challenges and launch a new round of nuclear projects.

