GOING FOR GOLD

Prairie Atoms: The Opportunities and Challenges of Nuclear Power in Alberta and Saskatchewan

Duane Bratt, PhD

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The Western Canadian Economy in the International Arena

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Western Canada's economic prosperity is not only good for the West, but for Canada as a whole. But the West can not rest on its laurels. Like the athletes training for the forthcoming Winter Olympics in Vancouver, western Canada needs to be at the top of its game if it is to continue to compete successfully in the international economic arena, especially as its competitors step up their games. If we are not successful, our standard of living will fall.

The Going For Gold Project is examining how best to position western Canada in the global economy through a series of research papers, provincial research roundtables, public opinion and expert surveys, and will end with a seminal international economic conference in Vancouver in the fall of 2009.

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Executive Summary

The world is in the midst of a nuclear revival. Nuclear reactors are being planned and constructed at record rates across the globe. China and India are poised to lead the way, but they are being joined by Europe, South America, Japan, the United States and Canada. This revival is due to four vectors coming together at the same time: 1) the substantial rise in the global demand for electricity; 2) the need to replace or refurbish the reactors that were built in the 1960s and 1970s; 3) the increased attention placed on the problem of greenhouse gases (GHGs) contributing to climate change; and 4) the need to diversify electricity supply away from fossil fuels.

Canada is part of this revival with both Ontario and New Brunswick planning to expand their existing reactor fleets. They may be joined by Alberta and Saskatchewan. Saskatchewan is already one of the world's largest uranium suppliers, and there are tremendous export opportunities for uranium. In addition, it is considering ways to move up the nuclear fuel cycle to include not just mining, but also uranium processing, reprocessing, enrichment, and power reactors. In the case of Alberta, Bruce Power has submitted a site licence to the Canadian Nuclear Safety Commission for four 1,000 megawatt reactors on the shore of Lac Cardinal just outside of Peace River. The Alberta government has recently appointed an expert panel to prepare a comprehensive report on nuclear power in Alberta.

This paper examines the economic, political, technological, and environmental opportunities and challenges to developing/expanding the use of nuclear power in Alberta and Saskatchewan. This paper makes explicit comparisons to other energy sources and to jurisdictions in other parts of Canada and around the world and concludes with a list of public policy recommendations.

Opportunities

- The development/expansion of nuclear power in Alberta and Saskatchewan would contribute to the international economic competitiveness of those provinces. The global nuclear revival will see increased employment in the design, construction, operation, and maintenance of nuclear reactors, as well as uranium mining, processing, reprocessing, and enrichment. The only way that Alberta and Saskatchewan would be able to participate in the global nuclear revival is if they themselves became part of Canada's nuclear industry.
- The nuclear industry is a high-tech field; one of the few high-tech fields where Canada (primarily Ontario) is among the global leaders. Do the prairie provinces want to stay at the level of primary resource extraction (oil, gas, uranium) or move toward the more technologically advanced economic production (reactor design/building/maintenance, uranium reprocessing, etc.)? Given its large pockets of uranium, Saskatchewan, in particular, could greatly benefit from uranium upgrading such as conversion, reprocessing, and enrichment. High-tech sectors also create the conditions for technological spin-offs. Thus, investment in nuclear power allows for the possibility of participation in new high-tech industries. Previous spin-offs from nuclear research and development include medical isotopes, flight simulators, food irradiation, vibration technology, and cooling systems. Future technological advances may be in energy (nuclear fusion, hydrogen, recycling used fuel, etc.), but others may be in totally unrelated areas.

Specific opportunities include:

- Canada's nuclear research and development can be diversified by establishing a centre of excellence on the Prairies.
- Nuclear power can be used to help meet the growing electricity demand in Alberta and Saskatchewan.
- A move towards greater utilization of nuclear power would help to mitigate the problem of climate change.
- Nuclear power can play a role in lessening Alberta and Saskatchewan's dependence on the dwindling supply of natural gas.
- Saskatchewan can increase its uranium exports to meet the growing demand for nuclear fuel. There is also an opportunity for Saskatchewan to move up the fuel cycle to include processing and enrichment.

Challenges

- There are concerns about the safety of nuclear reactors, related primarily to the accidents at Chernobyl and Three Mile Island, which continue to haunt the industry. Despite this, when compared with other energy sources, nuclear power has a better safety record.
- Nuclear waste is highly toxic and radioactive and some elements of nuclear waste have very long half-lives. These health and environmental risks exist for tens of thousands of years. There are, however, other key aspects of nuclear

waste. First, it is very small in volume compared to wastes created by many other industries or by burning coal for energy. Second, nuclear waste, unlike coal, is contained on-site instead of being directly emitted into the atmosphere. Third, while the half-lives of some nuclear waste are very long, the most highly radioactive substances die out very quickly, and those with the least amount of radioactivity have the longest half-lives. Finally, since spent fuel retains much of its energy, the possibility of recycling nuclear waste means that the actual amount of waste can be further reduced.

- Proponents of nuclear power need to prepare an extensive education campaign explaining a complex, and frequently misunderstood, technology to government, business, and the public.

- There are a number of different ways that nuclear terrorism could occur: planes hitting the containment domes or the storage site for spent fuel rods; fires at a nuclear power plant to disperse radiation; combining conventional explosives with radioactive material to produce a "dirty bomb"; and stealing spent fuel waste that could be separated to make a nuclear weapon. These fears about terrorist attacks ignore the fact that a theft of spent fuel would require elaborate separation technology to convert it into the highly enriched uranium that is needed for a nuclear bomb. Moreover, there are stringent safeguards on nuclear facilities such as a hardened containment structure and on-site security requirements.

- Alberta, in particular, lacks many of the highly skilled and specialized workers that are needed to operate (and regulate) nuclear reactors. Since there is a global shortage of nuclear engineers and technicians, Alberta and Saskatchewan need to get their own post-secondary institutions to establish university and technical programs in the field of nuclear science.

- Alberta requires a substantial increase in electricity, but this increase cannot be currently absorbed by the electrical grid. The issues with the electrical grid are independent of the energy source; whether the supply comes from nuclear, coal, or natural gas, an upgrade of Alberta's transmission system needs to occur.

- There are a number of challenges around government regulation of the nuclear industry. First, is determining the areas of federal and provincial responsibility. Second, is to reduce the amount of time that a nuclear project takes from initiation to completion. While the removal of red tape is a desirable goal, governments still need to keep in mind the fundamental role that regulation plays in ensuring public health and safety. Striking that balance could be assisted by learning from other jurisdictions like the United States and the United Kingdom.

- The nuclear industry must address the legacy of past cost overruns in the building of nuclear reactors. Critics of AECL point out the substantial cost overruns not just with the Darlington reactors but also the MAPLE reactors at Chalk River. On the other hand, AECL built a functioning MAPLE reactor in South Korea, and the last seven CANDUs were completed on time and under budget in South Korea, China, and Romania.

- A final challenge surrounds government funding of the nuclear industry. The notable feature of the Alberta and Saskatchewan reactor proposals is the reliance on private entrepreneurs. This could come in the form of a Green Plan, economic diversification, or an upgrade of physical infrastructure like electrical grids. The Saskatchewan government is lobbying for a uranium processing and enrichment facilities, but is it willing to help fund or subsidize projects?

Recommendations

On balance, the opportunities outweigh the challenges with regard to the expansion/development of nuclear power in Alberta and Saskatchewan. The economic and environmental benefits make the case for nuclear power a compelling one. In addition, while the challenges to nuclear power are not unimportant, they can be refuted with comparisons to other energy sources (safety and waste) or can be minimized with appropriate strategies (terrorism, labour force, regulations, public education, cost overruns, government subsidies). The purpose of the following recommendations is to allow the governments of Alberta and Saskatchewan to properly maximize the opportunities presented by the expansion/development of nuclear power in their provinces.

1. The governments of Alberta and Saskatchewan should support the expansion of the nuclear industry in their two provinces.

2. To meet the growing global demand for nuclear fuel, the governments of Alberta and Saskatchewan should encourage more uranium exploration.

3. The governments of Alberta and Saskatchewan should take a "technology neutral" position on the type of reactor that could be built in Alberta and/or Saskatchewan. The

decision should be based on the best possible technology, lowest long-term economic cost, and additional economic spin-off benefits.

4. The government of Saskatchewan should strongly encourage the private sector to invest in nuclear processing, fuel fabrication, and enrichment facilities in the province.

5. The government of Saskatchewan should convince Ottawa to get an exemption for Canada from the G8 moratorium on uranium enrichment technology.

6. A western Canadian nuclear centre for excellence should be established in either Alberta or Saskatchewan.

7. More research and development money needs to be dedicated by governments and the nuclear industry for recycling nuclear waste into reactor fuel.

8. The governments of Alberta and Saskatchewan should encourage their post-secondary institutions to establish educational programs in the areas of nuclear science. In particular, the Universities of Alberta and Saskatchewan should be encouraged to develop undergraduate programs in nuclear engineering and nuclear physics, and NAIT, SAIT, and SIAST should be encouraged to create nuclear technician diploma programs.

9. The federal government, through the CNSC, should create two different types of regulatory processes for nuclear facilities: 1) a streamlined process for the expansion of pre-existing nuclear facilities (like adding a second reactor at Point Lepreau); and 2) a comprehensive process for brand new nuclear facilities (like the proposed four reactors at Peace River).

10. The federal government should monitor, and learn from, other jurisdictions (United States, France, Australia, etc.) in how they regulate their nuclear industry.

Abstract

This paper examines the economic, political, technological, and environmental opportunities and challenges to developing/ expanding the use of nuclear power in Alberta and Saskatchewan. It makes explicit comparisons to other energy sources and to jurisdictions in other parts of Canada and around the world. The opportunities include: increasing international economic competitiveness by participating in the global nuclear revival, establishing nuclear R & D on the Prairies, meeting growing electricity demand, mitigating climate change, lessening the dependence on natural gas, and increasing uranium exports. Challenges include: nuclear safety, nuclear waste, nuclear education and public opinion, proliferation and terrorism, human resources, electrical grid capacity, regulation, cost overruns, and government funding. On balance, the opportunities outweigh the challenges with regard to the expansion/development of nuclear power in Alberta and Saskatchewan. The report's public policy recommendations would allow the governments of Alberta and Saskatchewan to properly maximize the opportunities presented by the expansion/development of nuclear power in their provinces.

1. Introduction

The world is in the midst of a nuclear revival. Nuclear reactors are being planned and constructed at record rates across the globe. China and India are poised to lead the way, but they are being joined by Europe, South America, Japan, the United States and Canada. The International Atomic Energy Agency (IAEA) estimates that 75-300 new reactors will be built by 2030 (International Atomic Energy Agency 2007). This revival is due to four vectors coming together at the same time: 1) the substantial rise in the global demand for electricity; 2) the need to replace or refurbish the reactors that were built in the 1960s and 1970s; 3) the increased attention placed on the problem of greenhouse gases (GHGs) contributing to climate change; and 4) the need to diversify electricity supply away from fossil fuels.

Canada is part of this revival with both Ontario and New Brunswick planning to expand their existing reactor fleets. These traditional locations of Canada's nuclear industry may be joined by some of the western Canadian provinces.

Saskatchewan is already one of the world's largest uranium suppliers, and there are tremendous export opportunities for uranium. In addition, Saskatchewan is considering ways to move up the nuclear fuel cycle to include not just mining, but also uranium processing, reprocessing, and enrichment. Finally, Bruce Power, with the full support of the provincial government, is conducting a feasibility study to determine whether to build two 1,000 megawatt reactors in Saskatchewan.

Without a doubt, Saskatchewan has become the most nuclear-friendly province in Canada. Premier Brad Wall has stated: "we would like to lead. It's time for the country to have a national vision on nuclear energy—and we want to aggressively pursue that" (Howlett 2008). When the opposition NDP was in power it was similarly pro-nuclear. In a 2004 speech at the World Nuclear Association annual symposium, former NDP Premier Lorne Calvert said that "as the demand for uranium fuel rises there would be an increased need for uranium refining and we would welcome further private investment in the province" (Harding 2007, 225). (1)

In the case of Alberta, hitherto virgin territory for nuclear power, Energy Alberta Corporation (EAC), a small firm headed by two prominent Alberta-based entrepreneurs (Wayne Henuset and Hank Swartout), began to investigate the possibility of building nuclear reactors in Alberta in 2005. In the spring of 2007, with an exclusivity contract in hand with Atomic Energy of Canada Limited (AECL), they submitted a site license to the Canadian Nuclear Safety Commission (CNSC) for a twin ACR-1000 megawatt reactor on the shore of Lac Cardinal just outside of Peace River. In late 2007, EAC sold out to Bruce Power, the largest nuclear operator in Canada, which subsequently revised the site application to include four 1,000 megawatt reactors. Notably, the exclusivity with AECL was ended, and the bid process was opened up to include three other firms: Areva, General Electric-Hitachi, and Westinghouse. This $10 billion project, if approved, would see construction beginning in 2012, and producing electricity by 2017.

In response to these developments, the Alberta government, in April 2008, appointed an expert panel, headed by former federal Conservative Cabinet Minister Harvey Andre, to prepare a comprehensive report on nuclear power in Alberta. This panel would examine: environmental, health and safety issues; waste management; comparing nuclear energy with other electricity generation technologies; current and future nuclear power generation being used in Canada and around the world; Alberta's future electricity needs; and social issues/concerns related to nuclear energy. The panel's report, which is intended to provide the basis for future public discussions, is due in the fall of 2008 (Government of Alberta 2008).

This paper examines the economic, political, technological, and environmental opportunities and challenges to developing/expanding the use of nuclear power in Alberta and Saskatchewan. The focus of this report is on the middle two western Canadian provinces because the other two western provinces do not seem to have an interest in nuclear power. Manitoba does not need nuclear because it has a huge hydroelectric capacity and the likelihood of British Columbia choosing the nuclear option seems remote given the large anti-nuclear sentiment in the province. The BC government has even taken steps to prevent nuclear development by renewing a lapsed 1980 moratorium on uranium exploration and development in the province (Stueck 2008). This report makes explicit comparisons to other energy sources and to jurisdictions in other parts of Canada and around the world. It concludes with a list of public policy recommendations.

2. Opportunities

The development/expansion of nuclear power in Alberta and Saskatchewan would contribute to the international economic competitiveness of those provinces. The global nuclear revival will see increased employment in the design, construction, operation, and maintenance of nuclear reactors, as well as uranium mining, processing, reprocessing, and enrichment. The only way that Alberta and Saskatchewan would be able to participate in the global nuclear revival is if they themselves became part of Canada's nuclear industry. Previous Canadian export opportunities (India, Romania, Argentina, China, South Korea) predominantly benefited the province of Ontario with lesser benefits accruing to companies across Canada as well as to the federal government. Ontario will continue to play an international nuclear role, as will New Brunswick, which has established a nuclear centre of excellence and is planning to build a second reactor, primarily for electricity exports to the

New England states, but also for local consumption. If Alberta and Saskatchewan do not establish a foothold in the nuclear industry now, they will be left behind as Ontario and New Brunswick exploit national and international opportunities.

Related to the above point is the fact that the nuclear industry is a high-tech field—one of the few high-tech fields in which Canada (primarily Ontario) is among the global leaders. Do the prairie provinces want to stay at the level of primary resource extraction (oil, gas, uranium) or move toward more technologically advanced economic *production* (reactor design/building/maintenance, uranium reprocessing, etc.)? Given its large pockets of uranium, Saskatchewan, in particular, could greatly benefit from uranium upgrading such as conversion, reprocessing, and enrichment. It could join the United States, Russia, and France, which have an oligopoly on the world's uranium upgrading. The benefits to Saskatchewan of the current situation of exporting natural uranium to Ontario or France for conversion and reprocessing are limited.

High-tech sectors also create the conditions for technological spin-offs. Thus, investment in nuclear power allows for the possibility of participation in new high-tech industries. Previous spin-offs from nuclear research and development include medical isotopes, flight simulators, food irradiation, vibration technology, and cooling systems. Future technological advances may be in energy (nuclear fusion, hydrogen, recycling used fuel, etc.), but others may be in totally unrelated areas. However, if Alberta and Saskatchewan do not have a presence in the nuclear industry, they will be left outside watching the US, Russia, China, France, India and Ontario develop new technologies in new economic sectors.

Prairie Opportunity 1: Centre of Excellence

Lessons can be learned from New Brunswick where there are two major nuclear projects that are either being undertaken or at the planning stages. First, there is the very first refurbishment project on the Point Lepreau CANDU 6 reactor. Refurbishment involves greatly extending the life cycle of existing nuclear reactors through re-tubing and other upgrades. Second, there are feasibility studies being completed by both the New Brunswick government and a nuclear consortium of private sector firms (called Team CANDU) to build a second reactor (the ACR-1000) at the Point Lepreau site. This new reactor would furnish electricity for New Brunswick, the other maritime provinces, Quebec, and the New England states. To help leverage this activity, the New Brunswick government convinced AECL to establish a centre of excellence in Saint John.

This centre of excellence means the relocation of nuclear scientists and engineers from Ontario to New Brunswick to conduct research and development. New Brunswick officials believe that AECL's decision will spur on the private sector firms in Team CANDU to similarly move some of their operations to Saint John creating a nuclear cluster. In fact, one of the reasons that Team CANDU was chosen for the project, instead of Areva, was its willingness to conduct research and development in the province instead of just building a reactor. (2) In fact, the New Brunswick strategy is exactly what Saskatchewan is pursuing. Saskatchewan Premier Wall has said that "we're going to continue to make the case that this ought to be the place for a nuclear research centre of excellence" (Regina Leader-Post 2008).

Prairie Opportunity 2: Meeting Electricity Demand

A second opportunity is that nuclear power can be used to help meet the growing electricity demand in Alberta and Saskatchewan. According to the Alberta Electric System Operator (AESO), Alberta needs another 6,650 megawatts of electricity by 2024. This is a 75% increase. The surge in electricity demand is due to three factors: an increase in population; the increased use of electricity in the production of other energy fields (most notably oil and gas); and the expected shut-down of coal plants that contribute to greenhouse gas emissions. AESO's long-range planning saw them model a number of different scenarios and many of them included nuclear power in their projected electricity generation (Alberta Electric System Operator 2007).

Prairie Opportunity 3: Mitigating Climate Change

A third opportunity is the role that nuclear power can play in mitigating the problem of climate change. Alberta is Canada's largest producer of greenhouse gases. Despite having only 10% of Canada's population, Alberta produces 31% of its GHG emissions (Simpson *et al.* 2007). Currently, Alberta produces about 23 million tones of GHGs per year. Because of the expansion in oil sands production, Alberta is also the fastest growing source of GHGs in Canada. Without new technology, the oil sands will emit 156 million tones of GHGs by 2015 (Simpson 2007). Saskatchewan is not immune from the problem of GHGs; it is the second fastest growing emitter, exceeded only by Alberta.

Since nuclear power does not emit greenhouse gases (although there are small emissions from the entire fuel cycle), a move toward greater utilization of nuclear power is better for the environment. Using a life cycle comparison (mining and processing, construction of facilities, waste management, etc.), nuclear power's GHG emissions are comparable to renewables, but are immensely better than conventional fossil fuels (see Figure 1).

Figure 1: Greenhouse Gas Intensity by Electricity Options (grams of CO2-equivalent/kWh)

	Greenhouse Gas Intensity	
	Estimate	Likely Range
Electricity Technology		
Hydro	15	6.5-44
Wind	21	13-40
Nuclear	62.5	10-125
Solar	106	53-217
Natural Gas	664	491-891
Coal	993	774-1,506

Source: McLellan 2008, 16.

The development/expansion of nuclear power on the Prairies would have both domestic and international benefits in the response to climate change. Domestically, nuclear reactors in both Alberta and Saskatchewan are being considered as a replacement for coal and gas plants that are major emitters of GHGs. Internationally, Saskatchewan, as a major uranium supplier, can help the environment by providing a cleaner fuel for the world's nuclear industry.

Today and for the foreseeable future, the basis of Alberta's (and to a growing extent Saskatchewan's) economy is oil and gas. The major challenge facing the oil and gas economy is climate change. If the environmental problem of GHG emissions is not effectively dealt with, this could result in long-term damage to both Alberta's economy and its quality of life. Already, there are increasing warnings from a variety of high-level political actors in the United States about restricting imports of Canada's "dirty" oil. There are a number of environmental problems that nuclear power could help to mitigate: expanding electricity to meet Alberta's growing demand in a cleaner fashion, reducing GHG emissions by displacing dirtier electricity sources, and reducing GHG emissions in oil sands production. In short, the long-term international competitiveness of Alberta and Saskatchewan is jeopardized by climate change, and nuclear power offers some ways to reduce the threats posed by it.

A final comment on the link between climate change and nuclear power is needed. As governments around the world start to add a price to carbon emissions, the cost advantage of nuclear power over coal and gas plants begins to emerge. An influential study out of the Massachusetts Institute of Technology demonstrated that "nuclear does become more competitive by comparison if the social cost of carbon emissions are internalized" (Massachusetts Institute of Technology 2003, 7). This removes a major argument from the anti-nuclear forces who have traditionally maintained that nuclear power is too expensive. The fact that private firms, like Bruce Power, are the ones promoting the expansion of nuclear reactors shows that it realizes the economic advantage of nuclear power when the price of carbon is included.

Prairie Opportunity 4: More Natural Gas for Value-Added Applications

A fourth opportunity is the role that nuclear power can play in lessening Alberta and Saskatchewan's dependence on natural gas. Natural gas is valuable because it is a cheap, efficient, and relatively clean energy source. In addition, natural gas is a versatile resource that allows it to generate electricity, heat homes and businesses, and is a key ingredient in many petrochemicals. Finally, natural gas exports have contributed greatly to the economic prosperity of Alberta and Saskatchewan. In the case of Alberta, natural gas royalties amounted to $42.6 billion between 2000/2001 and 2006/2007 (www.energy.alberta.ca/OurBusiness/Gas.asp).

Unfortunately, we are starting to run out of natural gas. While there has been lots of discussion about peak oil, a more immediate concern, especially for Alberta, is the long-term supply of natural gas. David Hughes, of the Geological Survey of Canada, has argued that Canada's natural gas production peaked in 2001. Hughes, working with estimates from the National Energy Board, determined that at current production rates, Canada had only 9.4 years of proven reserves, 4.9 additional years of resources, and the possibility of 46.9 more years of undiscovered resources. Already gas production in Alberta is declining, and the rate of decline would be even worse were it not for the increased use of unconventional sources like coalbed methane and upgraded bitumen gas (Hughes 2008).

Nuclear power can help conserve the supply of natural gas in two major ways. First, it can replace natural gas as a source of electricity generation. Currently, 38.4% of Alberta's electricity and 22% of Saskatchewan's electricity is generated by natural gas (www.saskpower.com and www.energy.gov.ab.ca). Adding several thousand megawatts worth of electricity to the grid from nuclear would reduce the demand for gas-fired plants. Second, nuclear power could be used in the oil sands. In fact, the initial proposal of nuclear power was to place a nuclear reactor in Fort McMurray to extract and upgrade the bitumen in the oil sands. (3) After all, it takes about 1,200 cubic feet of natural gas (a cleaner fuel) for every barrel of bitumen (a dirtier fuel). The National Energy Board also predicts that "natural gas requirements for the oil sands industry are projected to increase substantially from 0.7 billion cubic feet per day in 2005 to 2.1 billion cubic feet per day in 2015." (National Energy Board 2008). Unfortunately, there were technical problems, especially with regard to the distance that steam produced by the reactor can travel, so the EAC/Bruce Power proposal changed to using nuclear power for pure electricity generation. This does not mean that nuclear power has no role in the oil sands as bitumen upgrading also requires electricity. Moreover, there are new technologies that are being developed that would separate bitumen through massive amounts of electricity instead of using natural gas. (4) The more that nuclear power can be used as an alternative to natural gas (electricity production and oil sands extraction) the longer that natural gas supplies can last. Since natural gas is a key component in the international economic competitiveness of Alberta and Saskatchewan, it makes sense to take steps to ensure the long-term supply of this valuable, but non-renewable, resource.

Prairie Opportunity 5: Increased Exports

A fifth opportunity is for Saskatchewan to increase its uranium exports to meet the growing demand for nuclear fuel. Canada (largely as a result of uranium mines in northern Saskatchewan) is the world's largest uranium producer, supplying 30% of the global demand, and in terms of proven reserves, Canada is third behind Australia and Kazakhstan. Like other commodities, there are great fluctuations in the value of Canada's annual uranium exports due to both demand and price. For example, in the 1997-2002 period, uranium exports were in the $700-900 million range, but in 2005-2007 they had climbed to between $4-5 billion (Statistics Canada 2007). Because of the currently high price of uranium, (5) there should be further exploration in northern Saskatchewan, perhaps even re-opening Uranium City, which was closed in 1982 due to the collapse of world uranium prices. Geologists are also discovering uranium pockets in the Athabasca Basin along the Saskatchewan border as well as central and southern Alberta, so there is an opportunity for Alberta to get involved in the front-end of the nuclear industry (Alberta Geological Survey 2008). An additional incentive to further exploration is the fact that in Australia, the other major uranium producer, "the governments of New South Wales and Victoria prohibit nuclear exploration and mining, while Queensland, Western Australia, South Australia, and the Northern Territory still have a 'no new mines' policy" (Australia 2006, 28).

While there are tangible economic benefits to increasing uranium exports, the global nuclear revival also offers Saskatchewan a chance to move up the fuel cycle. Instead of relying solely on uranium mining, Saskatchewan could be involved in more value-added uranium processing. This has been a long-standing goal of successive provincial governments going back to the 1970s. However, with the current global nuclear revival, the timing is right to further pursue this option. There are two major uranium mining companies, Cameco (Canadian-owned) and Areva (the majority stake is held by the French government), and both have their more advanced uranium facilities outside of Saskatchewan. Cameco refines, processes, and converts its uranium at facilities in Ontario (Blind River and Port Hope) and the United Kingdom. In the case of Areva, all refining, processing, conversion, and fabrication occurs at its facilities in France. (6) Saskatchewan, which sits at the front end of the fuel cycle, should attempt to add a conversion plant, a basic processing refinery for heavy water reactors, and a more advanced re-processing facility for light water reactors. A reprocessing facility is needed because the world's supply of highly enriched uranium, which was being taken from the decommissioning of American and Soviet nuclear weapons, is dwindling. Therefore, in five years time, there could be increased demand for slightly enriched natural uranium. To meet this demand Saskatchewan needs to build an enrichment facility.

On the issue of enrichment, Saskatchewan clearly wants a uranium enrichment facility built in the province. In fact, Cameco has already been investing in advanced US enrichment technology (Warrick 2008). There are a number of economic arguments in favour of acquiring an enrichment facility. First, the vast majority of nuclear reactors require enriched uranium for fuel, including the new ACR-1000, but there are very few enrichment facilities in the world. This means that regardless of the model chosen in the next round of reactor purchases in Canada, there will be a domestic demand for enriched uranium. Second, Saskatchewan wants to be in a position to take advantage of the growing export opportunities for enriched uranium because of the global nuclear revival. Finally, as is the case with conversion and reprocessing that was discussed above, there are economic benefits from going into the value-added field.

There are, however, a number of barriers that prevent Saskatchewan's entry into the enrichment field. Canadian uranium is currently enriched in the United States and France and those countries would not want to see additional competition. A second major political obstacle is the G8's decision, because of fears of nuclear weapons proliferation (see Iran and North Korea), to establish a moratorium on countries with enrichment technologies. The IAEA and the Global Nuclear Energy Partnership (GNEP) would like to have multilateral control of the entire nuclear fuel cycle including enrichment technology. (7) Canada needs to decide whether it wants an independent enrichment capacity or whether it accepts the goal of multilateral control of enrichment. If it decides to pursue enrichment, the Prime Minister could make a compelling case to the G8 by arguing that Canada is the world's largest exporter of uranium, a major player in reactor technology, and is a non-nuclear weapons state. In short, Canada is a responsible nuclear country, it is not Iran, and it should not be treated like Iran. If Canada was granted an exemption to the moratorium, it would remove the major political obstacle to Saskatchewan's pursuit of an enrichment facility.

Beyond the fuel cycle debate, Saskatchewan is starting to consider building its own nuclear reactors. In the early 1990s, AECL tried to market a small CANDU-3 for Saskatchewan, but this initiative died. The current proposal from Bruce Power is a twin 1,000 megawatt reactor that would be used either for electricity generation in Saskatchewan or for the oil sands across the border in Alberta. In contrast to the economic problems that Saskatchewan was suffering in the 1990s, the province is in the midst of an economic boom. This has increased the demand for electricity, but electricity that is clean and reliable. This high degree of economic growth, combined with the fact that Saskatchewan is the home of Canada's front-end uranium industry, make the possibility of a nuclear reactor quite realistic.

Australia is very similar to Saskatchewan in that it is the other major uranium producer and also lacks processing and enrichment facilities as well as power reactors. A 2006 Australian nuclear review taskforce noted that there are advantages to pursuing conversion, enrichment and fabrication technology, but was dissuaded by the challenges. "The commercial viability and international competitiveness of a new plant will depend on factors such as capital investment cost, operating costs, the ability to access technology on competitive terms, the state of the international market, access to the required skill base and regulatory environment and, in the case of enrichment, nuclear non-proliferation issues" (Australia 2006, 4). It concluded that Australia should focus on its core business of uranium mining, but that it should start to build power reactors because "nuclear power is the least-cost low-emission technology that can provide baseload power " (Australia 2006, 5). More recently, the newly-elected Australian Prime Minister Kevin Rudd dampened expectations that Australia would generate nuclear power by saying that "[w]e believe that we have a full range of energy options available to Australia beyond nuclear with which, and through which, we can respond to the climate change challenge and we are confident we can do it." (Radio Australia 2008).

If Australia has decided to pass on the opportunity to move up the nuclear fuel cycle, why should a similar jurisdiction like Saskatchewan do the opposite? This is because while Saskatchewan, like Australia, currently lacks the advanced nuclear technology and regulatory framework necessary to expand the industry, the rest of Canada does. There are already conversion and fabrication facilities in Ontario and power reactors in Ontario, Quebec, and New Brunswick. Moreover, the CNSC is a robust regulatory body with a skilled workforce and detailed operating policies and procedures. Australia, like Canada, is a federal state, but unlike Canada, the federal government does not have exclusive jurisdiction over nuclear materials. This has created a set of overlapping regulations throughout Australia. In addition, Australia would have to make some significant legislative changes if it was going to move beyond simply uranium mining. In short, Saskatchewan is better placed than Australia because of the absence of a number of technological, political, and legal barriers in its plans to advance along the nuclear fuel cycle.

3. Challenges

Challenge 1: Nuclear Safety

To fully exploit the above opportunities, political and business leaders need to successfully meet a number of challenges. The first challenge is nuclear safety. The safety record of nuclear power worldwide, and particularly in Canada, is very high, but there are concerns, related primarily to the accidents at Chernobyl and Three Mile Island, that continue to haunt the industry. In the case of Three Mile Island (1979), the reactor's safety features kicked in and shut down the reactor and its containment structure prevented the emission of large doses of radiation into the environment. Nobody died or was injured. Chernobyl (1986) was much more serious as it led to the death of 31 people within hours and radiation was spread across thousands of kilometres. The most authoritative study of Chernobyl, undertaken by eight UN agencies and the governments of Russia, Belarus, and Ukraine has indicated that 4, 000 deaths will ultimately be attributed to the accident (International Atomic Energy Agency 2005). However, the Chernobyl disaster was due primarily to a political and social culture in the former Soviet Union that did not emphasize safety. A sense of the uniqueness of the Chernobyl disaster is provided by the fact that the facility, incredibly, lacked a fully capable containment structure and the steam explosions occurred during a test where the reactor's safety system was turned off. It must be stated that these two nuclear accidents were over two decades ago; in contrast, coal mine disasters and pipeline explosions are still occurring at a rate of more than one per year. Experts in the United States, using Probabilistic Risk Assessment, have estimated that reactor core damage is likely to occur less than once in 10,000 reactor-years (Massachusetts Institute of Technology 2003). (A reactor year is one year of reactor operation. If you have 10 reactors that have each run for one year, then you have 10 reactor years.)

Nuclear power, more so than any other energy source, is heavily regulated to prevent and mitigate accidents. There are built in safety redundancies (the suspenders and belt approach) to ensure that the reactor is automatically shut down in the case of an accident. In addition, a major feature of all reactors is the containment dome which is designed to prevent the release of radiation. There are international efforts, led by the IAEA, to ensure reactor safety. For example, the 1996 Convention on Nuclear Safety established international safety standards maintained through a peer review system. The idea of peer review also led to the formation of the World Association of Nuclear Operators (WANO). The result of these initiatives is that nuclear power has a safety record that is better than any other major energy source (see Figure 2). The new Generation III+ reactors, including the ACR-1000, have even more enhanced safety features.

Figure 2: Comparing Fatal Accidents Across Energy Sources (1969-2000)

	Accidents	Direct Fatalities
Energy Source		
Coal	1,398	32,197
Oil	397	20,283
Natural Gas	125	1,978
Hydro	21	33,876
Nuclear Reactor	1	31

Source: Australia 2006.

The concern about nuclear safety is less about actual safety than it is about perceptions of risk. People tend to fear things that are unknown or where they lack control. However, these fears are not always rational. For example, air travel is fundamentally safer than automobile travel. This is due to the professionalism of pilots, the lack of traffic, constant safety checks of airplanes, etc. Nevertheless, there are many people who are scared of flying, in spite of its superior safety record, because they are not in control. Since the process of nuclear fission is so complex and difficult for laypeople to understand, it becomes more fearful than other energy sources. This is why there is a gap in support for nuclear power between scientists and the public. "In 2002, a survey of 865 American members of the American Association for the Advancement of Science (AAAS) and 1,332 members of AAAS in the then fifteen states of the European Union found that respondents considered the benefits of nuclear power to outweigh the risks" (Cravens 2007, 12). The best way of addressing nuclear risk perceptions is through a public education campaign (discussed below).

Challenge 2: Nuclear Waste

A second challenge is the issue of nuclear waste. The waste issue continues to be the Achilles heel of nuclear power. Nuclear power, like other energy sources, produces waste, but nuclear waste is highly toxic and radioactive. Moreover, because nuclear waste has very long half-lives, these health and environmental risks exist for tens of thousands of years. While there is a short-term solution for the storage of nuclear waste on-site, no long-term solution has been agreed upon. No country, including Canada, has successfully implemented a way for disposing of nuclear waste. It is true that Canada's Nuclear Waste Management Organization (NWMO) has brought in an "Adaptive Phased Management" process for nuclear waste disposal through the "isolation and containment of used nuclear fuel in a deep repository constructed in a suitable rock formation." However, a permanent site has not been selected, and, in fact, the NWMO is only at the stage of designing a process for site selection. Although the NWMO has a detailed process that has been approved by the federal government, it does not expect to have an operational nuclear waste facility for at least the next ten years (Nuclear Waste Management Organization 2008).

The issue of nuclear waste frequently becomes contaminated with emotion, overheated rhetoric, half-truths, and exaggeration. Therefore it is important to identify other key aspects of spent fuel nuclear waste. It is very small in volume compared to wastes created by many other industries or by burning coal for energy. On discharge from a CANDU, only about 1.1% of the fuel material can be viewed as waste (Tammemagi 2002). One reactor will generate about 30 tonnes of high-level waste per year. After over 40 years of power production, Canada's reactors have accumulated just over 2 million bundles of nuclear waste (each of which weigh about 24 kg and are the size of a fireplace log), enough to fill up "six hockey rinks from the ice surface to the top of the boards" (Nuclear Waste Management Organization 2008, 5). The waste is initially contained on-site in water filled storage pools. After five to seven years in the pools, the waste is then transferred to secure on-site concrete canisters which have an effective life of many decades. This means that, unlike coal, nuclear waste is not emitted into the atmosphere. Both CNSC and the NWMO estimate that nuclear waste can be safely stored on-site for several more decades. While the half-lives of some nuclear waste are very long, the most highly radioactive substances die out very quickly, and those with the least amount of radioactivity have the longest half-lives. Finally, since spent fuel retains much of its energy, the possibility of recycling nuclear waste means that the actual amount of waste can be further reduced. Right now, and in the near future, closed fuel cycles (the recycling of waste into fuel through fast breeder reactors) are substantially more expensive and have more weapons proliferation issues than "once through" fuel cycles (where spent fuel automatically becomes waste) (Massachusetts Institute of Technology 2003). Canada is not a potential weapons proliferator, but it does need to spend more research and development dollars on the recycling of nuclear waste to make it more cost effective and safer.

The popular discussion over nuclear waste often focuses on high-level waste from spent fuel, but uranium mining also produces waste. This needs to be discussed since it is expected that there will be a ramping up of uranium mining in Saskatchewan and Alberta. Of particular concern are uranium tailings, the sand-like material that is leftover after uranium is milled into yellowcake. The environmental risks associated with uranium tailings are ground and surface water contamination, releasing dust containing radionuclides, and a catastrophic failure in the tailings containment site (Pembina Institute 2007). It needs to be recognized that there are a number of important differences between spent fuel and uranium tailings waste. First, unlike spent fuel, the amount of waste generated from uranium is huge in volume. As of 2004, there were 214 million tonnes of uranium tailings in storage sites across Canada (Low Level Radioactive Waste Management Office 2004). Second, spent fuel rods are high-level nuclear waste, but uranium tailings are considered low-level waste. Low-level waste is substantially less dangerous because its radioactivity is lower and shorter-lasting. This means that unlike the problem of finding a permanent facility for high-level waste, uranium tailings are disposed of near the mill. A barrier made up of a material like clay is constructed on top of the tailings pile to prevent radon from escaping into the atmosphere. The tailings pile is then covered with soil, rocks or other materials to prevent erosion.

Nuclear critics argue that while climate change is indeed a major problem, nuclear power, because of the challenges of safety and waste, is not the answer (Winfield, et al. 2006). Instead, there should be greater reliance on renewable energy sources like solar and wind, combined with concerted efforts at conservation. There are, in fact, advantages with solar and wind power, and they should be part any province's energy mix. However, the problem with most nuclear critics is that they look at nuclear power in isolation. They do not produce a comprehensive cost/benefit analysis of all energy sources; instead they focus on the negatives of nuclear power and rarely look at its positive features. Instead of objectively looking at the cost/benefits of renewables; they simply claim that they (along with conservation) are the solution.

Renewable sources should be part of Alberta and Saskatchewan's energy mix, and, in fact, their use needs to increase. But, like all energy sources, there are a number of significant flaws with renewable energy sources. They cannot provide the sustained high base load of electricity that nuclear provides. Renewables also require backup power systems (nuclear, coal, or natural gas) for when the sun is not shining or the wind is not blowing. It also needs to be stated that, because of the substantially greater efficiency of nuclear power, it has a quantitatively smaller environmental footprint. Ausubel has measured the efficiency and environmental footprint of different energy sources (watts per square metre of land), and shows that the "extraordinary energy density of nuclear fuel allows compact systems of immense scale," that renewables like solar, wind, and biofuels cannot even come close to matching. For example, "a wind farm occupying about 770 square kilometres could produce as much energy as one 1,000 MWe nuclear plant," while a solar plant "would require about 150 square kilometres plus land for storage and retrieval (2007, 229-243)." The relatively smaller environment footprint of nuclear power is starting to be recognized by political leaders. For instance, Saskatchewan Environment Minister Lyle Stewart has noted that "we need to find energy solutions that have a small footprint on (the environment). We believe nuclear energy is a fit in that regard" Kyle 2008).

Challenge 3: Nuclear Education and Public Opinion

Due to the arguments presented by nuclear critics, any expansion, or even maintenance, of nuclear power is connected to education and public support. While Saskatchewan is quite familiar with the uranium side, Alberta has absolutely no experience with nuclear power. Therefore, the third challenge is for proponents of nuclear power in Alberta to prepare an extensive education campaign explaining a complex, and frequently misunderstood technology to government, business, and the public. Before selling its stake to Bruce Power, EAC was quite effective in the area of nuclear education. EAC had its people, and outside nuclear experts, do various media work and presentations to the public throughout the province. A particular selling job was done in the two candidate communities: Whitecourt and Peace River. One high-profile event involved taking the Peace River Council to New Brunswick to tour the Point Lepreau reactor. The Alberta Panel on Nuclear Power, with its public hearings across the province scheduled for summer/fall of 2008, will perform a similar educational function.

Related to the issue of nuclear education is public opinion. The development/expansion of nuclear power requires public support. Public attitudes concerning nuclear power have been tracked since the 1970s (for a series of Ipsos-Reid polls see http://cna.ca/english/studies.asp). Examining this data yields several conclusions. First, support for nuclear power across Canada has been slowly, but steadily, growing since the early part of the decade. Second, the level of knowledge of nuclear energy by the public is quite low; opinions about nuclear energy tend to be more emotional than rational. Third, places that already have nuclear power are more supportive than where it is being proposed. This was very evident in perceptions of nuclear safety. For example, support for nuclear power is highest in Saint John (with the Point Lepreau reactor nearby), Saskatchewan (with its uranium mines), and Durham county, Ontario (with their ten Pickering and Darlington reactors). Generally, in Ontario, the level of acceptance exceeds 60%. The NIMBY syndrome means that it is easier to add another reactor to an existing plant than to build a new plant. The fact that Albertans are slowly increasing their support for nuclear power, despite not having an existing nuclear foothold, shows that popular support for the industry is increasing (Angus Reid Strategies 2008).

Challenge 4: Proliferation and Terrorism

A fourth challenge is nuclear weapons proliferation and the possibility of nuclear terrorism. Alberta and Saskatchewan are not going to develop nuclear weapons, but there is a concern that a nuclear plant could be a target for a terrorist attack. Graham Allison, a prominent international relations expert at Harvard University, has written about the different ways that nuclear terrorism could occur. Those most relevant to nuclear power plants (as opposed to the security of nuclear weapons) include: planes hitting the containment domes or the storage site for spent fuel rods; fires at a nuclear power plant to disperse radiation; conventional explosives combined with radioactive material to produce a "dirty bomb"; and stolen spent fuel waste that could be separated to make a nuclear weapon (Allison 2005).

The terrorist fears that Allison documents in great detail are indeed scary, but in the case of Canadian nuclear facilities, he has greatly exaggerated the threat. With respect to the theft of weapons-grade materials, a traditional CANDU uses natural uranium as its fuel (0.7% U-235) and the ACR-1000 or a light water reactor (LWR) would use slightly enriched uranium (U-235 that is enriched to around 3-5%). Even with the use of low enriched uranium, it is still a long way from the highly enriched uranium (U-235 that is enriched above 20%, usually fully enriched to 98%) that is used for nuclear weapons. If spent fuel from a LWR or ACR-1000 was stolen, it would also require elaborate separation technology to convert it to the highly enriched uranium that is needed for a nuclear bomb. A further deterrent to theft is the fact that a terrorist group would have to steal about 100 spent fuel bundles to acquire enough reactor-grade plutonium to convert into a bomb and deal somehow with the deadly irradiation field surrounding the bundles. As Whitlock has pointed out, "this would require 100 spent fuel bundles, weighing two tonnes without shielding. Not only would the theft be extremely difficult, but since it would also be easily and quickly detected, it would be followed by the necessary evasion of a top-priority manhunt employing most likely the full resources of the country's security infrastructure" (Whitlock).

Fears about terrorist attacks also ignore the fact that there are stringent safeguards, enforced by the IAEA, on nuclear facilities. Even prior to 9/11, nuclear plants represent hardened targets and already had strong security forces in place. The containment structure, part of the defence-in-depth strategy for reactor safety, is simultaneously also a very effective defence against sabotage or terrorism. In the 1980s, Ontario Hydro determined that even in the extremely unlikely event that a 747 jumbo jet was able to successfully hit a CANDU plant, there would be no significant damage due to the facility's very thick reinforced concrete and steel roofs and walls. The pool water that immerses the spent fuel rods would act as an additional security barrier from falling debris. Finally, all reactors are designed to automatically shut down in the event of a physical attack (Rossin 2005).

After 9/11, the IAEA and domestic nuclear regulatory agencies, including the CNSC, increased their already tough guidelines related to the security of nuclear facilities. The IAEA held a major conference in October 2001 and undertook, with the cooperation of its member states, an action plan designed to prevent nuclear terrorism that emphasized physical protection of nuclear materials (International Atomic Energy Agency). As part of this action plan, the 1980 *Convention on the Physical Protection of Nuclear Material* was amended. The CNSC, as part of its support of the IAEA's action plan, also amended its *Nuclear Security Regulations* to include the following provisions: better threat and risk assessment; a permanent on-site armed response force at major nuclear facilities; enhanced security screening of employees and contractors; enhanced access control to nuclear facilities (including reactors, uranium refineries, fuel fabricators); design basic threat analysis for nuclear facilities; uninterrupted power supplies in place for alarm systems; and contingency planning involving drills and exercises. The CNSC monitors licensees to ensure that they are compliant with these new enhanced security regulations (Canadian Nuclear Safety Commission 2007 and 2008c). In short, if the possibility of major radioactivity or weapons proliferation because of a terrorist act against a nuclear power facility was remote prior to 9/11, the steps taken by the world's nuclear community in the last few years have made it even more remote.

Challenge 5: Human Resources

A fifth challenge is the labour force in Alberta. The labour crunch affects the proposed reactor project in two ways. The first, a shortage of construction workers and support resources (motels, restaurants, retail, etc.), is common across all mega-projects in Alberta. This means that building a reactor in Alberta will likely be more expensive, and possibly even take longer, than it would in other jurisdictions. However, a nuclear project faces a second, and more unique, challenge. Alberta lacks many of the highly skilled and specialized workers that are needed to operate (and regulate) nuclear reactors. When EAC was developing its proposal for a twin ACR-1000, they estimated that to properly operate the reactors they needed 150 highly trained nuclear engineers, scientists, and physicists. These positions would require, at a minimum, a university degree in a nuclear field, and in some cases, post-graduate degrees. A further 720 reactor operators, mechanical and electrical maintenance workers, chemists and chemical technicians, physics and radiation technicians, and other managers would be needed. Many of these positions would require 2 or 3 year specialized technical diplomas (8). These estimates were for a twin ACR-1000, but when Bruce Power revised the bid by doubling the number of reactors, it is obvious that even more skilled workers would be required. Throw in the possibility of a twin reactor in Saskatchewan and the demand goes even higher.

Where are these nuclear workers going to come from? There is no university in western Canada that has a nuclear engineering program. Recruiting from other parts of Canada will be difficult because there is an overall shortage of skilled nuclear workers. Duncan Hawthorne, President of Bruce Power, has admitted that "the industry has not been doing any long-term planning for a number of years, either in terms of investing in the assets or the people. As a consequence of that, we haven't been refreshing the work force" (Howlett 2006). (9) Simple attrition through retirement is one cause of the nuclear skills shortage, but the problem is greatly compounded because both Ontario and New Brunswick are also expanding their nuclear fleet. Recruiting foreign workers will be just as difficult because the global nuclear revival has placed a great demand on nuclear engineers and scientists. An IAEA study identified a deterioration in the size of the nuclear workforce in China, Germany, Russia, the United Kingdom, and the United States. To deal with this growing knowledge gap, the IAEA has established a *Knowledge Management Programme* that will "focus the attention of governments on the need to preserve nuclear knowledge and accumulated experience; render assistance in implementing knowledge management programmes; and maintain a knowledge base and create and carry out special projects on the retention of knowledge in critical areas" (Yanev 2007). The legacy of the A.Q. Khan network may also lead Ottawa to impose restrictions on foreign scientists (particularly from certain countries) working in the Canadian nuclear industry.

Simply put, a "made in the prairies" solution is required. However, there is some good news. Given the 8-10 year lag time that exists between project submission and a reactor coming on-line, there is time to get some local university and technical programs established. The University of Alberta, because it already has a slowpoke research reactor on campus, would be the obvious candidate to develop programs in nuclear engineering and nuclear physics. The University of Saskatchewan, which already offers some graduate courses in nuclear physics and is establishing a new multidisciplinary Centre for Energy Strategies based in its engineering department, would do the trick in Saskatchewan. The Northern Alberta Institute of Technology (NAIT), the Southern Alberta Institute of Technology (SAIT), and the Saskatchewan Institute of Applied Science and Technology (SIAST) should all be encouraged to create nuclear technician diploma programs. Encouraging Alberta and Saskatchewan's post-secondary institutions to establish nuclear programs of study can only come from the provincial governments, but there are ways that the nuclear industry can provide support. For example, in New Brunswick, AECL has partnered with New Brunswick Community College to promote the nuclear industry and introduce career opportunities. This has involved scholarship programs and the hiring of recent graduates (Atomic Energy of Canada Limited 2008).

Challenge 6: Grid Capacity

A sixth challenge is Alberta's electrical grid capacity. (10) It was noted in the opportunities section, that Alberta requires a substantial increase in electricity, but this increase cannot be currently absorbed by the electrical grid. Don Lowry, the President of EPCOR Utilities, has warned that due to a shortage of new transmission lines, "it will only be a matter of time before there is a catastrophic failure" in the Alberta electricity transmission system (CBC News 2008). It is true that the issues with the grid are independent of the energy source; whether the supply comes from nuclear, coal, or natural gas, an upgrade of Alberta's transmission system, as AESO has recommended (Scotton 2008), needs to occur. That being said, building a 4,000 megawatt facility in an isolated north-central locale like Peace River, as Bruce Power is proposing, would increase the transmission requirements and expense because of the distance.

Challenge 7: Regulation

A seventh challenge is around government regulation of the nuclear industry. The very first issue is determining the areas of federal and provincial responsibility. Nuclear power is in federal jurisdiction (administered by CNSC), but there are other related aspects, like transmission lines and water usage, that are in provincial jurisdiction. Since nuclear power in Alberta, as opposed to Saskatchewan, is a new proposition, sorting out the relationships between different federal and provincial departments, as well as regulatory bodies like the CNSC and the Alberta Utilities Commission, will take some time. There is a distinct possibility of intergovernmental hostility. This is because some officials from Alberta's Department of Energy have privately speculated that the province may be reluctant to pursue nuclear power because it involves federal jurisdiction. (11) Federal jurisdiction over Alberta's energy resources has a very long and difficult history. This was best seen in the province's fight to acquire control over natural resources in the 1905-1930 period and its battle over the introduction of the National Energy Program in 1980. That being said, the potential benefits of nuclear power in Alberta should not be sideswiped by intergovernmental turf wars. Alberta can take some cues from how Ontario and other nuclear provinces have sorted out their roles and responsibilities, but there will be a learning process among federal and provincial bureaucrats.

The other major regulatory issue is the amount of time that a nuclear project takes from initiation to completion. There are five separate steps that require approval from the CNSC: 1) licence to prepare site; 2) licence to construct; 3) licence to operate; 4) licence to decommission; and 5) licence to abandon. In addition, prior to any of the licensing steps, an Environmental Assessment must be successfully completed (Canadian Nuclear Safety Commission 2008a). The Environmental Assessment alone can take three years. This elaborate process explains why it takes over a decade before a nuclear reactor can go on-line. Canada has a lot to learn from other countries where the regulatory process is much smoother. For example, the United States Nuclear Reactor Commission (NRC) has combined two steps (construction and operation) into one (United States Nuclear Regulatory Commission 2007). The United Kingdom has also streamlined its regulatory process to attract investment in nuclear energy (United Kingdom Department for Business Enterprise and Regulatory Reform 2008). Barclay Howden, Director General of Regulatory Improvement and Major Projects Management for CNSC, has acknowledged that "with the industry looking like it's going into a renaissance and expanding, the CNSC has to do a better job in planning to deal with all of these applications that are coming in" (Wood 2008). In fact, there have been recent steps to do some pre-licensing. In the federal government's 2008 budget, they allocated $300 million for the CNSC to begin the process of pre-licensing the ACR-1000 (McCarthy 2008a).

David Martin, Energy Co-ordinator of Greenpeace, has correctly warned that "there's huge pressure from the industry to speed up the process, to minimize the public involvement and regulatory review that takes place, to make them quick and dirty" (Wood 2008). Therefore, while the removal of red tape is a desirable goal, governments still need to keep in mind the fundamental role that regulation plays in ensuring public health and safety. Maintaining this balance should be the goal of government.

Ottawa has taken some steps toward simplifying the process by establishing the Major Project Management Office which will streamline the regulatory process for nuclear power and other large resource projects. However, Ottawa also needs to identify ways that it can streamline its regulatory approval in ways that do not jeopardize public safety. One possibility is to have two types of processes: 1) a streamlined process for the expansion of pre-existing nuclear facilities (like adding a second reactor at Point Lepreau); and 2) a comprehensive process for brand new nuclear facilities (like the proposed four reactors at Peace River).

The final aspect of nuclear regulation that needs to be addressed is the dispute between AECL and CNSC over the Nuclear Research Universal (NRU) reactor at Chalk River, Ontario that burst into public consciousness in December 2007 after brewing for several years. This is a very complicated issue that affects many different aspects of nuclear power in Canada and will have a long legacy. However, for our purposes here, the discussion will remain restricted to the regulatory impact upon nuclear power in Alberta and Saskatchewan. The NRU reactor, which had been built in the early 1950s, was used to produce medical isotopes. CNSC had shut down the NRU reactor in November of 2007 over the non-compliance of its safety requirements. It needs to be stated that the issue was not public safety– it was a dispute over whether an emergency backup safety system could withstand a hypothetical earthquake scenario– but whether AECL was operating the NRU within its licensing framework. On December 10, 2007, during an emergency session of Parliament, the reactor was re-opened for medical isotope production. In the aftermath of this decision, Linda Keen, the President of CNSC, was subsequently fired by Natural Resources Minister Gary Lunn.

The public relies on the CNSC to certify that nuclear facilities are safe. However, the firing of Linda Keen potentially jeopardizes the credibility of CNSC. It is one thing for a Cabinet Minister to resolve a scientific dispute between two acknowledged nuclear expert groups (AECL and CNSC), but it is quite another thing to then fire one of those experts for "speaking truth to power." Independent quasi-judicial administrative tribunals, like CNSC, must be truly independent of government interference. Just prior to her firing, Keen publicly released a set of correspondence between herself and Minister Lunn (Canadian Nuclear Safety Commission 2008b). In these letters, Keen emphasized that "while the CNSC reports through you to Parliament, neither the CNSC nor its President are obliged to report to you on the status of particular licensing matters before the CNSC." She also reminded Lunn that a "fundamental element of independence of quasi-judicial bodies like the CNSC is security of tenure for members," but, in her case, "the threat of removal is entirely and exclusively based on an assessment of the steps taken– or not taken– by the CNSC in respect of the extended shutdown of the NRU reactor." Based on this precedent, if, in the future, the CNSC declares that nuclear facilities in Alberta and Saskatchewan are operating in a safe fashion, how can the public be sure that this is not due to political interference as opposed to expert judgement?

Talisman International, an American consulting firm with extensive experience in nuclear regulation, was commissioned by AECL and CNSC to deliver a lessons learned report (Talisman International 2008). Talisman, whose terms of reference asked it to focus on process and procedures and not individual shortcomings, identified communication problems and unclear licensing conditions. Blaming both sides, Talisman made a number of detailed short-term and long-term recommendations in the areas of operating licence, commitment management, communications, licence renewal, assessing interim operation, probabilistic safety assessment, enforcement, regulatory compliance, modification management, project management, work management, corrective action program, self-assessment, and oversight. If these recommendations are implemented, and both AECL and CNSC have accepted the report in its entirety, this will substantially strengthen Canada's regulation of its nuclear industry.

Challenge 8: Costs

The eighth challenge is the legacy of past cost overruns in the building of nuclear reactors. It is commonly pointed out that the reactors that were built in Ontario in the early 1980s had billion dollar cost overruns. However, there were a number of extenuating circumstances. First, the early 1980s saw interest rates hitting 18-20%. With interest rates at that level, all types of projects would see their budgets inflated, not just nuclear reactors. Second, the Ontario government kept starting and stopping the project creating obvious delays which translated into massive cost overruns. Third, cost overruns occur in most construction projects. If there are cost overruns in home renovations, why is it surprising that there are cost overruns in a multi-billion dollar nuclear project? It is difficult to accurately forecast the cost of a project a decade into the future because of the vagaries surrounding labour costs, interest rates, supply costs, additional regulatory requirements, and other inputs. Fourth, these reactors were built by Ontario Hydro (a provincial utility) and the current projects in Alberta and Saskatchewan would be built by Bruce Power (a private sector firm). While the private-public comparison does not end the possibility of cost overruns, in general, private sector firms have better fiscal management skills than Crown corporations. More importantly, the governments of Alberta and Saskatchewan could take steps to ensure that Bruce Power, and not the public, would be on the hook for any additional costs.

Even though Bruce Power will be using an open bid process for its reactor projects on the Prairies, AECL is a leading contender because it is the only Canadian firm and has had a historic monopoly over the Canadian market. As a result, it has undergone the most public scrutiny of its record on completing projects on-time and on-budget. Critics of AECL point out the substantial cost overruns not just with the Darlington reactors but also the MAPLE reactors. The MAPLE reactors were two 10-megawatt reactors designed to replace the NRU reactor in the production of medical isotopes, but the MAPLE reactors were several years late making it a contributing factor to the CNSC-AECL dispute over the NRU (Office of the Auditor General of Canada 2007). Eventually the entire MAPLE project was cancelled after hundreds of millions of dollars had been spent (McCarthy 2008b). AECL and SNC-Lavalin recently requested Ottawa's assistance in covering any potential cost overruns in their efforts to win the bid for two new reactors in Ontario (McCarthy 2008c). These events, and especially the MAPLE debacle, put a major question mark on AECL's ability to deliver on-time and on-budget. AECL has correctly argued that there are big differences between a 10 megawatt reactor for medical isotopes and a 1,000 megawatt CANDU power reactor, there is a functioning MAPLE reactor in South Korea, and the last seven CANDUs were completed on-time and under budget in South Korea, China, and Romania. However, these are nuances that may well be missed by politicians and bureaucrats as well as the general public. To them, the question is whether AECL has the management and technical ability to get its projects done on-time and on-budget in Canada. The MAPLE issue has also given the anti-nuclear movement a lot of ammunition, which will put pressure on political leaders. It does need to be said that AECL is not the only nuclear vendor with these types of problems. For example, Areva's completion of its generation III+ reactor in Finland has been pushed back two years to 2011 at a cost in the hundreds of millions of dollars. This delay in Finland, as admitted by Areva, is due to a combination of Areva's unfamiliarity with the Finnish regulator, difficulty of establishing a local supply chain with the appropriate nuclear qualifications, and general project management difficulties (World Nuclear News 2007).

Challenge 9: Government Funding

A final challenge surrounds government funding of the nuclear industry. The notable feature of the Alberta and Saskatchewan reactor proposals is the reliance on private entrepreneurs. Perhaps this could come in the form of a Green Plan or economic diversification. Or it could be an upgrade of physical infrastructure like electrical grids. The Saskatchewan government is lobbying for a uranium processing and enrichment facilities, but is it willing to help fund or subsidize projects? What incentives will it provide companies such as Areva or Cameco to invest in the province? Anti-nuclear groups pay very close attention to public funds in the nuclear industry and make it a fundamental plank in their public relations strategy. (12) But government funding is not necessarily a bad thing, nor is it unique to the nuclear sector. For example, would government money that led to a reduction in GHG emissions by replacing coal with nuclear be wrong? It is for this reason that the MIT study recommended a tax credit for private sector investors who successfully build new carbon-free technologies including nuclear plants (Massachusetts Institute of Technology 2003). Similarly, would government funding that helped to diversify the economy by bringing in higher paying jobs be wrong? The issue should not be whether government money is involved; it should be assessing the extent to which society benefits both economically and socially from government incentives to business. Governments of all stripes in Canada (and for that matter across the world) frequently offer tax breaks, interest free loans, and other financial incentives to private businesses. This is especially true in the high tech sector where firms like General Motors and Bombardier have all benefited from industrial policies that involve government largesse. Again, the pros and cons of these strategies can be debated, but the debate should not become fixated on only one sector.

4. Policy Recommendations

On balance, the opportunities outweigh the challenges with regard to the expansion/development of nuclear power in Alberta and Saskatchewan. The economic and environmental benefits make the case for nuclear power a compelling one. In addition, while the challenges to nuclear power are not unimportant, they can be refuted with comparisons to other energy sources (safety and waste) or can be minimized with appropriate strategies for addressing terrorism, labour force issues, regulations, public education, cost overruns, and government subsidies. The purpose of the following recommendations is to allow the governments of Alberta and Saskatchewan to properly maximize the opportunities presented by the expansion/development of nuclear power in their provinces.

- The governments of Alberta and Saskatchewan should support the expansion of the nuclear industry in their two provinces.
- To meet the growing global demand for nuclear fuel, the governments of Alberta and Saskatchewan should encourage more uranium exploration.
- The governments of Alberta and Saskatchewan should take a "technology neutral" position on the type of reactor that could be built in Alberta and/or Saskatchewan. The decision should be based on the best possible technology, lowest long-term economic cost, and additional economic spin-off benefits.
- The government of Saskatchewan should strongly encourage the private sector to invest in nuclear processing, fuel fabrication, and enrichment facilities in the province.
- The government of Saskatchewan should convince Ottawa to get an exemption for Canada from the G8 moratorium on uranium enrichment technology.
- A western Canadian nuclear centre for excellence should be established in either Alberta or Saskatchewan.
- More research and development money needs to be dedicated by governments and the nuclear industry for recycling nuclear waste into reactor fuel.
- The governments of Alberta and Saskatchewan should encourage their post-secondary institutions to establish educational programs in the areas of nuclear science. In particular, the Universities of Alberta and Saskatchewan should be encouraged to develop undergraduate programs in nuclear engineering and nuclear physics, and NAIT, SAIT, and SIAST should be encouraged to create nuclear technician diploma programs.
- The federal government, through the CNSC, should create two different types of regulatory processes for nuclear facilities: 1) a streamlined process for the expansion of pre-existing nuclear facilities (like adding a second reactor at Point Lepreau); and 2) a comprehensive process for brand new nuclear facilities (like the proposed four reactors at Peace River).
- The federal government should monitor, and learn from, other jurisdictions (United States, France, Australia, etc.,) in how they regulate their nuclear industry. ☐

Endnotes

1. Jim Harding, and other Saskatchewan anti-nuclear critics, have often derided the NDP (under previous governments of Tommy Douglas, Allan Blakeney, and Roy Romanow) as the "Nuclear Development Party."

2. Interviews with Claire Lepage, Deputy Minister, Department of Energy, New Brunswick Government and Stephen Waycott, Director of Electricity, Department of Energy, New Brunswick Government, June 2, 2008.

3. Confidential interview with Energy Alberta Corporation official, July 2007.

4. Confidential interview with Alberta Department of Energy official. Edmonton. February 2008.

5. In 2008, the price of uranium has fluctuated between $87-95. In contrast, in 2000 the price had bottomed out at $9 a pound. See www.cameco.com/investor_relations/ux_history/complete_history_long_term.php.

6. Both companies are planning new enrichment facilities, but not in Saskatchewan. Areva is planning a centrifuge enrichment facility in Idaho and Cameco has joined a consortium that may build an enrichment plant based on SILEX laser separation technology in North Carolina. See "AREVA Selects Bonneville County, Idaho, for its U.S. Uranium Enrichment Facility" (May 6, 2008) http://www.areva-np.com/scripts/press/publigen/content/templates/show.asp?P=924&L=US&SYNC=Y and "Cameco Joins GE Hitachi Enrichment Venture" (June 20, 2008) www.cameco.com/media_gateway/news_releases/2008/news_release.php?id=230

7. The future of the GNEP is in doubt because the US Congress recently cut its contribution to zero. World Nuclear News, "Yucca funded, GNEP 'zeroed'" (June 26, 2008).

8. Confidential interview with Energy Alberta Corporation official, July 2007.

9. The University of Ontario Institute of Technology in Oshawa is now graduating about 50 nuclear engineers a year, and expect this number to grow. Thanks to Dan Meneley, the Acting Dean of the Faculty of Energy Systems and Nuclear Science at the UOIT, for pointing this out to me.

10. Saskatchewan is in a much better situation than Alberta. See Saskatchewan Power 2002.

11. Confidential interviews with Alberta Department of Energy officials, February 2008.

12. One obvious example is Martin 2003.

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A leading source of strategic insight, conducting and communicating non-partisan economic and public policy research of importance to the four western provinces and all Canadians.

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In 1970, the One Prairie Province Conference was held in Lethbridge, Alberta. Sponsored by the University of Lethbridge and the Lethbridge Herald, the conference received considerable attention from concerned citizens and community leaders. The consensus at the time was that research on the West (including BC and the Canadian North) should be expanded by a new organization. To fill this need, the Canada West Foundation was created under letters patent on December 31, 1970. Since that time, the Canada West Foundation has established itself as one of Canada's premier research institutes. Non-partisan, accessible research and active citizen engagement are hallmarks of the Foundation's past, present and future endeavours. These efforts are rooted in the belief that a strong West makes for a strong Canada.

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Canada West FOUNDATION

Manitoba Office:
#400, 161 Portage Avenue East
Winnipeg, Manitoba, Canada R3B 0Y4
Telephone: 204.947.3958

British Columbia Office:
#810, 1050 W. Pender Street
Vancouver, BC, Canada V6E 3S7
Telephone: 604.646.4625

Head Office:
#900, 1202 Centre Street SE
Calgary, Alberta, Canada T2G 5A5
Telephone: 403.264.9535

www.cwf.ca