Draft

Nuclear Power

A Report Examining Scenarios, Options, and Issues for its Implementation in Saskatchewan

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A. INTRODUCTION & EXECUTIVE SUMMARY

Uranium as with Coal, water, and gas, exists in Saskatchewan as a significant resource base. SaskPower, in delivering reliable, reasonably priced, sustainable electricity to Saskatchewan ratepayers, has established a diverse portfolio of generation assets all of which link to a Saskatchewan resource base.

While proposals for the development of Nuclear Power have been brought forward in the past, issues associated Nuclear Power have also been socially controversial, and for that reason development within Saskatchewan has not occurred. With the maturing of the Nuclear Power technologies, and with the emergence of global climate change issues, many of the reasons Nuclear Power has been rejected have disappeared. At the same time the traditional large scale generation options of Hydro development and coal are receiving considerable opposition. As a result of this change, a considerable social debate on the issue of Nuclear Power is under way.

It is not the purpose of this report to engage in that debate.

It is the purpose of this report to provide relevant technical, environmental, and regulatory information to aid decision makers who examine Nuclear Power as a generation alternative as compared to other options for Saskatchewan.

This report will provide a brief overview of available technologies and describe some high level scenarios that could be considered within Saskatchewan. As opposed to making a judgement as to whether a particular scenario is workable or not, the report offers, “what it would take “to make it work.

Benefits, risks, characteristics, and barriers are described, and examination of potential business models and partnerships that are possible is completed. Transmission requirements, generation reserve requirements, cost comparisons to other technologies, siting considerations and environmental approval and licensing requirements will be described. Finally an overview of expected Engineering, procurement, construction schedules and issues will be identified.

B. NUCLEAR REACTORS IN THE WORLD TODAY, AND DEVELOPMENTS IN CANADA

1. Emerging Designs

The (U.S. - Department of Energy) table below provides a summary of the current developing and modern licensed nuclear reactors worldwide. The sizes of these commercial reactors range from 180 MWe to 1600 MWe, with one model potentially being available in a 10 -50 MWe size. The reference to licensing refers to the United States, and each of the described units would require Canadian Licensing. The Candu unit’s are designed to meet all applicable Canadian standards. In addition to the referenced designs below, the Candu 600 is available as a proven, though older technology unit.

Except for the smallest units, there are three basic types of reactors, the Boiling water reactor (GE), the Pressurized water reactor (Westinghouse and AREVA), and the Candu's Pressurized heavy water reactor. These modern reactors are generally referenced as 3rd generation reactors because the manufacturers have taken the traditional models and employed passive safety elements, extended design life to 60 years, and utilize modular construction methodologies to create predictability, enhance quality, and reduce cost. These designs represent an incremental improvement to traditional reactor designs.

The Candu ACR (Advanced Candu Reactor) has taken the cost issue a step further, reducing the size of the calandria (reactor) by more than half, introducing the Canflex fuel bundle (with enhanced fuel burn up and flexible fuel utilization), all retaining the on line fueling advantage Candu has had since its introduction.

There are a number of truly innovative, and market responsive designs underway, that can be characterized as 4th generation Nuclear reactors. All of these designs are sized from 10 MWe to 360 MWe. The Westinghouse IRIS reactor (360MWe), with all primary parts completely integrated in the reactor, can serve smaller jurisdictions, can operate without refueling for up to 4 years and is targeting a lifetime capacity factor of 95%. The Pebble Bed Modular Reactor (PBMR, 180MWe, Westinghouse Eskom) is a completely new concept that utilizes tennis ball sized carbon covered nuclear fuel whose design is inherently safe. This reactor is sized for small jurisdictions, can be fueled on line, and a prototype is currently planned for construction in South Africa. Two other evolving designs are the General Atomics GT-MHR (285-325 MWe) and the Toshiba 4S (10-50 MWe) are less advanced in their development.

More information on each of these reactor designs can be obtained on the links in the table.

It should be noted that none of the designs currently meet licensing requirements in Canada

Reactor Design	Vendor	Approximate Capacity (MWe)	Reactor Type	Certification Status	Target Certification
AP600	Westinghouse	650	PWR	Certified	Certified
AP1000*	Westinghouse	1117	PWR	Certified	Certified
ABWR*	GE et al	1371	BWR	Certified	Certified
System 80+	Westinghouse	1300	PWR	Certified	Certified

Reactor Design	Vendor	Approximate Capacity (MWe)	Reactor Type	Certification Status	Target Certification
ESBWR*	GE	1550	BWR	Undergoing certification	2007
EPR*	AREVA NP	1600	PWR	Pre-certification	2009
PBMR	Westinghouse, Eskom	180	HTGR	Pre-certification	Not Available
IRIS	Westinghouse et al	360	PWR	Pre-certification	2010
US APWR	Mitsubishi	1600	PWR	Undergoing certification	2011
ACR Series	AECL	700-1200	Modified PHWR	Pre-certification	Not Available
GT-MHR	General Atomics	325	HTGR	Research prototype planned	Not Available
4S*	Toshiba	10-50	Sodium-cooled	Potential construction	Not Available

Note: Data are approximate targets which may change. Reactor types are defined below. Designs marked with an asterisk (*) are also supported by electricity generating firms or organizations publicly investigating possible construction in the U.S. AECL is Atomic Energy of Canada Limited.

2. Current Initiatives in Canada

Both Ontario Power Generation (OPG) and Bruce Energy are moving forward to expand the nuclear capacity in Ontario. OPG was directed by the Ontario Ministry of Energy to begin the Federal approvals process, including an environmental assessment to add new nuclear units at an existing site. As a consequence OPG has submitted a site application license to the Canadian Nuclear Safety Commission for a new nuclear plant to be constructed at the existing Darlington Nuclear Station site. It is expected that this site will potentially be the home of 4 new ACR 1000 Nuclear units. Bruce Energy in Ontario is also examining the potential for new built units (potentially 4 x ACR 1000 units) in the Bruce Peninsula and has initiated the 3 year environmental approval process.

Rehabilitation work is currently underway in both Ontario and New Brunswick on existing Candu units. Bruce “A” (4x750 MWe Units) is currently being rehabilitated by Bruce Power through a $4.25 Billion project designed to extend the 4 units lives to 2043, with a target in service for unit 1 in 2010. New Brunswick’s 23 year old; Point Lepreau Candu 635 MWe unit is also being rehabilitated, with a planned cost of $1.4 Billion (including replacement power). The rehabilitation outage is planned to begin April 2008 and be in service October 2009.

C. THE SASKATCHEWAN AND ITS POWER SYSTEM IN 2020

1. Overview

The Saskatchewan power system today and in 2020 is described in the table below. SaskPower’s system (as part of the eastern interconnect) is relatively small and has benefited greatly since it became synchronously interconnected first with Manitoba, and North Dakota, and then to Alberta (part of the western interconnect) through the McNeil converter station.

Saskatchewan	2007 MWs			2020 MWs		
Peak Load	3125			3604		
Installed Capacity	3534			3961		
Planning Reserve Req’t @ 13%	389			445		
Operating Reserve Req’t (largest Contingency)	288			288 Assuming Max 288 MW net unit		
Energy Requirement	2007 GWh			2020 GWh		
(Most Likely-Scenario)	19,771			23,468		
Inter-connection capacity (All MWs)	Design	ATC Import	ATC Export	Design	ATC Import	ATC Export
Manitoba	550	225	225	TBD	TBD	TBD
North Dakota	215	150	150	TBD	TBD	TBD
Alberta	150	75	15	TBD	TBD	TBD

2. Energy Role

A change from Saskatchewan’s traditional generation approach is the Nuclear energy profile. All of these units are intended for a base load role in the power system with lifetime capacity factors exceeding 95%. To illustrate this, a medium sized unit with a 750 MW net rating (or equivalently 2 units split between Alberta & Saskatchewan) would produce 6,242 GWh of energy or 27% of Saskatchewan’s energy needs in 2020. This compares to the current entire energy output of the 6 Boundary Dam Power Station (BDPS) units 6,340GWh).

3. Waste and Emissions Profile for Nuclear Power

The waste issue in Canada, and around the world, has been a major issue since the inception of Nuclear Power. In 2004, the Canadian Government created the Nuclear Waste Management Organization with the purpose of working with Canadians collaboratively and deliberately to sort out the issues associated with nuclear waste management. The organization recently submitted their final report and is recommending that a deep underground repository be the technology embraced, and a process of implementation called “adaptive phased management” be the framework utilized.

It is relevant to compare the emission profile of Nuclear to coal technology. (recognizing that clean coal is emerging option, as well).In 2005 SaskPower released 13,892,766 tonnes or approximately 24 % of Saskatchewan’s greenhouse gas emissions (2005). Boundary Dam Power Station alone released 6,751,088 tonnes. While waste from nuclear power plants continue to raise major concerns in terms of safe multi generational storage and non-proliferation safeguards, there are no greenhouse gas, particulate, nitrogen, or suphur emissions at all. In terms of the priority to reduce greenhouse gas emissions, the implementation of a medium sized nuclear plant in Saskatchewan (replacing a coal fired station such as BDPS) would immediately reduce Saskatchewan’s greenhouse gas emission profile by 11.6% from the current levels.

4. Transmission and Reserve Issues

SaskPower plans its system in alignment with NERC (North American Electric Reliability Corporation) standards, uses a planning reserve of 13% (based on a combination of Hydroelectric and fossil fired generation), and establishes its operating reserve based on its single largest contingency (currently 288 MW, the largest net rating of its generating unit) on the Saskatchewan power system.

When considering the introduction of Nuclear into Saskatchewan, “size matters” to the degree that it can be integrated into the power system. The system must be able to deliver its designed capabilities, and be able to respond to contingencies that occur in very short periods of time, all while keeping the power system reliable and secure. SaskPower is obligated to provide sufficient reserves to withstand its greatest single contingency. Half to 40% of this 288 MW contingency must be spinning reserve, which means it is available only limited by “ramp rate” if a system event occurs. While the interconnections aid SaskPower substantially in keeping the system secure and reliable (and providing interconnectivity to surrounding power markets), they are typically not counted toward the reserve requirements unless accompanied with firm transmission and energy arrangements.

Another aspect associated with the interconnections is that in the event of a major contingency (loss of generation or load), despite the existence of spinning and operating reserve, there is an instantaneous in rush or out rush of energy. While our reserve can adapt only as fast as the ramp rate of the spinning generation assets (measured in MWs per minute), the interconnections react instantly, limited by the protections and control , which if exceeded will cause the system to separate at our interties.

The Nuclear units available can range from 10 MWe to 1600 MWe. Relative to today's reserve requirements, any unit that connects with Saskatchewan's power system (above the 288 net rating) would have to have both sufficient operating reserve and sufficient capacity in the interties to withstand the dynamic impacts at the interties.

To put all of this into perspective, for the purposes of this report, Nuclear options that are: small (10-360), can likely be integrated without major issues (other than a small increase in operating reserve); medium (361- 750) will require innovative partnership arrangements and likely significant investment in both reserve capability and transmission interties capability; and large (750 and above) will require major and far reaching investment in both transmission and reserve.

5. Transmission Studies Required

1. In all cases: Transmission impact and requirements studies will determine the integration requirements "internal" to Saskatchewan,
2. In the medium and large options, multi jurisdictional studies will be required to determine the impact in surrounding regions and at our interconnections,
3. Transmission Investment for large options external to our jurisdiction will likely be required potentially as far reaching as North Dakota and Minnesota.

6. Physical Siting Saskatchewan

In addition to the transmission and power system requirements, the establishment of a physical location for a nuclear plant requires a number of important factors to be considered;

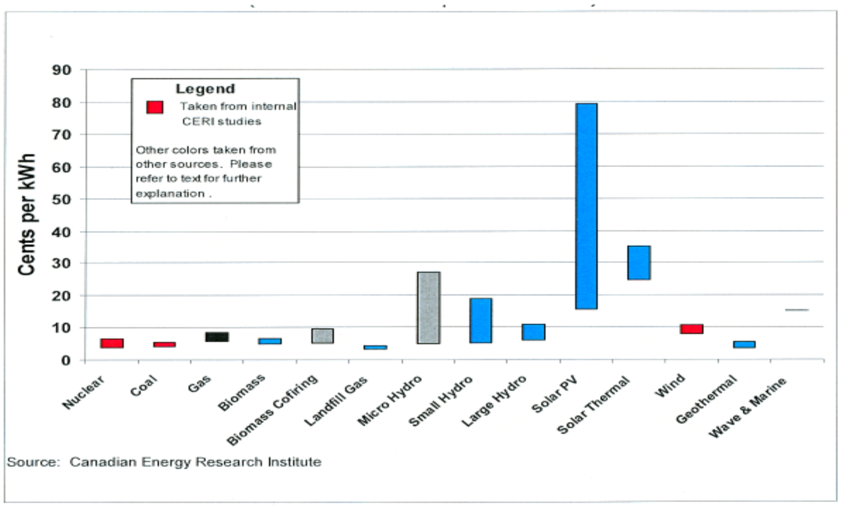
- Sufficient quantity and temperature of cooling water
- Minimal conflict with other land uses
- Minimal proximity to populations yet sufficiently close to load and transmission
- Geological and seismic stability, meteorological conditions, and sensitivity to flooding
- Aboriginal interests
- Environmental, ecological, and aquatic impacts, meeting all applicable regulatory requirements
- Cost of construction, transportation, and operations, along with the ability to sustain the access to critical capabilities, skills, and trades
- Archaeological and Heritage impacts
- Site development potential and access
- Accommodation for employees
- Access to technological, community, and service support

As can be seen above, the issue of physical siting is a complex one. In addition to the technical, regulatory, community, and access to human capital issues, any final decision will depend on the business arrangements and model, the preferences of our shareholder, and of course input from affect stakeholders.

D. GENERATION COST COMPARISONS

While generation costs in western Canada are in transition as a result of an overheated oil sands expansion program, the diagram below shows, on a relative basis, the costs of differing generation technologies. All of the newer nuclear generating options, may on a relative basis, be considerably less expensive than other options, with the advantage of reduced fuel price and volatility, enhanced fuel burn up, flexible fuel utilization, reduced reactor size, passive safety system, modular construction techniques, and a mature and predictable technology base.

We need updated costs in this area both our internal and these CERI cost are no longer accurate.



Despite these key design developments and advanced construction techniques, the fact that the new designs have yet to be built, introduces the concern of construction cost risk. For Saskatchewan this will be a critical issue if Nuclear is to be considered in our jurisdiction.

E. A SCENARIO FRAMEWORK

Retaining the small medium and large unit reference, we can also consider three approaches: 1. Saskatchewan “go it alone”; 2. A Saskatchewan / Alberta partnership; and 3. A fully integrated Sask./AB/MB prairie regional pact, which together can form the basis of 9 scenarios. The table below provides some context on these scenarios and are coloured green to show it is doable, yellow that it may be doable under certain conditions, and red to show it is not doable or is impractical.

The identification of potential partnerships/pacts in no way suggest that those jurisdictions are willing, or able, to engage in such pacts, but is used as an illustration of the technical potential to implement.

The key message here is that on a regional basis, Nuclear would become more technically and economically feasible, as support investments such as transmission become smaller on a percentage of the total capital required. In addition, although not obvious, there may be a significant advantage to jurisdictions such as MB participating to mitigate their energy uncertainties, and to leverage the value of their hydroelectric exports to external markets. In essence a nuclear regional pact would establish a predictable, sustainable, competitive energy supply base for the Prairie Provinces while freeing up traditionally marketable energy products for export.

A medium unit regional pact strategy would be the most feasible economically and technically. This option would also allow a substantial advantage to allow an orderly expansion of multiple nuclear units, creating economies of scale, offsetting emissions, and in creating energy cost certainties within the Prairie region.

The scenarios do not make a judgment as to manufacturer or model embraced, however some models identified will not be ready for the time frame (2020) should they be considered

	Large	**Medium**	**Small**
One Province Saskatchewan			
	A large unit simply could not be integrated into the power system as it will exist 2020.	A medium unit with appropriate firming of transmission at our interties may be technically feasible.	Any of the small units can be integrated without major issues, if economic.
Saskatchewan/ Alberta			
	A large bifurcated unit with appropriate firming of transmission at each jurisdiction may be technically feasible.	A medium unit, with a bifurcated steam path, with a generator on each side of the AB electric system and SK electric system would be technically feasible.	Any of the small units can be integrated without major issues, if economic.
Full Scale Regional Pact (MB/SK/AB)			
	A large bifurcated unit, within a full regional pact may establish an attractive economic basis for both the Nuclear unit investment along with substantial transmission	A medium unit, with a bifurcated steam path, with a generator on each side of the AB electric system and SK electric system would be technically feasible, and have a stronger economic basis if shared with MB as well.	Any of the small units can be integrated without major issues, if economic.

F. POTENTIAL BUSINESS MODELS AND PARTNERSHIP OPTIONS

While Nuclear Power has traditionally been developed (with the aid of AECL) by Provincial Crown Corporations in Canada, (Ontario, Quebec, and New Brunswick), recently companies such as Cameco, TransCanada Energy, (who have interests in Bruce Energy) and AREVA (Canada) have shown interest in vertically integrating their business model through the development of operating, rehabilitation and green field development of Nuclear generation.

This section will expand on potential frameworks that the three regional aspects might include as well as speculate on potential business models in each case.

Business Model Illustration			
	Large	**Medium**	**Small**
One Province Saskatchewan			
		Unit Development by SaskPower International in partnership with private developer (TCE, Cameco, or Areva), ½ unit output planned for Saskatchewan domestic load, ½ planned for export to Alberta Electricity Market	Unit developed by SaskPower or in partnership with private developer, for serving domestic load.
Saskatchewan/ Alberta			
	Unit Development by SaskPower International in partnership with private developer (TCE, Cameco, or Areva), ½ unit output planned for Saskatchewan domestic load, ½ planned for export to Alberta Electricity Market	Unit Development by SaskPower International in partnership with private developer (TCE, Cameco, or Areva), ½ unit output planned for Saskatchewan domestic load, ½ planned for export to Alberta Electricity Market in partnership with Alberta Government or Oil Sand Developers	Multiple Units Unit Development by SaskPower International in partnership with private developer (TCE, Cameco, or Areva), ½ unit output planned for Saskatchewan domestic load, ½ planned for export to Alberta Electricity Market in partnership with Alberta Government or Oil Sand Developers
Full Scale Regional Pact (MB/SK/AB)			
	A true private public partnership between	A true private public partnership between	A true private public partnership between

Business Model Illustration			
	Large	**Medium**	**Small**
	AB/Sask/MB governments with development partnership involving SPC, MH, Private investors, with major investments made in transmission to facilitate a secure and reliable system.	AB/Sask/MB governments with multiple medium unit development (on a single site) partnership involving SPC, MH, Private investors.	AB/Sask/MB governments with multiple small unit development (on a single site to create economies of scale) partnership involving SPC, MH, Private investors.

G. CONCLUSION

Notwithstanding the leadership and social dialogue that consideration of Nuclear Power Development in Saskatchewan will bring, there are potential business models and nuclear units in development that would allow for Saskatchewan alone, or in partnership with Provinces and/or private generation developers to add nuclear development to its portfolio of sustainable generation options.