# Small Nuclear Reactors and

# Alberta’s Oil Sands Development

NOTES FOR REMARKS BY

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## Introduction

Thank you very much. It's good to be back in Alberta.

I'm particularly pleased to have an opportunity to focus on such a critical subject as developing and maintaining a sustainable oil sands infrastructure, and on the role nuclear technology can play in achieving that objective.

My organization, the Canadian Nuclear Association, represents all nuclear technologies in Canada. The tens of thousands of Canadians whose jobs are connected to those technologies work in nuclear power generation, nuclear medicine, pharmaceuticals, food safety, materials science, engineering, science and technology services, and many other areas.

The CNA is about opening up the opportunities to keep bringing the benefits of nuclear technology to Canadians decade after decade. That's why today I'm going to focus on one of those opportunities, namely the technology of Small Modular Reactors, or SMRs, and the role they might play in the oil sands now and in the future.

We have a collective opportunity in relation to the oil sands. Our challenge is one that the oil sands have seen before: a need to bring together a team of people to work through a complex set of problems over a significant period of time. Albertans know how to do this. Today we'll talk about what will be involved this time round.

## Alberta's Energy Vision

The use of nuclear energy in the oil sands is an idea whose time has come.

At the same time, we believe that small modular reactor technology represents a unique and discrete change in the possibilities for applying nuclear energy in the oil sands.

It is a technology that can help achieve the vision expressed in *Alberta's Provincial Energy Strategy*. The Strategy recognizes that we are entering a future where emissions of carbon into the atmosphere will be constrained.

SMR technology creates an opportunity for Alberta to show the world that you have the courage and commitment to live up to your vision.

## Why Small Nuclear for the Oil Sands?

At this point you may wonder why I think nuclear is a good fit for the oil sands. After all, haven't there been a number of studies that seem to suggest that it's not? Well, the problem with these studies is that they were looking at the wrong size reactors.

Large reactors present a challenge for use in the oil sands. These include, among other things:

- Large, permanent installations with high capital cost;
- Large support staff with high operation and maintenance costs;
- Relatively short maintenance and/or refueling cycles;
- Excessive energy production (thermal & electric);  and,
- Concerns about whether the steam is of adequate temperature and pressure.

To our knowledge, there have not been any comparable studies of SMRs for the oil sands. However, very preliminary evaluations that have been carried out by some in the nuclear industry suggest that SMRs can overcome these shortcomings and that they provide a vastly better match for SAGD.

**The Hydrocarbon Value Chain**

Today, most bitumen production is from in-situ processes, and of these, the SAGD process is the fastest growing. The SAGD process uses high-temperature, high-pressure steam for extraction of the bitumen from the oil sands, and for the most part this steam is currently generated using natural gas.

> "… if SAGD production is to expand greatly, much of the new production will need to be upgraded to higher value product."

- *Quote Source: Oil Sands Technology Roadmap*.

> "Using natural gas to produce oil from tar sands is akin to turning gold into lead."
>
> Source: Canadian Energy Executive, as reported by David Hughes, Geological Survey of Canada

## Reducing Greenhouse Gas Emissions

Possibly the most critical issue that has stimulated interest in using nuclear power to produce steam for the SAGD process rather than natural gas is the growing concern over greenhouse gas emissions.

At present it takes up to 30 cubic meters of natural gas to produce a barrel of oil. With projections of three million barrels per day by 2016, a great deal of natural gas will be required.

Quite apart from the question of gas availability, this has major $CO_2$ implications. Essentially, the equivalent of about 20% of the energy in the oil is required to produce it and about 80 kilograms of $CO_2$ is released for every barrel of oil produced.

This is even before refining begins – and without even talking about a price on carbon. If any substantial price were put on carbon, we could be talking about a very great deal of money indeed in this context.

Alberta is the first jurisdiction in North America to set legislated targets for emissions reductions from industrial facilities. The *Climate Change Strategy 2008* vows a reduction of 50 megatonnes by 2020. By 2050 emissions are to be reduced 50% below business as usual levels.

Nuclear power generation is an important part of a clean energy solution for Canada as it produces virtually no greenhouse gas emissions. The emissions are actually zero from the heat generation process itself, but we say “virtually no emissions” because building and servicing any plant still requires using trucks, equipment and so on that do emit some greenhouse gases.

How clean is nuclear compared to the alternatives? Well, it has been calculated that the use of nuclear power generation instead of coal avoids about 90 million tonnes per year of GHG emissions. And nuclear is a strategy for making that kind of change in the oil sands.

## Small Modular Reactors: How Small Is Small?

The acronym SMRs originally referred to Small and Medium Reactors, where “small” was defined to be less than 300 megawatts of electricity and “medium” reactors to be between 300 and 700 megawatts. The SMRs of interest in the oil sands typically fall into the “very small” range.

There is a subset of very small reactors called Mini Power Reactors (MPRs), which have a power rating less than 50 MWe and are typically designed for distributed electric and heat production.

Typical applications for MPRs include the oil sands and mining industries, remote locations, military facilities and water desalination and purification. Although it is the MPRs that are primarily of interest in the oil sands, I will continue to use the term SMRs because that is the term that is most commonly used.

**The Role of SMRs in the "Nuclear Renaissance"**

There are currently 440 reactors operating globally with another 62 reactors under construction. Worldwide some 154 reactors are planned and expected to come online by 2020, with a further 342 proposed and expected to come online by 2030. This is the anticipated "nuclear renaissance."

Among the more important drivers of this renaissance are:

- Increasing energy demand, particularly in emerging market countries.
- The growing need for 'low-carbon' energy sources.
- Increased concern by many nations about the adequacy, diversity and security of energy supply.

In spite of these drivers, the large capital investment required, along with cost overruns and schedule delays in recent large reactor projects, have created serious challenges for utilities contemplating new nuclear projects. This has a lot to do with size.

Moody's Investor Services has commented that "new nuclear plants are a 'bet the farm' endeavor for most companies, due to the size of the investment and length of time to build a nuclear power facility."

The 'typical' nuclear company has on the order of $13 billion per year in revenues and $40 billion in assets. These are big companies. Even so, at a cost of about $10 billion, undertaking a new large nuclear power plant represents a difficult economic challenge.

These concerns, along with a number of perceived benefits which I'll be talking about, have led to the rapidly growing interest in SMRs.

Much of the interest in SMRs is driven not just by the desire to reduce capital costs, but also to provide power in locations away from large electrical grid systems. There is good reason to think SMRs might capture a significant portion, maybe even a majority, of the new reactor market.

As for process heat, as opposed to electricity generation, SMRs have a number of advantages over natural gas as a potential source of steam for the SAGD process. In addition to carbon mitigation, the drivers for the oil sands industry are also to diversify energy sources for both security and cost stabilization.

Various proposals have been made to use nuclear power to produce steam for extraction of the bitumen from oil sands deposits, as well as producing electricity at the same time. An important conclusion is that the steam supply needs to be semi-portable in the longer term. This is not true of large reactors, but it is potentially true of SMRs. Relatively small reactors could be moved every decade as extraction proceeds.

To be suitable for the oil sands, the characteristics of a reactor must be a good match for the characteristics of the SAGD fields.

**Small Reactors: History in Perspective**

Small reactors are not new. The first nuclear reactor designed for electricity generation was a 5 megawatt power reactor that was started in Russia in 1954. The 22 megawatt Nuclear Power Demonstration reactor was constructed in Canada in 1962 as a prototype for the pressurized heavy water reactor that's now known as the CANDU.

The use of small reactors for purposes other than electricity generation is also not new. Work on nuclear marine propulsion started in the 1940s, and the first prototype test reactor started up in the US in 1953. The first nuclear-powered submarine (USS Nautilus) was commissioned and went to sea in 1955.

Other early uses of small reactors in the US date back to the 1950s and were mainly military plants such the 1.5 megawatt reactor that operated in Antarctica from 1962 to 1972. Four small reactor units have been operating in remote Siberia since 1976, producing steam for district heating as well as some electricity. Other examples abound in France, the UK, China and Russia.

**Relevance of Operating SMRs to the Oil Sands**

As a general matter, research reactors and power reactors are built one at a time on a fixed site, they require substantial infrastructure, and they stay there until they are decommissioned. These characteristics are not very compatible with use in the oil sands.

Marine propulsion reactors such as those used in aircraft carriers and submarines since the 1950s, on the other hand, are quite different in that they are much smaller, make very efficient use of space, operate in a moving and rolling vehicle, and are modular in design. Being modular means that instead of being constructed on site, they are manufactured using modular components in a workshop- or factory-like environment. They are then installed and operated in very large vessels that can travel long distances – with limited opportunities for supply, service or refueling.

What made these seagoing reactors so successful, so early in the development of the technology? Three attributes were critical:

- First was the ability of a reactor-driven vessel to be virtually independent of ports or supply chains for fuel. These vessels go twenty or more years without refueling. Moreover, the vessel capacity that would have been taken up by coal or oil is free to use for payload and crew. This is a desirable attribute for both submarines and for aircraft carriers.
- Second was low air consumption and emissions. This is overwhelmingly important for submarines for reasons of both tactical advantage and life support.
- Third was the sheer amount of energy made available by nuclear fuel. This is important for aircraft carriers, which must be able to push a large mass huge distances through a dense liquid and also to follow their aircraft during operations. Nuclear technology can provide that power without being prohibitively bulky or expensive.

These advantages of nuclear marine propulsion reactors have been demonstrated over decades of successful operation in the fleets of several countries. These systems have proven to be affordable, reliable, scalable, and powerful – not to mention quiet and clean.

These attributes of marine SMRs are precisely the characteristics that are important to the use of nuclear power in the Alberta oil sands.

And, to recap those benefits in the context of the oil sands, they are:

- Minimal on-site infrastructure
- Ability to operate in remote locations
- Independence from fuel supply chains, i.e. security, availability and price
- Minimal emissions
- Transportability
- High energy density
- Proven, reliable operation
- And an outstanding safety record

## **Safety**

Let me address the issue of safety by stating, first of all, that safety is our number one priority.

Canada’s nuclear power operations have a proven track record of being among the safest in the world.

They are highly monitored, stringently regulated and continuously improved through the daily efforts of qualified professionals who are committed to ensuring public safety.

Since the tragic events in March, 2011, the nuclear industry – at home and around the world – has been working tirelessly to share valuable lessons learned from the tragedy to ensure safety standards and policies reflect current findings.

To date, Canada's nuclear industry has:

- Participated as a nuclear community to review and respond to the situation in Japan;
- Has outlined to the CNSC a series of actions to verify the safety of our nuclear generating stations; and,
- My colleague Tom Mitchell, the President of Ontario Power Generation, was appointed by the World Association of Nuclear Operators (WANO) to chair a special 14-member, "Post-Fukushima" commission to review the lessons of this event and develop recommendations on an appropriate industry response.

In fact, our industry is always looking at ways to address even the most UNLIKELY and IMPROBABLE events – like major flooding and major earthquakes and ensuing emergencies in their aftermath. We will continue to be open and transparent about our safety measures.

Notwithstanding the excellent safety record of nuclear power to date, the new generation of small modular nuclear reactors currently being developed offer *further* potential safety and security advantages over larger commercial reactors.

They are being designed to have lighter security requirements, to operate at lower pressures, to have accident scenarios that progress more slowly, and to be meltdown-proof. The result of all this design work is going to be big advantages for owners, operators and users.

**Regulation and Licensing**

There is growing work, particularly in the USA but also in Canada, on how to regulate and license Small Modular Reactors.

Issues being identified in the U.S. can generally be categorized as licensing framework issues, licensing application issues, and design and manufacturing issues. Many of these issues are embedded in the U.S. regulatory framework and can only be resolved through changes in the regulations.

The issues are similar in Canada, but an important difference is that these issues can be addressed within the Canadian regulatory framework without requiring changes in the regulations.

Our federal regulator, the Canadian Nuclear Safety Commission (the CNSC), has so far published two Regulatory Documents stipulating the requirements for licensing SMRs.

The CNSC has stated that they expect that SMRs can be licensed in Canada in significantly less time than would be required in the US. Accordingly, they have invited US suppliers of SMRs to apply for a pre-licensing design review.

The CNSC also stated that SMRs will be licensed for operation more quickly than larger nuclear plants – in about six years rather than nine years. This tightening of the timeframe would be mainly achieved by doing the environmental assessment, the site preparation licence, and the construction licence in parallel.

While there are many uncertainties around the issues that need to be addressed to successfully license an SMR in Canada, this rather proactive stance by the main regulator is a very positive sign.

## A Path Forward

The path forward can be stated in quite simple terms, but getting it right will take application and imagination. So, what is the path forward? Here is how I see it.

**Accept that it's not simple or quick.** Everybody involved needs to understand that this is not a decision like buying a truck or a diesel generator. In other words, it is not a matter of acquiring an off-the-shelf technology. SMRs are relatively new and applying them to the oil sands is entirely new. So, rather, this is comparable to the oil sands industry's experience with its original development of SAGD. A diverse team of skilled and dedicated people will need to get involved and stay involved for some time. And many small innovations will contribute to a successful outcome.

**We need good lines of communication** between nuclear and oil sands. People in my industry need to understand your industry's requirements comprehensively and in detail. We'll also need to understand how they are likely to change over time. And we'll need to be fully transparent with you about the status and capacities of what we have. Anything less than a very fulsome, multi-level conversation will not be enough for success.

**We need to map out all the obstacles.** From the start, we'll have to work out the constraints we will need to meet collectively, and the uncertainties we will need to account for. These are not only complex, but likely to change with time, so that map of obstacles will need to be updated.

**Develop a menu of options with costs and benefits.**

**Work out a competent, robust solution.** Competent, in that it delivers what's needed and stays within the constraints. Robust, in that it looks ahead, and is adaptable to accommodate future requirements and future constraints.

**Conclusion**

I am convinced that the nuclear option has all the characteristics needed to be successful in the oil sands.

We at CNA believe the range of possibilities for nuclear technology is great. We are not advocating any one technology, any one vision of the future, or any one structure for our industry or yours. Those paths will be chosen by people like you, making energy supply choices for their homes, their companies, organizations, towns, cities and provinces.

And I encourage all of you to please visit to follow us on our social media channels - our "TalkNUclear.ca" blog, and our Twitter and Facebook pages - to give us your views on this issue and on any issue to help encourage an ongoing dialogue on energy technologies in Canada.

Thanks very much.