Council for Clean & Reliable Electricity
transforming the way we think about power

UNIVERSITY OF Waterloo
Waterloo Institute for Sustainable Energy

Summary Report
of the Conference held in Ottawa
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PREPARED BY: WATERLOO INSTITUTE FOR SUSTAINABLE ENERGY, UNIVERSITY OF WATERLOO

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Acknowledgments

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Message from the CCRE Chair

This is a summary of presentations and discussions that took place during an interesting and worthwhile day spent exploring the important topic of nuclear energy and its role in society's future. The conference was the fourth that the Council for Clean and Reliable Electricity has organized. Previous conference titles were "The Future of Coal in Ontario?", "Biomass and Energy for the Great Lakes Economy" and "Distributed Generation and the Future of Ontario's Grid".

The Council is a non-partisan, not-for-profit, independent organization comprised of representatives from academia, public and private sectors, energy and strategic planning professionals that promotes public dialogue related to the generation, transmission and distribution of clean, affordable and reliable electricity.

This conference continued the tradition of our previous events in fostering a constructive dialogue on the role that nuclear may play in a national and global strategy to help us adapt to the challenge of meeting society's energy needs while reducing our reliance on fossil fuels. Questions on our minds when preparing the program included "Will nuclear power play a pivotal role in reshaping the national and global energy system? Or, will its own limitations reduce the role to a marginal contribution in the supply mix and final share of energy consumption?" The conference examined in depth three major nuclear themes – cost, safety and waste management – and focused on future directions for Canada. Geopolitical aspects of nuclear development, novel uses, international trade and impacts on the Canadian economy, employment and investment were explored through a panel discussion of energy thought leaders in business, industry and government.

Leaders look to the Council as a forum for neutral public dialogue on electricity. We hope that the following summaries and the concluding recommendations provide a useful input to the formulation of electricity policy by all levels of government, to the initiatives of the broader stakeholder community as well as to the plans and activities of the electricity and nuclear industries themselves.

Glen Wright, Chair
Council for Clean and Reliable Electricity

Excerpt from a Speech at the Opening Dinner for the Conference

by The Honourable Jim Prentice, Minister of the Environment, Government of Canada

Nuclear will play a key role in our clean energy strategy. And the reality is: nuclear is non-emitting.

Nuclear energy displaces between 40 and 80 million tonnes of greenhouse gas emissions annually relative to producing the same quantity of electricity from gas or coal.

Canada has been a pioneer in the development of nuclear technology for peaceful purposes. Today our nuclear industry generates billions of dollars of economic activity and accounts for thirty thousand direct and indirect jobs.

While the global nuclear sector is poised for growth, our industry is operating in a very competitive environment against some very big and some very well financed vendors. That's one of the reasons why we announced in May, that we're moving forward with restructuring of AECL. We want to strengthen its ability to compete internationally and take full advantage of the emerging opportunities. This will put it in a better position to build on Canadian technology and access opportunities at home and around the world.

One of the key phrases that you hear is that we're undergoing a nuclear renaissance. It's a form of electricity that is being embraced by many countries around the world.

At the International Energy Agency Meetings in Paris last week, leaders around the world re-stated what we have known for some time: without a significant increase in nuclear power, the world will be unable to meet required greenhouse gas reduction targets.

So there's a market for nuclear power -- and restructuring AECL will give Canada's industry the power to access it.

Session 1: Introduction

Challenges of a Sustainable Energy Future – Jatin Nathwani, Professor & Executive Director, Waterloo Institute for Sustainable Energy

Jatin Nathwani identified the lack of access to electricity services by a large proportion of the global population as a primary driver of many of the public policy debates about energy access, energy security, energy affordability and unintended consequences to energy use. Availability of energy has a significant impact on quality of life and is a key determinant of productivity, national income, health, education and social development.

A near doubling or tripling of energy demand arising from population growth and prosperity poses a significant challenge for future energy policy because of the impact of carbon emissions on climate change and the need to reduce the emissions. For example, over the last 30 years, the global GDP grew at an annual rate of 3 per while carbon emissions grew at a rate of 1.5 percent per year. The trajectory of global economic growth and the dominance of a fossil fuels based energy system means the rate of carbon emissions will have to decline just as fast as economic growth to achieve the required level of stabilization of carbon in the atmosphere by 2050. This translates into a significant change to the global energy supply mix required to be accomplished over a relatively short time period.

Alternative sources of supply such as renewables, nuclear, clean coal (with sequestration and storage) and a significant emphasis on efficiency gains will comprise the set of solutions that may be effective in a transition away from fossil fuels. In addition, there is a compelling need to develop right combination of policies that fosters innovation and support for the investments required to sustain transformation of the energy system.

To shape discussion for the conference, the following areas were identified.

Cost:

- What level of confidence do we have that nuclear can meet the test of affordability?
- What are the costs of energy from nuclear fission and how comparable they are from other low carbon sources?
- Are there any specific commercial arrangements or policy fixes required for the next generation reactors?

Safety:

- Is the existing technology sufficiently safe and how do past experiences help in future design and safety?
- Is the regulatory framework, both national and international, sufficiently robust to provide social confidence in a continuing role for nuclear?
- What is the best strategy for aligning safety goals with social acceptance?

Waste:

- What are the solutions to safely isolate nuclear waste?
- What's our confidence level for future of nuclear waste management?

Social, environmental and political issues:

- Can nuclear be considered a sustainable solution without a social consensus on its role?
- What's the role of nuclear in a cap and trade system for emissions from carbon-based fuels?
- What are the issues related to global trade and considerations of compliance to the existing non-proliferation framework?

Practical Foundations for Energy Policy – Jan Carr, former CEO Ontario Power Authority; former Vice Chair, Ontario Energy Board

Jan Carr emphasized the need for rational decisions when it comes to both energy policy in general and nuclear decisions specifically.

For the existing energy systems, each investment decision has been made on the basis of meeting customers' requirements while minimizing the life-cycle costs, and incorporating identified externalities as they relate to emission and land uses. Establishing quotas for renewable and non-renewable energy or defining specific quotas for technology groups will result in higher costs than would be the case if carbon were priced and factored into investment decisions for electricity generation.

Nuclear energy in Canada has significant industrial and economic policy implications at both federal and provincial levels, because the technology is owned by the federal government and provincial governments are responsible for electricity supply policies and in many cases are also the potential plant owners. Carr discussed two aspects of nuclear energy in Canada: 1) CANDU technology and its implications 2) Corporate structure of AECL.

CANDU technology has many advantages for Canada, since it attracts countries not wanting to depend on major nuclear power providers for uranium enrichment and also allows transition to a thorium based fuel cycle in the long term. AECL's corporate structure as a combination of a commercial corporation with non-commercial responsibilities and financed as a government department is a recipe for failure. The current review by the government of AECL's corporate structure has the potential to put CANDU technology on a business footing, by ensuring commercially motivated capital and diplomatic and trade support from government. Challenges

include a determination of AECL's value which depends on provincial decisions, and provincial decisions depend on cost-effective risk sharing with AECL.

The nuclear industry is disadvantaged in getting decisions at the top of governments' agendas because of lack of public support arising from concerns related to safety, waste management and cost which are the relevant topics for the conference.

Session 2: Cost and Schedule Experience

Anatomy of Darlington – Elgin Horton, former Vice President of Nuclear Operations and Chief Nuclear Officer Ontario Hydro

Elgin Horton reviewed some of the problems during construction that resulted in significant delays and cost overruns at the Darlington nuclear station and summarized recent performance.

Darlington station, with a capacity of 4 x 881 MW, was approved by the Ontario government in July 1977; first site preparation work began in 1978, and units were scheduled to be in service between 1985 and 1988. The last unit was brought into service in 1993, an exceptionally long construction period. Several unanticipated problems resulted in a schedule delay of 5-6 years. The influencing factors were:

- Economic Conditions: A significant change in demand growth and Federal government monetary policy that allowed interest rates rise up to 20%, thereby increasing the borrowing cost, persuaded politicians to stop the construction on several occasions. Since

a major part of the project cost had already been committed, the interest on that part continued to accumulate. Also the interruptions had a significant cost penalty associated with extra effort required for training and project management each time work was restarted.

- Design: In addition, two significant design problems contributed to the delay in the schedule. The safety shutdown system software design issues caused a 2 year delay and increased that cost by more than a factor of 10. The second problem was related to fuel bundle damage that was caused by hydraulic vibrations from the reactor cooling pumps, and the correction took about 20 months.

- Major equipment failure: There were two significant equipment failures. First was the failure of a faulty main unit voltage transformer, and the second was a crack in the shaft of one electrical generator, which took many months to be repaired.

- Staffing: Limitations on hiring staff and training added 6 months to the schedule and the electrician strike in the mid 1980s lasted about 6 months.

- The 1977 planning cost estimate was about $5 billion and in 1981, Ontario Hydro board of directors approved a definitive estimate of $7.46 billion. At this stage, 15 percent of engineering had been completed and major equipment purchased. The final cost of the project was $14.33 billion. In summary, schedule changes, financial policy changes and re-engineering and resolution of design problems all contributed to the cost increase. The impact of schedule delays was due to the accounting policy to capitalize all the cost of financing until the asset was in service. Therefore, when the schedule was extended and the rate of borrowing was high, the capitalized interest became a very significant portion

of project cost, at $6.2 billion (or about 43% of total project cost). Also, new corporate accounting changes to capitalize all training cost and to spread all the costs of common station facilities over 4 units, increased the total project cost by $1.3 billion.

In the early years of Darlington operation, the government ordered a downsizing at Ontario Hydro, which was then followed by an 8 year rate freeze. Loss of experienced operating staff ultimately translated into poor performance and lower output.

Currently, with more adequate resources, Darlington has achieved a 2008 annual capability factor of 94.5% and produced more than 17% of Ontario's electricity needs that year. As for safety, Darlington received a "fully satisfactory" rate by Canadian Nuclear Safety Commission (CNSC) in 2008. In 2007 it received the its best ever performance review from WANO.

Contracting for Major Infrastructure – Patrick Lamarre, Executive Vice-President, Global Power, SNC-Lavalin Group Inc., and President, SNC-Lavalin-Nuclear Inc.

Patrick Lamarre reviewed the critical elements of construction contracting available for nuclear projects. Essentially, the construction contracts assign risks as follows:

- Project execution (quality, schedule and cost)
- Financial factors (escalation, foreign exchange and cost of money)
- Market factors (supply-demand)
- Regulatory factors

For the nuclear industry, additional costs are assigned because of uncertainties of long project duration (10 years), limited number of qualified suppliers and the nuclear regulatory approval processes.

The magnitude of the costs involved for a nuclear plant means a greater focus on risk allocation. Total risk is most economically handled by allocating each subsidiary risk component to the party best able to manage it. For instance, requiring the contractor to bear the risk of design changes will result in un-economic levels of contingency and on the other hand, exposing the owner to unknown construction or equipment costs may make the project un-financeable. Thus risk allocation is a balance between the owner and contractor, and it also reflects the reality of the regulatory environment and associated impact on project scope and schedule.

Different contracting methodologies were identified as follows:

- Reimbursable EPC (Engineer, Procure, Construct) – Equipment Costs Reimbursable with a Mark-up on the Construction Cost: In this mechanism the owner controls everything regarding, contingency, scheduling, monitoring and optimizing the project as it goes along. However, the owner will have full risk exposure, lack of cost certainty until the last stages of the project and limited financing options. On the other hand, contractors have minimum risk exposure and certainty of cost recovery, while they have predictable revenues and earnings, although markups will be low as the lack of risk, and consequent limited financial resources necessary, makes it possible for many contractors to compete in the contract award competition.
- LS (Lump Sum) - (a) for engineering only or (b) for engineering, equipment and materials: These options reduce the risk for the owner but at the expense of providing the

owner with less flexibility. The contractor sticks into the signed contract and if the owner wants to change scope, additional cost will be incurred by the owner.

- Lump Sum for full EPC: It has more risk on the contractor. Therefore, owner has early cost certainty and flexible financing options, but there might be premium cost due to contractor's contingency and risk, and the owner will have even less ability to make design changes without an onerous change order process and has limited ability to intervene or influence the contractor's project execution performance. On the other hand, the contractor will earn higher margins since there will be less competition due to the limited number of contractors with the higher financial capacity necessary to accept the higher risk. The contractor can often be more innovative as the owner has little ability to intervene in project execution. The contractor also has maximum risk and exposure to market demand and escalation which is difficult to predict.
- Lump Sum from FEED (Final Engineering and Equipment Design) – cost estimate based on reimbursed design work which can therefore be more detailed and result in a higher confidence cost estimate for the balance of the project: This approach allows everybody (contractor, owner, and regulator) to be involved in the project at the stage where they can make the biggest contribution to managing risk. LS mark ups will be negotiated and fixed up-front based on known scope. In this mechanism, late changes can be incorporated at minimal cost and it has potentially lower risk premiums. This approach is a staged contract approach and therefore it's well suited to the nuclear industry. It takes advantage of the 3 year licensing period to complete a majority of the engineering so that material quantities are known and equipment pricing is firm. It also allows the owner flexibility during the licensing period to implement design changes necessitated by

regulatory requirements, moreover it shortens the forward window on construction to 5-6 years allowing more confidence in price and escalation forecasts.

Finally, he concluded that successful "fast track" projects don't exist and the natural "ABC" sequence of the projects which are planning, engineering, procurement and construction shouldn't be changed. Planning and alignment of interests at all stages is very important.

Business Case Necessities for Nuclear Projects – Alexander Pourbaix, President, Energy and Executive Vice-President Corporate Development, TransCanada Corporation

Alexander Pourbaix reviewed the experience at Bruce 1 & 2 and highlighted the need to focus on engineering changes in the planning, design and construction stages of the project and to introduce sufficient flexibility in the process to ensure productivity is not degraded when unplanned incidents happen. Also, with regard to contracting strategy, the best approach for an investor is getting a fixed price, turnkey or EPC contract for the entire refurbishment project. However, this option was not available for Bruce at that time; therefore they did the next best thing which was individual fixed price contracts. The challenge is as follows: if a contractor did not perform they could be penalized, but Bruce Power wasn't able to impose penalties sufficiently large to offset the extra costs caused to other contractors due to the non-performance. In effect therefore, Bruce Power retains some construction risk on the scope of the whole project.

Pourbaix further described the commercial aspects of the project. He mentioned that there does not exist a strong enough power market that could justify a merchant plant that could be built on

the basis of forward price curves. The refurbishment investments are large and they need to be supported by long term power purchase agreements. And since there is a long time to see the cash flow from the commencement of the project, there should be a significant risk sharing among stake holders. Therefore, government should have a great involvement both in development and execution of the project.

Pourbaix highlighted the nuclear project requirements with respect to project management. For a multi-million dollar nuclear project, it is critical to consider project management execution as stage gates, and to maintain this discipline throughout the whole project, by not going to the next stage before successful completion of the required predecessor stages. The other important aspect is to understand the scope of the project and, especially, if it is a refurbishment project there should be a rigorous assessment of the condition of the existing plant prior to initiation of work. He observed that tooling performance has been a challenge in the Bruce refurbishment project. Good performance of robotic tools under laboratory conditions did not translate well under field conditions. The necessity of an independent oversight, by bringing independent experts for audit, is another key element and he emphasised the importance of leadership in mega projects and praised Bruce project for having successful leadership.

Finally, Pourboix discussed the capacity of the industry to undertake such large projects and noted that when suppliers are not able to deliver what they promised, the industry should have mechanisms to respond to these situations. Also, regarding workforce productivity, he emphasised that a young labour force must be well trained and aligned with project outcome. As for regulatory certainty, he emphasized the need for a transparent but predictable and fair regulatory process to give investors peace of mind.

Session 3: Safety

Canadian Nuclear Safety in Practice – Michael Binder, President and CEO, Canadian Nuclear Safety Commission

Michael Binder defined CNSC as Canada's nuclear watchdog, which has the objective of protecting the health, safety and security of persons and the environment; and to respect Canada's international commitments on the peaceful use of nuclear energy. CNSC regulates all nuclear facilities and activities in Canada (nuclear power plants, uranium mines…). The Commission itself is an independent quasi-judicial administrative tribunal, supported by a strong scientific and technical staff.

He emphasised that the nuclear industry is the most heavily regulated industry in Canada, and the CANDU design has operated safely for decades providing 50% of Ontario's electricity.

Binder noted that uranium mining is also more rigorously regulated than any other type of mining in Canada and Canada's four licensed uranium mines in Saskatchewan supply 25% of the world market.

On the subject of radiation and the environment, he emphasized the stringent license conditions that conform to international standards and the low level of exposure to radiation during normal operation. In addition, he noted that there are a million medical isotope procedures annually in Canada, and Canadians receive more than half of their life time radiation dose from natural resources. Using internationally accepted health guidelines, he stated there is no credible evidence of health concerns at any nuclear site in Canada.

Binder noted that the level of ignorance when it comes to nuclear energy is widespread and society's perception about nuclear is polarized; emphasizing that significant outreach is required in order to obtain a social licence to proceed.

Safety and Reliability in Nuclear Reactor Operations – Ronald D. Crawford, Deputy Director, Regional Centre – Atlanta, World Association of Nuclear Operators

Ronald Crawford discussed the role of the World Association of Nuclear Operators (WANO) which has the single aim of promoting the highest levels of safety and reliability at nuclear power plants around the world. WANO was formed in 1989, following the 1986 accident at Chernobyl nuclear plant in Ukraine. WANO's governing board establishes strategies and policies and the mission is carried out by a coordinating center and four regional centers which work closely together as a team to ensure activities are coordinated across the regions. Four basic programs which include peer reviews, operating experience, technical support and exchange and professional and technical development are implemented.

WANO's membership includes 447 operating nuclear units located in 32 countries or regions. In addition to its technical employees, WANO relies on industry peers to carry out its key programs, such as peer reviews and technical support missions.

Crawford explained that WANO's operation is different than nuclear regulators such as CNSC, since regulators assess plant performance relative to minimum standards that are essential for safe operation while WANO peer reviews compare plant performance to standards of excellence,

identifying potential gaps to industry best performance. After utilities receive WANO's feedback, WANO Atlanta Center checks on their progress in addressing the mentioned areas for improvement on a mid-cycle review visit, about one year after the completion of the peer review.

Ronald further explained the operating experience program as a tool for members with the intent of learning from each other and avoiding a repeat of similar events. Also, he mentioned that technical support missions are to help resolve known issues, identified by peer review teams. In addition, WANO publishes performance indicators in the areas of nuclear safety, plant reliability and personnel safety.

Health Effects and Radiological Safety - Experience from Accidents – Daniel Krewski, Professor & Director, Centre for Population Health Risk Assessment, University of Ottawa

Daniel Krewski discussed the radiological impacts of the Chernobyl accident that occurred in 1986 and summarized the studies and assessments performed to date to evaluate cancer increases from the radioactive fallout.

Krewski outlined the approach and basis of assessments. Average region-specific whole-body and thyroid doses were estimated, then numbers of deaths and cancer cases caused by the incident approximated, and by using risk models, the approximate future outcomes are predicted. Also, trends in cancer incidence were examined over time and by dose level. The results indicate that the accident contributed to approximately 1,000 additional cases of thyroid cancer and

25,000 cases of other cancers; this comprises a small increase – about 0.01% - in the context of cancers in the population expected from all other causes.

Krewski further discussed the social impacts of disasters and described a model for developing an understanding of psychological impacts of catastrophic events involving chemical, biological, radiological, and nuclear facilities. The framework to assess the psychosocial impacts is based on aspects of the situation, nature of the event, involved population and mechanisms to control the event. One of the main contributions of this research has been a structured mechanism to respond potential attacks of terrorism that address different time frames, including post event, recovery and construction.

Luncheon Presentation – Duncan Hawthorne, President & CEO, Bruce Power

Duncan Hawthorne reflected on the history of the nuclear power industry and pointed out that the industry must accept a considerable part of the blame for the public's view of nuclear as being expensive and late. He pointed out that not one of the key contractors and suppliers to the current refurbishment project ongoing at the Bruce Power site has fully delivered on their contractual promises. While government action will be helpful to the industry's future, it must be complemented by initiatives from industry players themselves to restructure their businesses and operations so that they can reliably deliver quality products and services on time and on budget.

He then analyzed the nuclear renaissance that is sweeping the world and concluded that the projected rate of construction of new nuclear plants was not achievable. Considering only the expansion plans for countries that presently have nuclear power will require construction of between 6 and 20 new reactors each and every year for the next 20 years – one new unit coming into service every 3-8 weeks. Adding in the plans for countries considering adopting nuclear for the first time could double or even triple these estimates. Given that construction activity has been virtually non-existent for the past decade, the supply chains for most of the nuclear technologies have atrophied and simply do not have the capacity to fulfil these forecast requirements. The world's only supplier of forgings for pressurized water reactors presently has the capacity to fulfill orders for just two reactors a year. As well, there is a shortage of experienced and qualified engineers, skilled trades and operating personnel which is growing as demographics lead to the retirement of most who designed, built and now operate the existing nuclear facilities.

Session 4: Waste Management

Canada's Waste Management Plan – Ken Nash, President and CEO, Nuclear Waste Management Organization

Ken Nash described the initiation of the Canadian nuclear fuel waste management program 1980, as a result of growing nuclear program in Ontario. In 1977, a report commissioned by the Federal government (Hare Report) recommended geological disposal of nuclear waste in the rock of the Canadian Shield. In 1978, the Porter Commission recommended progress on waste disposal research. In mid 1980, the AECL geological disposal program was

considered to be the world leader. In 1998 the Seaborn Panel reported adequacies of technical safety at the conceptual level but noted that public support had not been demonstrated. The Panel made 52 recommendations that were largely translated into the Nuclear Fuel Waste Act in 2002. It also resulted in formation of the NWMO, an advisory council and trust funds. In 2005, a study of alternatives was completed by NWMO and in 2007 the government accepted the NWMO recommendation.

The study of alternatives conducted by NWMO between 2002 and 2005 engaged 18,000 Canadians in120 information and discussion sessions and involved 500 experts. There was a wide range of views but common ground that safety and security is the highest priority; that action should be taken now; that the approach should be consistent with best international practice and it should be adaptable to both technical advances and changes in social values.

Nash explained that in 2007 the federal government decided to adopt NWMO's proposal for adaptive phased management approach. NWMO's research showed this approach best met the values and priorities of Canadians. Technically, APM has the end point of isolation of used nuclear fuel in a suitable geological formation. He also explained that the process to get there was equally important and involves an open and transparent process, flexibility in the pace of implementation, and an informed and willing host community. Nash illustrated that most countries with major nuclear activities have national plans for geological repositories.

According to Nash, the key objectives for NWMO are:

1. Maintain a social license to proceed by involving aboriginal people, municipal, public, interest groups and governments in decision making

2. Further developing repository design and confidence in safety supported by collaboration with other countries

3. Collaborative design and implementation process for site selection: It's a 9 step process, involving social, safety and environmental evaluation. It embodies the concept that a community chooses to participate and has right of withdrawal.

4. Refining formula for trust fund contributions to ensure that those that benefit from nuclear power pay for long-term waste management costs,

5. Researching alternative methods and changes in societal values,

6. Continually improve governance structure and organizational capability.

Nash concluded his remarks by summarizing that as a result of 25 years of studies, dialogue and government decision making, NWMO now has a mandate to proceed that is consistent with the expectations of Canadians and that mandate includes taking action now to protect the interest of future generations.

Social Acceptance and Siting – David Cameron, Chair and Professor, Department of Political Science, University of Toronto

David Cameron described the role of the Advisory Council under the Nuclear Fuel Waste Act, membership and operation.

He explained that the NWMO advisory council is required to examine and comment on NWMO study of management approaches for used nuclear fuel. It also has an ongoing responsibility to

provide written comments in the NWMO triennial reports.

Cameron elaborated on the council's report to the government in 2005 that emphasized the need for NWMO to operate with integrity and transparency. He further described some of the specific advisory council recommendations, supporting good governance, adaptive phased management (APM) and aboriginal engagement, and concluded his remarks by observing that the NWMO is an exemplary organisation in its commitment to deep and thorough public engagement.

Yucca Mountain and the US Waste Management Program – Tom Isaacs, Consulting Professor, Stanford University & Director of Policy, Planning and Special Studies, Lawrence Livermore National Laboratory, California

Tom Isaacs gave a quick review on US repository plan and the situation in Yucca Mountain. He indicated that the program is changing dramatically.

The Yucca mountain project has had a dramatic budget cut (under $200 million), and staff reduced from 650 to 100 employees. On the other hand, consumers have contributed $30 billion to this program, and over $7.7 billion has been spent on research, and in conclusion there is no evidence to disqualify Yucca Mountain as a repository. In August 2008, all ten national labs signed a letter advocating continuing licensing.

Isaacs explained that industry is focusing on new reactor orders and reprocessing of fuel, and a possible new back end for the existing fuel cycle.

The only deep geological US repository, Waste Isolation Pilot Plan (WIPP), is being hosted by a community (Carlsbad) in New Mexico and the community is willing to host a high level waste (HLW) facility as well.

The current administration has promised to establish an 11 member commission to complete the study about nuclear waste. Isaacs said, this presidential commission will evaluate the entire range of back-end issues, study alternative management and financing strategies, technical concepts and timing, and evaluate safety, environment, risks, costs, security, transport and incentives for the host community.

Isaacs talked about the key differences between American and Canadian nuclear waste management programs. First, planning is very difficult in the USA because of short term political considerations, and there are tight deadlines in law with respect to liability implications. Also, in the USA siting is imposed based on site specific scientific data and promise, but not the notion of a willing host community, and finally, the American nuclear industry is not always united.

Issacs concluded his remarks by mentioning a few lessons. Although politics are clearly valid and important, a buffer should be always considered for overall effectiveness. Also, overly ambitious, artificial timelines hinder progress and erode confidence. Moreover, adaptive staged approach often seems to work. And interests of the host community should always be considered.

Session 5: Future Directions for Canada

Moderator: David McFadden, Partner, Gowling Lafleur Henderson LLP & Chair, Gowlings International

Participants

- Hugh MacDiarmid, President & CEO, Atomic Energy Canada Ltd.
- Duncan Hawthorne, President & CEO, Bruce Power
- Al Kupcis, former CEO Ontario Hydro, former Chair Canadian Nuclear Association
- Trevor Findlay, Professor and Director, Canadian Centre for Treaty Compliance, Carleton University
- Sean Conway, Director, Institute of Intergovernmental Relations, Queen's University

David McFadden, the moderator of the session, structured the discussion around 5 questions. Following is the summary of this roundtable discussion:

Question1: What regulatory concerns arise when countries move to nuclear generation for the first time, in relation to compliance with the nuclear non-proliferation treaty?

Trevor Findlay: It depends on which countries are moving towards nuclear generation. Some developed countries have already demonstrated a sound regulatory system, and they are in a good standing with NPT. However, several other countries that have indicated a desire to establish a nuclear program have not developed an adequate regulatory infrastructure and do not have a "safety and security culture" to be able to mange technologically sophisticated power plants. Thus, some of these countries are major concerns.

Al Kupcis listed some countries like Azerbaijan, Mongolia, Bangladesh, Uganda, Namibia, and Yemen, which have showed interest in having nuclear options. Then he asked what should be the

global institution to make sure these countries have appropriate infrastructure to manage this sophisticated technology. The IAEA guideline indicates it takes 8-10 years for a country to demonstrate adequate competency and the capability of running nuclear technology by improving its legal structure, safety culture, technical skills and education.

Duncan Hawthorne mentioned the role of IAEA and WANO in setting up the road map for new entry countries. He raised two main challenges in this regard:

The first contact for a new country interested in nuclear is a vendor and vendors are not talking about safety and regulatory issues. Therefore, there is no informed customer with sufficient knowledge about the safety and regulatory side of nuclear technology. The second thing is the political barriers that arise when politicians get into the process. For example, Iran has nuclear technology built by Russians, however due to political barriers, WANO, cannot send technicians from its USA office for the monitoring and critical reviews.

Hugh MacDiarmid believes that there is an industry infrastructure dimension to this subject and it falls along the line of vendors and operators, in the sense that there has been a globalization of the vendor community, and that drives us to global standards and harmonization of a lot of components which may take decades.

Sean Conway commented on the politics of globalization. He mentioned the need for international governance and the importance of strong regulatory regime. Otherwise, the historically politically unstable countries will create significant problems.

David McFadden continued this conversation by asking another supplementary question, which was on how the willing some of the potential new nuclear power countries would be to adopt international regulatory agreements.

Duncan Hawthorne noted that he didn't see this as a big a hurdle as the financial implications in a country's decision to adopt nuclear power. He felt that countries smart enough to manage the capital investments involved are also smart enough to see the cost savings from adopting internationally established standards and could be counted on to make the right decision. He gave as examples Jordan and UAE, and explained how capable these countries are in their commitment to a regulatory framework.

Al Kupcis gave an example of China and explained how successful the Chinese are in this industry by having plants with best ratings in respect to their competence, morale and safety.

Trevor Findlay mentioned the physical and financial capacities of some poor countries and explained that although some countries are interested, they may not be able to pass the first steps due to financial and physical limitations such as grid size.

Question 2: How do we evaluate the potential of nuclear energy to meet the growing demand around the world?

Al Kupcis mentioned that nuclear is the answer for growing base load, and he emphasized that we don't have enough project supply-chain capacity yet and it is not going to be adequate any time soon but perhaps by 2050. Referring to the talk by Duncan Hawthorne, he said we have not built in Canada for a long time. Developing nuclear depends on regional resources which are influenced by economics, cost and availability of critical components and competent technical staff. The other point that he raised was the political short term decisions and interventions by governments that often lead to delays on large nuclear projects.

Duncan Hawthorne observed that over the last 30 years, 400 reactors have been built and he mentioned that we were doing much better at that time than now. He mentioned that today there

are only four major vendors in the nuclear industry and they each need to build 10 reactors per year to meet the demand projections of an expansive nuclear program. He said that appears to be totally unrealistic. He criticized the Canadian government for not having any long term plan for the future unlike France where they have a detailed plan for expansion of their nuclear capacity over the long term. The main problem in Canada is a lack of commitment to the international market. Hawthorne indicated there could be about 10 more plants built over the next 25 years and anything more than this is unrealistic.

Sean Conway referred to Duncan's talk about the element of uncertainty and unpredictability in this area. He emphasised that Canada has no other choices than going towards nuclear if it wants to say NO to coal. And he mentioned that the main question for Canada is what nuclear technology should be used? Finally, he referred to Ontarian's values on the importance of security of supply, and said since Canada has the technology and expertise in nuclear it would be the main source of energy in order to adhere to this value.

Hugh MacDiarmid values the diversity of supply and he focused on the evolution of nuclear technology in Canada. According to Hugh, with regard to nuclear energy, we are facing an S curve. Measuring our progress against time and effort, we can realize that the progress is slow in the beginning but as time goes by the speed becomes faster. He concluded that we need to be patient with decision makers on this subject because the time frame associated with this technology is long.

Question 3-a: Where do you see the nuclear industry contributing to the Canadian economy in the longer run?

Duncan Hawthorne: The Canadian nuclear industry can leave a bigger foot print than just restricting our activities to CANDU technology. He mentioned that there are lots of needs in international power supply and Canada has enough capability and trust to fill this gap. Also in Canada, all nuclear reactors which exist now will remain for the next 25 years by refurbishment; therefore all 30,000 direct jobs will stay as a result.

Sean Conway: the future of nuclear technology is quite promising and even under the modest scenario there will be good opportunities for Canadians. He expressed his concerns about the bad image the Canadian nuclear industry has picked up due to the recent problems with medical isotopes and mentioned that we as a country must resolve these issues.

Al Kupcis expressed disappointment with the Canadian and Ontario government for not making decisions in a timely manner about the future of this industry while we have good amount of expertise because the potential exists for nuclear to play an important role in mitigating the challenge of reducing carbon emissions.

Question 3-b: How do you evaluate the future of nuclear industry generally?

Hugh MacDiarmid: nuclear is an industry which is central to the future of our planet. When you bring together energy, economy and environmental policies, potentially the core answer is nuclear. As he described, nuclear is an enabler of societal progress. For example, a country like India has significant plans to expand nuclear capacity by building 50 reactors in the next 40 years. He said nuclear is helping us to have energy security and independence, and in Canada we

do have capacities to be significant player in this industry. However, we need to learn a lot by building managerial, technological and execution capacities.

Sean Conway explained that one of the real issues over the last 25 years has been the conflicted nature of the "shareholder" of AECL, namely the government of Canada. He said that regardless of who was in power, a substantial part of shareholder sentiment did not even support being in the nuclear business and in order to move forward this problem should be resolved.

Question 4: What's happening in terms of evolution of nuclear technology and the impact it has globally and also in Canada?

Duncan Hawthorne explained that since there are different types of customers, different types of nuclear technologies might be needed. For instance rich developed countries try to spread the high capital cost of construction over more capacities (more than 1000 MW), however some smaller regions like Saskatchewan don't really need the large capacities, unless they want to export the extra capacities to other provinces. Therefore there is a tremendous market for smaller sized nuclear generators with capacities of less than 200 MW. Similar to the size of the early , CANDU reactor (i.e. Douglas Point), Candu technology could be readily adapted to serve such a need and would be a good example for these types of generators. According to him these small size generators would enable Canada to invest in developed countries at a lower investment risk.

Al Kupcis backed up Duncan's remarks on good opportunities for small size reactors. He mentioned that these reactors not only solve some issues like constructability but also they don't need off-site emergency planning. He explained that there is a rush to capture this market and great interest among several vendors to develop small reactors, including the Chinese who are trying hard to be competitive in this market.

Trevor Findlay: small size plants are sensible for developing countries in terms of economics but they do raise questions about safety, security and non-proliferation, which haven't been looked at thoroughly for these types of reactors. These issues have always been considered in the context of large size reactors. So before spreading these small reactors among developed countries we need to make sure that the regulatory system is effective to guarantee their safety and security.

Question 5: How is the public opinion about acceptance of nuclear energy globally as well as in Canada?

Sean Conway mentioned that the acceptance of nuclear has improved a lot during the last 10-15 years. For instance, compared to other technologies like wind, nuclear is in a better position now. He also said our experience shows that siting should be where public acceptance exists.

Al Kupcis: All polls in Canada and USA show that there is greater public acceptance in areas which have had experience with nuclear energy facilities, compared to regions which do not have such facilities. The acceptance of nuclear and strong support in communities that have nuclear facilities is an important indicator of how well the industry has addressed concerns of citizens and it also speaks to corporate responsibility. As he mentioned, it is totally opposite for wind energy, since people who have it don't want it anymore while those who have just heard about it are enthusiastic. He also observed that European countries are now getting back to nuclear (Italy, Sweden, Belgium).

Duncan Hawthorne started by talking about the definition of public acceptance. According to Duncan, public acceptance is achieved when the community is happy with what they have. It is basically a social license that generators should have to be able to proceed. The main problem is

not public acceptance; the challenge is acceptance by politicians. Politicians are biased toward more popular alternatives such as solar, wind and conservation rather than supporting nuclear.

Sean Conway added another point that there is a need to preserve the institutional memory, given that anything more than 5 years is old, looks very different in the new context.

Trevor Findlay confirmed that people who are close to nuclear sites tend to be accepting of the technology; however one major accident could easily turn public opinion around. If nuclear energy is going to spread globally we need to make sure everybody who's involved has the same safety and non-proliferation standards as the good players in this industry.

Audience

Jan Carr added some comments on public acceptance and institutional memories. He mentioned that in Ontario important decisions are in the hands of government departments where leadership turns over in less than a year on average. And since new people are also new into industry, there is no institutional memory on the government side of the equation. He continued by sharing some of his experiences when he was in public sector. For example, he mentioned public that politicians were amazed when they found that their nuclear announcements attracted little or no public attention – pro or con.

Audience: Due to economic recession there isn't that much attention on building new nuclear generators. What would be the necessary actions if economy goes back to normal?

Duncan Hawthorne: it would be a big challenge to meet demand and especially for nuclear generators to get back on again.

Sean Conway observed that we are suffering from a culture of plenty in our country. As he described, our society hasn't experienced shortages like other countries and that makes policy making for future more challenging.

Audience: Since we have experience by building reactors overseas and refurbishing at home, after the announcement of restructuring AECL, how can we maintain control of our expertise if it is privatized given that there is a large inertia towards replacing nuclear power right in our own home market?

Hugh MacDiarmid mentioned that human resources is a major challenge that we face in this regard, for instance, there are 700 AECL people involved with the refurbishment project and we should make sure we have jobs for those people after they are done.

David McFadden, in his final summation, thanked the speakers for sharing their perspectives in a candid manner and noted the excellent potential for nuclear to play a constructive role in the global supply mix and the range of initiatives underway at the Federal and Provincial government levels bodes well for the future. It will take a good combination of managing the governance issues, development of required policies and strong support by the industry and private sector entities to deliver on the promise of Canadian nuclear technology.

Conclusions

Nuclear power is an essential ingredient for meeting global energy needs while simultaneously reducing the production of greenhouse gases and making progress on the alleviation of poverty. The nuclear industry does not enjoy unqualified public confidence in part due to concerns around

safety and waste management which have no foundation in factual experience. The nuclear industry's reputation for delivering late and over budget is exaggerated but has some basis in fact.

Canada's CANDU technology has a role to play due to its unique characteristics but its full potential cannot be realized with the present commercial structure of its owner, AECL. The Government of Canada's announced corporate restructuring of AECL is a positive step toward realizing economic benefits from the substantial investment it has made over many decades in nuclear power.

Nuclear power's contribution to future global energy supplies will be limited by the lack of capacity in the existing supply chain. It will also be limited by the challenges of propagating to new entrant countries the comprehensive regulatory oversight and peer review programs that are essential to maintaining safety standards and a regime of non-proliferation treaties.

Overall, the promises of Canadian economic success while making a valuable contribution through its nuclear industry to reducing geopolitical tensions by facilitating sustainable energy supplies far outweigh the challenges in realizing these goals. To facilitate this, the Government of Canada should act on its announced intent to restructure AECL without delay. As well, the nuclear industry should address its chronic inability to complete projects on time and on budget such that commercial performance achieves the same high standards it has achieved in both its technical operations and its safety record.

Jatin Nathwani and Jan Carr

Conference Co-Chairs