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GREENHOUSE GAS REDUCTION AND CANADA'S NUCLEAR INDUSTRY

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Abstract

The Kyoto Protocol of the United Nations Framework Convention on Climate change, dated December 10, 1997 committed Canada to reduce greenhouse gases to 6% below 1990 levels by 2008-2012. Subsequently the federal government initiated a broad review of the implications of such a reduction across all sectors of the Canadian economy to identify options for eventual implementation. The Canadian nuclear industry participated in this review. This paper examines the status of this review to date and identifies options, which may significantly influence the use of nuclear energy domestically and internationally.

This paper provides a review of options established by the three key Issue Tables in the context of implications to the nuclear industry. Several of the other Issue Tables have also identified options, which have major future implications for the use of nuclear energy. For example the Transportation Table has addressed the possible production and use of hydrogen fuel as an energy carrier. Biological and geological sinks are emerging technologies which will likely lead to increased energy demand. Development of the necessary infrastructure to support these new technologies could lead to a substantial need for increased production of electricity from greenhouse gas free sources in Canada in coming decades.

In conclusion, international concern with climate changes re-focuses attention to human application of nature's energy sources. The studies implemented by the

Climate Change Secretariat have resulted in a comprehensive evaluation of opportunities for Canada to contribute to reduction of greenhouse gas emissions in Canada and abroad. The ability of Canada's nuclear industry to provide greenhouse gas free energy in the large quantities needed by modern society is recognized.

INTRODUCTION

The Kyoto Protocol of the United Nations Framework Convention on Climate change, dated December 10, 1997 committed Canada to reduce greenhouse gases to 6% below 1990 levels by 2008-2012. The federal government initiated a broad review of the implications of such a reduction across all sectors of the Canadian economy to identify options for eventual implementation. The Canadian nuclear industry participated in this review. This paper examines the status of this review to date and identifies options, which may significantly influence the use of nuclear energy domestically and internationally.

The federal government enlisted, through the recently established Climate Change Secretariat, some 450 experts from government, business and industry, the academic community, environmental groups and non-government organizations. These experts participated in the work of 16 Issue Tables (Tables) examining and analyzing the impacts, costs and benefits of options to address climate change. The Tables began their work in July 1998 and have now prepared some 22 options reports. Most of these are available at the Climate Change Secretariat's public WWW site[1]. The options in the reports are currently under review to determine actions needed to address climate change and their level of priority. The outcome of the review will form the basis of Canada's national implementation strategy for consideration by joint Ministers (federal, provincial and territorial) of Energy and the Environment over a series of meetings in 2000-01.

The Canadian Nuclear Association (CNA) supported four experts to participate in the work of the Tables and the Integrative Group. The Tables supported were the Electricity, Kyoto Mechanisms and Technology Tables. These Tables were deemed to be of prime importance to the nuclear industry.. The Electricity Table reviewed emissions from domestic electricity production and recommended options for consideration to reduce GHG emissions. The Kyoto Mechanism's Table is of particular importance to the export of reactor systems and uranium as cost benefits to nuclear may result from any actions taken to constrain greenhouse gas emissions. The mandate of the Technology Table enveloped all sectors and focused on the identification of options to develop Canadian technology that could play a role in reduction of GHG emissions. A prime goal was to encourage early development of promising Canadian technology in order to take advantage of the international market expected to develop up to 2008-20012 and beyond to 2020 – 2030 as actions are taken to implement the Kyoto Protocol.

The Integrative Group is composed of the co-chairs and selected representatives of the Issue Tables and has undertaken review of all of the Issue Table Options Reports. It is assisting the National Air Issues Coordinating Committee with the preparation of the national implementation strategy for consideration by Ministers of Energy and Environment.

These paper reviews in some detail the options recommended by these three key Tables in the context of implications to the nuclear industry. Several of the other Tables have also identified options, which have major future implications for the use of nuclear energy. For example the Transportation Table has addressed the possible production and use of hydrogen fuel as an energy carrier. Development of the necessary infrastructure could lead to a substantial need for increased production of electricity from greenhouse gas free sources in Canada in coming decades.

TABLE MODE OF OPERATION

The final reports of the Tables represent a major investment by Canadian governments and industry to review the status of climate change and greenhouse gas emissions in Canada. On average the tables were made up of 30 individuals representing a broad range of expertise and stakeholders. Membership was carefully established to ensure that regional, government, industry and non-governmental interests were represented in a balanced way. The work of the Tables typically began in the spring of 1998 with options reports, for the most part, essentially completed and circulated within the Tables by the end of 1999. Meetings were held at appropriate locations across Canada on approximately a monthly basis. Most Tables also engaged specialized consultants to collect and analyze information needed to understand the climate change implications of the sectors represented.

In general, Tables were asked to focus on the time period established by the Kyoto Protocol. The Protocol committed the so-called developed nations to reduce greenhouse gases to a specified level relative to 1990 levels by 2008 to 2012. Canada's commitment was to a level of emissions 6% below 1990 levels. The Tables first task was to prepare a Foundation paper, which established the anticipated scope of work and detailed mandate of each Table. (*These reports are also published and available on Canada's Climate Change WWW site*[2]*.)* The next order of business was to review and establish the status of emissions from the sector and to project expected emissions to ~2010, assuming that business would proceed as usual without the additional constraints imposed by the Kyoto Protocol. The final step involved review and identification of potential measures, which could be implemented to reduce emissions. To varying degrees, Tables evaluated the effectiveness of measures and packages of measures. The final Options Reports of the Tables recommend measures options for consideration by ministers. The Table's work was completed at the end of March 2000.

The Tables, for the most part, considered their sectors in isolation from the remainder of the Canadian - and International - economies. *(The electricity table, for example, did not take into account major changes such as a possible shift of transportation to electricity as the main source*

of energy.) Two additional "Groups" were formed early to consider the work of the Tables in an integrative mode. The Integrative Group, initially formed from the co-chairs of the Tables, and later supplemented with selected members of the Tables, remains involved in reviewing the work of the Tables with the goal of establishing understanding and appreciation of overlapping and complimentary aspects of the Tables. The Analysis and Modelling Group is undertaking economic modeling of the Canadian economy based on input from the Tables. The intent is to provide integrated analysis of proposed measure packages that will quantify greenhouse gas reduction and associated consequences to the Canadian economy. Modelling which takes into account the entire economy has the capability to capture changes which cut across economic sectors.

Some of the Tables (the Technology Table and the Kyoto Mechanisms Table are examples) deviated from the above mode of operation as their topic was of significance to many sectors of the economy. The Technology Table reviewed greenhouse gas reduction technology with the twin goals of identifying technology that could be developed to reduce greenhouse emissions in Canada and marketed to other countries. The perspective was to propose measures that would begin enhancing the Canadian innovation system so that technology that could be deployed well beyond the Kyoto commitment date would be well established by that time. The Kyoto Mechanisms Table examined the potential of economic instruments, or measures intended to manage the economic cost that may be imposed on greenhouse gas emissions. These "flexibility" mechanisms potentially involve all other economic sectors.

Generally the Tables paid little attention to possible variations in primary energy source in terms of greenhouse gas emission intensity. The background of many participants often focused their attention to renewing past efforts to improve energy efficiency as a means of reducing emissions associated with energy use. The Electricity and Technology Tables did include explicit discussion of nuclear energy. The measures proposed by these tables included options intended to enhance the deployment and development of nuclear energy. Several other Tables included measures that could encourage the use of more electricity, thus potentially expanding the scope for utilization of nuclear energy. The following sections summarize analyses and measures proposed across Tables in the context of potential impact on the nuclear industry.

THE ELECTRICITY TABLE

Electricity production in Canada is a relatively small producer of GHG as approximately 75 to 80% of Canada's electricity is derived from nuclear energy and waterpower. Many other countries, the United States for example, depend much more on fossil fuels to produce electricity. The goal of the Electricity Table, to reduce emissions within the sector to meet the Kyoto Protocol, thus has only a modest effect on the overall Canadian GHG emissions reduction needed to meet the Kyoto goal.

The Table undertook its work in three phases. The first established terms of reference and prepared the Foundation Report. The second involved data gathering and analysis. Finally Table members examined the results of analytical work and developed measures that could contribute to Canada's emission reduction target to and beyond the Kyoto period.

The Foundation Paper established the current state of the sector. The Electricity Table used a Natural Resources Canada report[3], Energy Outlook 2020, as the reference for its "Base Case" as a known starting point. The report represents NRCan's best estimate of future electricity demand in Canada assuming that additional measures to reduce greenhouse gas emissions are **not** introduced. During the course of the work the NRCan report was updated[4].

The assumptions used to prepare Energy Outlook 2020 also imposed constraints on nuclear energy which remained throughout the modeling process. These included:

- A minimum ten (10) year lead time for project implementation
- No new nuclear plants initiated until 2010
- Bruce A and Pickering A out of service until their scheduled return to service dates

This resulted in no new actual nuclear generation being introduced up to 2020.

The "business as usual" projections of Energy Outlook 2020 do not show a large increase in demand or installed capacity.. It was deemed beyond the mandate of the Table to consider major changes in energy demand that might be induced by GHG constraints. The Electricity Table assumed that the effects of interaction with other sectors would be captured by the work of the Analysis and Modelling Group. As a result of these constraints the Table focussed on the cost of changing the mix of generation to reduce emissions to 6% below 1990 levels.

In the second phase some additional analyses were undertaken to examine the impact of electricity demand beyond NRCan projections based on business as usual. The analysis was directed to finding the least cost changes in the electricity mix to reduce emissions from generation. A computer model known as MARKAL was chosen to undertake the analysis. It was calibrated using data to allow modeling of the Canadian electricity sector. The model has the ability to model international influence on the Canadian electricity production.

Consultants were hired to assemble data on projected costing of the various technologies which formed the basis for updating the information in the MARKAL model. The nuclear and fossil generation pricing information was extracted from the most recent information publicly available. Information which was considered proprietary was either carefully guarded by the process or not made available to the model. Utilities were concerned with sharing strategic projections in the face of future competition in the sector and technology pricing in areas where international competition is contemplated. As a result technology costs are not methodically documented on a comparative basis in the Options Report.

The model was run to 2040 in five (5) year intervals. The main analysis centered on the information and results up to 2020. The model is capable of determining the following based on the least cost option:

- Electricity generation required
- Capacity required with adequate reserves
- Transmission line requirements
- Inter-provincial electricity trading
- Retirement of capacity

The model outputs for each scenario included the following for Canada and each province:

- Price per ton of CO_ avoided
- Installed capacity required for each technology each year
- Actual expected electricity generated
- Cost of electricity

The sensitivity model runs indicated that the following variables had a significant effect on the output of the model:

- Demand
- Gas pricing

The modeling of nuclear electricity posed some difficulty in view of uncertainty with respect to the restart of Pickering A and Bruce A. It was assumed, for the base case, that both would be refurbished as planned by OPG. New nuclear plants were not allowed in the base case modeling. Sensitivity studies included a case allowing new nuclear plants starting in 2010 and another case also considered the possibility that Bruce A not be restarted. The model did not call for new nuclear in the first variation while meeting the target of GHG emission of 94% of 1990 levels. The second variation resulted in increased electricity production from hydraulic and gas powered sources while simultaneously decreasing generation from coal. The net increase in annual emissions with failure to restart Bruce A was thus calculated to be only 6 Mt. The potential contribution from restarting Bruce A is thus underestimated by a large factor as each unit of Bruce is capable of avoiding about 6 Mt relative to coal powered generation. Perhaps a revision of the modeling to credit export of more electricity to the US, where most electricity is from coal, would result in better utilization of North American resources?

The Table observed that there is a defacto moratorium on new nuclear capacity in Canada. There are also significant restrictions on new, large hydro projects. These coupled with anticipated stable prices for natural gas and emerging high efficiency gas turbines generally tipped the

economic balance in favor of using natural gas for the limited growth in electricity supply capacity envisaged.
The constraints and economic conditions imposed on the modeling were such that nuclear energy production was projected to change very little during and beyond the Kyoto commitment period.

Finally, in the third phase of it's work, the Table considered measures in two phases that could be implemented in a staged manner. The first phase measures were identified as "preparatory" and are intended to encourage, over the next one or two years, the availability of least cost technology for deployment in the commitment period. The Table identified GHG emission pricing as the most efficient means to reach a given constraint in emissions from the sector.

The preparatory measures proposed include provision of GHG emissions information to consumers of electricity, Policy clarification and regulatory efficiency measures for nuclear and hydro electricity, research and development support for low emission fossil fuel technology such as CO2 capture and geological storage, removal of barriers for interprovincial transmission capacity and short term support for so-called "emerging" non GHG technology. The support for "emerging" technology relates primarily to small scale hydro, wind and solar energy and is intended to be in place only till GHG constraints allow these technologies to become naturally competitive.

The Table recommended only emission pricing as an effective means to constrain GHG emissions up to the Kyoto period and beyond. A minority of the Table felt that a large-scale binding portfolio standard (mandated percentage of generation from non-emitting technology) could also play a role. The Options Report mentions "carbon tax" only twice and then in the context of pointing out that the proposed measure should not be considered a carbon tax. The concept of "energy tax" is not mentioned in the report at all.

The membership of the electricity table included representatives of environmental non-government organizations. These members expressed reservations with respect to nuclear electricity in spite of demonstrated near zero GHG emissions. The Options Report clearly states that "**representatives of environmental groups believe the use of nuclear power as a response to climate change poses an unacceptable risk to human health an safety and the long term contamination of ecological systems. Consequently they recommend that government not pursue that option**". Some of the environmentalists have similar reservations, although not in bold type, with respect to large hydroelectric developments. These opinions are implicitly identified as a minority position.

In summary, the analysis undertaken by the Electricity Table is not surprising with respect to the scant expectations for increased nuclear capacity up to 2020. The business as usual growth rates for electricity, combined with large existing nuclear capacity and low anticipated gas prices lead to the use of natural gas for the small growth in system capacity anticipated. Clearly, once

the large nuclear plants are retired, beyond the timeframe on which the bulk of the analysis of the Options Paper were based, there will be a significant requirement for replacement non-GHG emitting technology. The possibility of increased need for GHG free energy to fuel other sectors has not been included in the analysis undertaken by the Electricity Table. Should GHG restraints become a reality across all economic sectors the need for electricity from GHG free sources is likely to expand still more.

THE TECHNOLOGY TABLE

The imposition of constraints on GHG emissions will result in substantial changes to the technology underlying energy production and use. Energy use pervades almost all aspects of the worlds economy from communications to agriculture and forestry. Technology development will be a fundamental part of Canada's National Implementation strategy. The Technology Table was established with the dual mandate to identify measures to advance the development, demonstration and deployment of innovative GHG reduction technology while enhancing national and international market opportunities for Canadian companies.

The Table went through a multi stage process to accomplish this end. The first stage of the process involved parallel and independent reviews of technology needs, availability, and measures to promote development. The next stage of the process included identification of existing Canadian technology responsive to needs and arranging available technology into groupings deemed "promising illustrative technologies". The final stage consolidated measures into a set of options aimed at enhancing Canada's ability to encourage invention, development and demonstration of technologies needed to reduce GHG emissions and bring them to readiness for commercial deployment as constraints on GHG emissions begin to be imposed.

Nuclear fission is included in the promising technologies. *(Nuclear fusion was discussed and was deemed of little promise with respect to the Kyoto and beyond (to ~ 2020) commitment period.)* The promising technologies are each discussed in the framework of “innovation” terminology . The capability of nuclear energy as a means of reducing GHG emissions is established and Canada’s nuclear “innovation” capability is established by reference to AECL and utility facilities, expertise and accomplishments in Canada and abroad. Barriers to commercial opportunities are identified and measures to enhance innovation in the nuclear industry are suggested. Suggested measures include improvement of the nuclear knowledge infrastructure through R&D to improve reactor performance and efficiency and support of demonstration projects to prove the use of nuclear energy for heating purposes (i.e. oil sands extraction). Additional funding support for development of nuclear fission, ramping up to $30 million/year is suggested. This is in addition to the current federal funding of approximately $100 million/year. Perhaps more significant to the future of nuclear fission in Canada is technology development recommended for the so called cross-cutting/enabling technologies. These include the development of fuel cells and other electrotechnologies which will ultimately increase the demand for GHG free energy in a GHG constrained world.

The Table developed "bottom up" (Appendix B) and "top down" (Appendix A) estimates of the funding levels deemed needed to encourage development of the promising illustrative technologies, and to implement improvements to Canada's innovation system, respectively. Comparison of the two appendices reveals a fairly close correspondence between the two estimates. The estimate based on summing up of the notional funding needs of the promising technologies is somewhat less than estimates for the broad measures intended to promote technology development through generally increased funding to Canada's existing innovation system. The funding recommendation sums to about one and one/half billion dollars focused on enhancing development of GHG reduction technology.

The summary provided by Appendix A (Based on Appendix 4 of the Technology Table Options Report) is of particular interest to the nuclear industry. It provides the Tables notional estimate of increased funding needs the technology families identified as promising illustrative technologies. Note that about $15 to $30 M/yr increased development funding is deemed necessary for nuclear fission. However, funding needed for technologies which could increase the demand for GHG free electricity is estimated to be about $200 M/yr. These technologies include fuel cells ($60 M/yr), transport ($30 M/yr), hydrogen ($20 M/yr), enabling technologies ($50 M/yr) and electrotechnologies (35 M/yr). These technologies will do little to decrease GHG emissions if GHG free primary energy is not made available for their implementation

The total package represented by the promising illustrative technologies thus includes recommendations for increased funding of research, development and demonstration measures which are significant to the future of nuclear power. The nuclear industry should also note that the options put forth by the Technology Table for consideration by ministers are not explicitly linked to specific promising technologies. They are very general in nature. Should ministers adopt them the implication is that a competitive process for allocation of the funding will be established. We can anticipate that the process will include some kind of evaluation of technology on the basis of dollars spent on development per unit of GHG reduction. History suggests that the nuclear industry can mount a strong case on that basis.

THE KYOTO MECHANISMS TABLE

The Kyoto Mechanisms Table was one of the first Tables to get underway. The impetus for this came from a need for early input to Canada's negotiators on International teams which are establishing the framework under which mechanisms for valuing and trading credits for reduced greenhouse gas emissions. The mandate of the Table was to provide advice to Ministers, government officials and interested stakeholders on Canada's strategic interests, and in particular, positions Canada should take on the elaboration of international market based mechanisms. These "Kyoto" mechanisms include Joint Implementation (JI), the Clean Development Mechanism (CDM) and Emissions Trading (ET).

A word count of key terminology often expressed in the Tables is revealing when applied to the Kyoto Mechanisms Table Options Report. Words related to specific technology, which are heavily used in most Tables' reports, are barely mentioned here. For example nuclear (0), solar (1) natural gas (1), oil (1), wind (1 - association name only), energy efficiency (1) and coal (1) are barely mentioned with the count in parentheses. Phrases and words like clean development mechanism (150), joint implementation (75), emissions trading (60) sustainable (25), flexibility (17), fungibility (24), supplementarity (21), eligibility (22) additionality 36) and baselines (40) are heavily used. The Options Report has apparently achieved a level of generality which is admirable and necessary at this early stage of development of the concepts behind the Kyoto mechanisms.

The "N" word is not used. Other technology specific terminology is barely used and then only to provide trivial example. Nevertheless the concepts and implementation details behind these heavily used words are highly important to the nuclear industry. These mechanisms, alone or together, establish a means to provide economic credit to technologies and processes that reduce greenhouse gas emissions. The Kyoto Mechanisms Table Options Report provides an extensive review and explanation of the CDM, JI and ET concepts. Their recommendations to government are derived from the principles of environmental effectiveness, economic efficiency, flexibility, sustainable development, clarity and simplicity, the engagement of developing countries and balance with respect to impact on Canada's international competitiveness. The recommendations of the Options Report are generally consistent with the goals of the nuclear industry.

The Table supports the concepts of CDM and JI as means to reduce emissions economically. The nuclear industry sees these mechanisms as a way for Canada and/or the nuclear industry to receive economic credit for nuclear power projects outside Canada. Constraint of emissions and Emissions Trading (of credits), if implemented will ultimately attach an additional cost to competitors with high greenhouse gas emissions.

The Table supports the concept of "fungibility", whereby emissions credits associated with the three mechanisms and different types of projects are fully interchangeable. This is of course consistent with the nuclear industry position that a tonne of GHG avoided by a nuclear power

plant is as important to the atmosphere as a tonne avoided by reducing combustion product releases from fossil fuel.

The issue of "supplementarity" is important to the nuclear industry. This term is used to describe the concept that the total credits achievable by use of the Kyoto mechanisms should be supplemental to and limited by a correlation with GHG reductions achievable within the country. The Table could not reach a consensus on this. On one hand, industries such as the nuclear industry could be severely restrained in the credits that could be accumulated. Others note that, although increases in global emissions might be avoided through application of ET and CDM, full flexibilty to apply these mechanisms is counter to actual GHG emissions reduction in the developed countries.

"Additionality" is another concept of developing definition. Credits for CDM projects may be linked to the idea that GHG creditworthy projects are only those which have been undertaken to reduce GHG emissions. Thus, it might be argued that a nuclear plant, viable on the basis of economic factors might be built without any credits. On this basis it would not warrant credits. The Table noted this is a critical issue on which Canada should take leadership in attempting to arrive at a more concrete definition.

Another concept of importance to the nuclear industry is the concept of "baselines" Should a nuclear plant be built as a CDM project, the alternative must be established in terms of GHG emissions. Alternatives to nuclear power plants could conceivably range from solar to coal power installations. The credits to the nuclear plant would need to be relative to the baseline case, presumably requiring a full life cycle assessment of the alternatives.

The Table supports the concept that the Mechanisms should contribute to the achievement of sustainable development. The Kyoto protocol requires that CDM projects contribute to sustainable development. This is another concept lacking a universally understood and accepted definition. The Table recommended that Canadian industry, environmental non-government organizations and governments establish a dialogue on this issue to provide voluntary guidelines for Canadian entities to take into account when investing in CDM and JI projects. Since some might argue that nuclear power is not sustainable it behooves the nuclear industry to examine this concept in depth and establish a strong rationale for sustainability.

The Kyoto Mechanisms Table's Options Report makes it clear that the Mechanisms are far from clearly and unambiguously defined. Much work remains to be done nationally and internationally to establish working Mechanisms. The Options Report provides a good primer for lay persons coupled with critical feedback to governments from other Canadian stakeholders.

SECTOR TABLES AND NUCLEAR ENERGY

Our participation in the deliberations of the Technology Table, combined with an appreciation of the Sector Tables analyses and recommendations, through participation in the Integrative Group, has led us to additional observations relating to energy use and the importance of biological processes to future greenhouse gas reduction.

The options put forth by the Technology Table and the Sector Tables tend to emphasize the importance of energy efficiency as the way to future reduction of greenhouse gases. This is a natural consequence of the great additional emphasis placed on energy efficiency over the last twenty or thirty years. Many research and development programs are already in place and have been carried forward in the name of greenhouse gas reduction. Engineers have sought greater efficiency of energy production and use for decades. These efficiency improvement programs will sometime reach the point of diminishing returns, particularly if full life cycle accounting with respect to preparation of materials is taken into account.

Many of the technologies proposed to reduce greenhouse gas emissions will actually be retrograde with respect to energy efficiency. Carbon management technology via biological sinks and geological sequestration will likely require even more energy input with respect to end use application.The preparation of hydrogen for use as a transportation fuel will introduce inefficiencies of energy use to meet the primary end goal of reduced GHG intensity per unit of end use. In Canada we expect population growth and consequent pressure for increased energy use. We thus need to keep our sights firmly focused on the need to produce even more energy in the future even though there is some room for increased efficiency with respect to energy supply and use.

Overall studies of the annual carbon cycle indicate that biological systems are responsible for at least an order of magnitude more carbon cycling through the atmosphere than human use of fossil fuel. Humans are already responsible for managing - or mis-managing - a major part of this. There is a lot of technology involved with the biological systems: irrigation systems, fertilizer production, tillage practice, genetic manipulation, etc. Many of these involve the use of a energy. Canada has a lot of land, water and the means to produce energy to help in the management of biological processes to maximize biological carbon sequestration.

The reports from the Forestry, Sinks and Agriculture Tables, taken together, confirm the potentially major importance of biological sinks. The Sinks table has estimated that sinks in Canadian forestry and agriculture could total about 100 Mt/yr. The reports of the tables indicate there is still a lack of knowledge of the potential for management of GHG emissions via forestry and agricultural practice. It seems that the development of policy, science and technological solutions for greenhouse gas management through application of life science knowledge is far

behind the thinking process related to reduction of fossil fuel use. This is understandable, as the GHG life cycle assessment of life is far more complex than the simple reduction of combustion processes applied to problems associated with fossil fuels.

However, it is likely that management of the biosphere to control emissions will require the use of or redirection of energy sources. Fertilizer production requires energy. Redirection of water supplies to improve growth of carbon sinks could reduce our hydropower resources. Enhancement of standing forests to serve as sinks could reverse the use of wood as fuel in many parts of the world. Nuclear energy stands ready to provide the energy needed to implement the technology which will be developed to make the best possible use of Canada's and international biological sink possibilities.

CONCLUSIONS

The deliberations of Issue Tables constitute a massive and useful statement of Canadian greenhouse gas emissions relative to the commitments of the Kyoto Protocol. Our participation in the Tables has been interesting and illuminating, as we have learned many do not have quantitative appreciation of the significance of nuclear energy in this regard. We have been given an opportunity to clarify the role nuclear could play while gaining more insight to the view of nuclear from other perspectives. We believe that the case for nuclear energy as a GHG free energy source has been made in the relevant Options Reports of the Issue Tables. The Kyoto Mechanisms Option Report provided recommendations for the consideration of Ministers that strive to be free of bias to any particular industry or energy source. The groundwork is in place to establish the case for nuclear fission as a major factor in Canada's program to comply with the commitment made at Kyoto.

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[1] Canada's National Climate Change Process, http://www.nccp.ca/html/index.htm

[2] Loc. cit. 1

[3] Natural Resources Canada, Canada's Energy Outlook: 1996-2020, http://www.nrcan.gc.ca/es/ceo/napr-96b.html

[4] Natural Resources Canada, Canada's Emissions Outlook: An Update, http://www.nrcan.gc.ca/es/ceo/outlook.pdf

Appendix A - Summary of Options and Funding Profiles (From Technology Table Options Report - Table 6, Page 63)

Options	Objective	Funding					Sources
		Year 1	Year 2	Year 3	Year 4	Year 5	
1. National Climate Change Discovery Competition	To develop new concepts and ideas that could lead to new greenhouse gas mitigation technologies	$25M	$25M	$25M	$25M	$25M	federal
2. Enhanced Support for Basic Knowledge Generation	To enhance the knowledge base for opportunities that could have a long-term impact on greenhouse gas mitigation technologies	$5M	$5M	$5M	$5M	$5M	federal
3. Climate Change Technology Development Fund	To assist in developing technologies from concept to point of demonstration	$20M	$40M	$80M	$150M	$200M	federal: up to 50% provincial: 25% industry: 25%
4. Climate Change Technology Demonstration Program	To alleviate some portion of the financial risks involved in early domestic commercialization of greenhouse gas mitigation technologies	$60M	$90M	$150M	$240M	$300M	provincial and industry: 70% federal: 30%
5. International Marketing	To create the climate for enhanced international marketing of climate change technologies and thus achieve the second part of the Technology Table's mandate	$400K	Dependent on strategy				federal (for year 1)
6. Reducing Risk and Facilitating Accreditation	To undertake comparative analyses of the recognition of risk in the technology innovation process granted by other countries	$200K					federal and provincial
7. Technology Nodes and Roadmaps	To develop improved strategic understanding of technological opportunities for greenhouse gas mitigation technologies in and across industrial sectors, and between technology suppliers and technology users	$5M	$5M	$5M	$5M	$5M	federal: 60% provincial: 40%
8. Communication Forum	To ensure that decision-makers responsible for the investment of the limited resources available for technology development have the benefit of adequate knowledge and information for informed and sound decisions	$300K	$300K	$300K	$300K	$300K	federal and provincial
Totals		**$115.9M**	**$165.3M+**	**$265.3M+**	**$425.3M +**	**$535.3M +**	

Appendix B - Promising Illustrative Technologies - Funding Summary (Based on Appendix 4 - Technology Options Report)

Promising Technology Name - App. 4 Page	Technology Needs Category	Timeframe To Commercial (s/m/l)	Cost Information	Annual Cost circa "2005"	Annual Cost circa "2010"	Annual Cost Circa "2020"
Natural Gas Pipelines - 33	Fossil Fuel Supply	Short- and medium-term (now to 2012)	$10M/yr	$10.0	$10.0	$0.0
Process Technologies Related To Energy And Carbon Processing Efficiency - 36	Fossil Fuel Supply	Short- and medium-term (now to 2012)	$10M/yr	$10.0	$10.0	$0.0
Reduce Or Use Fugitive Gas Emissions From Fossil Fuel Production - 39	Fossil Fuel Supply	Short- and medium-term (now to 2012)	$5M/yr	$5.0	$5.0	$0.0
Technologies For Increased Natural Gas Supply - 42	Fossil Fuel Supply	Tight sands and coalbed methane – short; gas shales – medium; natural gas hydrates – long	$10M/yr (50% Govt – 50% Industry) for 25 years	$10.0	$10.0	$10.0
Electricity From CO2-Free/Renewable Sources - 45	Energy Production	Short-term (before 2008)	$20M/yr for 5 years, split between government and industry	$20.0	$0.0	$0.0
Biomass Combustion - 49	Energy Production	Short-term (before 2008)	$5M/yr	$5.0	$0.0	$0.0
Biomass Conversion - 51	Energy Production	Short- and medium-term (now to 2012)	$5M/yr	$5.0	$5.0	$0.0
Nuclear Fission - 54	Energy Production	Short (before 2008) for waste management infrastructure; medium (2008-2012) for fuel cycles refinement; long term (after 2012) for more advanced fuel cycles or alternative reactors and development of significant CANDU cooling system changes	$15M/yr immediately followed by increase of $15M circa 2012 for heating demonstration	$15.0	$15.0	$30.0
Stationary Turbines - 58	Energy Production	Short-term for cogeneration and indirectly-fired gas turbines (present to 2008); short-to-medium term for further advanced gas turbine developments including integrated gasification (present to 2012)	$10M/yr	$10.0	$10.0	$0.0
Large Scale Hydro - 61	Energy Production	Short- to long-term (now to 2020 and beyond)	$30M/yr	$30.0	$30.0	$30.0

Promising Technology Name - App. 4 Page	Technology Needs Category	Timeframe To Commercial (s/m/l)	Cost Information	Annual Cost circa "2005"	Annual Cost circa "2010"	Annual Cost Circa "2020"
Fuel Cells - 65	Energy End-Use	Medium-term (2008 to 2012)	$20M/yr from governments which would be directly leveraged with $40M/yr by industry. These numbers would not include direct R&D and commercialization expenditures by industry of more than $100M/yr (mostly Ballard).	$60.0	$60.0	$0.0
Buildings - 68	Energy End-Use	Medium- to long-term (2010 and beyond)	$15M/yr	$15.0	$15.0	$15.0
Transportation And Transportation Systems: Intelligent Transportation Systems - 71	Energy End-Use	Short to long-term (before 2008 to beyond 2012)	For R&D, $2M/yr over 5 years for a total of $10 million to be matched 50/50 by the private sector. For deployment, $15 million per year over 5 years, for a total of $75M to be matched 50/50 by other public sectors (provinces and municipalities) and/or th	$30.0	$30.0	$30.0
Geologic CO2 Management - 77	CO2 Management	Short to long-term (before 2008 to beyond 2012)	$10M/yr (split 50/50 between government and industry) for 25 years	$10.0	$10.0	$10.0
CO2 from Cement Production - 80	Non-Energy GHG Emissions	Short-term (before 2008)	$1M/yr for five years for the measures listed under 'knowledge infrastructure and commercialization & demonstration'. Of this amount, approximately half would be public funds, and the rest would be supplied by industry.	$1.0	$0.0	$0.0
Technologies To Capture Methane From Landfills - 83	Non-Energy GHG Emissions	Short-term: up to 2008	$1M/yr over the next ten years split between the federal government (50%), the provincial governments (25%) and the private sector (25%)	$1.0	$0.0	$0.0
Methane From Manure Management - 86	Non-Energy GHG Emissions	Short-term: up to 2008	$1M/yr over 10 years split between the federal government (50%), provincial government's (25%) and the private sector (25%)	$1.0	$1.0	$0.0
Anaerobic Digestion Of Municipal Solid Waste - 89	Non-Energy GHG Emissions	Short-term: up to 2008	Partial funding for first full-scale demonstration ($5M)	$1.0	$0.0	$0.0
Nitrous Oxide (N2O-) From Fertilizers - 92	Non-Energy GHG Emissions	Short-term: up to 2008	$2M/yr over 10 years split between the federal government (50%), provincial governments (25%) and the private sector (25%).	$2.0	$2.0	$2.0

Promising Technology Name - App. 4 Page	Technology Needs Category	Timeframe To Commercial (s/m/l)	Cost Information	Annual Cost circa "2005"	Annual Cost circa "2010"	Annual Cost Circa "2020"
Hydrogen - 95	Enabling/Cross-Cutting Technologies	Medium- to long-term (2008 to beyond 2012)	$10M/yr from governments which would be levered by an equivalent amount by industry	$20.0	$20.0	$20.0
Enabling Technologies - 98	Enabling/Cross-Cutting Technologies	Short, medium, long	$50M/yr	$50.0	$50.0	$50.0
Biotechnologies - 103	Enabling/Cross-Cutting Technologies	Short to long-term (before 2008 to beyond 2012)	Incremental funding required = $20- 30 M over 5 years, split between public and private sector	$30.0	$30.0	$30.0
Catalysis - 107	Enabling/Cross-Cutting Technologies	Not specified.	$20M/yr	$20.0	$20.0	$20.0
Membrane-Based Separations - 109	Enabling/Cross-Cutting Technologies	Short, medium and longer term	$5M/yr	$5.0	$5.0	$5.0
Electrotechnologies - 111	Enabling/Cross-Cutting Technologies	Short, medium and longer term	$35M/yr	$35.0	$35.0	$35.0
Gas Technologies - 114	Enabling/Cross-Cutting Technologies	Short-term: up to 2008	$10M/yr	$10.0	$0.0	$0.0
Simulation And Modeling - 117	Enabling/Cross-Cutting Technologies	Short, medium and longer term	$5M/yr	$5.0	$5.0	$5.0
Storage Technologies Profile - 119	Enabling/Cross-Cutting Technologies	Short, medium and longer term	$10M/yr	$10.0	$10.0	$10.0
Systems Integration Technologies - 121	Enabling/Cross-Cutting Technologies	Short, medium and longer term	$10M/yr	$10.0	$10.0	$10.0
Use Of Less Carbon-Intensive Energy Sources (Industrial Sector) - 124	Enabling/Cross-Cutting Technologies	Short and medium (now to 2012)	$10M/yr	$10.0	$10.0	$0.0
Totals				**$446.00**	**$408.0**	**$312.00**