NUCLEAR WASTE MANAGEMENT AND BEYOND:
SELECTED CURRENT REALITIES IN CANADA AND PROSPECTS FOR CHANGE

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ABSTRACT

Canada has embarked on a process of determining the long-term management of nuclear fuel waste through the Nuclear Fuel Waste Management Organization (NWMO). The NWMO is legislated to both engage the Canadian public in dialogue about the choices available as well as to make recommendations by 15 November 2005. This paper investigates both the extent and framing of the dialogue. A selection of considerations beyond nuclear waste management are also raised, such as the strength of the nuclear export industry, health risks, and questions of climate change, in an effort to broaden the Canadian dialogue.

Canada has been at the forefront of nuclear power for more than half a century due to rich reserves of uranium and investment in the development of nuclear technologies. Throughout this time no long-term method has been put in place to manage the waste that is necessarily produced in the life cycle of nuclear power, which includes mining, use, and the final decommissioning of sites. In an effort to address part of this problem, Canada has instituted the Nuclear Waste Management Organization (NWMO) as legislated by the *Nuclear Fuel Waste Act* (NFWA) of 2002. The mandate of the NWMO is to begin "a process of dialogue with Canadians which will attempt to seek answers in one domain – the long-term management of used nuclear fuel" (NWMO 2003, 4). The NWMO is required to submit its final study to the Minister of Natural Resources Canada by 15 November 2005, having produced three annual reports documenting the Canadian dialogue. The first of these studies, *Asking the Right Questions? The Future Management of Canada's Used Nuclear Fuel*, was released at the end of 2003. It outlines the ten guiding questions the NWMO has been posing to Canadians, ranging from ones of institutions and governance, Aboriginal values, ethical considerations, environmental integrity, security, and technical adequacy. The NWMO is, therefore, considering complex issues around nuclear waste management as it "requires a public dialogue, one that extends beyond nuclear industry circles" (2).

This paper is guided by the principle that any deliberation over nuclear waste management should be undertaken in tandem with considerations of power provision. Canada is embarking on a necessary and forward-thinking venture to determine the handling of nuclear waste. This is taking place in the absence of communication over energy policy and budgets at both the provincial and federal levels that ostensibly

increase nuclear power in the energy mix. The first part of our discussion is an assessment of the institutional infrastructure handling the management of nuclear fuel waste decisions, examining the reasons for and extent to which the NWMO has overlooked the question of energy provision. Other countries have already made significant progress in the dual considerations of nuclear waste and power in meeting their citizens' energy needs. A comparison of nations' responses is outlined so that points of confluence and leadership might be sought.

The second part raises a selection of specific concerns. For instance, what has been the impact of restricting the public discussion on nuclear matters, given the government's support for Canadian nuclear power exports? Beyond the known health effects of high-level nuclear radiation, what are the more controversial concerns of low-level radiation exposure associated with nuclear power? Canada's energy footprint is one of the largest of the Organisation for Economic Co-operation and Development (OECD) member nations. In beginning to address this problem, we have ratified international agreements such as the Kyoto Protocol. Does nuclear power significantly reduce our emissions, climate change impact, and associated health risks? Behind these concerns also lie the equally significant considerations of long time frames, high costs, and security issues that are particular to nuclear power. By engaging in dialogue about nuclear waste and power, it is hoped that not only might some perspective be gained of recent governmental initiatives relating to nuclear power and waste but also some insight about the sustainability of our collective future.

I

NUCLEAR WASTE MANAGEMENT AND THE FUTURE OF NUCLEAR POWER IN CANADA

What is the relationship between the management of high-level nuclear waste and the pursuit of nuclear electricity? There is, first of all, a practical connection: spent nuclear fuel, or high-level nuclear waste, is a by-product of nuclear power generation. Without such power generation, Canada would not now be considering various options for the long-term management of high-level nuclear waste. The NWMO is the body currently charged with studying and recommending an approach to managing nuclear waste in Canada. Spent nuclear fuel, and the NWMO itself, plainly owe their existence to nuclear power generation. Might the future of nuclear power generation in Canada depend, in turn, on the way in which the NWMO approaches its work? A great deal is at stake in how the Canadian public interprets the process of planning the long-term management of spent nuclear fuel.[1] The process might, on one hand, be understood to belong to the larger project of accommodating the nuclear industry in Canada. On the other hand, the current nuclear waste management decision might be the perfect occasion for questioning the very existence of such an industry.

The high stakes of the nuclear waste management decision inform the manner in which that decision is framed and described by the institutional infrastructure surrounding nuclear waste in Canada. In choosing a management approach, the federal government ought, in principle, to be acting on behalf of all Canadians. The NWMO mission statement, for example, identifies four broad normative ideals: a good waste management approach is "socially acceptable, technically sound, environmentally

responsible and economically feasible" (NWMO 2003, 6). In reality, however, at least some public institutions, and several private ones, operate on a diverging interpretation of nuclear waste management. On this diverging view, whether and how to plan the disposal of spent nuclear fuel is decided by the interests of the nuclear industry.

Evidence of this interpretation can be found in the very structure of the NWMO. The NFWA provides that the board of directors of the NWMO consist of representatives of Canada's nuclear corporations (NFWA s. 6.1), yet these corporations are clearly interested in furthering the pursuit of nuclear activity in Canada. One of those corporations, Atomic Energy of Canada Limited (AECL), has a mandate to develop and sell nuclear reactors. According to its website, Ontario Power Generation (OPG), another Canadian nuclear corporation, considers nuclear power "a very attractive option for meeting the province's electricity needs well into the future" (OPG 2004a). As such, it is questionable whether the NWMO's process of deciding what to do with nuclear waste could remain genuinely oriented to the public interest.

A similarly biased interpretation of the waste management process exists in other parts of the institutional infrastructure surrounding nuclear waste, such as the NWMO's reporting structure to the Minister of Natural Resources. Natural Resources Canada (NRCan) has, since 2001, operated on the view that nuclear waste management is a component of the management of the nuclear industry in Canada. A 2001 *Toronto Star* report described a plan for government "restructuring of Canada's nuclear industry" contained in a "formal cabinet memorandum" prepared by Ralph Goodale, then Minister for Natural Resources (Calamai). According to Goodale, the passing of the NFWA later that year represented the first stage of such a restructuring. A 2003 NRCan *Performance*

Report confirms that the Ministry continues to consider Canada's chief legislation concerning radioactive waste as advancing the interests of the nuclear industry. With the enactment of the NFWA, the Ministry claims to have "promoted the sustainable development of nuclear energy" (NRCan 2003a, 42).

More recently, a 2004 speech by NWMO President Elizabeth Dowdeswell to the Canadian Nuclear Association, a private lobbying organization, contained the following characterization of the task of deciding on a method of nuclear waste management: the challenge of the NWMO is to "develop a contract between science and society; a contract that [will] allow us to benefit from technology while reducing risks and respecting the values of Canadians" (Dowdeswell 2004). If the NWMO understands its task as partly to preserve the benefits of nuclear technology[2], its conception of the decision as to the management of nuclear waste is radically biased. Rather than choosing a management approach which is best for Canada, on this view, the NWMO would choose an approach which is best for a Canada in which the nuclear industry continues to have an important role.

Clearly, then, the institutional infrastructure surrounding nuclear waste in Canada operates on a view of nuclear waste management as essential to the continued health of the nuclear industry.[3] An alternative view would be to use the decision about nuclear waste management as an occasion for reconsidering whether to pursue nuclear energy itself. The possibility of this second interpretation of the waste management decision also informs the institutional approach to nuclear waste in Canada. Specifically, the current process could trigger a wider public debate about the merits of nuclear energy,

motivating the NWMO to deny publicly that the nuclear waste decision is significant at all.

One aspect of this denial is the NWMO's tacit encouragement of the belief that the management of nuclear waste is unrelated to its production. In its first of three planned discussion documents, the NWMO estimates the total number of spent fuel bundles to be managed at 3.6 million (34). But this figure is simply the sum of the existing spent fuel across Canada as of December 2002 and the estimated number of bundles to be produced by each nuclear energy corporation, according to the projected operating lives of their reactors. As it stands the NWMO figure assumes, without justification, that none of these reactors will be refurbished and that no new nuclear power generating plants will be built. Confirmation of such assumptions is yet to appear, but would be gained by determining the extent that nuclear power figures in the energy provision plans of each province.[4]

A prime reason for the NWMO to refuse to acknowledge the undeniable connection between sound waste management and energy planning is to convey the impression that nuclear waste management is a mundane, procedural matter of public policy. An acknowledgement that sound waste planning must be informed by a picture of the future of the nuclear industry would, first of all, allow the conclusion that the size, character, and existence of the waste management challenge has everything to do with the activities of that industry.

Radioactive waste has long been recognized to be the Achilles' heel of the nuclear industry. Public concerns about nuclear power generation are concentrated in the waste management phase of the fuel cycle. There is a disparity between the understanding of

the nuclear waste management decision on which Canadian institutions operate and the view the NWMO presents for public consumption. It is clear to both nuclear advocates and their opponents that the process of deciding on the long-term management of radioactive waste cannot help but deeply resonate with citizenry. In general terms, the decision has the power to secure or undo the nuclear industry in Canada. No wonder, then, that the institutional infrastructure handling the decision, with its commitment to the nuclear industry, should attempt to prevent any kind of resonance. A public debate over the merits of nuclear energy initiated by concerns over nuclear waste would be a foolish risk.

COMPARISON FRAMING OF THE NUCLEAR POWER ISSUE

Spent nuclear fuel remains dangerously radioactive for thousands of years, and thus the focus on what to do with it is indeed important. However, embedded within the support for the NWMO's work is the assumption that Canada will continue to produce waste, a decision that has been made without any public involvement. The question that needs to be asked is whether Canada is typical or exceptional in its approach. A comparative analysis of three selected countries will demonstrate that Canada is rather exceptional and that other countries, including Germany and Sweden, have in fact posed the larger question of what place nuclear power has in their countries. If Canada is to move beyond the status quo, the government would be well served to look to these other countries as examples of how the conversation has been successfully broadened.

In much of the Western world a political agenda, driven by the desire for modernity and distinction among states, has influenced the quest for nuclear capability

(Welsh 2000, 19). This agenda was shaped both by the desire for post-war military capacity and the tradition of national sovereignty (20). In both capitalist and socialist countries, nuclear capability became a defining feature of the ideological, political and economic composition of the state. In the Canadian context, nuclear power promised so much that successive governments have been unwilling to let that dream die. Hence, the nuclear power discourse has been framed so that it reflects the supportive governmental stance towards it.

The nuclear power story in the United States is somewhat similar to Canada in that there has never been a public discourse over whether the country's energy needs should continue to be met by nuclear power. The discourse has been largely influenced by the historical context of nuclear power. Despite dangerous piles of radioactive waste and a steadily waning level of public confidence, the US administration continues to support its nuclear industry. Born out of the commitment for President Eisenhower's 1950's Atoms for Peace Program, the Atomic Energy Commission (AEC) was created in 1954 to supervise all nuclear developments (IAEA US, 2002). Because of its affinity to the Program, the commission had no room for those who lacked belief in the pursuit of nuclear power. The AEC immediately embarked on nuclear production, building five separate reactor technologies. The first nuclear power station in the US started operating in Shippingport Pennsylvania in 1957 (962).

Public approval for nuclear power diminished significantly following the nuclear reactor accident at Three Mile Island, and so no reactors have been built in over two decades. Still, the US is home to 100 nuclear power reactors, and since 2000 the operating licenses of 10 units have been extended (963). Additionally, support for

nuclear power has received a boost from George W. Bush's new commitment to expand the industry to meet the nation's tremendous demand for energy. This strategy will also satisfy citizens' apprehension towards reliance on outside sources (Leventhal 2001). In the US, nuclear power is once again purported to be the inevitable answer to Americans' energy woes. The discussion over the extra generation of waste to come from expansion has been largely absent from the discourse. Furthermore, the fact that solar and wind energy cannot meet the nation's electricity needs is seen in the American context as largely a foregone conclusion (Frost and Sullivan 2001).

However significant the American government's support for nuclear power might be, the Canadian government's support for it has more political salience. This is due to the fact that the American system of government offers those with divergent views a level of recourse not found in Canada. For example, if President Bush were to act today on his support for nuclear power and citizens were to oppose his plans, they would have several political levels to operate through: Congress, the Department of Energy, the AEC, the independent Nuclear Energy Commission, and finally and perhaps most importantly, the courts themselves. President Bush and his administration might want to promote nuclear power and ignore the issue of waste, but they very likely might not be able to do so.

The nuclear power story changes significantly with regards to several European countries. For instance, both Sweden and Germany are countries where the issue of nuclear waste has been coupled with the larger issue of nuclear energy. At times both countries have acted under the assumption that if the waste problem cannot be solved, then the production of it must cease. Both countries have furthermore made the commitment to phase nuclear power out in the near future. The debate over nuclear

power has allowed serious consideration of alternative and more sustainable forms of energy and methods of use to take place within both countries.

In Sweden, the production of nuclear power became a prominent political issue just before the general elections in 1976. Following the election of the anti-nuclear Center Party to parliament, the nuclear power discussion became a prime issue (Center Party Sweden 2004). An energy commission was set up and upon review of its findings the government passed the *Stipulation Act* in 1977. According to the Act, no nuclear utility would be allowed to load fuel into a new reactor before it had adequately demonstrated that it had an absolutely safe way of managing the waste (IAEA Sweden, 812). While the Act did not lead to the immediate phaseout of the reactors that could not meet its requirement, presumably covering all of them, its focus on safe waste management is evidence to the fact that the Swedish government has traditionally approached questions of nuclear power and waste together. Yet despite the passing of the Act, nuclear power remained a contentious issue.

Concerns about nuclear power safety following the nuclear power accident at Three Mile Island, US, was the impetus for Sweden's 1980 referendum in which the majority of Swedes voted for the eventual phaseout of nuclear power in their country (812). Following the referendum the government set an embargo on further nuclear expansion and aimed to have all plants decommissioned by 2010. In January of 1998 the *Nuclear Decommissioning Act* was brought into law. It effectively made it possible for the government to decide to close down a reactor immediately if deemed necessary (813). In 1999, Barseback 1 was the first Swedish reactor to be closed down, commencing the decommissioning process.

In allowing for the broadening of the nuclear power discussion, Sweden has been engaged in a serious discussion about more sustainable forms of energy. The Social Democrats remain in power today and are known for advocating sustainable development and the efficient use of energy. Since 1997 they have been in the process of realigning their energy policy so that it reflects the government's commitment to further developing the use of renewable energy sources (Swedish Government 2000). In Germany, a similar change has been taking place as the general sentiment is that people are unwilling to continue producing nuclear energy without resolution of permanent waste disposal. While nuclear energy produced from Germany's 18 reactors still accounts for about 30% of their electricity, the resistance over the last 20 years to the industry is not expected to dissipate any time soon (Wenisch 2002).

The German electricity market was liberalized in 1998 and under legislation for the reorganization of the electricity supply, the nuclear industry fared poorly. In April 2002 the *Atomic Energy Act* was amended to reflect a common agreement between the nuclear utilities and a coalition government. In June 2001 the Social Democrat and Green Party Coalition stated that licenses for the construction and operation of nuclear power plants would no longer be granted. Several of the plants remain operational within their lifetimes of production, but all 19 plants are slated for decommissioning within the next decade (IAEA Germany 2002, 314). The Germans have been conscious of the problem of final waste disposal of used nuclear fuel. In light of the impending phaseout, the German government has increased its efforts to close off the fuel cycle and to set up a high-level waste management program for disposal (315). Concurrent to the priority

placed on waste disposal, the German government has started promoting the utilization of renewable energy sources (317).

While nuclear power has been questioned in Sweden and Germany, and arguably even to a certain extent in the US, in Canada its use remains somewhat of a foregone conclusion. Partly this is because of the way the issue has been framed, since the government continues to focus merely on the waste issue, limiting meaningful conversation about alternative and more sustainable forms of energy and use. News reports from the spring of 2004 speak to the Ontario government's continued support for nuclear power in light of the province's energy crisis, despite its enormous costs and long time-frames. Significantly, time is of the essence: "[w]ith the blackout of August 14 [2003], when over 50 million people across eastern North America lost power, the question of energy went from the theoretical to the urgent" (Heintzman and Solomon 2003, xiv). Shortly after this public crisis, a three-member government commission, the OPG Review Committee, was created and chaired by former Deputy Prime Minister John Manley to review the province's energy portfolio. The Committee released its report, recommending increased nuclear power in the provincial mix. The report suggests that "only nuclear reactors can supply the electricity needed in Ontario....Rebuilding the three Pickering A units would be the fastest and cheapest way to add badly needed supplies of power" (Mackie 2004).

Nuclear power has once again been portrayed as the only option, but perhaps the outcome in Ontario would look quite different had citizens engaged in this issue prior to the crisis. In the same week in March 2004 that the report from the OPG Review Committee was released, so was the financial performance review of OPG for the years

1999-2003. The OPG financial statement, produced by KPMG, notes a net loss of $491 million (OPG 2003b, 1). It is stated that "OPG's financial condition is deteriorating and its viability under the current business model is in question. OPG's cost challenges are primarily twofold: (1) the cost of operating the nuclear generation assets; and (2) the impact of escalating fuel prices associated with fossil generation" (OPG 2003c, 6). The incongruity between these two OPG documents suggests serious confusion about the best way forward in providing energy to Canadians. Yet as seen in the case of both Germany and Sweden, the broader nuclear power dialogue undertaken during a non-crisis time allowed for the discussion of alternatives to nuclear energy to be thoroughly engaged. This broader conversation is still absent in the Canadian case.

II

CANADIAN NUCLEAR POWER REACTOR EXPORTS

One of the reasons for the deliberate framing of the nuclear power conversation in Canada relates to the export of Canadian Deuterium Uranium (CANDU) reactors. A potential Canadian phaseout of nuclear power would undoubtedly halt AECL's export agenda and might possibly bring to light questions about previous exports as well. An in-depth look at Canada's nuclear industry reveals that AECL has for a long time been in the business of exporting Canadian reactors to countries who, like Canada, have themselves not broadened the nuclear power discourse. India, for example, has benefited from the import of Canadian nuclear technology and has not yet broadened the nuclear power discussion. In fact, the Indian nuclear industry has operated under the assumption that the expansion of nuclear power is required for the development of their economy (Kakodkar 2002). Arguably, the Canadian government has much to lose by opening up the discussion, such as the possible loss or reduction of export-generated income, and this quite possibly is the reason why it has been reluctant to do so.

The export of CANDU reactors has for decades required both strong financing and promotion on behalf of the Canadian government. Generally, commercial lenders prefer to avoid the risk associated with the nuclear export business. Hence, Canada has supported its CANDU exports mainly through the Export Development Corporation (EDC), its export credit agency. EDC uses two accounts to grant financing for the selling of CANDU reactors, the Corporate Account and the Canada Account. For commercial loans the Corporate Account is used (Martin *et al.* 2001, 44). The Canada Account is

used in cases where the loan is particularly risky. It may be used when the loan has already exceeded the maximum coverage for a given country, yet the extension of the loan is considered to be in the best national interest (Auditor General 1992, sec.10.9). Lenient financial terms are usually granted, and the Canadian government guarantees the loans, assumes the risks and costs for as long the recipient nation is unable to pay off the debt (sec.10.8 and 10.9). As is shown in table 1, the government has backed several nuclear power reactor exports to various countries through the Canada Account. In order to ascertain this information, significant efforts were made to obtain accurate financial information through alternative sources because of EDC's confidentiality policies. Most CANDU exports need government financing to some degree, due to the highly risky nature of the investment and long payback periods. These circumstances only add to the public's need to continue to demand governmental transparency, given that this industry is heavily financed with Canadian taxpayers' money and most transaction terms remain undisclosed.

Table 1: Loans for Canadian reactor exports*

Reactor/Country	Commercial Operation	EDC**Corporate Account $ (millions)	EDC**Canada Account $ (millions)	Governmental Aid US$M
CIRUS/India	Jul 1960	-	-	9.5^{+}
KANUPP/Pakistan	Oct 1972	$25.5	-	25.5^{++}
RAPP-1/India	Dec 1973	$37	-	-
RAPP-2/India	Apr 1981	$38.5	-	-
Wolsong-1/Korea	Apr 1983	$50 (US$112.5)	$250	-
Embalse/Argentina	Jan 1984	(US$60)	$124	-
Cernavoda-1/Romania	Dec 1996	(US$820) § (US$19.4) §	(US$300)	-
Wolsong-2/Korea	Jul 1997	-	-	-
Wolsong-3/Korea	Jul 1998	-	-	-
Wolsong-4/Korea	Sep 1999	-	-	-
Qinshan-1/China	Jan 2003^{+++}	-	$1,500	-
Qinshan-2/China	Jul 2003^{+++}	-	(US$350)	-

*Taken and modified with permission from Martin *et al.* 2001.
** Dollars of the year. Figures are in Canadian dollars, except where otherwise noted
+ Columbo Plan.
++ External Aid Organisation (later Canadian International Development Agency).
§ US$820 million loan date: 1978; US$19.4 million loan date: 1992
+++ Updated from AECL, www.aecl.ca.

Not only has the Canadian government continuously backed nuclear reactor exports financially, but also through political relations such as Team Canada. A partnership directed by the Prime Minister alongside the Minister for International Trade, provincial premiers, and territorial government leaders, Team Canada was set up with a mandate to increase the growth of Canadian international trade. In fact, former Prime Minister Jean Chrétien led the Team Canada mission that sold two nuclear power reactors to China (Nichols 1996, 28). This sale in November 1996 was controversial because the Canadian government changed the regulations of the *Canadian Environmental Assessment Act*, exempting projects abroad from having to undergo a comprehensive assessment (McIlroy, and McCarthy 1998). After the Sierra Club unsuccessfully challenged this deal, EDC implemented higher environmental standards in its lending policies.[5]

Environmental assessments should figure significantly in any nuclear waste or power facility. The nuclear industry wants to maintain its image as a clean energy provider to maintain governmental support, as well as to garner public support. To this end, it has exported waste storage units to Romania. However, the guiding principle behind nuclear exports remains that each CANDU facility is responsible for safely managing their own waste (Kalos, personal communication). While a responsible approach for Canada would be to take care of the waste CANDU reactors generate, Canadians do not want to see foreign nuclear fuel wastes imported for disposal in Canada on a commercial basis. Officials of NRCan have assured Canadians that there is no policy to import nuclear fuel waste for its disposal, but these declarations have done little to appease concerns due to the transience of public policies (CEAA 1998, sec. 7.3.1).

Central to the energy policy currently being tabled in Ontario by the new Liberal Energy Minister Dwight Duncan is a debate about the role of nuclear power. If Ontario, the largest user of nuclear power, and the whole nation of Canada decide not to use, or vastly reduce, nuclear power in the provincial mix, it will be increasingly difficult to support an export industry. AECL currently has little to worry about, though, since the development of nuclear technology shows potential in Canada, particularly in Ontario. Ontario has the largest number of CANDU reactors and the current Liberal government has promised to phase out coal-burning power plants by 2007. Concurrently, nuclear plants are reaching the end of their lives, so the decision over whether to expand nuclear power is imminent. With the support of the OPG Review Committee, AECL is now strongly pursuing the refurbishment and construction of new nuclear plants domestically.[6] An increase in domestic sales will signal to the international market that Canadians have confidence in CANDU technology. AECL also has a view to replace aging reactors abroad, as evidenced in its current bidding to build a CANDU reactor in Bulgaria. It will be interesting to determine the financing terms offered given the existent strong competition with American, Russian, French, and Czechoslovakian bidders. Past experience demonstrates the dependency of nuclear power sales are on international public opinion. Bulgaria invested more than US$1 billion through the 1980s to build a nuclear plant, but the project was frozen in 1990 under pressure from environmentalist groups (Bulgaria News Network 2004).

The Canadian government has demonstrated a strong commitment to nuclear reactor exports through their noteworthy investment of financial and political capital. While there is an in-house debate on the suitability of nuclear power technology, it would

be increasingly difficult if not impossible to pursue CANDU exports. Consequently, one of the reasons why the federal government has decoupled the issue of nuclear power from that of nuclear waste is certainly to protect the interests of the nuclear power export industry. In this way, the government avoids endangering the exports of CANDU technology in an international market that has proven to be both highly competitive and fragile. Although this has been the historical case, this is an inadequate response for the future of Canada. The nuclear power industry must improve, becoming fully transparent and accountable to the public and its values. Both the domestic and international markets should be required to uphold financial and environmental standards. In every country where this technology is sold there should be a comprehensive public dialogue that goes beyond the waste issue and engages the question of the future of nuclear power. Such discussion would be useful in elucidating the impact that this source of energy has on the health of the biotic and abiotic environment.

HEALTH IMPLICATIONS BEYOND NUCLEAR WASTE

Health impacts of nuclear energy on the public and future generations are among the key issues of nuclear management in both Canada and other nations. High-level radioactive wastes are known to be associated with radiation sickness, the symptoms of which include nausea, weakness, hair loss, skin burns, diminished organ function, or even death, given a fatal dose (US EPA 2004). However, the health effects of low-level radiation and the dose rate limit are more controversial subjects that cause much debate and concern.

Although Atomic Energy Control Board has set regulatory limits based on the International Commission on Radiological Protection (ICRP) recommendations made in

1977 (AECL 1994, 233) for radiation doses for nuclear facility workers and the general public, the safety and credibility of those limits are questionable. First of all, ICRP failed to make a distinction between different age groups and sensitivity communities such as children and patients in calculating the overall risk of cancer accepting average values instead. This is inadequate as the risk for children in the first decade of life is about two times higher than that for an average adult (Slovis *et al*. 2002). Importantly, the safe dose of radiation for an average adult might cause serious damage in a child or fetus.

Concerns have also been raised about the credibility of the epidemiological studies and statistics. A large number of findings, such as potential genetic effects caused by changing the molecule of inheritance, DNA, (Gardner 1991, 5) and increasing the susceptibility for cancer induction (Center for Environmental Health Studies 2003), are simply dismissed or even ignored in revisions of radiation protection standards. By contrast, some inconclusive experimental evidence is mentioned by AECL in the Environmental Impact Statement, suggesting that low doses of radiation may be able to stimulate the repair of prior radiation damage or strengthen the body's natural defense mechanisms (ICRP 1991). These mechanisms, however, have been denied by external studies based on US vital statistics data (Nussbaum and Köhnlein 1994).

A number of debates of concern have arisen in official nuclear radiation statements such as the issue that in comparison with natural background radiation, the regulated man-made radiation is too low to cause health concerns. This, however, is not the case. Nuclear radiation has attracted tremendous attention because an accident of any import in nuclear operations would not only be a disaster for the local community but the international one as well. Also, there is no regulatory limit on the size of a nuclear

facility and therefore no control on the dose of radiation to either workers or nearby residents during an accident. One of the proposals currently considered by the NWMO for the long-term disposal of nuclear waste in Canada would entail the transportation of waste to a central facility. Considering the frequency of traffic accidents, the idea of the continual and frequent transport of trucks containing nuclear waste to the disposal site is of deeply disturbing. Also, extensive studies on occupationally exposed persons have confirmed that no threshold exists for radiation effects. From a public health perspective, all ionizing radiations are potentially harmful. This suggests that any additional amount of radiation is likely to increase the incidence of cancer, cataract or even genetic damage in the nation's citizenry. This finding negates any comparison with natural background dose. Finally, unlike natural background radiation, some radiation from nuclear facilities is avoidable. A question that should be raised in public debate is that it is not where we should put our nuclear waste or how much radiation exposure should be allowed. Rather, it is about whether the nuclear power plant is necessary at all. To gain perspective about this question, a comparison to the health impacts associated with alternative energy sources, such as solar, wind, and efficiency is needed.

Solar energy is utilized through solar thermal and photovoltaic systems, where no air pollutants or green house gases are emitted when heat or electricity is produced. The major human health risks associated with solar energy are caused by particulates and fly ash from coke released during the refining of silicon oxides, the raw material for photovoltaic cells. Estimates of the occupational health risks associated with solar photovoltaics per unit energy include 11 to 21 deaths for every 10^{15} joules of energy produced (Whiffen 1994). However, solar systems are noted for their reliability and low

maintenance, and produce fewer and far less significant health effects than most fossil fuels, as demonstrated by table 2. With financial assistance, solar energy is especially beneficial for rural residents in developing countries, who suffer from poor indoor air qualities from the burning of biomass.

Table 2: Fatalities and Work Days Lost of Different Energy Systems*

Energy System	Employment	Fatalities		Work Days Lost (WDL)	
	(10^3WYr/10^{18}J)	(D/10^{18}J)	(D/10^3WYr)	(10^3WDL/10^{18}J)	(WDL/10^3WYr)
Flat-plate solar thermal	56-310	16-86	0.28-0.29	41-220	710-730
Refined oil products	3.5-3.8	1.1-1.2	0.31-0.32	1.8-2.1	510-550
Solar photovoltaic	44-120	11-21	0.18-0.25	39-90	750-890
Conventional coal	42	35	0.83	57-58	1400
Nuclear Light Water Reactor	18	4.7	0.26	13-14	720-780

*Source: Hall *et al*. 1986, 429.
Note: WYr = Worker years

Both wind power and increased energy efficiency produce no emissions of any kind during operation. Germany has been actively promoting wind power to phase out nuclear energy over the last decade (Bartlett 2002). A significant amount of energy, 4 x 10^{14} joules, may be saved by increasing energy efficiency in Canada (Torrie and Parfett 2003). These sustainable energies are so far more environmentally sustainable than nuclear power. However the viability of such alternatives deserves more research.

The world is currently experiencing climate change and there is evidence indicating that greenhouse gas (GHG) emissions are the main reasons for global warming. It is essential to make large and continuing reductions in GHG emissions to stabilize and then roll back the concentration of these gases in our atmosphere (Friedlingstein *et al.* 2001, 1544). The majority of GHG emissions come from the energy sector, mainly from fossil fuel energy generation. Stabilizing GHG levels requires a sustainable energy system, including energy efficiency and alternative energies with lower-carbon emissions (Jean-Baptiste and Ducroux 2003, 156). Every country has various options in making the most appropriate choice, which should be done while considering the different parameters found in the nation.

The Kyoto Protocol, an international agreement on GHG emissions, has been initiated in order to reduce global GHG emissions. Canada's ratification of the Kyoto Protocol indicates a commitment to reducing GHG emissions by almost half of current levels over the next quarter century (Torrie *et al.* 2002, 3). In fact, the challenge embedded in the Kyoto Protocol is to begin by reducing emissions to 6% below 1990 levels in the next 10 years (25). Canada has an energy-intensive economy and more than 50% of the GHG emissions come from the energy sector (CNA 2002, 2). It will then be a particular challenge for Canada to develop a sustainable energy system, which must be based on Canada's current energy use and supply system.

Canada is the fifth largest energy producer in the world (EIA 2004). The primary components of Canada's energy products include natural gas, oil, hydropower, coal, nuclear power, wood, and renewable energy products (Torrie and Parfett 2003, 21). Heavy reliance on fossil fuels has resulted in environmental concerns. From 1990 to

2001, Canada's energy consumption increased 14.1%, which resulted in a 16.1% GHG increase[7]. The disproportionately large increase in GHG emissions is a testament to Canada's use of fossil fuels while meeting changing energy demand. Meeting Canada's obligations to the Kyoto Protocol appears to be an almost insurmountable task, given that the current GHG concentrations are far beyond target levels (Torrie *et al.* 2002, 25). It is essential that a swift transition be made to a sustainable energy economy.

Renewable and alternative forms of energy refer to any source that comes from the natural environment and may be used with low environmental impact: solar, wind, hydro, biomass, and geothermal energy. Canada's abundant natural resources provide great potential for renewable energy in Canada and their development is essential to Canada's sustainable energy system. In the last two decades, great advances have been made in renewable energy technologies including higher efficiencies, improved quality and increased reliability, allowing them to be more widely used. Canada's alternative energy production comes mostly from large hydro-electricity projects, with 11% of Canada's primary energy supply sourced from hydro, representing 6.7×10^{10} watts of capacity (REEEP 2003, 14). Wind power grows apace internationally, but currently Canada has only 2.3×10^{7} watts of wind capacity installed. Solar power has significant heating and electrical potential in Canada, yet there are only 1.2×10^{4} residential solar water heaters installed (CNP 2001). There are more than 1.0×10^{9} watts of biomass in Canada, which supplies 7% of all energy use, most of which is directed to the pulp and paper industry (CNP 2001). Altogether, Canada has about 17% of its primary energy supply coming from alternative sources, which is much higher than the world average (CNP 2001). Although renewable energies are clean, affordable, sustainable, and have a

great potential to substitute the traditional fossil fuel energy in the future, they cannot play a key role in providing sufficient energy in the immediate future.

The most instant, cheapest, and cleanest way to maintain an adequate energy supply with minimum environmental impact is simply to consume less energy, both through conservation and use of efficient technologies. As Canadians are one of the highest per capita consumers of energy in the world, the potential for efficiency is significant (CNP 2001). In the decade from 1990 to 2000, energy efficiency measures created a savings of 9.4% of the overall energy demand, since energy use increased by only 16.7 % rather than 26.1% (NRCan 2001). One estimate shows that primary energy usage could be realistically reduced by up to 50% in the next twenty years simply by using conservation and energy efficiency technologies currently available (Torrie and Parfett 2003, 45). Irregardless of these promising findings, there is still real concern about possible gaps between energy demand and supply, as was so clearly illustrated by the August 2003 blackout in the northeast of North America.

Proponents of nuclear power suggest that it is an important component of Canada's energy mix, particularly in times of supply instability when it is essential not to have the lights go out (CNA 2002, 2). There are 17 nuclear power reactors in Canada, most of which are located in Ontario and owned by the OPG (8). Nuclear power has been demonstrated to be very expensive in Canada, maintained primarily through a phenomenal amount of government subsidies. A recent investigation estimates that the cumulative government subsidies to the nuclear industry are around $13 billion (Torrie and Parfett 2003,15). One stated advantage of nuclear power is low emissions during the energy production phase of the reactor's life cycle, making it one of the few options that

might help countries meet base load electricity demand without unduly impacting on the atmosphere. However, due to the fossil fuels used in other phases of nuclear power such as fuel enrichment, emissions are a concern; as are serious health risks and high costs. To date, nuclear power has not been approved by signatories of the Kyoto Protocol as an acceptable mode to meet their targets in reducing GHG emissions. Still, over the last 50 years, the Canadian nuclear industry has taken great strides in developing solutions that minimize environmental impacts. Nuclear power now plays an import role in some Canadian provinces and will continue to do so until the end of the lives of the current reactors in the next 15 years. Nuclear power will remain a part of our nation's energy mix for the foreseeable future and bolsters the role of both efficiency and alternative energy sources in ensuring the gap is closed between the future's energy demand and supply.

III

The first part of this discussion focused on the role of institutions in Canada for dealing with nuclear waste management and the existence of the nuclear power industry itself. It appears that support for the industry is embedded in formal institutional documents and the framework for the creation of various Canadian power generation institutions themselves. One significant problem with this situation is the limited amount of public discourse that is involved between the government and its citizens. In veiling the role of the nuclear power industry from the public, the provision of good governance is significantly limited. Other countries appear to have approached this same problem in alternative ways, recognizing that it is neither possible nor advisable to entirely separate the questions around waste from considering the use of the power it comes from. In the US, where the government arguably supports better public participation and the rule of law, the debate about nuclear power appears to be slightly more open than in Canada. Important leadership may be drawn from the approach taken in other developed nations such as Sweden and Germany. In these countries the public has been involved in a coupled discourse about types energy and associated wastes and the government has been transparent and accountable. In contrast to the approach currently taken in Canada, both of these nations have embarked on a nuclear power phaseout, with energy supply being replaced by increased efficiency and renewables.

In the second part of this discussion, selected concerns around the nuclear power industry were raised. To begin with, Canada has created a nuclear power reactor export industry that historically engaged in financing projects to foreign powers which were

mostly underwritten by the Canadian taxpayer. Hundreds of millions of dollars have been embedded in the export industry to support purchasing nations, many of which have developing economies and varying standards for environmental assessment. The government has deliberately restricted the dialogue to protect the Canadian nuclear industry. The Canadian government and associated crown corporations such as the AECL are in fact accountable and responsible for these issues related to export deals. However, no true system has been put in place either to seriously include the public in meaningful dialogue, nor to require the purchasing nations in treating the nuclear technology to the same standards required in Canada, nor to ensure that Canada accepts its responsibility with respect to the technology and limits financial liability while addressing waste and security issues associated with nuclear power.

There are real social issues of concern related to nuclear power which the formal governmental debates often avoid. Two of prime concern are health issues related to radiation effects on all living beings and the impact on our natural environment. As biotic and abiotic factors in the earth are connected in a complex synergistic web, impacts on one aspect may have unforeseen and far-reaching results. Although the effect of high levels of radiation are well documented, the role of low levels of radiation in human health are more controversial. A significant finding relates nuclear energy's radiation to permanent damage to the molecule transmitting genetic information, DNA. This one source of energy has the potential to change the genetics and the existence of our species on a cellular level.

Equally of concern is the fact that our lifestyle choices and dependence on large amounts of energy have already changed the abiotic environment. The air we breathe has

more carbon dioxide in it now than it has for hundreds of millions of years. Since the industrial revolution, power provision has increased alongside economic gains, resulting in pollution. The public and governments have assumed that we are faced with "an implicit trade-off between an attractive environment and economic growth" (Labatt and White 2002, 1). Yet this need not be the case. It is our duty to address the problem of the changing climate in the best ways available to us. This will begin with putting in place an energy system that has at its heart efficiency and relies on renewable energy. Nuclear power, with arguably lower carbon dioxide emissions during the use of the reactor, cannot be considered a zero-emissions power source due to the large quantities of fossil fuels involved in enriching uranium and constructing the sites. Nuclear power also has serious and long-term health risks associated with radiation which renewable sources do not. The timeframes and costs associated with nuclear power are long and high and do not reflect a system that will see Canadians into a sustainable future. It is our responsibility as Canadians to engage in public debate about the role of nuclear power and its associated waste in the energy mix of our nation. In recognizing that there are alternative ways to frame our institutions as shown by other countries alongside the costs and risks associated with nuclear power, the debate has been initiated. Let us hope that the first century of the new millennium will be remembered for its ingenious approaches to our common problems and our common future.

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ENDNOTES:

[1] The process of coming to a decision as to the long-term management of spent nuclear fuel in Canada has been going on, with several starts and stops, for decades. The first major decision-making initiative dates back to 1978, with the launch of the Canadian Nuclear Fuel Waste Management Program. Under this initiative, the federal and Ontario governments charged AECL, a crown corporation, with developing and refining a plan to dispose of high-level nuclear waste in an underground vault in the Canadian Shield. The Canadian Environmental Assessment Agency conducted a review of AECL's deep geological disposal concept beginning in 1994. By 1998, the review panel, headed by Blair Seaborn, came to the conclusion that public acceptance of the deep geological disposal concept was insufficient to proceed (CEAA 1998, s. 7.1). After the Seaborn Commission, in 2001, the Canadian government re-initiated the decision process by passing the NFWA. This piece of legislation required Canada's nuclear corporations, AECL, OPG, Hydro-Québec, and New Brunswick Power, to form a waste management organization. The NWMO, created in 2002, answers this requirement. According to its legislative mandate, the NWMO is currently studying various approaches to the long-term management of nuclear waste. The three most likely approaches are those which the NFWA requires the NWMO to examine: some form of deep geological disposal in the Canadian Shield, reactor-site extended storage and centralized storage. The NWMO is scheduled to recommend a management approach to the federal government by November 2005.

[2] Dowdeswell does not specify the sort of science and technology in question. Nuclear science and technology, however, is the only field of science and technology whose risks the NWMO's work helps to reduce.

[3] A final basis on which to make this argument is the institutional disposition to treat the waste management decision as already made. NRCan, the authority to which the NWMO reports, appears to have already settled the question of nuclear waste. NRCan shows its bias towards deep geological disposal in describing the NWMO process thus: "[o]nce the general approach is approved, the NWMO will embark on a siting process" (NRCan 2003a, 41). Strictly speaking, this remark is evidence that NRCan is biased in favour of either centralized storage or deep geological disposal, the only two approaches requiring a "siting

process". Given the long history of, and widespread institutional preference for, the deep geological disposal method, however, a more likely explanation of the NRCan remark is the Ministry's tacit prejudice in favour of the burial concept.

[4] Only in very small print does the NWMO admit the contingency of its waste management plans, given uncertainty about the future of nuclear electricity. A footnote to the NWMO's otherwise confident-looking table estimating the total quantity of fuel to be managed admits the need to revise the final figure pending the decision as to whether to refurbish Gentilly-2, and Hydro-Québec reactor (NWMO 2003, 34).

[5] The Romanian import of a CANDU in 2003, reveals that policies were somewhat improved. AECL and EDC invited the public to comment on the Environmental Assessment conducted by AECL and the Romanian nuclear company Societatea Nationala Nuclearelectrica. Still, the Halifax Initiative, a government watchdog, complained to EDC regarding the inadequacies of the Environmental Assessment. Following the investigation, EDC's Compliance Officer recommended in December 2003 that a Compliance Audit be done on the application of their policies. EDC management decided to accept in part the recommendation (Lawford 2004). However, there remain limits in the company's environmental accountability as the EDC management maintains autonomy.

[6] Bruce Power has stated its interest in building one or more new reactors at its nuclear power complex. In addition, it will study the possibility of refurbishing four Bruce B reactors (*The Record* 2004, A1); the OPG Review Committee led by John Manley backed-up nuclear power as a way to meet future energy demand disregarding all others forms of energy production (Sokoloff 2004, A12).

[7] From 1990 to 2001, Canada's energy consumption change was from $6.9 – 7.9 \times 10^{18}$ joules. The GHG emissions changed from $4.1 – 4.7 \times 10^{8}$ tonnes (NRCan 2003b).