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Slowpoke Reaction at the University of Saskatchewan

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At a May 12, 1989, press conference, President Kristjanson announced that the University of Saskatchewan was considering "heating buildings on campus with a Slowpoke Energy System [which] would be part of a long-term program of improving energy efficiency."[1] The president justified the initiative on several grounds. First, he claimed the university is familiar with Slowpoke technology because it is similar to its own research reactor. Second, the university would realize long-term savings by converting its heating system from steam to hot water. Third, the Slowpoke would not contribute to the greenhouse effect - unlike the current system - because it releases virtually no wastes into the atmosphere. Finally, he anticipated technological and business spin-offs for Saskatoon.

We think all these positions are highly contestable and do not reveal the whole picture. For example, though expressing concern for the environment, he failed to mention the problem of nuclear waste management. He was silent on the link with the military. Even more curious, he did not demonstrate the need for increased heating capacity. Finally, he would have us assume that supply-side solutions are better than increased energy efficiency.

That a university should provide the fullest rational inquiry into important theoretical and practical issues is among its most cherished ideals. This lofty goal is not always fully realized in the way in which it conducts its own business. The proposal to build a new atomic reactor on campus will provide an interesting test for the University of Saskatchewan. Thus far, the administration has communicated with its faculty through the media and Atomic Energy Canada Limited's (AECL) sales force - not a promising sign.

Because construction of a heating reactor would set a precedent for the province, it is important for the university and surrounding community to understand the Slowpoke proposal. The issues are not simply or primarily technical. They require us to see ourselves as citizens of the world and stewards of our environment. They raise political, moral, and medical questions. We need to debate openly and thoroughly. This essay is intended to contribute to this discussion. We invite the administration to join in a dialogue.

The article assesses each of President Kristjanson's claims in order and then turns to some thorny questions he fails to address. But first, it offers some background in recent Canadian reactor history.

Why Is AECL so Eager to Set Up Shop in Saskatchewan?

Because AECL has been unable to sell a reactor for several years and has undergone severe budget cuts at the hands of the federal government, it is desperate for sales and needs a showplace for its new, untested Slowpoke-3. The University of Saskatchewan is volunteering to be the demonstration site. Thus far, the AECL offer of a free reactor has been spurned in six other Canadian locations: the Arctic Circle (1983), North West Territories (1985), Fort Nelson (1986), Winnipeg (1987),[2] Peterborough General Electric Plant (1988), and Sherbrooke (1988). The president of the Makivik Corporation, Mark Gordon, rejected AECL's pitch to the Inuit for a nuclear reactor, allowing that they would not "serve as AECL's guinea pigs."[3]

On December 21, 1988, the University Hospital Board of Directors in Sherbrooke rejected the Slowpoke thermal reactor that the AECL wished to install to heat its buildings and produce isotopes for medical research. Many people expressed concern about the accumulation of radioactive waste, the risk of nuclear accidents, and the need for an evacuation plan for the hospital in case of an accident. More than 1600 of the 2000 staff, nurses, and interns at the hospital opposed the project.[4] A coalition of more than 20,000 members of environmental, peace, nursing, and labour groups convinced the hospital board to reverse its decision.

This victory reaffirmed Quebec's provincial moratorium on nuclear reactor construction declared in 1977 and renewed in 1982 after unsatisfactory experiences with AECL's two Gentilly reactors. On December 28, 1988, seven days after the directors of the Sherbrooke University Hospital announced that they would not accept the reactor, Western Project Development Associates (WPDA) announced their proposal to build a Candu reactor in Saskatchewan. AECL had turned its sights westward.

For several years, public support for AECL has dipped sharply. A Decima poll, taken in June, 1989, found that "Canadian public opinion is firmly rooted against the use of nuclear energy to generate electricity in Canada."[5] This marked a significant decline in support since a previous poll conducted only seven months before. While those strongly and somewhat in favour of nuclear energy for electricity dropped from 17 to 14, and 45 to 36 percent respectively, those strongly and somewhat opposed increased from 15 to 24, and 22 to 25 percent respectively. Canadians are concerned about the transportation and disposal of high-level nuclear waste, waste tailings, new findings about levels of radiation around reactors, and reactor accidents. This public distrust has been fanned by recent reports of widespread government and industry deception about contamination around major U.S. weapons facilities.[6] Accidents such as the ones at Three Mile Island and Chernobyl raise alarm. The public sees nuclear waste and pollution as part of a general environmental crisis. An embattled AECL needs a fresh start.

AECL knows that, at present, the political infrastructure in Saskatchewan supports nuclear development. The PC government agrees in principle with nuclear-generated electricity and is prepared to consider a privately-owned reactor. The newly appointed Lieutenant-Governor is an outspoken nuclear advocate. The government has supported nuclear development through the Saskatchewan Mining Development Corporation (SMDC), while uranium companies and the Saskatchewan Mining Association act as a ready lobby. The University of Saskatchewan's new Chair of the Board of Governors, John Nightingale, is also president of Key Lake Mining.

With this support, the industry has targeted the province for a hard sell. The Canadian Nuclear Association (CNA), made up of 130 companies and agencies, has undertaken a massive, multi-million-dollar public-relations and education campaign to advance the nuclear industry in Canada. Saskatchewan church, media, labour, government, and education leaders have been selected as key figures to promote the industry.[7] AECL contributed $2.5 million in the first year of the industry's public relations campaign.[8] Ed Hinckley of AECL and Rita Dionne-Marsolais of the CNA have joined Colin Hindle of WPDA to promote the Candu reactor among Saskatchewan town councils and chambers of commerce throughout the province.[9] The University of Saskatchewan invited AECL to locate in the city, and several AECL personnel arrived to support the project. The uranium section of the Saskatchewan Mining Association also initiated a public-relations offensive this spring, which included opening a $300,000 mobile trailer to take the pro-nuclear message to schools, among other places. Sylvia Fedoruk, in her role as Lieutenant-Governor, officially opened the mobile, thus bestowing the government's blessing.

Q. When is a Slowpoke not a Slowpoke?

A. When it is a Slowpoke-3.

President Kristjanson would have us believe that Slowpoke-3 is similar to, or an extension of, the "mini" research reactors. However, the ten-megawatt reactor differs significantly from the twenty-kilowatt and two-megawatt research reactors already installed at the U of S and Pinawa (Manitoba). So different are they that two-and-a-half years ago, Slowpoke research scientists met with AECL to register their opposition to using the name "Slowpoke" for the ten-megawatt reactor.[10] Research reactors are relatively benign, minimally powered, and use small amounts of enriched fuel. However, the Slowpoke-3 has markedly different features:

- The Slowpoke-3 is about 500 times more powerful than our research reactor. The latter has the capacity to operate at 20 thousand watts, while the proposed Slowpoke-3 is designed to operate at 10 million. The significant difference in size reflects differences in routine radioactive emissions and fuel requirements.

- The research reactor generates neutrons without producing commercially usable quantities of heat for distribution. Because the Slowpoke-3 circulates fluids to distribute heat like other power reactors, it can develop the same problems of corrosion, failing pumps, sticky valves, and radioactive leaks.

- The university research reactor uses about one kilogram of highly enriched uranium for fuel. It produces a comparatively small amount of highly radioactive fission products which are removed after twenty years. The proposed ten-megawatt Slowpoke-3 would use 1,200 kilograms of about 3 percent enriched uranium every three or four years.[11] Every four or five years, the reactor would generate one tonne of spent fuel, which includes five to six kilograms of plutonium, a substance that is millions of times more radioactive than the fuel itself. Disposal of this waste requires remote-control equipment, elaborate packaging, and specialized transport.

- Research reactors have beryllium rings (neutron reflectors) which are not part of the Slowpoke-3 design.[12]

The technical differences between the Slowpoke-3 and the research reactor are the basis of concerns about health and safety. Whereas the research reactor is tested and demonstrated to be safe, the ten-megawatt reactor is an untested, unproven technology. Furthermore, critics claim that venting radioactive gases on campus, possible deterioration of fuel casings, and lack of emergency cooling and containment systems could be problems with the Slowpoke-3 but not the research reactor.

The Alleged Economic Advantages of Slowpoke-3

AECL needs the U of S to help solve its own economic problems. Metro Dmytriw, an AECL official, said it threw its marketing activities into high gear in the spring of 1985 when Finance Minister Michael Wilson announced that its research and development budget would be cut in half to $100 million by 1990.[13]

What has been the experience of other would-be recipients of "free" reactors? According to BC Minister of the Environment Jack Davis, a former economist with AECL, "Costs would be too high even if Fort Nelson were offered the reactor free of charge and only had to pay operating costs."[14] General Electric in Peterborough rejected the plant because they found that it was not cost effective.[15] A study by the Sherbrooke Hospital and AECL in 1988 showed that, with or without the Slowpoke, natural gas remained the least expensive option for heating. In Sherbrooke, David McDougall of AECL is reported to have argued "AECL looked toward Quebec to market the Slowpoke because natural gas is inexpensive in Western Canada and the Slowpoke would be harder to sell."[16]

The Slowpoke-3 would be prohibitively expensive without the multi-billion dollar subsidies to AECL. With unlimited public funds, it can conveniently undercut all clean heating options in part because it does not have to recover installation, research, development, and marketing costs. For example, no unsubsidized system could compete with a taxpayer's grant of $9 million to change the university's steam system to hot water.

The Alleged Ecological Safety of Slowpoke-3

Although AECL promotes the Slowpoke as a way to lessen the greenhouse effect by reducing fossil fuel consumption, critics have shown that even a vigorous reactor-construction program would only minimally address the greenhouse effect. Furthermore, such a program is economically unfeasible. The University of Saskatchewan heats its facilities with natural gas. Because natural gas produces 40 percent less carbon dioxide than gasoline and 85 less than coal with virtually no sulphur compounds, it appears as the percent best fossil fuel option. Would a change to Slowpoke-3 prevent more carbon dioxide emission than is produced by the automobiles that arrive on campus each day? If the university system is already 85 percent less polluting than coal, it may not be a significant contributor to the greenhouse effect, and it may be reasonable to maintain the present system.

Based on business-as-usual projections, substituting nuclear power for electricity generated by fossil fuels would reduce the global warming trend by only about 11 percent.[17] Although methane, tropospheric ozone, and clorofluorocarbons contribute, carbon dioxide is responsible for 50 percent of the warming trend. Four-fifths of this carbon dioxide comes from fossil fuel combustion, the rest from deforestation. The generation of electricity accounts for 30 percent of fossil fuel use, transportation for a further 35 percent, with agricultural and industrial processes making up the balance. To substitute nuclear for fossil fuel electrical generation, the worldwide demand for which is expected to double by 2025 - would require a new nuclear reactor every 2.4 days. Reactor demand would then exhaust uranium resources in a few years forcing us into a much more dangerous plutonium economy. In any case, the radioactive pollution created by the mining and processing of uranium, operating reactors, and disposing of the highly toxic wastes creates its own problems. Replacing fossil fuel generation by nuclear power is practically and economically unfeasible.

Claims that a major program of reactor construction would the greenhouse effect by reducing carbon dioxide emissions are overstated. Instead of echoing AECL's response to the greenhouse effect, the university should explore conservation approaches more fully. Several programs in the United States and Canada have demonstrated their long-term economic and environmental advantages. Some studies show that investment in energy efficiency can be two to ten times more cost-effective than investment in energy supply. By the end of 1989, "US utilities will spend at least $1 billion a year on energy conservation, which will save 21,000 MW of power equal to the output of 21 large nuclear power plants that might have cost $5 billion each to build."[18] Northeast Utilities in Connecticut budgeted $24 million for conservation projects with its customers to prevent power plant construction.[19] Unlike the Saskatchewan government which disbanded its department of conservation, American private utilities have taken leading roles in advancing conservation in domestic and commercial use.

If the university were to continue to emphasize energy efficiency in planning its new buildings, it would not need more generating capacity. Recent campus buildings have been constructed to make minimal demands on heating facilities. For example, the new agriculture building will draw more than enough of its heating from its growth chambers and from lighting even in the winter. The problem will be to provide refrigeration to cool the building! The new engineering building is heat efficient. Improved insulation and other heating efficiencies in older buildings could reduce fuel consumption significantly.

The university has a good record of conservation projects. It pioneered development and installation of a computer-based Central Control and Monitoring System to manage the heating, ventilation, and air-conditioning systems in campus buildings. The energy saving in the sixteen connected buildings is 35 percent. University insulation codes are more stringent than the National Building Code requirements. The university retains the services of one of North America's foremost architectural conservationists. Thermal transmission piping is insulated to the highest standards in the industry and much inefficient pipe insulation has been replaced. Several improvements have made the Central Heating plant more efficient. Various heat reclaim systems have been installed. According to a university document, "Literally hundreds of conservation measures have been employed in specific areas of many campus buildings."[20]

Light energy reductions have resulted in a 2.4 million kilowatt hours (kwh) or $63,000 per year energy saving. Higher efficiency exterior lighting has resulted in a 500,000 kwh annual savings. Variable-speed drives and pump systems provide a 1.375 million kwh plus a saving of $20,000 per year. Energy efficient motors provide 700,000 kwh per year of reduced consumption, and the installation of capacitors to correct power locally and at the main substation reduced charges by $250,000 per year. As the author of these university reports recognizes, "there are many more items that could be done to reduce energy consumption."[21]

Nobody Wants the Garbage

In spite of assurances by AECL, there is no safe method for disposing of high-level nuclear waste. In 1988, the House of Commons Standing Committee on Environment and Forestry recommended that no more nuclear reactors be built in Canada until the waste problem is solved. *High-Level Waste In Canada: The Eleventh Hour* stated that short-term economic goals should not take precedence over Canadian health and safety.[22]

By the end of 1987, Canada had generated 12,400 tonnes of spent reactor fuel, an amount which will likely reach 100,000 tonnes by 2024. The Standing Committee warned that storage of high-level wastes "takes on great importance indeed in light of the fact that there is no proven method for disposing of these dangerous by-products."[23] Canada's 3000 used uranium fuel bundles, misleadingly called "spent" fuel, are lethal and will remain so for 500 years.

AECL proposes to store the radioactive waste from the Slowpoke-3 reactor temporarily in a pool at Chalk River until permanent storage is arranged. Although AECL is conducting research into waste disposal - primarily in deep shafts in the Canadian shield at Lake DuBonnet, Manitoba - the provincial government has prohibited the disposal of high-level nuclear there. Geology cannot predict with certainty the effects of storing nuclear waste in shafts. Gordon Edwards in the *Eleventh Hour* observes that the "Achilles heel of the idea of deep geological disposal lies in the impossibility of refilling the shaft that has been drilled in such a way that the drilled rock regains the integrity it had as solid rock."[24] As a result of the Standing Committee's deliberations, the very concept of deep geological disposal, which AECL has pursued for years, is now under review.

Permanent disposal of nuclear waste is a major international, technical, and political problem and has not been solved in any country.[25] In the United States, for example, waste from commercial reactors, defence facilities, and hospitals is stored at hundreds of locations.[26] As the safety, design, and construction of proposed waste sites in the U.S. are shown to be inadequate, the reactor industry is being forced to shut down.

Proliferation of Slowpoke reactors in Canada and the world would begin another generation of radioactive pollution. This proliferation would result in increased waste tailings, high-level reactor wastes, increased traffic in radioactive materials, and reactor accidents. The International Atomic Energy Agency's experience in monitoring nuclear traffic demonstrates that loss of radioactive materials is inevitable.

Dr. Gordon Edwards, a critic of the Sherbrooke proposal, argued that if an accident occurred in the transport of waste from a Slowpoke-3, enough radiation could be released to kill hundreds of people.[27] Highly radioactive spent fuel is shipped in twenty-tonne flasks that are lifted onto flatbed trucks by specially designed cranes. He contends that dropping a flask, a transportation accident, or an accident or fire near a Slowpoke could result in a mini-Chernobyl. Other provinces are likely to refuse to accept high-level nuclear waste from a Saskatchewan reactor just as Britain refused to accept Canada's PCBs. In these circumstances, would the university and the province be happy to dispose of it on their own turf?

Nuclear reactors are decommissioned by burying them in concrete and by stashing most radioactive components in long-term storage facilities at enormous cost. The Slowpoke reactor on campus will have to be decommissioned. Even though the nuclear industry needs to address the issue, the federal government has delayed research on storage sites and regulatory processes.[28]

Research Opportunism?

Besides justifying the reactor as a source of thermal energy, AECL and the university have claimed that the Slowpoke-3 will be valuable for research.[29] No research programs for the reactor have yet been publicly announced, although applied research related to the heating system may be considered.

Faculty and the public need to examine claims about "research" to ensure that it does not become the marketing slogan in Saskatoon that "isotope production" was in Sherbrooke. After failing to convince the Sherbrooke hospital Board of Directors that a Slowpoke was needed for thermal energy, AECL promoted the reactor as an isotope producer. This promotion played on the public's need for health care. Authorities did not acknowledge that the primary source of radio isotopes used in medical research and diagnosis has been accelerators rather than reactors. The medical emphasis was intended to enlist the internal political support of the university's prestigious medical profession.

Initially, Sherbrooke University Hospital's director general, Normand Simoneau, announced that the reactor project would go ahead because "the important aspect is that we will be able to produce radio-isotopes used in nuclear and forensic medicine."[30] To make it absolutely clear, he went on to say that accepting the reactor was based on "scientific reasons."[31] The research vice-dean in the Faculty of Medicine claimed that the reactor would promote patient recovery, be important for training students, and make isotopes more readily available for area hospitals.[32] This strategy disintegrated when letters from prominent scientists argued that using a ten-megawatt reactor was neither an efficient nor economical way to produce isotopes.

In his press release, President Kristjanson identified this proposal with the university research into the "small scale nuclear technology" of the cobalt-60 therapy unit, radioactive tracers in agriculture, and the linear accelerator. He did not acknowledge the differences between these research projects and energy-producing reactors. Power and heating reactors generate large quantities of high-level waste in contrast to the minimal amounts from medical and research isotope production. Nor does nuclear research confront us with the massive problem of decommissioning reactors. Finally, research does not routinely release radioactive emissions into the atmosphere.

What's One Small Disaster?

It is now well known that people will accept frequent small disasters far more readily than rare catastrophes. . .Although we may have to endure the legacy of Three Mile Island for many years, a decentralized system of small reactors which effectively eliminates the possibility of a single big accident may have a significant advantage in licensing, insuring and gaining public acceptance.

Eventually, the public may accept accidents to small reactors to the same extent that they accept fires, explosions, and airplane crashes, as long as the consequences are not obviously worse. It would be unrealistic, however, to expect many communities to welcome nuclear reactors within their boundaries until there are severe regional shortages of gas and electricity.

(John Hilborn, Slowpoke designer, in a 1981 Atomic Energy of Canada document. Taken from *The Record*, Sherbrooke, June 23, 1988.)

Slowpoke-3 is not just *different* from our research reactor, it is *brand new*. All technologies break down; untried technologies are likely to breakdown more frequently. The words of John Hilborn are not reassuring.

In the most recent issue of *The Sciences*, Jonathan Jacky[33] relates the tragic saga of the AECL's Therac-25, a linear accelerator used in the radiation treatment of cancer patients. Introduced in 1983, it is believed responsible for five deaths by 1987. The U.S. Food and Drug Administration advised clinics "to discontinue routine use of the Therac-25 until safety features could be installed. . ."[34] The apparent cause was a malfunctioning of the machine's software. Jacky explains in some detail why a breakdown of this kind is unsurprising given the complexity of the computer's program. We presume that Slowpoke-3 will also make use of computers to run its operations. Were its complex and sophisticated software to malfunction, no one should be surprised. Breakdowns go with the territory.

But Jacky is not content to point to human failure in the technical aspects of developing technology. He accuses AECL directly:

> The fault cannot be placed on the programmers who wrote software for the Therac-25; even the best programmers make lots of mistakes, because software writing is a painstaking task. The underlying problem was that Atomic Energy of Canada failed as an organization to guard against such errors. One of the earlier models, the Therac-20, contained electric circuits that prevented the beam from being turned on in such instances of malfunction. This mechanism was omitted from the Therac-25, and it is evident that no sufficient review of the safety implications of this omission ever was made.[35]

The adminstration is entrusting our fate to the AECL.

So far, the Slowpoke-3 reactor is only an idea on a drawing-board. No prototype has ever been constructed. This untested technology would be built on our campus as an experiment. Whatever goes wrong will be chalked up to the need for improved design. Prototypes are studied for inadequacies in design and operation in order to make improvements. Prototypes often suffer flaws that produce breakdowns, loss of operation time, delays, and expense. The NRX prototype to the Candu was so flawed that it was involved in a major accident in 1952. The first Candu reactors in Ontario required major repair. Would it not make more sense, if one were interested in nuclear generated heat, to wait until a reactor is proven rather than acquire the prototype?

The two-megawatt Slowpoke research reactor at Pinawa might have served as the best model. While this reactor "is intended by AECL to provide the information which can be used to design the ten-megawatt version,"[36] caution has been expressed. The Director General of Reactor Regulation has stated that the "ten-megawatt reactor will be significantly different from the SDR (two-megawatt Slowpoke Demonstration Reactor)."[37] This SDR reactor was licensed to operate to a maximum of one-megawatt for the first time in the second week of May, 1989.[38] Until then, it had operated at 200 watts, enough to power two electric light bulbs, considerably less than the twenty-kilowatt capacity of the U of S research reactor! When Dr. Max Krell (a University of Sherbrooke computer science professor and formerly a nuclear physicist at German and Swiss nuclear facilities) met Dr. Zygismond Domaratzki, General Director of Reactor Regulation at the Atomic Energy Control Board (AECB), to examine the official 1986 safety report of the two-megawatt reactor at Pinawa, dozens of pages under "Safety of the Reactor" were left totally blank. According to Krell, "the information is classified...many words and lines in the remaining pages were also deleted."[39] As for the 10-megawatt reactor, there was no information whatsoever! Without the technical details and conceptual development for the reactor, not even the AECB can examine the reactor for safety. We are the guinea pigs.

Radiation Risks: Just Think of It as Science

Critics argue that the Slowpoke-3 is different from the research reactor because of the risks to health it could present. Unlike commercial reactors constructed at considerable distances from towns and cities and designed with venting systems that discharge radioactive gases at high altitudes, the Slowpoke-3 is to be located in a population centre and will discharge radioactive gases in close proximity to university faculty, staff, and students. Dmytriw acknowledges that "the new reactors will generate radioactive gases that will have to be vented into the air."[40] Instead of diluting radioactive waste over a large remote area, Slowpoke-3 radiation will be vented on campus.

Low-level radioactivity will emanate from the facility and increase background radiation levels on campus in spite of shielding. Radioactive gases are generated during normal plant operation and possibly by leaking fuel elements which cannot be examined separately without closing down the reactor. The reactor is designed to run with no emergency cooling system and without an operator present. The plant would not have airtight containment. The reactor's water filters would accumulate radioactive particles and would have to be replaced regularly. These filters would be shipped with other contaminated materials to Chalk River, where the wastes would be stored until AECL and the federal government decide on a permanent waste disposal site.

While fuel rods are changed in Candu reactors regularly, they are removed from the Slowpoke-3 operation once every four years. The Candu method of refuelling allows for the continuous inspection of pressure tubes in the reactor. The long period between refuelling in the Slowpoke leaves more time for cracks and deterioration to develop in the casing of the fuel elements, through which radioactive gases could leak.

Krell claims that Slowpoke-3 has the potential to cause a bigger catastrophe than the PCB warehouse fire in St. Basile-le-Grand.[41] He argues that the biggest danger with the Slowpoke is the absence of an emergency cooling system. Because reactors do not stop producing heat when turned off, he argues that such a system is necessary in the event that heat exchangers fail.

Although AECL constructs credible accident scenarios, incredible accidents happen. The real world is unpredictable. For example, the industry testified that Candu reactor pipes could not break before they leaked. However, they did break in 1983 prior to leaking. Over 33,000 reactor accident reports were filed in the U.S. in the last decade.[42] AECL has not published any safety studies for the Slowpoke-3. AECB has not seen or produced an analysis of possible accident scenarios. What would happen, for example, were a canister of spent fuel to drop releasing high-level radiation? Even the Slowpoke designer recognizes the possibility of such accidents and hypothesizes that communities would not likely favour Slowpoke reactors unless there were severe shortages of electricity and gas.

In discussing radiation risks, we need to consider the standards for levels of exposure as well as the effects on the public of low-level radiation. Although the International Commission for Radiation Protection recommends one millisievert per year as the limit for radiation exposure, Canada adopted a standard that allows five times more radiation exposure than the recommended ICRP standard, ten times more than the British standard (0.5 millisieverts) and twenty more than the U.S. standard (0.25 millisieverts). University faculty and staff and the citizens of Saskatoon deserve protection at least equivalent to the recommended international standard and those in other industrialized countries.

Contrary to speculation that low-level radiation improves health,[43] recent research supports the view that "continued exposure to low levels of radiation can be more harmful than short exposures to higher levels."[44] Dr. Abram Petkau of AECL in Pinawa claims "that in a membrane system, chronic exposure to low levels of radiation is more effective in breaking down the system than a large short term exposure."[45] Dr. Kazuto Okamoto, University of Toronto, says that there is good evidence for agreeing with Petkau that low-level radiation damages membranes and DNA, which interact, accelerating the damage. Several recent studies indicate that those living near nuclear reactors are more likely to suffer radiation-related diseases.[46]

The Economics of the Reactor Industry

Development of the Slowpoke-3 for export is no guarantee of financial success if the past record of Canadian reactor export sales is any indication. One claim of Slowpoke advocates is the promise of economic pay-off. Using taxpayer's money to retrofit the university to hot water and to pay for Slowpoke marketing and capital costs of constructing a single reactor are only the most recent subsidies in an uneconomic venture.

On September 28, 1981, when the Supreme Court was delivering its decision on the legality of patriating Canada's constitution, Prime Minister Trudeau was in South Korea attempting to sell a Candu reactor for Canada's ailing industry. The visit was typical of efforts by Canadian governments over thirty-five years "gambling that nuclear power will become a commercial success."[47] In the 1980s, Canada's nuclear reactor industry declined dramatically in the face of "excess capacity."[48] At the same time, the federal government forgave $800 million in unpaid loans owed by AECL.[49]

To maintain the industry, the government sought sales in Korea, Pakistan, Argentina, India, Mexico, Yugoslavia, Algeria, Saudi Arabia, Egypt, and Romania. Where sales were made, Canada still lost millions. Charges of bribery, corruption, and financial mismanagement followed.[50] In an international market where it is difficult to turn a profit and maintain lofty principles, the Canadian government has been pressured to authorize costly marketing programs, allow illegal business practices, grant generous financing terms, and negotiate special agreements.[51]

A review of AECL reactor sales to other countries shows that the reactor business has been a losing proposition and has needed constant subsidises from the Canadian taxpayer. Canadian reactors exported by AECL are listed below along with their costs:

1. India (1955, Cirus, 40MW): A $9.2 million gift from Canadian taxpayers. India (Rapp 1 in 1963 and Rapp 2 in 1966, both 203MW): $140 million loan, 6% for 15 years, 6 years grace.
2. Pakistan (1965, Kanupp, 125MW): Of $63 million cost, $51 million financed by Canada at rates of .75% over 40 years, and 6% over 15 years, plus several years of grace.
3. Taiwan (1969, 40MW Research Reactor): The details of the deal were never released to the public.
4. Argentina (1973, 600MW): Canada lost $130 million on a 25-year loan that did not account for inflation, as much as $15 million to retune a reactor, and $2.4 million to an unidentified Argentine agent.
5. Korea (1975, 600MW): $530 million in loans at subsidised rates and a $18.5 million agent fee. Romania (1978, 600MW): $1 billion line of credit by Canada Export Development Corporation.[52]

Given the operating record of many of AECL's nuclear projects in Canada, what has been the return on investment to the taxpayer? We can start with this list:

- In the 1950s, the NRX reactor suffered a serious accident.
- Rolphton Nuclear Power Demonstration reactor (22 megawatts), a prototype, required major changes in design which caused delays and cost overruns, experienced heavy water

leaks, and had a dismal performance record until it was shut down.[53]

- The Douglas Point reactor (200 megawatts) was mothballed because of serious radioactive contamination and safety related problems.[54]
- AECL Gentilly-1 reactor in Quebec operated for less than 200 days over a ten-year period then was mothballed.
- Gentilly-2 produces electricity at twice the unit price of Quebec Hydro. Quebec had to pay the one-billion dollar cost overrun for construction, while Ottawa paid one-half of AECL's estimated $400 million.[55] The reactor was also discovered to have many hair-line cracks, apparently due to a design flaw.
- The $600 million AECL heavy-water plant at La Prade never operated.[56]
- AECL's little-known, patriotically-named Maple-X reactor now being developed for the export market was designed to cash in on medical and industrial uses as an isotope producer. The project was stopped because it suffered several setbacks.[57]
- Cracks were discovered in the Point Lepreau reactor containment walls.[58]

The Slowpoke-3 is another stab at the reactor market. It is possible because of lavish government support over many years in spite of government cutbacks in other areas.

In the United States, by contrast, banks have refused to fund loans for new reactors. The free-market economy has virtually ended their nuclear reactor construction. No new reactors have been ordered since 1978, and fifty-four under construction have been stopped.[59] Meanwhile, several electrical utilities are finding more profit in marketing energy efficiency than in generating more power. They reward efficient energy consumers, offer rebates, sell consulting services, stimulate the market for improved technologies, change rate structures, and implement "least cost" programs to reduce peak demand for homes, business, and industry. Recent developments in lighting, insulation, and refrigeration have reduced energy consumption in buildings that were retrofitted only a few years ago. Why does the university wish to install obsolete technologies when there are new, exciting possibilities to pursue?[60]

Nuclear Weapons: The Slowpoke Connection

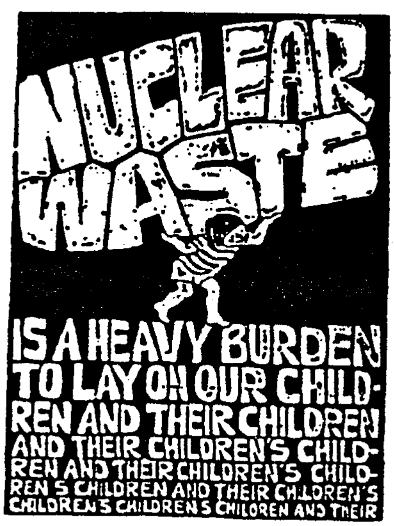
Canadians are reluctant to acknowledge that any of their enterprises might have distasteful military connections. In the case of Slowpoke-3, they are of two kinds. First, we need the services of American uranium enrichment plants used by its military because we have no plants of our own. Enrichment plants in France, Britain, Russia, and the U.S. were constructed for and continue to serve nuclear weapons programs. The three U.S. plants were constructed as part of the production process for nuclear warheads. While uranium is enriched to a bomb grade of 90 percent, that used for civilian utilities is drawn off at levels as low as 3 percent. To enrich the uranium required by any power reactor, we must piggy-back onto the U.S. military nuclear weapons programs.

Second, should the trial of Slowpoke-3 prove successful, we would expect to sell it to as many countries as possible and, if past practice is any guide, we will not be too exacting about their military intentions. Every four years, this reactor would produce enough plutonium in the spent fuel to produce two nuclear bombs. Exporting Slowpoke reactor technology could increase the risk of nuclear weapons proliferation, just as the export of the Candu has. The use of the Slowpoke-3 for Canadian military purposes could be a violation of our agreements.

By 1987, Canadian reactors in India produced enough plutonium-239 to construct 411 bombs, Pakistan 167, Taiwan 19, Argentina 180, and Korea 180.[61] India has a store of warheads and has recently developed its missile delivery capability.[62] Pakistan has developed warheads. Taiwan was forced by the U.S. to dismantle its plutonium reprocessing facilities for weapons production. The U.S. discovered Korea's clandestine plans to create nuclear weapons,[63] and Argentine officials stated publicly their interest in a Candu for weapons when the sale was opposed by Canadian citizens groups.[64] The Carnegie Endowment for International Peace reported that Iran, Iraq, Libya, Syria, South Yemen, Egypt, Saudi Arabia, and other countries are developing long-range ballistic missiles and "require only the nuclear warheads to become instant superpowers."[65] Proliferating small quantities of plutonium throughout the world in heating plants increases the possibility of the diversion of plutonium for nuclear weapons. To enter the export market, AECL has been negotiating with China and South Korea,[66] and more recently, Hungary to sell Slowpoke reactors. They are interested in the Slowpoke but are "reluctant to enter into a binding arrangement before a prototype is operational."[67]

Conclusion

Our Common Future, a report of the World Commission on Environment and Development, argues for sustainable development to meet energy needs without mortgaging the prospects of future generations. Nuclear reactor technology increases the accumulation and proliferation of high-level nuclear waste, increases the possibility of spreading nuclear weapons, and releases low-level radiation to the local environment.[68] *High-Level Waste in Canada: The Eleventh Hour* report, which calls for a moratorium on reactor construction, recommends development of renewable energies and fusion.[69] The most important advances to be made are in the area of new technologies and the restructuring of electrical utilities to produce energy efficiencies. Shouldn't the university re-consider its position and offer the people of Saskatchewan options that are safe, cost effective, and sustainable?



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[4] See the coverage in several articles in *The Record* (Sherbrooke) from September to December, 1988.

[5] M. Gooderham, "Support for nuclear power still low, poll finds," *Globe and Mail*, June 3, 1989.

[6] J. Cramer *et al.*, "They lied to us," *Time*, October 31, 1988, and T. Morganthau *et al.*, "Nuclear danger and deceit," *Newsweek*, October 31, 1988.

[7] For a more comprehensive analysis of this campaign, see "Atomizing dissent: The nuclear industry's educational strategy," *Scrutiny*, 2(5), 1989.

[8] Memo from R. Veilliux, AECL, to De[illegible] lauriers, September 18, 1987.

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[10] T. Vandermeulen and the Coalition CHUS, *Beware AECL Bearing Gifts: A Slowpoke Journal*, (Lennoxville, Quebec: Citizens for Nuclear Responsibility, 1989), 35.

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[22]Report of the Standing Committee on Environment and Forestry. *High-level Radioactive Waste in Canada: The Eleventh Hour,* (Ottawa: Queen's Printer, January, 1988).

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[24]*Ibid.,* 25.

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[27]M. Gruer. *op. cit.*

[28]R. Sheppard, *op. cit.*

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[32]*Ibid.*

[33]J. Jacky, *The Sciences,* The New York Academy of Sciences, 29(5), (September-October) 1989, 22-27.

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[35]*Ibid.,* 24.

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[60]For further information, one can contact the Rocky Mountain Institute, 1739 Snowmass Creek Road, Colorado 81654-9199, U.S.A., and the New England Energy Policy Council, 3 Joy Street, Boston, MA 02108, U.S.A.

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