Nuclear power: Boon or Bomb?

by John McEwan

Since the mid-1960's, nuclear power programs in North America and Europe have expanded very rapidly. In 1974, the world was generating electricity from 149 nuclear power stations. In Canada, there are 4 nuclear power stations, the largest being a 4 reactor plant at Pickering near Toronto. Three more plants are under construction. Atomic Energy of Canada Ltd. is anticipating 126 power reactors in Canada by the year 2000.

A growing number of people however, believe that nuclear power entails unacceptable health hazards for present and future generations. Nuclear critics in many American communities have delayed or prevented the construction of nuclear power plants. Strong opposition to nuclear power also has emerged in European countries. The recent defeat of the Swedish Social Democratic Party was caused, in part, by the Social Democrats pro-nuclear position. In Canada, the Canadian Coalition for Nuclear Responsibility (CCNR), a coalition of environmental groups and citizen's organizations, is generating widespread support for a public inquiry "to acquaint the public with the hazards and benefits of all aspects of nuclear energy development".

The main health hazards are caused by the accumulation and transportation of intensely radioactive substances, some of which must be completely isolated from the

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environment for thousands of years. These substances are created in the reactors of nuclear power plants as atoms of the uranium fuel generate heat by spliting into simpler elements.

Among the substances created are Strontium 90, iodine 131, cesium 137, americium and comparatively large amounts of plutonium 239. Plutonium is one of the most toxic materials known. Some scientists estimate that **one millionth of a gram** of plutonium in the lung of a healthy person could cause lung cancer. A Pickering-size reactor produces about 227,000 grams of plutonium each year. In 24,400 years, only one half of this amount will break down into other substances. If even a few thousand grams of plutonium particles entered the air or the water system of a population center, thousands of cancer cases and genetically-based disorders could result.

In order to protect future generations from tons of radioactive by-products lasting thousands of years, we clearly need a safe storage scheme. Even the nuclear industry realizes this, and so it is studying the possibility of burying the wastes permanently in apparently stable rock formations or in salt mines. Yet according to Peter Dyne, a waste management expert with Atomic Energy of Canada Ltd. (AECL), burial of radioactive wastes may be "marginally less safe than...continually monitored surface storage." (**Science Forum**, Dec. 1975, p. 16) Sir Kingsley Dunham, director of the Institute of Geographical Sciences in London, has said that no place on earth can be guaranteed to remain stable for thousands of years. It seems, therefore, that the nuclear industry has no widely accepted solution to the problem of containing high-level radioactive material for very long periods of time.

But this is not the only hazard. Waste storage is only part of a larger nuclear energy system which includes uranium mines, ore processing plants, reactor fuel fabrication plants and nuclear power stations. Each of these facilities produces or handles substances which are at least mildly radioactive. Each facility, therefore, is a potential source of radioactive pollution as are the trucks and trains which carry radioactive materials from one facility to another. In Port Hope, Ontario for example, radioactive rubble from the Eldorado uranium refining plant was used as land-fill a number of years ago. Recently, serious amounts of radon 222, (a radioactive gas) from the rubble were found in several homes and in two shcools in Port Hope. Radium leaks, arsenic leaks and wind dispersal of radioactive dust also have occured over the years. Unprocessed tailings from mining and refining operations can continue to be sources of radon gas and radioactive dust for centuries. Removing dangerous substances from the tailings, an expensive operation, would yield concentrated radioactive material, some of which would have to be stored safely for thousands of years.

Much of the current debate about nuclear power has centered around the possibility that large amounts of highly radioactive material will escape from the nuclear plants themselves. In the United States, the Atomic Energy Commission* responded to nuclear critics by hiring Dr. Norman Rasmussen to conduct a major study of possible reactor accidents. Dr. Rasmusson's report concluded that the worst possible reactor accident would cause "2300 immediate deaths, 8000 injuries and 6.2 billion dollars in property damage". The long-term effects could include thousnds of deaths due to cancer and to genetic disorders. Such disastrous consequences could follow an accident in which an overheated reactor core burned through the floor of the nuclear plant and into the ground below. As the "core meltdown" occurred, exploding hydrogen gas would scatter intensely radioactive substances into the atmosphere. In many cases, underground waterways would be contaminated by the molten, burning mass of core material.

There has not yet been a major "breach of containment" accident but many safety-related mishaps already have occurred. American incidents include an explosion and fire (1959), a fuel rupture (1962), jammed control rods (1963,1966), and a large release of radioactive gasses (1959). Ten of the world's more serious reactor accidents are described by Walter Patterson in his recent book, **Nuclear Power**. In several of these cases, an unpredictable combination of human errors and mechanical failures brought nuclear plants perilously close to breach of containment disasters. On October 8, 1957, for example, the core of Britain's Windscale reactor #1 overheated and then burned for one and a half days before the fire was brought under control. The design changes required to prevent a similar accident in the second reactor were prohibitively expensive. So both reactors were shut down and entombed in concrete. Only time can tell how successful the containment will be.

The Canadian CANDU reactor seems to be safer than most other models. During a public discussion in March, 1975, however, the president of Atomic Energy of Canada (AECL), J.S. Foster, admitted that a serious CANDU accident was possible and we can get some indication of accident possibilities by examining a reactor breakdown which occurred in 1952 at the AECL research center near Chalk River, Ontario. On December 12, 1952, several human errors and mechanical faults caused the core of the NRX reactor to overheat severely. Important reactor components, including the tank that holds the fuel bundles and the heavy water moderator, ruptured or melted. The clean-up operation involved dismantling the reactor and dumping a million gallons of water which contained "radioactivity equal to seven times the world production of radium" up to that time. (Eggleston, W., **Canada's Nuclear Story**, p. 223)

In 1972, a number of safety-related faults were recorded in the Pickering power station. In 1974, the #3 reactor was shut for months in order to repair leaking pressure tubes in the system. Similar leaks appeared in reactor 4 in May, 1975. None of these faults increased greatly the probability of a "breach of containment" accident. Yet they were disturbing reminders that the CANDU system is not immune from technical deficiencies or human errrors.

As the nuclear industry grows, the transportation of highly radioactive reactor materials will become frequent and widespread. Before being transported, these materials are sealed in heavy lead and steel casks. Reports indicate that a serious highway accident could rupture a cask, releasing gaseous radioactive substances into the air. As the number of shipments increases, such accidents will become more likely. One physicist at Michigan State estimated that at least 162 serious highway accidents involving casks will occur in the United States 20-25 years from now if the reactors which the U.S. Atomic Energy Commission planned to build are constructed. In Canada, spent reactor fuel has been shipped by truck from Douglas Pt., Ontario to Pinawa, Manatoba on several occasions and other shipments are planned.

Transportation dangers are increased by the possibility that radioactive shipments will be hyjacked or sabotaged. Stolen radioactive poisons could be used for terrorism, extortion or mass murder. A relatively small quantity (approximately 11 pounds) of plutonium could be sold for an enormous sum ($100,000/kg) on the black market or used to manufacture a crude atom bomb. Even elaborate security measures may not prevent a sophisticated theft.

Many pounds of plutonium and other radioactive material already are "unaccounted for" in inventory assays. The discrepencies may have been caused largely by failure to account for traces left in wastes. In addition, some of the missing material may have been misplaced during shipment. In 1969, Sam Edlow, a consultant on nuclear materials transport, told the Institute of Nuclear Materials Management that weapons-grade material "in amounts sufficient for dozens of bombs" was "routinely lost, misrouted and overlooked by airlines, trucking companies and freight terminals." (Patterson, Walt, **Nuclear Power**, p. 249). Theft also may have been a factor. In 1974, the **New York Times** reported that there were two known cases in which "Government employees were discovered to have smuggled out of guarded facilities enough...material to fashion a nuclear weapon." (**N.Y. Times**, Dec. 1974, p. 26, 29. Cited in Lovins, A. **Non-Nuclear Futures**, p. 91, note 106.)

There have been several attempts to sabotage partially-completed nuclear facilities. A plant nearing completion in New York State, for example, was severely damaged by arson. In addition, operating reactors in the U.S. and Britain have been threatened by terrorists.

Efforts to maintain security in an expanding nuclear industry could increase restrictions on civil liberties. Texas state police already are compiling dossiers on nuclear critics.

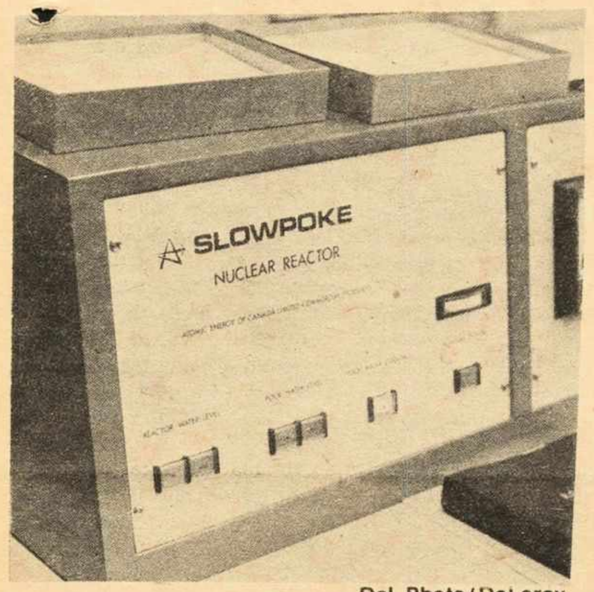
The creation, accumulation and transportation of intensely radioactive materials constitute the primary danger of nuclear power. But nuclear critics also are

A nuclear reactor will produce, at most, 10-15 times the energy required to build and fuel it.

concerned about the emission of low-level radioactive waste from nuclear facilities. Nuclear plants routinely discharge krypton-85 gas, tritium and traces of other radioactive substances. Uranium mining operations, uranium refining plants and reactor fuel re-processing plants (see below) also release low-level radioactive waste. The International Atomic Energy Agency assumes that any exposure to radiation involves some risk of genetic damage or cancer and that the risk is directly proportional to the exposure. (There are "permissable" levels but there are no theoretical safe levels). This assumption is supported by a number of major studies on the long-term biological effects of low-level radiation.

The CANDU reactors at Pickering use natural uranium fuel rather than enriched unanium or plutonium from spent fuel rods. In the United States and Europe, however, a large amount of spent reactor fuel has been **re-processed** to extract plutonium for nuclear bombs or for new fuel rods. Re-processing involves dissolving spent fuel in nitric acid and producing hot, highly radioactive liquid wastes which must be stored and, eventually, solidified. In 1969, approximately 80 million gallons of these wastes were stored in the United States alone. The storage systems have not been entirely sucessful. The Hanford plutonium recovery installation in Washington state, for example, has had over a dozen serious leaks. Most of the currently stored liquid waste in the U.S. was produced by bomb manufacturing projects. Solidification of this waste is supposed to be accomplished by 1977. As long as plutonium extraction occurs, however, large quantities of extremely toxic liquid waste will be produced. This waste will have to be stored and, in some cases, transported before it is solidified.

Solidification does not eliminate the waste storage problem. It creates a mess of concentrated, hot, highly radioactive material which must be transported safely and completely isolated from the evnironment for centuries. The extracted plutonium requires even greater care not only because it has a very high black market value but also because it is a highly volatile substance.



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Plutonium has low thermal conductivity, a low melting point and a tendency to burn spontaneously on contact with the air. Plutonium also is a "fissile material". This means that when certain quantities of plutonium are brought together, the resulting mass will reach high temperatures and give off bursts of radiation.

The nuclear industry in Canada has taken elaborate safety precautions to minimize hazards. Supporters of nuclear power argue that such precautions reduce the likelihood of major accidents to an "acceptable" level. The accident probability figures, however, are essentially educated guesses based on careful speculation, computer simulations, materials testing and comparasons between nuclear systems and conventional technology. Human errors, (including those of the designers), sabotage, and **unanticipated** technical faults cannot be accuratley taken into account. Much more operating experience is required before reliable estimates of accident probabilities can be made.

Arguments for accepting the risks involved in nuclear power development often are based largely on (1) the idea that nuclear power can be an abundent source of relatively cheap electricity, and/or (2) the assumption that we must have nuclear power to satisfy our energy needs over the next 100 years.

The first notion was widely held in the 1950's. Over the past ten year, however, the escalating capital cost of nuclear power has become a major problem for the nuclear industry in Europe and in North America.

For example, the Point Lepreau plant under construction in New Brunswick was to have cost approximately $450 million not counting interest payments. Official estimated construction costs are now $684 million. Total costs, including interest payments, may be over $2.3 billion.

If one makes the conservative assumption that the average cost of nuclear power in Canada will be about $1.5 billion per reactor, then total federal and provincial expenditure on nuclear power could be at least $189 billion by the year 2000. Canada's GNP for 1974-75 was only $140.3 billion. If much of the $189 billion is raised by borrowing outside Canada, (Ontario Hydro already has floated a $1 billion bond issue in New York.) then the Canadian economy will be hurt by an enormous outflow of interest payments to foreign financial agencies. These effects will not be offset by the availability of cheap electricity.

The idea that nuclear power is needed to satisfy future energy requirements is difficult to accept when one looks at a comprehensive set of alternative energy sources, including energy conservation. The potential of **renewable** energy sources such as solar power, wind power, wood and organic waste material recently was examined in the Canadian context by Peter Middleton and Associates, an environmental consultancy firm. The Middleton study concluded that renewable sources could satisfy 2 per cent to 4 per cent of Canadian energy requirements by 1990 and 20 per cent by 2020. The conclusion for solar heating was particularly impressive:

> Combined with proper waste heat management, solar energy technologies can probably supply the greater part of residential, commercial and industrial space heating needs or close to 25% of Canada's total energy demand.

The study estimates that by 1979, 70 per cent solar heating systems for many single family dwellings will be cheaper than all-electric heating and almost cost-competative with oil heating. The Middleton study also claims that "80 per cent more of residential electrical demand in southern Canada" eventually could be met by extensive use of photovoltaic systems.

Another major energy source could be methane gas generated from sewage, animal wastes, scrap wood and other organic material. For example, the Middleton study estimates that methane gas produced from 25% of Canada's "unused forest industry wood residues" would yield enough liquid fuel (methanol) to fulfill 7% of Canada's road fuel requirements for 1990.

The Energy Policy Project of the U.S. Federal Energy Administration was even more optomistic than the Middleton study about the potential of renewable energy technologies. The EPP concluded that direct and indirect energy from the sun could satisfy 5 per cent of U.S. total energy needs by 1990 and 31 per cent by the year 2020. According to Amory Lovins, these estimates are larger than even the most optomistic predictions about energy from nuclear power plants.

In the next century, renewable energy technology could provide increasing amounts of energy. For example, some scientists believe that temperature differences in water off the American coast could be used to generate huge amounts of electricity. Fuel cells, ocean waves, and heat from the earth (geothermal energy) are other sources with great potential. Improved methods of storing electrical energy (e.g. batteries, compressed air storage) will increase the value of wind mills and solar technology as sources of electricity. One of the most promising storage techniques is the production of hydrogen gas by electrolysis of water. This method already is about 60 per cent efficient. At high temperatures and pressures, efficiency could reach 90 per cent. Hydrogen is so attractive as a fuel that some people believe it could be the future "basis of our energy economy". (Wood, David, "Energy: Conservation and Alternative Sources", Energy Probe, Toronto, 1975, p29.)

Arguments in favor of nuclear power often are based, in part, on the assumption that energy consumption will continue to double every 10 to 15 years. If energy prices continue to rise, however, the rate at which energy consumption grows could diminish substantially over the next 25 years. Energy consumption could be moderated further by a major conservation program involving improved insulation, more efficient industrial processes, recycling of materials, expansion of public transit and increased use of waste heat. According to a 1975 report from Energy Probe in Toronto, a program which focused upon increasing the efficiency of energy use and eliminating waste could yield an accumulated saving of 85x10 15 BTU's over the next 25 years. This is roughly equivellent to the total output of 55 Pickering-size nuclear power stations.

A shift in resources from energy-intensive production to low energy industries would yield additional energy savings. In fact, a study done by Data Resources Inc. for the Ford Foundation's Energy Policy Project concluded that the United States could achieve zero energy growth by the year 2000 if the U.S. government imposed a 15 per cent across-the-board energy surchange and invested the resulting tax revenue in services and low energy production. The authors of the study believe that this scheme would have little effect on GNP.

A number of nuclear critics have proposed that energy conservation, fossil fuels (especially coal) and existing renewable energy technology be used to satisfy our short-term (25 years) energy needs while we convert to an energy system based largely on renewable sources. In this scenario, fossil fuels are used to support the development

The CANDU system, while one of the safest, is not immune from technical deficiencies or human error.

of renewable energy sources rather than the expansion of nuclear power. The scheme would promote labour-intensive, small-scale technology, avoid major, new health hazards and probably cost less than a nuclear program. (Reducing waste generally is much cheaper than building power plants.) It also may be less costly in terms of fossil fuels. Dr. P. Chapman and Dr. N. Mortimer of the British Open University estimated that a nuclear reactor will produce, at most, 10-15 times the energy required to build and fuel it. If the reactor is part of an expanding nuclear program, much of the net energy which it provides will simply replace energy consumed by construction of additional plants. Chapman has calculated that a nuclear program which doubles the number of reactors about every five years (e.g. Canada's nuclear program) would have energy requirements equivalent to at least 35% of the electricity it provides during the growth period.

A major nuclear power program will have profound implications for present and future generations. Yet federal government decisions about nuclear power generally have been made without public or Parliamentary discussion of the basic issues involved. By seeking a comprehensive public inquiry into the nuclear issue, the Canadian Coalition for Nuclear Responsibility hopes to involve more Canadians in decisions about energy policies in general and nuclear power in particular. Because a nuclear energy system may be unnecessary, very costly and extremely dangerous, widespread participation in the nuclear debate is crucially important to our society.

*The Atomic Energy Commission recently was replaced by the Nuclear Regulatory Agency and the Energy Research and Development Administration.