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Shifting strategies and precarious progress: Nuclear waste management in Canada

M.V. Ramana*

Nuclear Futures Laboratory and Program on Science and Global Security, Princeton University, 221 Nassau Street, Floor 2, Princeton, NJ 08542, USA

HIGHLIGHTS

- Canada has set up a process for siting a geological repository for nuclear waste.
- The current challenge is to find a community willing to host such a repository.
- Authorities are luring communities with the promise of jobs and local investment.
- Potential new nuclear reactor construction might become a locus of conflict.
- Success in actually setting up a repository is by no means guaranteed.

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ABSTRACT

Canada has a lengthy history of trying to find a path for dealing with radioactive spent fuel and nuclear waste from its nuclear reactors. In the last decade, it has taken major strides towards this goal by evolving a process through which a site for a geological repository to sequester nuclear waste is to be selected. The Canadian Nuclear Waste Management Organization (NWMO) is in the early stages of the process of finding a community that is willing to host such a repository. Differences between the broad principles underlying siting and the processes for actually selecting the site have emerged as the NWMO proceeds with engaging local governments and specific communities. These differences and other conflicts, especially over new nuclear reactor construction, might pose hurdles in the path of successfully setting up a repository.

1. Introduction

The management of radioactive wastes, especially spent fuel, has been a key challenge to the acceptance of nuclear power (Berkhout, 1991; Slovic et al., 1994). The debate over how to deal with spent fuel has been marked by a striking diversity of ideas, proposals and arguments (Högselius, 2009). Within the technical community, there is widespread consensus in different countries that spent fuel and other forms of waste can be safely disposed of in a deep geological repository (Meserve, 2004; Rempe, 2007).[1] Nevertheless, finding actual sites where such a repository could be built has proven politically very difficult and almost all countries that have tried to site repositories have had one or more failures (Feiveson et al., 2011).

In the last decade or more, Canada has emerged as one of the front-runners among countries dealing with this problem by evolving a process through which a site for a geological repository to sequester nuclear waste would be selected. Its Nuclear Waste Management Organization (NWMO) has recommended an approach that it terms "Adaptive Phased Management" which involves disposing of waste in a deep geological repository, but with the possibility of monitoring and retrieving the fuel for approximately 240 years after emplacement. NWMO is in the process of selecting what it calls an informed and willing community to host such a repository. Other countries, especially the United States, have been influenced by these developments in Canada.

This paper describes how this process emerged, how it is developing, and what challenges remain. We first describe the quantities of spent fuel involved and how they are managed currently. This is followed by a historical overview of nuclear waste management in Canada and a description of the NWMO and its consultation process. The next section discusses the relationship between the nuclear waste management efforts in Canada and those in other countries, in particular the United States. Finally, we discuss how this process is being implemented on the ground and three potential sources of discord that may be emerging.

* Tel.: +1 609 258 1458.
E-mail address: ramana@princeton.edu

[1] However, there remain significant uncertainties in projecting the performance of such repositories far into the future (Macfarlane and Ewing, 2006).

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2. Nuclear power and waste

Canada was part of the U.S. Manhattan Project to build the first nuclear weapons. In 1945, it set up its first reactor, the Zero Energy Experimental Pile at Chalk River, Ontario, followed by the National Research Experimental (NRX) reactor in 1947. Canada also set up facilities that recovered plutonium and uranium-233; these facilities were shut down by 1956 (AECL, 1997, pp. 67–68). The first power reactor was the 20-MWe Nuclear Power Demonstration reactor completed in 1962.

As of March, 2013, the International Atomic Energy Agency (IAEA) listed 19 power reactors operating with a total generating capacity of 13.5 GWe (net) located in the provinces of Ontario, Quebec, and New Brunswick.[2] All are operated by utilities owned by the provinces. Nuclear power contributed about 15.1% and 15.3% in 2010 and 2011 respectively of Canada's total electricity (IAEA, 2011, 2012, p. 12).

Table 1 lists the inventories of spent fuel at different sites in Canada. As of June 30, 2012, Canada had about 2.35 million fuel bundles in storage, 1.53 million in wet storage and 0.82 million in dry storage (Garamszeghy, 2012). Since each bundle contains about 20 kg of uranium, the total inventory is about 46,000 t of heavy metal.[3] The existing reactor fleet is projected to produce 3–5.2 million fuel bundles, i.e., approximately 61,000–104,000 t of heavy metal, over their lifetime.[4] There appears to be adequate available storage for the foreseeable future (Ramana, 2011). Therefore, there is no imminent necessity to construct a geological repository, allowing for a more deliberative and protracted process to be adopted.

2.1. History of nuclear waste management

The history of Canada's nuclear waste management policy dates back to the mid-1960s, two decades after the country embarked on nuclear power (Johnson, 2007). In 1969, the Atomic Energy Control Board (AECB, which became the Canadian Nuclear Safety Commission [CNSC] in May, 2000) officially requested Atomic Energy of Canada Ltd. (AECL) to conduct research on storing and disposing of nuclear waste. AECL joined with Ontario Hydro (OH, which became Ontario Power Generation [OPG] in April, 1999) and Hydro Quebec to form a committee of waste owners. The committee initially advocated monitored retrievable storage on the grounds that permanent disposal had yet to be proven and that incorporating the ability to retrieve allowed greater flexibility (AECL 1972; Durant 2009a).[5]

Retrievability also kept open the option of reprocessing the spent fuel to extract plutonium for potential fueling of reactors. AECL had considered reprocessing in the 1950s because of the concern that uranium reserves were limited. By the 1960s, however, abundant domestic uranium resources had been identified and the focus shifted to a once-through fuel cycle. Interest in reprocessing persisted within AECL's nuclear-energy R&D establishment, fueled in part by the assumption that nuclear power would expand rapidly in Canada.[6] This changed after the Indian nuclear test of 1974, which used plutonium from a research reactor supplied by Canada. After that, retrievability "became a political liability for commercial nuclear power, while permanent disposal lent support by removing waste from possible military uses" (Durant, 2009a, p. 901). Deep geological disposal was first endorsed in a joint statement by the federal government and the government of Ontario in 1974 after India's test.

In August, 1977, the Federal Department of Energy, Mines and Resources released a report that surveyed various spent-fuel management and disposal options, including reprocessing and immobilization; surface storage; and disposal in ice sheets, in space, on or beneath the sea floor, or in various types of underground rock (Aikin et al., 1977). This report, which became known as the Hare report, after its Chairman F.K. Hare, recommended burying the spent fuel at depths of 800–1000 m in the Canadian Shield, a large area of ancient igneous rock in eastern and central Canada (Aikin et al., 1977, p. 5).

The Hare report drew much criticism and started a public debate over nuclear waste disposal that may have played some role in reducing public support for expanding Canada's nuclear-power capacity (Mehta, 2005, p. 40). Attempts by the AECL to investigate locations in Ontario for waste disposal resulted in considerable local opposition.[7] Petitions against repository proposals garnered tens of thousands of signatures and Ontario parliamentary support dwindled (Durant, 2009a). This led the Governments of Canada and Ontario to announce in 1981 that no disposal site selection activities would be undertaken until after the repository concept had gone through a full federal public hearing and approval by both governments (King, 2002).

Soon after, AECL set up an underground research laboratory in the province of Manitoba (Chandler, 2003). A shaft was sunk to a depth of 445 m in granite and a number of galleries and rooms were excavated in which various experiments were carried out (Tammemagi and Jackson, 2009). The laboratory was also used for joint international work on waste management and included participation from France, Japan, South Korea, Sweden, and the United States. The United States repository program, for example, spent millions of dollars each year on work at the laboratory because, at that time, the U.S. repository program was not allowed by law to work at Yucca Mountain (Isaacs, 2008).

In June, 1978, the Governments of Canada and Ontario established the Canadian Nuclear Fuel Waste Management Program (Johnson, 2007).[8] AECL, with the assistance of Ontario Hydro, was directed to develop a generic concept for the deep geological disposal of nuclear waste.[9] The program's goals were "to develop and demonstrate technology to site, design, build and operate a

[2] This includes the Point Lepreau nuclear power station in New Brunswick that has been undergoing refurbishment since 2008; the refurbishment project is 3 years behind schedule and about one billion dollars over the original budget of $1.4 billion (Canadian Press, 2012). This does not include Bruce 1 and 2 reactors. All these reactors are moderated and cooled by heavy-water, and fueled with natural uranium.

[3] CANDU fuel bundles contain 19 kg of uranium, but NWMO estimates round this off to 20 kg.

[4] The low scenario assumes that reactors are shut down at the end of the projected life of the fuel channels, i.e., nominal 25 effective full power years (equivalent to about 30 calendar years of operation). In the high scenario, the reactors would be refurbished with a new set of pressure tubes and other major components, then operated for a further 25 effective full power years.

[5] According to AECL, "With the current state of knowledge… there is no proven safe permanent disposal method" (AECL, 1972; Durant, 2009a).

[6] For example, on February 28, 1977, the AECL organized a seminar on "Proposed Canadian Fuel Cycle Program" for Federal Government Agencies in Ottawa, where it projected between 67 and 90 GW by the year 2000, and added that "there is no indication of saturation in nuclear capacity by the end of the century" (CCNR, 2012a). Based on this, AECL projected that Canada would have committed its "measured resources" of natural uranium by 1978, its "indicated resources" by 1985, its "inferred resources" in the early 1990s and its "prognosticated resources" before 2006. This was used as an argument to embark on a program of reprocessing and fast breeder reactor construction.

[7] The first location to be chosen was Mount Moriah in Ontario, where AECL initiated a program of geophysical work with possible drilling, but was met with an overwhelmingly negative public response (CCNR, 2012b; NRCAN, 2012).

[8] The statement, however, explicitly stated that this "joint undertaking is not to be construed as a Canadian position on the question of the reprocessing of irradiated fuel. Canada's position in respect to its fuel cycle development program will be reviewed following the completion of the International Nuclear Fuel Cycle Evaluation now underway" (Boulton, 1978, p. 127).

[9] Ontario Hydro was to work on interim storage and transportation of radioactive wastes whereas AECL was to work on the immobilization and disposal of radioactive wastes from nuclear power reactors, including geological field and laboratory studies.