A team works with the NRU reactor at the Canadian Neutron Beam Centre in Chalk River, Ontario. National Research Council Canada photo

Nuclear Science and Technology: A Public Good?

John Barrett

Since antiquity, governments have invested in services and endeavours deemed to be in the public interest. Proving the strategic value in these "public goods" isn't always easy. Canada's nuclear industry and the research that keeps it safe and competitive constitute a public good with significant strategic value to Canada and Canadians, argues Canadian Nuclear Association President and CEO John Barrett.

Why do governments build lighthouses? Lighthouses are relatively cheap. They are far cheaper than the lives, ships and cargo they save, which in turn bring wealth to ports. This business model—one that pays off for society, if not for scavengers—merely requires a sovereign authority with access to both the coast and the port. Beachcombers may be poorer, but lighthouse-keepers are employed, ships go on plying their trade, and the kingdom as a whole is richer.

Lighthouses, which are classic public services, have been built since antiquity. Sovereigns everywhere provide such services, which also include law

enforcement, defence, and environmental protection. Economists call them "public goods."

Had our ancestors left such decisions to the market alone, life would have been an even riskier business than it was. But sovereigns had strategic goals (like growing the overall wealth of the kingdom). They provided public goods (like lighthouses) that served those goals.

It is sometimes difficult to *prove* the strategic value in public goods. One could try to amass anecdotes and evidence about the value of lighthouses, but this faces many challenges in terms of accuracy (how do you quantify the benefits; how far down the economy's value chain do you go?) and incentive (those best positioned to know the facts might overstate the value of services in order to get them increased—or understate it to avoid being taxed).

In the end, sovereigns might be forced to fall back on intuitive wisdom ("lighthouses just seem like the right thing to do") or a sense of best practices ("all the richest kingdoms appear to have lighthouses").

Today, government investment in science and technology presents an updated version of this classic problem.

In nuclear physics and engineering, for example, Canada hosts a number of world-class facilities (the world's largest cyclotron near Vancouver, the synchrotron light source in Saskatoon, and the nuclear laboratories at Chalk River, Ontario—not to mention other university-hosted facilities).

How do we know these are worthwhile? Why spend taxpayer dollars this way?

The answers are not easy. Even with today's data and methodologies, benefits can be difficult to measure. Commercial spin-offs depend on many factors: is someone ready to take on the risk and the venture? Is there a market available? Attempts to trace the links to commercial outcomes can also overlook incidental benefits, such as the career development of engineers, scientists and technicians.

Even now, we may need to fall back on best-practice analysis. Governments fund and operate scientific laboratories in all economically advanced countries. Either these governments are wasting their money, or there is some real, strategic value in these expenditures.

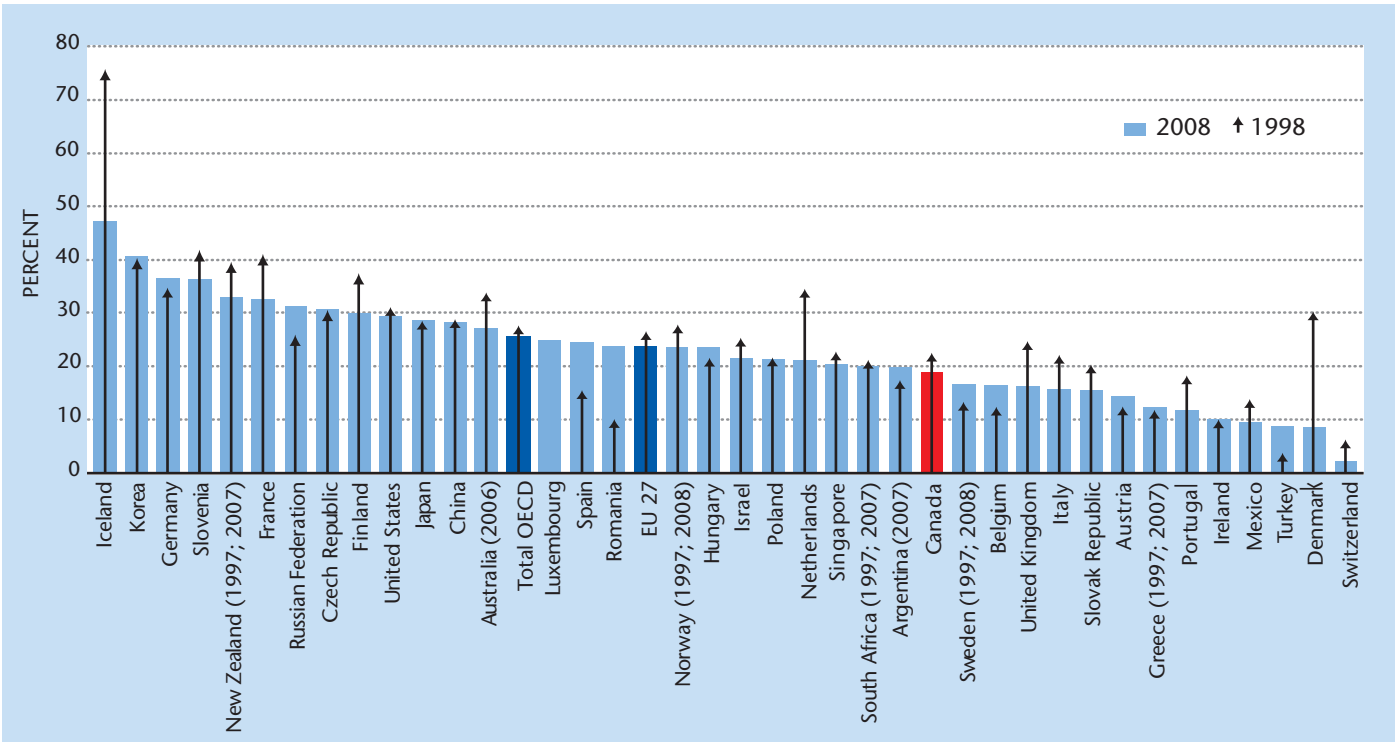
In recent years, Canadian policy has leaned heavily toward giving businesses tax incentives to perform science and technology. But it is false to assume that by getting businesses to do more *private* science, we reduce the need for government to do *public* science.

Rather, it's clear that the jobs done by government and industry are positively related, in other words, public and private science and technology are complementary. In fact, some aspects of science and technology are like lighthouses: only governments will fund them enough to reflect their strategic value.

First, public laboratory infrastructure permits investigations whose payoff may be very

FIGURE 1: Percentage of GDP spent on research in government institutes.

In the OECD's survey of 38 industrial or industrializing countries, Canada ranks 25th, far behind leading innovator countries (Korea is second, Germany third, the USA tenth, Japan eleventh, and China twelfth).



Source: OECD, *Science, Technology and Industry Outlook 2010*, figure 1.6.

large, but is too uncertain or unknowable for private firms to finance. Semiconductors and global positioning are most often cited as examples these days, but the first wave of practical nuclear reactors—both for power generation and for driving marine vessels—also paid off massively.

Second, there are "spillover" effects from public R&D that increase the chances of a successful outcome in the private sector. Publicly available science research, and the experts who perform it, help companies put their own knowledge into context and better judge its implications.

Third, public labs are a necessary enabler or precondition for some business R&D. Much Canadian corporate work on lightweight car engines, aircraft landing gear, or turbine blades could never occur without the non-destructive testing available at research reactors like the one at Chalk River Laboratories. Even the largest companies will not build research reactors for their own use, but they will use them if they exist.

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The very nature of science is that it happens a long way (in both time and development) from commercial results. Vannevar Bush, who authored the US government's science policy in the postwar era, stressed the need for such distance. Insisting that centres of basic research show commercial benefits would only undermine their value. "As long as they are vigorous and healthy and their scientists are free to pursue the truth wherever it may lead, there will be a flow of new scientific knowledge to those who can apply it to practical problems in government, in industry, or elsewhere," he argued.

Note that Bush didn't limit his argument to industry. Governments, too, are problem-solvers, and they benefit in many ways from having major science infrastructure.

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My organization, the Canadian Nuclear Association, recently made this argument with specific reference to the continued operation of the Canadian government's National Research Universal (NRU) reactor at Chalk River Laboratories. Here are just some of the strategic advantages we were able to identify from NRU's operation:

Canada's energy advantage at home – The NRU supports operating power reactors here in Canada, particularly in dealing with aging reactor components.

Key bilateral relations and energy partnerships – Six other countries use Canadian nuclear reactor technology. Should the NRU be shut down, it would be a signal of Canada's retreat from the nuclear energy market. Our reliability as a technology and investment partner would be less credible.

Strengthening nuclear security – More proliferation-resistant reactor fuels are currently under development in Canada with NRU support. Such fuels will strengthen nuclear security in Canada and elsewhere.

Increased safety – Canada is at the forefront of efforts to push reactor safety standards higher and higher, thereby reducing the risk of nuclear accidents. The NRU has facilitated this. It has also enabled a multi-disciplinary team that, when needed, can urgently analyze complex issues in reactor operations—a valuable safety resource for Canada and other countries.

Global market opportunities – Just two countries, India and China, between them have 35 reactors under construction and 230 more planned or proposed (Source: World Nuclear Association). Canadian reactor technology and intellectual property are already in use in both of these countries. Our technology may be a candidate for future purchases, provided we maintain its scientific base.

Highly qualified personnel in the knowledge economy – The NRU is a strategic training infrastructure. It develops the human capital Canada needs in all kinds of science and engineering fields.

Canadian influence in key international organizations – A quick look at top personnel in international nuclear organizations (e.g. World Nuclear Association, World Association of Nuclear Operators, International Atomic Energy Agency) shows Canadians in key positions where they exercise multilateral influence. Why? Because of Canada's skill, knowledge, practical experience, and credibility in nuclear science and technology.

Taken together, these add up to a strong case for treating Canada's experience, expertise and innovative R&D potential in the nuclear sphere as a strategic asset and a public good.

Other governments see the value. In fact, a 2013 commission led by former US national security adviser Brent Scowcroft argued that US civil nuclear technology constitutes a strategic asset for the United States; accordingly, maintaining its prominence and influence internationally constitutes a "strategic imperative".

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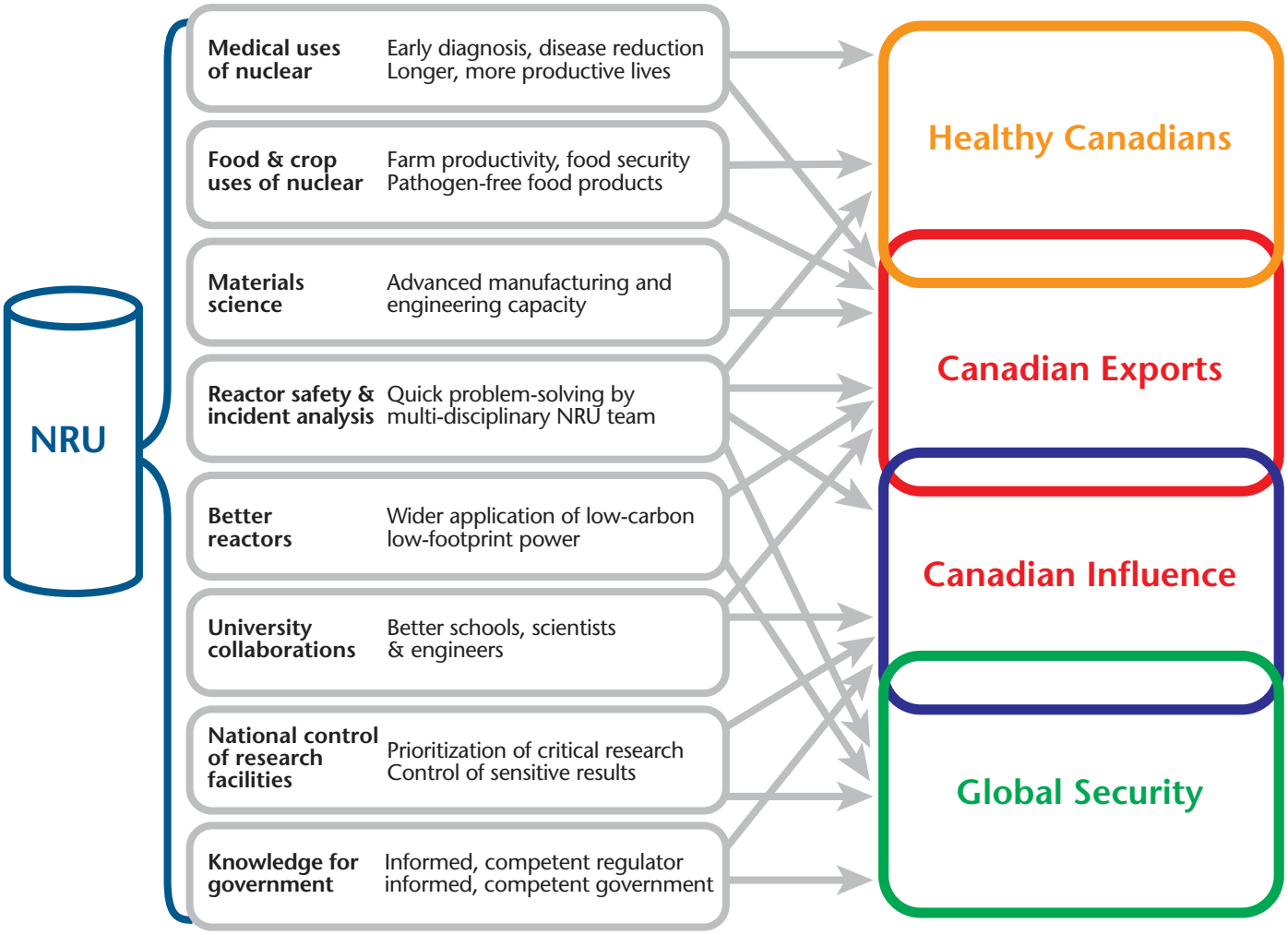
If all this did not provide a convincing case for strategic value in nuclear science, consider that nuclear power plants make a significant contribution to reducing carbon emissions, offsetting those of other Canadian resource sectors by avoiding the release of some 89 million tonnes of CO_2

FIGURE 2: An illustration of the value of a publicly-owned science facility, the National Research Universal reactor, to Canada's strategic national goals



Source: Canadian Nuclear Association

annually. A recent meta-study to be unveiled this fall by Hatch, the Canadian engineering and consulting group, shows that nuclear power generation would be roughly as "clean" as wind farms, even if the wind blew steadily, but is much cleaner if wind's intermittent character means that it is backed up by natural gas—which it often is.

The most common alternative to nuclear energy, here and abroad—and the main thing slowing its advance—are cheap and ubiquitous fossil fuels that do not pay the full cost of their own carbon emissions. The environmental impact of failing to advance nuclear power generation as rapidly as possible is accordingly huge, with soaring GHG emissions (on the climate front) and air pollution (affecting the health of hundreds of millions). Canadian technology is already mitigating this impact and has the potential to do much more, with world-beating proliferation resistance and safety.

The strategic value of Canada's nuclear technology can be grouped under four main headings that reflect the federal government's priorities: Healthy Canadians; Canadian Exports; Canadian Influence; and Global Security. (See figure 2.)

Yes, some propose leaving science (and other public goods—like security and lighthouses) to the markets. But countries have strategic goals. Public goods serve those goals, not just for industry but also for government and citizens. Governments of leading innovative countries do science for a reason. Canada should remain one of them. P

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