Are nuclear technologies clean, and are they compatible with a circular economy?

Brief for the Standing Committee on Environment and Sustainable Development

Study on Clean Technologies in Canada

Concerned Citizens of Renfrew County and Area

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The question of whether nuclear power is “clean” is of considerable importance in light of commitments to expand “clean energy” and “clean technologies” in Canada.

Nuclear reactors release a wide variety of air and water pollutants

Nuclear reactors routinely emit radioactive gases to the atmosphere during operation. These include fission and activation products such as tritium (the radioactive form of hydrogen); radioactive carbon-14; radioactive noble gases such as argon, krypton and xenon; radioactive halogens such as iodine-131; and a wide variety of radioactive aerosols.[1] Fuel reprocessing facilities, spent fuel storage facilities and other radioactive waste facilities also release radioactive gases. Heavy water (e.g. CANDU) reactors discharge higher amounts of tritium and carbon-14 than light water reactors.[2]

With regard to water pollution, the principal radionuclide in liquid effluents from nuclear reactors is tritium. Other liquid reactor effluents include radioactive isotopes of carbon, sulfur, chromium, manganese, iron, cobalt, zinc, strontium, zirconium, niobium and cesium. Radioactive liquid effluents from fuel reprocessing facilities, spent fuel storage facilities and other radioactive waste facilities can greatly exceed those from nuclear reactors during normal operation. As with airborne effluents, radioactive liquid effluents from heavy water reactors tend to be higher those from light water reactors.

Health risks associated with nuclear reactors

[1] Radioactive effluents from nuclear power stations and nuclear fuel reprocessing plants in the European Community - Discharge Data, 1976-1980 – Radiological aspects. F. Luykx and G. Fraser. Commission of the European Communities. Mar. 1983. http://aei.pitt.edu/49702/1/B0033.pdf

[2] Radioactive effluents from CANDU 6 reactors during normal operation. C.R. Boss and P.J. Allsop. Atomic Energy of Canada Limited. Dec. 1995.
https://inis.iaea.org/collection/NCLCollectionStore/_Public/27/056/27056914.pdf?r=1&r=1

It is clear that both gaseous and liquid effluents from nuclear reactors contain a wide variety of radioactive substances that pose health risks to people living near reactors.

Radiation health risks emissions vary according to ingestion and absorption pathways, sites of accumulation in the body, residence times for different radioactive substances, and age and gender of affected people. Children whose cells are actively growing and dividing have greater risks of adverse health effects from the radiation emitted by nuclear reactors. Female children have the highest risks, most likely because they have a higher concentration of stem cells than male children.[3]

The most comprehensive study of radiation risks from nuclear reactors done to date showed a strongly increasing risk for all cancers, and especially for leukemia, the closer that children had lived to nuclear reactors at the time of diagnosis, with the sharpest rise within five kilometers.[4] The power and scientific significance of this study is unique in radiation epidemiology.[5]

Wastes from nuclear technologies, and implications for a "Circular Economy"

All energy technologies produce solid wastes during mining of materials and manufacturing of components. During operation, energy generation facilities generate wastes when parts are replaced. Decommissioning activities following closure generate more wastes. For example, toxic substances such as cadmium and lead in solar photovoltaic modules have prompted research on ways to manage wastes arising from this particular energy technology.[6]

Recognition of the need to consider "life cycle" impacts of different technologies has stimulated interest in the concept of a "Circular Economy". The Circular Economy concept, which can be defined as "an approach to maximize value and eliminate waste

3 Dewan, P. Nuclear radiation risk impacts one group far more than any other. Newsweek, October 10, 2022. https://www.newsweek.com/newsweek-com-nuclear-radiation-risk-impacts-one-group-more-other-1750413#:~:text=Young%20girls%20could%20be%20up,boys%20of%20the%20same%20age.

4 Kaatsch, P., Spix, C., Schulze-Rath, R., Schmiedel, S. and Blettner, M., 2008. Leukaemia in young children living in the vicinity of German nuclear power plants. *International journal of cancer*, *122*(4), pp.721-726. https://onlinelibrary.wiley.com/doi/pdf/10.1002/ijc.23330

5 Nussbaum, R.H., 2009. Childhood leukemia and cancers near German nuclear reactors: significance, context, and ramifications of recent studies. *International journal of occupational and environmental health*, *15*(3), pp.318-323. http://www.elektrosmogreport.de/KiKKCommentaryJuly2009IJOEH.pdf

6 Management of end-of-life photovoltaic panels as a step towards a circular economy. D. Sica et al. Renewable and Sustainable Energy Reviews. 82: 2934–2945. Nov. 2017.

by improving (and in some cases transforming) how goods and services are designed, manufactured and used," is receiving growing attention in Canada and elsewhere.[7] [8]

Nuclear technologies represent a particular challenge for implementing the Circular Economy concept. Mining, milling and processing activities can result in significant exposures of workers and the public to the radioactive and hazardous properties of uranium, thorium, and their "progeny" (radium, radon, polonium, etc.). Leaving wastes containing these "naturally occurring" radioactive substances on the ground surface creates risks that are unique to the nuclear fuel chain.

The radioactive wastes (spent fuel, resins, filters, chemical sludges, fuel cladding, contaminated metal and concrete reactor components, etc.) that accumulate during reactor operations create additional long-term management challenges. Many of these reactor wastes cannot be reused or recycled, owing to health risks from exposure to gamma-emitting radionuclides, or from ingestion or inhalation of alpha- and beta-emitting radionuclides. Heavy water reactors generate more spent fuel waste per unit of power generated than light water reactors.

Of particular concern are ongoing delays in implementing socially and environmentally acceptable policies and strategies for dealing with the growing quantities of wastes from operating nuclear reactors, and the expensive and dangerous process of decommissioning reactors after shut-down.

The challenges of long-term radioactive waste management should not be minimized.

Artificial radioactive substances produced by nuclear reactors can have half-lives of thousands to millions of years. Health risks associated with exposure to these substances may impose serious burdens upon future generations if these risks are not promptly addressed by the present generation that benefits from nuclear power.

While wastes are produced in the front end (mining) and back end (decommissioning) of all energy technologies, including renewables, nuclear technologies are unique in producing very large additional quantities of waste during the operational phase.

The danger of widespread environmental contamination is an additional concern that is unique to nuclear technologies. Accidents such as those at the Chernobyl and Fukushima reactors have raised concerns that nuclear technologies are "compromising

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[7] Canada's Energy Transition: Getting to Our Energy Future, Together. Generation Energy Council Report. June 2018. https://www.nrcan.gc.ca/20380

[8] Getting to a Circular Economy: A Primer for Canadian Policymakers. S. Cairns and M. Ogden. Smart Prosperity Institute Policy Brief. Jan. 2018. https://institute.smartprosperity.ca/sites/default/files/spipolicybrief-circulareconomy.pdf

the ability of future generations to meet their own needs," and are hence incompatible with sustainable development.

Abundant evidence exists that nuclear technologies are not "clean".