Nuclear Reactors in Saskatchewan?

References and citations for information presented in the leaflet posted at http://cleangreensask.ca/no-smrs .

Technical information about the GE-Hitachi BWRX-300: The International Atomic Energy Agency is a United Nations organization which provides a central intergovernmental forum for scientific and technical co-operation in the nuclear field. Canada is a member. The IAEA publishes the Advanced Reactors Information System (ARIS), a web-accessible database that provides information about advanced nuclear plant designs and concepts. Design Descriptions are reviewed by IAEA and edited to remove overly commercial statements. Also, the IAEA edits the Design Descriptions to assure that safety levels, costs, projected construction times, projected availability factors, and commercialization dates are presented as "goals" or "claims" of the Design Organization - to be clear that IAEA has not reviewed or endorsed these claims.

The **ARIS report on the GE Hitachi BWRX300** is the source of following technical information in the leaflet:

- The BWRX 300 is considered in the "conceptual" phase.
- 75 permanent jobs will be required to operate the BWRX 300.
- The BWRX 300's operating lifespan is claimed to be 60 years.
- BWRX-300 uses Enriched Uranium fuel.
- Each BWRX 300 needs 77.76 tonnes of Enriched Uranium.
- Each BWRX 300 will emit 33 trillion bequerels (Bq) of radioactive gases annually.
- Each SMR will emit 732 million Bq of radioactive hydrogen (Tritium) annually.
- Reactions during BWRX 300 operation converts some of the uranium fuel to plutonium.
- Spent fuel containing deadly plutonium would be stored on site. The spent fuel pool has a storage capacity of 8 years of used fuel.
- Plutonium-containing spent fuel is considered a security risk, and the US government requires plant operators to maintain secret plans which include armed guards to prevent sabotage.
- Safety issues occur when weather is hot. The maximum acceptable ambient air temperature is and 37.8°C dry bulb (100°F) / 26.1°C (79°F) mean coincident wet bulb. Maximum recommended Inlet Temp for the main Condenser/Heat Exchanger is 37.8°C (100°F).
- The ARIS document is silent about decommissioning, other than mentioning the design will take decommissioning costs into consideration by "include using less concrete, as well as using bolts rather than welds wherever possible."

Saskatchewan Fleet of 4 SMRs: At least two documents indicate Saskatchewan envisions building four SMRs. Both state: "**Stream 1** proposes a first grid-scale SMR project of about 300 MW constructed at the Darlington site by 2028, ***followed by up to four subsequent units in Saskatchewan,*** with the first unit in Saskatchewan being in service in 2032." See *Feasibility of Small Modular Reactor Development and Deployment in Canada*, Prepared by Ontario Power Generation, NB Power and SaskPower, March 2021. and *A Strategic Plan for the Deployment of Small Modular Reactors*, prepared by the Governments of Ontario, New Brunswick, Alberta and Saskatchewan, March 2022

Regulatory issues: The document *SMR Strategic Plan for the Deployment of Small Modular Reactors* says "regulatory changes and clarity will be required to ensure reasonable costs and timelines for approvals for investors and operators." In other words, to make SMRs economically feasible for developers, safety regulations need to be lighter. The rationale for weakening regulatory requirements is based on the ***assumption*** that SMRs are inherently safer than larger nuclear power plants. However, to save construction costs, SMRs are being designed to use less concrete and other materials, which may make them higher risk when operating.

> *With a smaller output and the corresponding smaller revenue stream, it is essential that the regulatory processes apply a risk- informed and graded approach to acknowledge the unique features of SMR designs with respect to safety and environmental impacts. Similarly, the resources needed (i.e. cost, timelines) for a licence applicant to move through regulatory decision-making and approvals should be commensurate with the level of risk.* (Page 15, SMR Strategic Plan).

The strategic plan calls for safety and environmental regulations to be designed according the to the economic feasibility requirements of the developer, rather than for protecting the public and future generations. *SMR Strategic Plan for the Deployment of Small Modular Reactors*.

Insurance policies do not cover nuclear accidents. The typical SGI Homeowners policy states under *Property and Causes of Loss We Do Not Cover* "loss or damage caused by a nuclear incident as defined in the Nuclear Liability Act. Nor do we cover nuclear explosion or contamination by radioactive material." Nuclear power plants are covered by *The Nuclear Liability and Compensation Act*, which limits their liability in the event of an accident. Standard nuclear power plants' liability is capped at $1 billion – any damage above that would have to be covered by the taxpayer, and it is unlikely that all losses could be covered.

Not a climate solution – The Ontario Clean Air Alliance states "We need two things to deal with rapidly worsening climate change: speed and impact. Nuclear power can deliver neither. First nuclear plants take a long time to plan and build. Getting a nuclear plant built in a decade is considered an accomplishment. Compare that to the weeks or months it takes to erect a wind turbine or deploy solar panels. … The second big problem with nuclear as a climate solution is cost. Nuclear is now the highest cost ways to keep our lights on, which is why nuclear plants are either closing or begging for subsidies worldwide. We get far less "bang for our buck" from nuclear than from renewable energy or energy efficiency when it comes to reducing climate pollution." And power from the proposed SMR at the Darlington Nuclear Station in the Toronto area is estimated to cost 16.3 cents per kilowatt hour (kWh) while solar and wind projects are delivering power for 3-7 cents per kWh and Quebec is offering to sell Ontario waterpower at 5 cents per kWh.

Water for cooling. According to the University of Saskatchewan Centre for Hydrology, projections for future water flows and usage show that in drought years, the volume of water flowing through Lake Diefenbaker would not be sustainable in relation to expected needs. Conflicting demands for water that are outside of Saskatchewan's control could result in very low levels on Lake Diefenbaker. These projections do not factor in the proposed major irrigation development or a potential nuclear power plant. Page 24, *Impacts of Climate Change on Saskatchewan's Water Resources*, Cente for Hydrology Report No. 6, J.W. Pomeroy, X. Fang, B. Williams, Centre for Hydrology, University of Saskatchewan, 2009

The Rafferty Reservoir and Grant Devine Lake are in the Souris Rivers basin in southeastern Saskatchewan. Historic data shows this area has had multi-decade droughts when run-off was well below average. Patterns of long-term dry cycles means the reservoirs must collect more water than is needed annually to make up for multi-year deficits. Low precipitation combined with high temperatures cause high rates of evaporation, and thus additional water needs to be stored to make up for these losses. With climate change, longer summers and higher summer temperatures will intensify water uncertainty. *The Hydrology and Impact of the Rafferty Alameda Project*, W.J. Stolte, Canadian Water Resources Journal, 18:3, 229-245, DOI: 10.4296/cwrj1803229

Cost of the BWRX-300 In 2022, Don Morgan, Minister for SaskPower stated "A small reactor would cost in the range of $5 billion. So they're certainly not inexpensive." To pay for the reactors (the province's strategy calls for building four), Morgan said: "We've indicated to Ottawa that we will require significant support from them, as well as look at potential equity stakes from Indigenous groups." *Saskatchewan maps out plan for small nuclear power reactors* and *4 provinces push ahead with plan to build small nuclear reactors to supply power*.

The nuclear industry's financial trouble. In 2017 Westinghouse Electric declared bankruptcy. As reported by Reuters journalists, Tom Hals and Emily Flitter, "Even though Westinghouse's approach of pre-fabricated plants was untested, the company offered aggressive estimates of the cost and time it would take to build its AP1000 plants in order to win future business from U.S. utility companies. It also misjudged regulatory hurdles and used a construction company that lacked experience with the rigor and demands of nuclear work, according to state and federal regulators' reports, bankruptcy filings and interviews with current and former employees." *How two cutting edge U.S. nuclear projects bankrupted Westinghouse,* May 1, 2017.

Taxpayers in Georgia and South Carolina were left to pay billions of dollars to cover the costs of the failed project. "It used to be that you didn't start charging for a plant unless it was done and operating. Whether it was a nuclear plant, or a coal plant, or any other kind of thing." But because nuclear power involves heavier upfront capital costs and financing charges, former Nuclear Regulatory Commissioner Gregory Jaczko explained, states looking to revive nuclear power tried to bypass those extra costs by passing laws allowing companies to save money by recovering the cost of financing the projects during the period of construction." *South Carolina Spent $9 Billion to Dig a Hole in the Ground and Then Fill It Back In* by Akela Lacy, February 6 2019.

Other nuclear projects with massive cost over-runs include Finland's Olkiluoto 3, which cost US $12 billion, three times the original estimate, and took 14 years longer to build than planned. And Idaho's Nuscale, the first SMR project licenced in the USA, announced in January 2023 that it will raise the price to $89/MWh from $58/MWh, citing a "changing financial landscape for the development of energy projects nationwide," specifically inflationary pressures driving up the price of steel, electrical equipment and other construction commodities. The higher price resulted in difficulty contracting customers, and the plant currently does not have enough subscribers to meet its financial obligations. *NuScale must triple subscription level for small modular reactor in Idaho by early 2024, company says,* Published March 17, 2023, by Stephen Singer

Nuclear waste. There are no permanent facilities to safely store the high level nuclear waste produced by nuclear power plants in Canada. This waste creates penetrating radiation which requires shielding and contains significant quantities of long-lived radionuclides, which requires long-term isolation. Used nuclear fuel bundles are initially stored for 6 to 10 years in pools of water on the reactor site, then moved to dry storage in special concrete bunkers. Over 2.5 million used fuel bundles have accumulated in Canada since the 1960s. "At this time, the CNSC has not yet received any applications for site preparation and construction of a deep geological repository that will provide long-term management of radioactive waste." *High-level radioactive waste*, Canadian Nuclear Safety Commission.

When nuclear reactors are decommissioned, the pressure vessel where nuclear reactions take place, as well as other equipment exposed to radiation would become "intermediate level nuclear waste" that do not produce high heat, but contain high concentrations of dangerous long-lived radionuclides that require isolation and containment for hundreds of years. There is no requirement for this type of waste to be removed from the reactor site. The BWRX-300 proposals do not include decommissioning plans, and it is likely that this waste would be permanently buried on site, which would be along the shores of Lake Diefenbaker, the Rafferty Reservoir and/or Grant Devine Lake. *Low- and intermediate-level radioactive waste*, Canadian Nuclear Safety Commission.

Spent fuel is more radioactive than new fuel bundles. The BRWRX-300 is designed to use “enriched uranium” fuel, which is made by refining natural uranium (U238) to increase the fuel pellets’ concentration of isotope U235 from less than 1% to 3% - 5%. Before use, nuclear fuel pellets are only mildly radioactive, however spent fuel is high level nuclear waste that must be permanently shielded from living beings because direct exposure to its radiation would be immediately fatal. In a reactor, U235 atoms split when bombarded with neutrons, which causes the nucleus of the atom to split and releases large amounts of energy as radiation, and forms two new nuclei, releases more neutrons which cause more U235 atoms to split. Split U235 atoms become new, lighter radioactive atoms within the fuel bundles, such as cesium-137 and strontium-90. Some of the uranium atoms capture neutrons to become new heavier radioactive atoms, such as plutonium, neptunium, americium, and curium. An operating reactor is constantly converting U235 and U238 into other radioactive elements. After about two years, the fuel bundle’s proportion of U235 has declined to a point where the fission process is less efficient, and old fuel must be replaced with new fuel. The old fuel is called “spent” fuel because it is no longer useful. However, the transformations caused by the fission process make spent fuel much more radioactive than it was originally, because it now consists of many newly created highly radioactive atoms. These radioactive atoms are unstable and continue to change through the process of radioactive decay, producing more radiation and heat as the substance transforms into a series of radioactive chemicals over time until reaching a stable state. The half-life of a radioactive element is the time required for half the atoms of the particular radioisotope to decay into another isotope. Plutonium’s half-life is 24,000 years. *Backgrounder on Radioactive Waste*, United States Nuclear Regulatory Commission, and *Questions and Answers about Irradiated Nuclear Fuel in Canada*, by Dr. Gordon Edwards