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Monitored this issue:

Slovenia, nuclear or sustainable?

Slovenia before referendum on new nuclear power plant

Matjaž Valenčič

The Krško Nuclear Power Plant

As introduction, we are obliged to explain that the Krško Nuclear Power Plant (**NEK)** operates technically safe, but from the economic point of view only artificially successful. *The Nuclear Safety Administration of the Republic of Slovenia* (**URSJV)**, Slovenia's nuclear regulator, performs professional, administrative, supervisory and development tasks in the field of radiation and nuclear safety. However, the existing PWR 632 MW Westinghouse NPP, built in 1981, is old and dilapidated, and failures are expected most probably in the years to come. Last year, a hole the size of a sewing stitch in a reactor pipe shut down the NPP for two months.

Another important detail, the NPP is co-owned by Slovenia and Croatia. Each owns half, even though the location is in Slovenia. Such co-ownership of a NPP is unique in the world. The basic principle of decision-making is **consent of both owners** in all management bodies: the Board of Directors, the Supervisory Board and the General Assembly. However, the nuclear regulatory and the nuclear responsibility are entirely Slovenian.

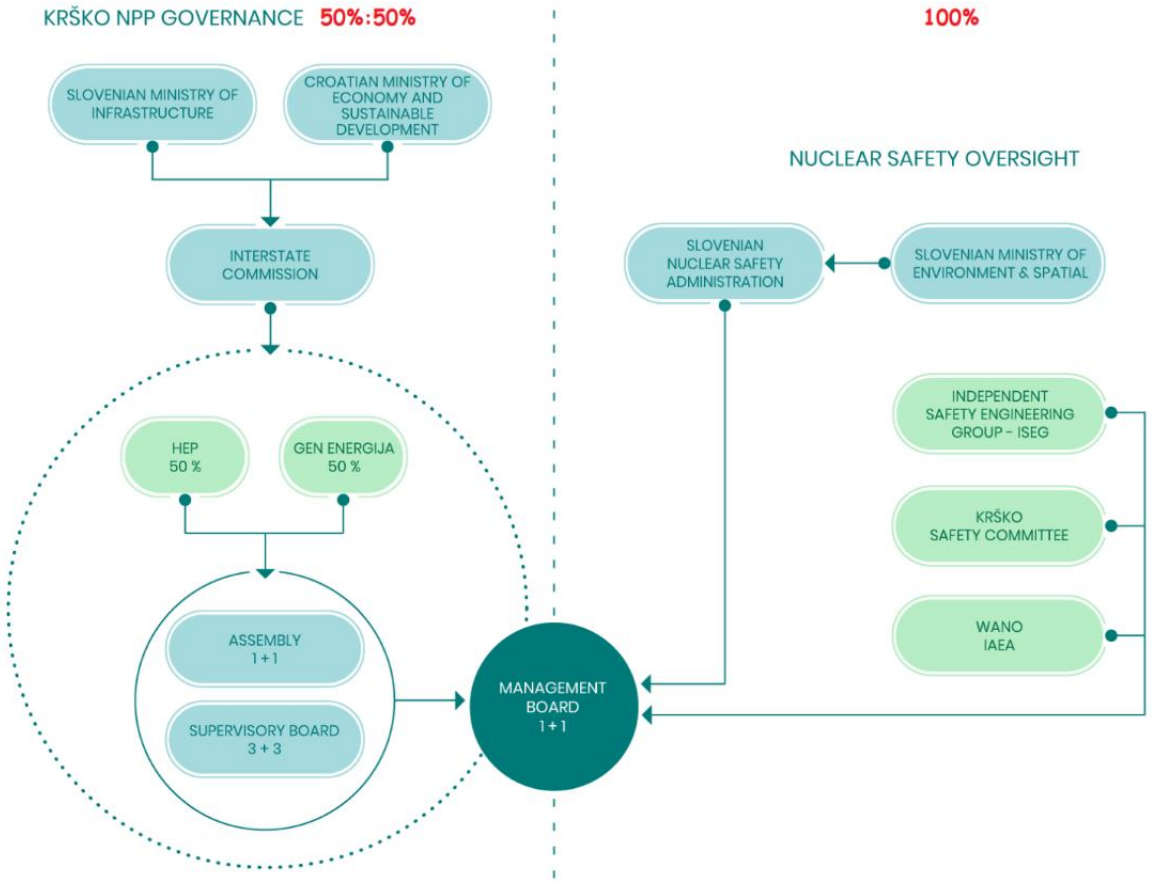

Figure 1: Sharing of co-ownership and responsibility, https://www.nek.si/en/about-us/governance

The smallest nuclear state and the largest proportion of protection areas

Slovenia is in surface the smallest nuclear state in the world and is, as such, the most exposed. In fact, Slovenia is so small that a possible nuclear catastrophe would endanger

the entire country and part of the nearby countries. In addition, it has the largest proportion of protected areas. The share of Natura 2000 covers 37% of the total territory and is with that the highest among all nuclear countries.
When the largest share of the territory is protected in the smallest nuclear state due to biodiversity, there is hardly space for the disposal of radioactive waste. Slovenia is probably the only nuclear country that does not have a regulated repository for any type of nuclear waste.
The situation in the field of radioactive waste is even more worrying than it was in 2022, see "Nuclear waste in Slovenia".

Civil society demands closure
As early as 1989*, the Slovenian Green Party* demanded as soon as possible closure of the NPP **NEK**, the Žirovski Vrh Uranium Mine **RUŽV,** and abandonment of the nuclear programme. In January 1992, the deputy Prime Minister of Slovenia, dr. Leo Šešerko initiated a referendum on the closure of the NPP until 1995, but was unsuccessful. After that, there were several more ineffective initiatives to close the NPP.
The general will of the citizens of Slovenia is not in favour of the nuclear choice. Since 1990 we have been expecting a referendum on the use of nuclear energy. However, today all parliamentary parties are for the construction of JEK2, in different shades.
A few non-governmental organisations actively oppose Slovenia's nuclear ambitions, notably the Association of Ecological Movements of Slovenia-ZEG, Greenpeace, Umanotera, Alpe Adria Green AAG and Focus.
ZEG, a non-governmental environmental organization, has been monitoring the activities of the Krško NPP since 1992. *The Ministry of the Environment and Spatial Planning* granted it the status of a secondary participant in the public interest for the preparation of Environmental Impact Assessment EIA for the construction of a repository for low- and intermediate-level radioactive waste (LILW), a dry storage facility for high-level radioactive waste (Spent Fuel Dry Storage – SFDS) and the extension of the operating period of the NEK until 2043.

Promotion of nuclear energy and lack of dialogue
Nuclear energy is being promoted covertly and openly. There is no dialogue in society about the use of nuclear energy. The media publish pro-nuclear articles on a daily basis, even if they are inaccurate or misleading, and nuclear-critical articles are mostly dismissed. Threats that without nuclear power we will be left in the dark and cold are common. Non-governmental organizations and individual institutions that do not advocate the use of nuclear energy are subject to financial, media and political blockades. It's hard to break through that blockade.

Seismic hazard of the location
The NEK is built on a potentially active seismic tipping point. The construction of a new NPP JEK2 is also planned at the same unsuitable location. Warnings from the Institut de Radioprotection et de Sûreté Nucléaire IRSN (the French independent technical support organisation of the nuclear regulator ASN) from 2013 were grossly rejected. The contract between the client GEN ENERGIJA d.o.o. (GEN), co-owner of the NEK and IRSN was terminated. There are no more warnings about the seismically exposed location. Subsequent research funded by GEN concludes that seismic safety risks are engineering-insignificant and within administrative constraints. Are they correct just because it is convenient for the client? Not only IRSN, others also point to the inappropriate location of the nuclear power plant. Dr. Reinhard Uhrig, nuclear energy expert at GLOBAL 2000, says: "*Krško is the only nuclear power plant in Europe that operates in the red seismic zone. Not only for us in Austria, but also for the affected people in Slovenia, Croatia, Bosnia and Herzegovina and Italy, this worn-out high-risk reactor is a cause of great concern*."
Proponents of the disputed site say it is possible to build a safe NPP at the earthquake fault point, and promise new studies to prove it. However, everyone knows that construction in a controversial location, in a densely populated area of Krško, is professionally and ethically unacceptable. In an earthquake-prone location, construction is more expensive and safety risks are greater.

Planning of the new nuclear power plant JEK2

The construction of a new NPP was determined in 2006 in the Resolution on National Development Projects 2007–2023. Since then, all governments have supported the construction of a new NPP. The current consultative referendum (which is not binding) merely seeks to shift the responsibility of building NPP onto the voters. Everything has already been decided, in the most undemocratic way. Supposedly, the positive outcome of the referendum will only allow the investor to spend more than €100 million by 2028 on studies on a new NPP. Planning for the construction of a new nuclear power plant was carried out all the time without public involvement. That is why in 2014 we published an article *Why Are We Not Talking About a New Nuclear Power Plant* in the Slovenian magazine EGES, which was reprinted in the Croatian newspaper EGE.

Nuclear fraud

The Centre for Energy Efficiency (CEU) at the Jožef Stefan Institute (JSI), has, together with its consortium partners in the Life Climate Path 2050 project, prepared the expert base for the Long-Term Climate Strategies of Slovenia (LTCS), which in turn is the expert base for the comprehensive National Energy and Climate Plan of the Republic of Slovenia (NECP).

These studies have shown that Slovenia can set the goal of achieving climate neutrality by 2050. Slovenia can achieve climate neutrality with at least two scenarios, namely an ambitious nuclear scenario and an ambitious scenario with a larger focus on climate-neutral gaseous fuels. Both scenarios involve a large volume of renewable energy sources (RES) and production from climate-neutral gaseous fuels is based on RES or other climate-neutral sources. For a choice of either path, a number of decisions will have to be made along the way. However, not yet all the necessary information is available for decisions on a strategic level. Results of the analysis are publicly available in the Summary of the Analysis of Scenarios for Decision-Making on LTCS by 2050. At the time of publication, as well as in the draft document, two scenarios were taken into account equally at all times.

However, it was envisaged that the necessary information and analysis would be provided before deciding or choosing between the options with or without nuclear energy. The Ministry of the Environment and Spatial Planning submitted these guidelines for public consideration. The same guidelines regarding decision-making on nuclear energy were also included in the publicly issued government material, which, however, was replaced the day before the decisive government meeting on the subject with a text confirming the choice of the nuclear option.

In accordance with the applicable legislation, the deadlines, procedure and tasks for decision-making on nuclear energy have also been clearly set out in the NECP, namely "*a comprehensive examination of the possibilities of long-term use of nuclear energy (economic and other expert analyses), on the basis of which it will be possible to make a decision on the construction of a new NPP by 2027 at the latest*". By the time the LTCS was adopted, these additional independent analyses had not yet been prepared for nuclear power decision-making, so it is unclear what justified the decision on nuclear power. A comprehensive environmental impact assessment (EIA) procedure is also mandatory for deciding on the further exploitation of nuclear energy.

The JSI CEU, which drafted the LTCS and participated in the coordination of the document, did not propose a nuclear scenario as the only possible one for good reason. Such a strategic decision requires the missing economic and other expert analyses, the so-called CPVO procedure to be carried out in accordance with international conventions, the European acquis and Slovenian legislation. And because it has to be taken in accordance with the national legislation still in force that regulates decision on energy policy.

The conclusion has to be that the inclusion of nuclear energy into ***the Resolution on Slovenia's long-term climate strategy until 2050*** is based on fraud. This deception also spilled over into the NECP and later into the nuclear resolutions.

Energy permit for JEK2 without legal and professional basis

In a continuation of this nuclear fraud, the Ministry of Infrastructure issued an energy permit for JEK2 for a PWR of 1.100 MW, without legal or professional basis. Three environmental organisations have filed a lawsuit against the Ministry of Infrastructure over this permit. The lawsuit was dismissed on formal grounds.

An attempt at rational decision-making

At the beginning of March 2023, Bojan Kumer, Minister of the Environment, Climate and Energy, announced a delay in the start of construction of the Krško Nuclear Power Plant (JEK2), because there is not in too much of a hurry and there's nothing wrong if the timeline is delayed.

Some opposition MPs reacted furiously and convened a meeting of the commttee of Control on Public Finance on delaying the JEK2 proceedings. The ministry rejected all the allegations.

Announcement of accelerated preparations for the construction of NPP

In June 2023, the Prime Minister announced at the consultation "The Future of Nuclear Energy in Slovenia" that procedures for the construction of one or two new NPPs would be launched as of 1 August 2023. Siting procedures will be governed by a special law. Instead of one reactor, two would be built, with a total capacity of 2,400 MW. A 1.100 MW power permit is clearly not an obstacle to the nuclear dream. At this consultation, the Prime Minister announced that a referendum would be held in 2027 or 2028, when the main data on the planned construction would be known.

In May this year, GEN presented the first cost calculations for the planned NPP JEK2 on only five pages. The assumptions are not based on independent international expert analysis or on references of new reactors in Western countries over the past three decades. The calculations are grossly underestimated and deficient.

Resolution on the Long-Term Peaceful Use of Nuclear Energy in Slovenia, Nuclear Energy for the Future of Slovenia

The resolution that provided the basis for the call for a consultative referendum is contrary to Article 44 of the Constitution of the Republic of Slovenia, in particular the constitutional right to informed and democratic decision-making on important strategic issues of the state in a referendum. It is contrary to the constitutional principles of equality, fairness and proportionality, and to the human right to free expression of opinion, which includes the right and duty to seek, receive and spread information.

For Slovenia, the smallest nuclear state, the JEK2 project would pose a significant risk of excessively relying on only one nuclear energy source. Due to total costs pressure on public funds, state guarantees, the country's creditworthiness would lead to a financial abyss or a potential financial collapse of the state. The resulting high price of electricity would greatly increase energy poverty. The costs of the nuclear scenario are undoubtedly and significantly too high for Slovenia.

Priorities are also mixed. *The resolution on the use of nuclear energy* should be based on the will of the people and not on this resolution predetermining the outcome of the referendum.

Despite a clear warning, the Resolution was approved.

Overture to the referendum campaign

In the second half of November 2024, there will be a referendum on the construction of new nuclear power plants. The proponents of the referendum promise to respect the decision of the people in the referendum, but at the same time they do not allow the people to receive neutral and complete information in a timely manner.

GEN is conducting an intensive information campaign even before the referendum is called. This year, GEN signed a contract for communication support in the field of public relations for €192,000 (+ VAT). In addition, it ordered the lease of advertising space in the media for €700,000 (+VAT). Most media publish favourable articles on nuclear energy, while features opposing it are mostly censored.

Recently, again, before the official referendum campaign, GEN increased its activities spreading pro-nuclear information:

- he opened an information office in the municipality of Krško,
- presentations of the JEK2 project are organized in all major Slovenian cities,
- at the Chamber of Commerce and Industry of Slovenia (GZS) there was a presentation of the possibilities of including Slovenian companies in international supply chains for the construction and maintenance of NPPs in Europe,
- regular monthly meetings of GEN with journalists who generate nuclear-related publications in the media,
- An increase in JEK2 posts on social media,
- The promotion of JEK2 is also helped by a number of "unofficial supporters", the http://www.jedrska.si portal, the Association of Nuclear Experts of Slovenia, the Engineering Academy of Slovenia IAS and many others.
- GEN has set up a JEK2 website in Slovenian and English. They differ.

A list of reports and studies prepared at the request of the Ministry of the Environment, Climate and Energy is published on the Slovenian website under the "Information for the Consultative Referendum", in order to provide the necessary information for the planned consultative referendum on the implementation of the JEK2 project. Before the start of the referendum campaign, seven reports out of eight are marked: ***Scheduled publication: until the start of the referendum campaign.***

The referendum question will be: "***Do you support the implementation of the JEK 2 project, which, together with other low-carbon sources, will ensure a stable supply of electricity, as envisaged in the resolution on the long-term peaceful use of nuclear energy in Slovenia?***"
This is a highly biased and leading question, unfair, illegal and unconstitutional because it does not allow for a NO answer. Namely, if voters answered "**NO**", it would mean that they continue to support the use of fossil fuels and thus the deepening of the climate and environmental crisis. Worse still, a NO answer would put voters in a position to shift the climate and environmental burden to the next generations.
The public does not yet have any verified data on the possibility of long-term use of nuclear energy (economic and other expert analyses), it does not have credible data on the price of the NPP and the price of electricity from nuclear energy, on the decommissioning and disposal of high-level wastes, seismic data on the suitability of the location, etc. It also does not have data on the appropriateness of the non-nuclear choice so it is able to choose between the RES scenario and the RES + NE (the renewable plus nuclear) scenario.
Opponents of the construction of a new NPP are deprived of financial resources and subject to media censorship. They protest against nuclear pressures in a different way. With the Blind Referendum campaign, civil movements have warned that they are intensively preparing for an unequal referendum campaign. At the same time, they warn that they need sufficient time to prepare civil society for the one-month campaign, as provided for in the Aarhus Convention.
ZEG is only advocating a referendum question in which voters should decide on renewable energy or renewable and nuclear energy. To make a decision, however, voters must be informed in a timely and objective manner.

Reasons for opposing the construction of JEK2

There are several reasons to oppose JEK2.

- It is economically unsustainable, as the investment in JEK2 would significantly exceed the annual budget of the Republic of Slovenia. Zoran Kus (former State Secretary at the Ministry of the Environment and Spatial Planning and an expert on the climate and sustainability crisis) commented in the media on the economic aspect of the investment. According to independent analyses and references in Western countries, the referendum on Slovenia's energy

Figure 2: Screenshot 07/08/2024, https://jek2.si/informacije-za-posvetovalni-referendum/

transition should choose the scenario of renewable energy sources (RES) and reject the nuclear scenario JEK2. The RES scenario is the cheapest, while the nuclear scenario is the most expensive among all energy sources, and the differences are increasing from year to year. For new NPP projects, according to references in Western countries for the last twenty years, the so called overnight cost of capital (OCC) today exceeds 10.000 EUR/kW of power (according to Lazard, an average of 10.400 €/kW). The overnight cost of capital, excluding financial cost would exceed €11 billion for the smaller, American APR1000 1.100 MW reactor, and €16 billion for the larger, French 1.600 MW EPR reactor. Overnight Construction Costs (OCC) represent only the cost of building a reactor in a very short period of time "a few months" and immediate payment without financial costs - borrowing money (debt capital). When we add the cost of financing to the OCC – the total cost of capital, which for large and high-risk nuclear investments in the EU exceeds the minimum discount rate of 5 to 7%, the total cost for a smaller reactor exceeds €20 billion, and the cost price of electricity (LCOE including OPEX operating costs) would exceed €130 or €145/MWh. After connecting to the grid, a smaller JEK2 reactor would record a financial loss of between €450 million and €600 million annually, given the current electricity price of around €80/MWh on the HUDEX stock market. For a larger reactor, this could be significantly more.

- The price of electricity from JEK2 would not be competitive at all. For new nuclear projects in Western countries that would start construction today, the cost price of electricity (Lazard) would exceed 170 EUR/MWh. GEN's internal calculation, with very low discount rate for borrowing the money of around 2 - 3 %, states that the cost price of electricity would be between 70 and around100 €/MWh, which includes operating cost of 44,5 €/MWh but this calculation has not been verified yet by the independent international verifier and is unrealistically low.
- The cost price of electricity from a new NPP is at least three times higher than the non-subsidized price of electricity from new large RES (mainly wind and solar power plants), which today reaches an average of €50 to €60/MWh.
- A new JEK2 alone is not enough, the green transition will also require investment in renewables, grids and energy storage. Joint investment in RES+NE scenario would inhibit all investments in the energy sector and in the economy, stop development, threaten social life, and increase energy poverty and likely delay carbon-reduction.
- The planned JEK2 far exceeds the need for bandwidth. Already the current half of the 350 MW NPP occasionally causes problems for the grid, and at least three times more powerful JEK2 will significantly increase these problems. In 2040 or a little later, it is planned to connect JEK2 with a capacity of up to 1.300 MW, at which time the 700 MW NEK will still be in operation, the total capacity of the HPP will exceed 2.500 MW, there will be on grid about 7.000 MW of solar power plants, 500 MW of wind power plants and other RES. It looks like JEK2 will be built too late and too big to decarbonize.
- To reduce the carbon footprint of electricity, fossil fuels need to be rapidly replaced by RES. JEK2 will not be compatible with volatile renewables and will not adapt to variable consumption. Trapezoidal operation, or the production of pink hydrogen from surplus nuclear electricity, would make the entire nuclear economy even worse.
- The NECP estimates that the effects of both scenarios of 100% RES and RES+NE are comparable. At the present value of the total costs, there are almost no differences between the two scenarios, but the decommissioning of a NPP and the construction of a high-level waste repository are not taken into account. Not only would this make the RES+NE scenario significantly more expensive

than the RES scenario, it would also be an unethical burden on the descendants and would pose a nuclear safety risk.
- JEK2 cannot become operational before 2040, which is too late to decarbonise the energy sector in time.
- Supporters of JEK2 refuse to talk about the HLW repository on the grounds that spent fuel is a strategic raw material and not radioactive waste. In fact, they want to defer the cost and implementation of disposing of HLW to next generations.
- Building nuclear facilities in an earthquake zone is and remains being risky.
- The public has no credible information about JEK2, other than the media deception dictated by the nuclear community.
- There is no reason to rush to build a nuclear power plant. New technologies are on the march, it is not appropriate to install obsolete nuclear technology.
- The nuclear industry is not contributing to the solution of the climate crisis or to the timely decarbonisation of energy by 2035 at the latest, in order to achieve the 1.5°C climate goal of the Paris Agreement. Contrary to the misinterpreted, erroneous and politically imposed position of the European Commission (2022 taxonomy), nuclear energy is certainly not sustainable or green, as it fully shifts the burden and enormous costs of disposing of deadly high-level nuclear waste to future generations for eternity, which is unethical.
- The financial, economic and environmental risks associated with the possible construction of JEK2 are so great that we will not only decide on the construction of a new nuclear power plant, but on the financial existence or collapse of Slovenians and the Republic of Slovenia.

What next?

We are increasingly convinced that nuclear advocates are driven by self-interest, promises, and empty assurances. The haste to decide on JEK2 points to the secret memorandum signed in 2020 regarding strategic civil nuclear cooperation, in connection with military cooperation. The signed memorandum is a kind of non-binding political ticket that helps the American industry open the door to the market, or a tool that helps to establish partnerships with the United States.

Nuclear power plants have run out of time. Nuclear advocates are stoppable. Renewable energy sources are advancing rapidly: faster construction of power plants, lower electricity prices, less burden on the environment, greater operational reliability, energy independence.

That is why the answer to a nuclear referendum has to be "NO"!

Matjaž Valenčič, independent energy expert
Association of Ecological Movements of Slovenia-ZEG, August 2024

Abbreviations:

- HLW: High-Level Waste
- HPP: Hydro Power Plant
- ILW: Intermediate Level Waste
- JEK2: Krško Nuclear Power Plant 2
- LILW: Low And Intermediate Level Radioactive Waste
- LLE: Low-Level Waste
- LTCS: Long-Term Climate Strategy
- NE: nuclear energy
- NEK: Krško Nuclear Power Plant, NPP
- NECP: National Energy and Climate Plan
- NPP: Nuclear Power Plant
- OCC: Overnight Construction Costs
- RES: Renewable Energy Sources
- SFDS: Spent Fuel Dry Storage
- SNF: Spent Nuclear Fuel
- URSJV: Slovenian Nuclear Safety Administration
- ZEG: Association of Ecological Movements

Small Modular Nuclear Reactors (SMRs) in Canada

Brennain Lloyd and Susan O'Donnell

Introduction: CANDUs versus SMRs

Canada developed the CANDU reactor, fueled with natural uranium mined in Canada and cooled and moderated with heavy water. All 19 operating power reactors in Canada – 18 in Ontario on the Great Lakes and one in New Brunswick on the Bay of Fundy – are CANDU designs with outputs ranging from about 500 to 900 MWe.

It's been more than 30 years since the last CANDU was completed and connected to the grid in Canada. Attempts to build new ones were halted over high projected costs, and CANDU exports have dried up. To keep itself alive, in 2018 the nuclear industry launched a "roadmap" to develop smaller reactors and kick-start new nuclear export opportunities.

From 2020 to 2023, the Canadian government funded six so-called "Small Modular Nuclear Reactor" (SMR) designs. Only one – Terrestrial Energy's Integral Molten Salt Reactor (IMSR) design – is Canadian.

The six designs are not only unlike the CANDU but also different from each other. The fuels range from low-enriched uranium, TRISO particles and HALEU (High-Assay, Low-Enriched Uranium) to plutonium-based fuel, and the different cooling systems include high-temperature gas, molten salt, liquid sodium metal and heat pipes. One design – Moltex – requires a separate reprocessing unit to extract plutonium from used CANDU fuel to make fuel for its proposed SMR.

Only one of the grid-scale SMR designs seems plausible to be built – the GE Hitachi 300 MW boiling water reactor (BWRX-300) being developed at the Darlington nuclear site on Lake Ontario. This design uses low-enriched uranium fuel and is cooled by ordinary water. The Darlington site owner, the public utility Ontario Power Generation (OPG), is planning to build four of them.

Canada gave OPG a $970 million "low-interest" loan to help develop the BWRX-300 design. The other five SMR designs received considerably less federal funding, from $7 million to $50.5 million each, and most SMR proponents have been struggling to source matching funds. One design, Westinghouse's off-grid eVinci micro-reactor, had early development costs funded by the U.S. military and now seems to have independent funding.

The Canadian Nuclear Laboratories (CNL) at Chalk River received more than $1.2 billion in 2023. CNL is operated by a private-sector consortium with two U.S. companies involved in the nuclear weapons industry and the Canadian firm Atkins-Réalis (formerly SNC Lavalin) which is also involved in almost every SMR project in Canada. CNL and Atomic Energy of Canada Limited are building an "Advanced Nuclear Materials Research Centre" at Chalk River, one of the largest nuclear facilities ever built in Canada, that will conduct research on SMRs.

Canada recently released a report suggesting that SMRs will be in almost all provinces by 2035, although most provincial electrical utilities have expressed no interest, and only Ontario, New Brunswick, Saskatchewan and Alberta are promoting SMRs. Alberta says it wants SMRs to reduce the GHG emissions generated in tar sands extraction.

SMR "project creep"

Proponents of most of the SMR designs keep changing the description of their projects. This is not unique to Canada, but is certainly apparent in Canada, and the regulator, the Canadian Nuclear Safety Commission (CNSC), aids and abets that practise for those SMRs in the review stream.

In the case of the BWRX-300 proposed for the Darlington site, the CNSC not only accepted a 2009 environmental assessment for very

different reactors as a stand-in for the BWRX-300 but also is carrying out the current review as if for a single reactor. The nuclear regulator made this decision despite Ontario Power Generation very publicly stating its intent to construct four reactors in rapid succession at the Darlington site.

The proposed "Micro Modular Reactor" (MMR) for the Chalk River site in Ontario is another example of "project creep" and demonstrates just how flexible "scope of project" is in the domain of the CNSC.

Earlier this year, CNSC staff released a document outlining communications from the MMR proponent, Global First Power, describing significant project changes. The proponent wants to triple power output, and to operate with fuel enrichment levels from 9.75% (LEU+) up to 19.75%.

Global First Power also wants a shift from no need to refuel in a 20-year operating life to provision for on-site refueling and defueling with periods varying from three to 13.5 years. They also want to double their facility design life from 20 years to 40 years.

Despite all these significant changes to key elements of the design, the CNSC staff concluded that the Global First Power MMR project remained within scope of its initial (very different) description.

Another example of SMR project creep is in New Brunswick. In June 2023, the provincial utility NB Power applied to the CNSC for a licence to clear a site for the ARC-100 design at the Point Lepreau nuclear site on the Bay of Fundy. The design for the sodium-cooled reactor requires HALEU fuel, which is scarce because of sanctions imposed on Russia, the sole supplier.
News reports have suggested the ARC-100 design might need to change because changing the fuel means changing the design. Meanwhile the ARC company CEO left suddenly, and staff received layoff notices. Despite these obvious problems, the application under CNSC review and a provincial environmental assessment underway with the CNSC are continuing with the original design.

SMRs complicate radioactive waste management

One of the (many) false promises floated about SMRs is that they will alleviate the significant challenges of managing radioactive wastes. This is patently false. Some of this misleading rhetoric stems from the notion of "recycling" and claims by some SMR promoters that their particular design of reactor will use high-level radioactive wastes as "fuel" for their reactor.

But the reality is that the introduction of so-called "next generation" designs of reactors in Canada will only complicate the already complex set of problems related to the caretaking of these extremely hazardous materials.

Canada's current fleet of CANDU power reactors all use natural uranium. The rather long list of small modular reactors under consideration or being promoted in Canada would all use enriched uranium.

Enrichment ranges from 3.4% to 4.95% for GE Hitachi's BWRX-300 reactor design selected for construction at the Darlington site, to 19.75% for Global First Power's MMR currently under review for the Chalk River site on the Ottawa River.

To date, the only reactors in Canada that have used enriched fuel are research reactors at universities and nuclear laboratory sites. Their enriched fuel has been imported from the United States with the subsequent wastes repatriated to the U.S. under the Global Nuclear Energy Partnership.

The shift from natural uranium to enriched uranium in commercial power reactors in Canada will fundamentally change the nature and characteristics of the spent fuel waste and will take away one of the nuclear industry's favourite pitch points for the CANDU design: that there is no potential for criticality after the fuel is removed from the reactor.

The new potential for the irradiated enriched fuel wastes to "go critical" is only one of the many problems being overlooked by both government and industry.

Another very obvious shift is in the dimensions of the fuel, from the relatively uniform dimensions of CANDU fuel to the widely divergent shapes and sizes of fuel being depicted for the various small modular reactor designs.

The CANDU fuel bundles are approximately 50 cm long and 10 cm in diameter. In contrast, the fuel waste dimensions are significantly different for SMRs. For example, the BWRX-300 fuel bundles are much larger, the casks much heavier, and the reactor will generate higher level activity wastes. These differences will require different approaches and designs for interim and long-term dry storage of used fuel.

SMR wastes not considered in Canada's repository design

As a fleet, small modular reactors will generate more waste per energy unit than the larger conventional reactors that preceded them. But in Canada they will also require redesign of the "concept" plan currently being promoted for the long-term dispositioning of the used fuel to a deep geological repository (DGR).

Since 2002 an association of the nuclear power companies, operating as the Nuclear Waste Management Organization (NWMO), have been pursuing a single site to bury and then abandon all of Canada's high-level nuclear waste.

Their siting process, launched in 2010, caught the interest of 22 municipalities that allowed themselves to be studied for the "$16-24 billion national infrastructure project." Hundreds of millions of dollars later – with tens of millions going directly into the coffers of the participating municipalities – the NWMO is now down to two candidate sites in Ontario.

The NWMO say they will make their final selection by the end of 2024. But even at this late date they have produced only "conceptual" descriptions of their repository project, including for key components such as the packaging plant where the fuel waste would be transferred into that final container, and the DGR itself. But all of the conceptual work is premised on the characteristics and dimensions of the CANDU fuel bundle.

The process lines of the used fuel packaging plant, the final container, and the spacing requirements for the repository will all need to be redone for different SMR wastes with their very different dimensions and characteristics.

While it could be said that the NWMO design progress has been surprisingly slow given their target of selecting a site this year and beginning the regulatory and licensing process next year, it will be back to square one if their proposed DGR is to accommodate SMR wastes.

There is, however, a strong possibility that the regulator, the CNSC, will allow the NWMO to skate through at least the first license phase with large information gaps, as the CNSC is doing with the plan to construct four BWRX-300s at the Darlington site.

As mentioned in the example of "project creep," earlier this year the CNSC announced it would accept an environmental assessment approval of a generic 2009 reactor proposal instead of requiring that the BWRX-300 be subject to an impact assessment. This was despite the marked differences between the technologies assessed in 2009 and the BWRX-300 technology.

These differences will impact the management of the project's radioactive waste. For example, the BWRX-300 public dose rates are estimated to be 10 x higher for one accident scenario (pool fire) and 54% higher in a dry storage container accident, the waste contains different proportions of radionuclides than the waste that was assessed in 2009, radio-iodine and carbon-14 emissions will be higher, alpha and beta-

gamma activity per cubic metre of waste will be higher and the BWRX-300 will generate higher activity spent fuel.

Despite the NWMO having successfully wooed two small municipalities, there is broad opposition to the transportation, burial and abandonment of all of Canada's high-level radioactive wastes in a single location, either in the headwaters of two major watersheds in northern Ontario or the rich farm lands of southwestern Ontario.

This opposition is amplified by concerns about SMR wastes and the NWMO's open ticket to add other operations to their DGR site. Of particular concern are the potential for the NWMO to add an SMR to power their repository site or even to add a reprocessing plant at the site to extract plutonium from the used fuel. The Canadian government's refusal to include an explicit ban on commercial reprocessing in the 2022 review of the national radioactive waste policy heightened the latter concern.

Who/what is behind the SMR push in Canada?

Although proponents claim that SMRs will contribute to climate action, critics are sceptical. It is doubtful that any SMR will be built in time to contribute to Canada's target to decarbonize the electricity grid by 2035, and independent research found that SMRs will cost substantially more than alternative sources of grid energy.

The high cost and lengthy development timelines of SMRs, the questionable claims of climate action, as well as the significant challenges related to SMR wastes, raises an obvious question: who is pushing SMRs and why?

A central reason is a political imperative to keep the Canadian nuclear industry alive. The industry is small in Canada, but nuclear power looms large in the political imagination. Canada sees itself as a global leader in the peaceful use of nuclear energy.

Without a nuclear weapons industry, Canada needs nuclear exports to keep its domestic industry alive and ensure Canada's membership in the international nuclear club. Earlier this year, Canada released an action plan to get nuclear projects built faster and ensure that "'nuclear energy remains a strategic asset to Canada now and into the future."

Since the start of the nuclear age, Canada has spent a disproportionate amount of research funding on nuclear reactor development. Politicians see the CANDU design as a success, despite its costly legacy and lackluster exports. The CANDU reactors in Canada have all required significant public subsidies, and the CANDUs sold for export have been heavily subsidized by Canada as well.

Selling more CANDUs outside Canada is unlikely in the foreseeable future. But Canada wants a nuclear industry, and that requires choosing and aggressively marketing at least one nuclear reactor design. Despite being a U.S. design, the G.E. Hitachi BWRX-300 is the chosen favourite in Canada. The reactor, in early development at the Darlington site, is being promoted globally by Ontario Power Generation as part of an international collaboration with GE Hitachi Nuclear Energy, the Tennessee Valley Authority, and Synthos Green Energy.

What's the future for SMRs in Canada?

Since the nuclear industry and its government partner Natural Resources Canada (NRCan) launched their SMR roadmap in 2018, the political and business hype for SMRs has been intense. The SMR buzz is meant to attract private sector investment, but so far that strategy is failing.

Almost everyone understands now that SMRs, like the CANDUs, are expensive projects that will need continuous massive public subsidies. To date, taxpayers have provided just over $1.2 billion in direct subsidies to SMR proponents in Canada, not nearly as much as the industry will need to develop an SMR fleet in the country.

A broad coalition of groups – from climate activists to Indigenous organizations and other groups protecting lands and waters from radioactive waste – have been pushing back against public funding for SMRs. A 2020 statement signed by 130 groups called SMRs "dirty, dangerous distractions" from real climate action. In March this year, 130 groups in Canada also signed the international declaration against new nuclear energy development launched in Brussels at the Nuclear Summit organized by the International Atomic Energy Agency.

While civil society opposition to SMRs is broad and substantial in Canada, ultimately the exorbitant cost of SMRs will be their undoing. Conclusive analysis shows that SMRs cannot compete economically with wind, solar and storage systems.

SMRs will last as long as governments are willing to pour public funds into them, and SMRs will start to disappear after the money tap is turned off. Already the nuclear hype in Canada is turning back to big reactors.

The Bruce Nuclear Generating Station on Lake Huron in Ontario, with eight CANDU reactors, is already the largest operating nuclear plant in the world. Bruce Power recently began the formal process to develop four new big reactors at the site, to generate another 4,800 megawatts of electricity. It remains to be seen if the sticker shock for the proposed big nuclear reactors will, like it has for SMRs, scare off investors.

Although more than six years of SMR promotion in Canada has produced almost no private investor interest, the SMR buzz remains strong. The SMR star may be fading but the SMR story is far from over.

Brennain Lloyd is the coordinator of Northwatch in Ontario. Susan O'Donnell is the lead researcher for the CEDAR project at St. Thomas University in New Brunswick.

NUCLEAR NEWS

World Nuclear Power Status

Number of Reactors
(as of July 2024)

Compared to the last edition of the Nuclear Monitor there have been quite some changes.

- Abandoned; In Brazil construction of the third reactor of the Angra NPP started in 2010 and was abandoned last year.

- Construction Start; in China three new reactors are being build
- Long-Term Outage; In Canada (1), India (1) and Ukraine (6, Zaporidzja)) in total 8 reactors are now in Long-term Outage.
- Closed: In Taiwan the Maanshan-1 reactor closed at the end of July 2024

The changes lead to a decrease in the operating reactor from 416 to 407.

High Assay Low-Enriched Uranium a major proliferation threat

Jan van Evert, reporter Nuclear Monitor
An alarming article in the journal Science warns that high assay low-enriched uranium or HALEU produced with U.S. federal subsidies for small nuclear power reactors can be used to make nuclear weapons. "Were HALEU to become a standard reactor fuel without appropriate restrictions determined by an interagency security review, other countries would be able to obtain, produce, and process weapons-usable HALEU with impunity, eliminating the sharp distinction between peaceful and nonpeaceful nuclear programs", according to five of the world's leading academic and independent proliferation experts.

HALEU is enriched to between ten and twenty percent uranium-235, which is much higher than the uranium used for commercial reactors which is enriched to less than five percent. For technical reasons, many of the nuclear reactor designs that engineers want to build today would use HALEU. Since HALEU is below the twenty percent enrichment limit that defines highly-enriched uranium (HEU), which is directly usable in nuclear weapons, development of these reactors has

not raised significant proliferation concerns. However, after reviewing information in the open literature to analyse the quantities and enrichment levels of HALEU that the new reactors would use, the authors of the Science paper concluded that HALEU above about twelve percent uranium-235 could be used to make practical weapons with yields comparable to the bombs that destroyed Hiroshima and Nagasaki. The researchers suggest that "a reasonable balance of the risks and benefits would be struck if enrichments

for power reactor fuels were restricted to less than 10 to 12% uranium-235", which would

allow many reactor designs to move forward with only modest economic consequences. The experts recommend that if higher enrichments continue to be used, the security standards for protecting HALEU from theft be strengthened to the levels that apply for weapon-usable materials.

German final nuclear waste repository delayed half a century

Jan van Evert, reporter Nuclear Monitor
The search for a final repository for highly radioactive materials in Germany may take decades longer than previously known. The Öko-Institut in the German city Freiburg draws this conclusion in a recent report, Deutschlandfunk reports. The report was commissioned by the Federal Office for the Safety of Nuclear Waste Management (BASE).

According to the Öko-Institut a site could be designated in fifty years at best. However, German law stipulates that a site should be designated in 2031, i.e. in seven years' time.

The highly radioactive waste is currently stored in over a thousand Castor casks in interim storage facilities at various locations in Germany. The licences for the Ahaus and Gorleben sites already expire in 2034, for other storage facilities in the 2040s. Moreover, the casks are not designed for such a long period of use in interim storage facilities.

Source:
https://www.deutschlandfunk.de/suche-nach-einem-endlager-fuer-atommuell-verzoegert-sich-um-jahrzehnte-100.html