Perfect Nuclear Storm Waiting to Happen in Russia's Northwest Region

The large-scale nuclear disaster at Japan's Fukushima Daiichi Nuclear Power Plant has acted as a wakeup call for the international community, engendering deep reflection on the consequences of using nuclear energy. The maintenance and servicing of nuclear plants either currently in operation or under construction, and the dismantling of those already decommissioned or on their way to being shut down, are issues of heated debate, as are possible future nuclear projects.

A crucial issue for European Union members, the United States, China and the whole world, is how to ensure appropriate maintenance practices and technology of Russia's nuclear waste disposal sites, particularly those in the north west of the country. It is predicted that an accident involving nuclear infrastructures in that region could easily be more devastating than that at Chernobyl in Ukraine in April 1986.

The North West Region, which includes the Murmansk and Archangelsk Oblasts (provinces), the Novaya Zemlya Territory (Okrug) and the White, Barents and Kara Seas, contains the largest concentration of fissile, radioactive and nuclear materials for either military or civilian application found anywhere on the planet.

Civilian Nuclear Energy fleet

Polyarny Zori, a city on the outermost western edge of the Murmansk Fjord, is the largest energy producing locality in the Murmansk Oblast. The city is home to the Kola Power Plant (NPP-1), whose 4 PWRs (pressurized water reactors) were built in two phases. Phase 1 went online in 1973-74, with two reactors of the VVER-440/230 type –Russia's first generation of PWR reactors using LEU (low-enriched uranium), with an enrichment level ranging from 2 to 4.95%. Phase 2 came online in March 1981 and October 1984, with the commissioning of the No. 3 and No. 4 reactors of the improved VVER 440/213 type. Reactors of the previous VVER-440/230 type (phase 1) were designed to have an operational lifespan of 30 years and scheduled to be decommissioned in 2003 and 2004 by the Russian Nuclear Energy State Corporation (Rosatom). However, the Russian government, under a cloud of controversy, extended their operational lifespan for 10 years in 2003, despite the high number of accidents seen around that time[1]. During the first two weeks of February 2011, for instance, five out of Russia's 32 operational reactors had to be shut down for emergency repairs and at least a dozen leaks of contaminated material were recorded[2].

These emergency repairs in the month of February, in only eleven days, are sad testimony to the fact that the Russian nuclear energy industry is in dire shape and simply unfit to be operated with any degree of reliability. As reactor equipment gets older its performance is reduced, making it prone to cause more and more incidents, especially given the apparently low standard of maintenance, which is not undertaken regularly anyway. Such a ticking time bomb not only creates additional expenditures and destabilizes supplies of energy but is a public health hazard waiting to happen. If repairs are hastily performed in order to bring power generation back on line, and the quality of this work is substandard as a result of this time pressure, more human errors and "glitches" are likely to occur – and with increased frequency. After each nuclear incident, the Russian nuclear authorities say that nothing of significance transpired. However, in its report on the Most Dangerous Reactors, released in 1995, the U.S. Department of Energy ranked the Kola Nuclear Power Plant as the most dangerous in Russia[3].

The antiquated technology of the KPP-1 and rising domestic energy demand in the region have prompted the Kremlin to build a new atomic complex, the Kola Power Plant 2 (NPP-2), located eight kilometers from NPP-1[4]. The Ministry of Energy plans to install at NPP-2 four next-generation reactors (VVER-620), a cross between the VVER-440 and KLT-40 models. The VVER-620 reactors represent the cutting edge of Russian nuclear engineering. They are a new generation of nuclear reactors designed during a three-year joint project conducted by Russian Ministry of Atomic Energy and the German companies Siemens and Gesellschaft fur Reaktorsicherheit (Association for Plant and Reactor Safety). They operate as pressurized water reactors (PWR), using 90% enriched uranium-235 fuel derived from marine plants. Each of these medium-power reactors will produce approximately 700 MWe of energy. The KPP-2 should be operational by 2018\2019, which will allow for the shutdown of the two old reactors of the KPP-1 facility.

In addition to grave concerns over the old NPP-1, the Murmansk Oblast is also confronted with the menace of another potential nuclear accident of significant amplitude and enormous environmental cost: The icebreaker fleet stationed in the port of the city of Murmansk.

Russia possesses six nuclear-powered civil icebreakers (the "Yamal," "Russia," "Arktika," "Taimyr," "Vaigach" and "Sovetsky Soyuz") which are equipped to carry out a range of operations[5]. Russia's fleet comprises two types of icebreakers: Sea-going-class icebreakers, which can operate in high waves, and shallow draught icebreakers, which can enter rivers. A third type of icebreaker is basically a nuclear-powered container ship. In total, 14 PWR reactors of the KLT-40 type, loaded with HEU (90%), propel these icebreakers. The Murmansk Shipping Company (MSC) operated all these vessels until August 2008, when the fleet was handed over to the Nuclear Energy State Corporation (Rosatom)[6]. The federal state-owned unitary enterprise Atomflot, based in Murmansk, has since been authorized to run the nuclear-powered vessels and deal with radioactive waste (RW), including its storage and processing.

Finally, Rosatom owns five service and storage vessels especially designed for dealing with radioactive waste (RW) and spent nuclear fuel (SNF), and stationed at the Atomflot base, only two kilometers from residential districts. The service ships "Imandra" and "Lotta" are used to store for six months – in dry, water-cooled containers – spent fuel from the Rosatom's civil ice-breakers. Imandra and Lotta can store 1,530 (i.e. fuel from six reactors) and 4,080 (i.e. fuel from 12 reactors) fuel assemblies respectively. However, since 1992 both service ships have been filled to capacity. Another problem is that just over one third (35%) of the fuel assemblies stored in Imandra and Lotta contain zirconium surrounding the plutonium fuel. Such fuel assemblies cannot be reprocessed. The vessel "Volodarsky" (1929, 96x15 m, 5,500 t) is used for keeping solid radioactive waste (SRW) and has a storage area of 300 m3. The tanker "Serebryanka" (1975, 102x12 m, 4,000 t) is used for collecting liquid radioactive waste (LRW) and its transmission to Atomflot. Finally, the "Lepse," a service vessel moored in a dockyard in the Kola Bay near Murmansk, was built more than 70 years ago for the refueling of the first nuclear-powered icebreaker, "Lenin," and later for "Arktika" and "Sibir," the next generation of icebreakers. In 1988 it was retired from active use, although it still contains two storage tanks for SNF materials from icebreakers.

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In July 2011 the Fincantieri shipyard, an Italian firm, handed over to Atomflot the multipurpose container ship Rossita, intended for shipments of SNF and materials from dismantled nuclear submarines from the Kola Peninsula and the White Sea – former Russian Navy bases in North-West Russia – to Murmansk[7].

The Andreeva Bay "Cemetery" on the Novaya Zemlya

The city of Murmansk is the most important strategic area in Russia's North West territory. Due to the warm North Atlantic drift, the city's ports and the southern half of the Barents Sea remain completely ice-free all year round, which makes them more easily navigable. Thanks to the influence of the Gulf Stream, the Barents Sea does not freeze and the majestic fjords at the entrance of the White Sea are also accessible year round without difficulty. For these reasons the Northern Fleet, formerly known as the Soviet Fleet of the Northern Seas, is the largest and most important of the former Soviet fleets, and has ever increasing strategic importance for Russia.

Since the 1950s the Kola Peninsula has witnessed a proliferation of shipyards, storage sites, decommissioning complexes, facilities for reprocessing nuclear materials and secret nuclear submarine bases. In the Former Soviet Union (FSU), Semipalatinsk in Kazakhstan and Novaya Zemlya in the Arctic were the two major fields for nuclear test explosions. Ninety three percent of the total power of these explosions – which were basically nuclear weapons tests – in the FSU was registered on Novaya Zemlya and the Kara Sea. These two areas were called by the Soviet authorities the Northern Nuclear Test Range, an entity established in 1954. In all, 132 nuclear tests – explosions – were conducted on Novaya Zemlya between 1950 and October 24, 1990, including 88 atmospheric (either close to the land or sea surface), 39 underground and 3 underwater in the Kara Sea. The total power of these explosions was 265 Megatons (Mt)[8]. They included the tests of "Tsar Bomba," the largest hydrogen bomb ever detonated on October 30, 1961, which had a force of 58 megatons or 58,000,000 tons of TNT. In comparison, the atomic bomb dropped on Hiroshima had a force of 20,000 tons of TNT. For good measure, the seabed of the Kara Sea is estimated to contain about 11,000 sunken containers of radioactive waste, a dozen dumped nuclear reactors and an unknown number of defective nuclear-propelled submarines.

Following the collapse of the Soviet system in December 1991 the Russian Federation inherited a little less than 200 nuclear powered submarines. At that time a significant number of these had been in use for about 30 years. During the first half of the 1990s the Kremlin decided to remove from active service all the older submarines, i.e. about 140 vessels, as part of downsizing the military budget. Over the following decade Russian leaders made great efforts to dismantle these rotting submarines and remove their nuclear fuel. However in the last 20 years the Russian Navy has been able to separate out and store the reactor compartments of only a few dozen submarines. At present all secured reactor compartments, including whole submarines, are stored and tied up in three traditional storage sites:

1) Andreeva Bay in the Zapadnaya Litsa fjord on the Kola Peninsula. Reportedly, the site hosts 21,000 spent fuel rods, equivalent to approximately 90 nu-

clear reactors, as well as thousands of tons radioactive liquid waste stored in decrepit stainless-steel containers filled to capacity since the 1990s. Three dozen of these containers are leaking radioactive material.

2) Nerpichya Port, on the Zapadnaya Litsa's east coast.,The site is home to 6 SSBNs (Ship Submersible Ballistic missile Nuclear [powered] vessels), better known as Typhoon ballistic missile submarines (of 25,000 tons), which still have on board torpedo tubes designed to handle and launch missiles. Each Typhoon has two pressurized water reactors of the OK650b type which use 20-45% enriched uranium-235 fuel. Each vessel's weapon system is composed of 20 submarine -launched ballistic missiles (SLBM) which can carry 10 Multiple Independently targetable Reentry Vehicles (MIRV), each able to produce a yield of 21 kilotons.

3) Gremikha Base, east of the Kola Peninsula. The second largest onshore storage facility for the Russian Northern Fleet's spent nuclear fuel, Gremikha contains around 800 spent-fuel assemblies. Reportedly, spent fuel from six liquid metal reactors (LMR), with 90% HEU are stored at this site, the largest for storing decommissioned submarines. The spent fuel comes entirely from the deactivated Alpha class submarines and, apparently, cannot be reprocessed with today's technology. LMRs have to be treated more carefully because they used higher enrichment levels, probably weapons-grade uranium. The banks of the Gremikha base serve as a "parking lot" for several old-generation submarines now abandoned and in a dire state of repair:

- 4 November class vessels, for a total of 8 VM-1 PWR loaded with 21% HEU;
- 1 Hotel Class vessel with 2 VM-A PWRs loaded with 21% HEU;
- 8 Victor I\Victor II class vessels, for a total of 8 OK-300 VM-4 PWR with 21% HEU;
- 4 Victor III class vessels, for a total of 8 OK300 VM-4 PWR with 21% HEU.

All the mentioned cities, districts and military bases on the Kola Peninsula and Novaya Zemlya have radioactivity levels a thousand times higher than the normal dose a human being can tolerate. Even three to five kilometers away from these places levels of radiation are hundreds of times above the normal and represent extremely serious risks to human health and the environment. Over the years entire villages have been evacuated and their populations relocated in urban centers nearby. In the 1980s about 30,000 people lived in the Gremikha region; however, since the breakup of the Soviet Union the population has decreased to about 10,000, due to economic hardship and ongoing substantial reductions in the Russian military program[9]. Some cities have been closed to both foreigners and citizens of the Russian Federation. Access to these is restricted to the military or duly authorized technicians and workers.

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Accident Risks and Conservation Programs

The volume of radioactive material on the Kola Peninsula is equivalent to about 150 nuclear reactors and thousands of tons of depleted uranium and plutonium. There are nine radioactive waste (RW) and spent nuclear fuel (SNF) storage facilities. In addition many shipyards, where civilian ships and military submarines are built, assembled and repaired, are located on the Kola Peninsula, particularly in Murmansk, Severodvinsk ("Sevmash" and "Zvezdochka") and Polyarny. These shipyards are an integral segment of the Russian Military Industrial Complex but also more closely connected to the Northern Fleet. In addition to the threat of radioactive pollution, the level of "conventional" pollution is also very high in that region, principally due to airborne chemical pollution from the mining, steel and metallurgical industries.

Unfortunately Russia has a historically dismal record of nuclear accidents and has never adequately demonstrated a capacity to cope efficiently and effectively with environmental emergencies. The risks of accidents on the Kola Peninsula are considerable and these could directly affect the Arctic and Scandinavian countries. The next radioactive toxic cloud formed on the Kola Peninsula might easily drift over Central Europe and the northern coast of Canada and even reach the United States.

The dreadful consequences of such an accident would be disastrous for Russia's future economic development. Moreover, it would inflict enormous damage, not only on humans and the environment, but also on the reputation of a country which has made its civilian nuclear power industry the spearhead of its export and technology development. In spite of the many irregularities and deficiencies in the nuclear reactor technology, Russian reactors are still in great demand on the international market.

In 2006 Rosatom announced that it wants nuclear produced energy to account for about one forth (23%) of the country's total energy production, and approximately one third (32%) of European Russia, by 2020[10]. To achieve this objective, the focus will be placed on the development of fast neutron reactors (FNRs), the Generation IV component of Rosatom's future nuclear energy policy. FNRs use uranium 238 (U-238) as fuel instead of the uranium 235 (U-235) commonly used by conventional reactors, such as PWRs. The 880 MWe capacity BN-800, a FNR reactor expected to enter into operation in 2014, offers, according to Rosatom, "natural radiation safety in all credible accidents caused by internal or external impacts, including sabotage, with no need for people evacuation."[11]

Conceptually, the refueling process for these reactors is more cost-efficient and simple to operate. They use only about 1 or 2% of the natural or depleted uranium required by a comparable PWR reactor (http://www.nikiet.ru/eng/structure/mr-innovative/brest.html). FNRs will permit Russia to produce more civilian energy with less fissile material and this advantage will allow for the further use of the depleted uranium now stockpiled as a result of the dismantling of nuclear submarines and warheads under the "new" START (Strategic Arms Reduction Treaty) agreement between the Russia and the United States. This transformation is part of the Megaton to Megawatts Program as first initiated by the two nuclear superpowers in 1993, which aimed to kill "two birds with one stone," i.e. to both proceed with disarmament and bring down the consumption and global price of non-renewable uranium, a resource now on the verge of being monopolized by China[12]. However, the U.S.-Russian agreement will expire in 2013 and will have to be renegotiated.

Economies made by introducing FNRs have been earmarked for the military. The plan is to replace Russia's Soviet-era nuclear submarines (the Typhoon class) with SSN (Ship Submersible Nuclear) Yasen-class attack submarines, also known as the Graney class and Severodvinsk class, by 2014. These new SSNs are also considered as a crucial tool for Russia to capture new arms markets. For instance, Russia is waiting for the Indian Maritime Force (IMF) to exercise its right to enforce the Indo-Russian agreement on the lease of a new Akula II class submarine, the SSN Nerpa. This 2005 deal is worth an estimated $1.8 billion to Russia. After some problems with the reactor cooling system, the Russia international News Agency (RIA Novosti) quoted a Russian Navy Staff admiral as saying, on March 16, 2011, that Russia will deliver the Nerpa to India by the end of this year.[13]

Since the 1990s the Kremlin has not paid much attention to the situation at the Kola Peninsula. The only initiatives of significance taking place are the trilateral agreements with Norway and the United States, known as the "Murmansk Initiatives," signed in 1996, and still in force. These agreements set up a fund to "improve the capability of the Russian Federation to comply with the requirements of the London Convention that prohibit ocean dumping of low-level liquid radioactive waste (LLRW)" and increase the pace of the construction of centers for the decommissioning of nuclear submarines.[14] All in all, the investment of several tens of millions of dollars still has not consistently improved the situation to an acceptable level. In Murmansk, the site for refining and disposal of Liquid Radioactive Waste (LRW) has been working for many years now and it is still involved in cleaning up what remains of the former floating technological base "Lepse."

The aftermath of the Fukushima nuclear power plant catastrophe in Japan resulted in the evacuation of all residents living within a 20 km radius of the Japanese nuclear plant, which is located in the city of Daichi. In late April 2011, the United States, Australia and South Korea, for their part, urged their citizens to move from areas within 80 km of the crippled plant, an evacuation zone which was substantially larger than the one mandated by the Japanese government. The disaster has been recognized as a perfect storm with the meltdown of three Japanese nuclear reactors, each involving approximately 300 tons of uranium. The event came as a surprise to many industry experts since it took place in such a technologically advanced country, especially one that is on the cutting edge in nuclear and earthquake mitigation engineering.

Considering the huge amount of spent fuel and depleted nuclear materials present on the Kola Peninsula, the poor state of maintenance on land-based storage sites, the decrepit infrastructure for the safe transport of spent fuel from naval bases and the aging technology and increased possibilities for human errors, the possible occurrence of an accident with even far more negative outcomes than the one that took place in Japan is not a far-fetched scenario. Based on recent problems experienced at the Kola Power Plant (NPP-1), the situation on the ground should be monitored closely by the world's leading countries and, particularly, by major European energy companies, as the nuclear reactors currently operational in Europe are very similar to those found in the KPP-1 plant and throughout the former USSR.

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Despite the constant warnings of environmental NGOs and European governments, the Kremlin continues to invest colossal sums in the development of a new generation of nuclear energy production and associated technology – as well as new in drilling and mining projects – thus further aggravating the environmental situation. Consequently, many Russian regions and neighboring countries are exposed to the danger of uncontrolled nuclear energy chain reactions. Finally, in light of the new battle for Arctic oil fields, the Russian government is motivated to rejuvenate its nuclear programs and to rebuild its nuclear icebreaker fleet. When all things are considered, it is clear that the Kola Peninsula – and the world as a whole – will continue to be at high risk for many years to come.

Notes:

* **Dr. Richard Rousseau** is Associate Professor and Chairman of the Department of Political Science and International Relations at Khazar University in Baku, Azerbaijan. He teaches on Russian politics, Eurasian geopolitics, international political economy and globalization.

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