Impact of Russia's Invasion of Ukraine on Nuclear Energy

BY JEFF COMBS

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Introduction

Russia's war on Ukraine has had a notable impact on the outlook for nuclear energy, both in the short term and likely for the foreseeable future, as the attack has created lingering questions about the future reliability of Russian energy supplies. The war's repercussions for natural gas prices and availability have caused Western European countries and others to rethink the operations of their nuclear power plants, especially those that sought to curtail or shutter their nuclear power programs following the Fukushima accident. In addition, the invasion is causing some countries to consider expanding their existing nuclear fleets.

While the invasion has created more demand for nuclear power as countries seek to move away from Russian natural gas supplies, it has also impacted the supply side of the nuclear equation. Russia is both a major supplier of nuclear reactors and nuclear fuel. With respect to nuclear fuel, its position is as strong or stronger than its supply of fossil fuels. Because of both these supply and demand impacts, Russia's invasion of Ukraine is complicating the future picture for nuclear energy.

Demand Developments

European countries, which have been the hardest hit by Russia's natural gas policies, have reconsidered the operations of existing nuclear power plants. Belgium has reached a preliminary accord with the utility ENGIE for ten-year extensions of two reactors that were previously scheduled to shut down in 2025. The German government has agreed to place two of its units on standby as it seeks to negotiate a difficult winter with reduced natural gas supplies. France is looking to shore up operations of its nuclear reactor fleet and prepare for a new reactor construction program by fully nationalizing EDF.

The renewed interest in nuclear power in Europe extends beyond delaying the shutdown of existing operating reactors and the restart of idled units. Developments in the Netherlands could lead to future new builds. France, which had its first big push into nuclear power during the 1970s Arab oil embargo and is dependent on nuclear for most of its electricity generation, is looking to build upwards of six large reactors. The United Kingdom is also planning to add to its nuclear capacity as it seeks to replace its rapidly aging gas-cooled reactor fleet. Nations in Eastern Europe, including Poland, Czechia, Romania, and Bulgaria, are also all accelerating plans for new reactor projects as they seek to increase their energy security.

The impacts are not just limited to Europe. Japan has also seen increasing pressure to restart idled reactors. Fumio Kishida, its Prime Minister, is seeking to have nine units in operation this winter and a total of 17 running by next summer. While this may be an ambitious plan given Japan's strict safety regime, it does indicate a desire for nuclear to regain an important role in Japan's energy mix in the aftermath of the Fukushima accident. In another notable development in Canada, Ontario's provincial government has asked for Ontario Power Generation to evaluate the viability of a refurbishment program could allow the Pickering B nuclear power station to operate for another 30 years.

The demand picture stemming from Russia's invasion is not completely positive, however. The first nuclear project to fall victim was in Finland, which canceled a new Russian-led reactor at Hanhikivi soon after the war broke out. Before the war, Ukraine was in discussions with Westinghouse to construct two new reactors, but these plans have been set back due to the war.[1] Ukraine has a large nuclear power program and currently operates Europe's largest nuclear power plant at Zaporizhzhia which has six reactors. This plant has been the subject of much attention as it is occupied by Russia's military and has been at the frontlines of fierce fighting. If the plant were severely damaged, not only would it be taken out of operation, but it would likely deal a blow to broader aspirations for new plants in Ukraine and perhaps Europe as well as elsewhere. Also, if Russia's economy slows down or collapses due to the war, its need for nuclear power would decline along with its ability to construct reactors. Russia recently announced plans to build up to 16 new reactors by 2045, increasing nuclear's share of electricity generation there from 20% to 25%.

Climate Change Considerations

The Russian invasion of Ukraine has come at a time of growing concern about climate change. This summer, the European Union accepted nuclear energy into its green taxonomy along with natural gas. With availability of natural gas now questionable in Europe, the green taxonomy designation has served to further boost interest in nuclear energy to meet climate goals. At the same time, the realization that renewable energy alone is unable to allow California to reach its climate goals has resulted in a change in policy to prolong the life of the Diablo Canyon nuclear power plant at least until 2030.

The overall political climate has also become more positive toward nuclear energy, largely separate from the impacts of Russia's invasion, and due more to a change in leadership in some countries, coupled with a concern over climate change. Leadership changes in South Korea and Sweden herald a more favorable disposition toward nuclear energy. The United States has also supported maintaining and expanding its nuclear

power capacity and massive new funding in recently passed major legislation is now aimed at the development of small modular and advanced reactors.

Because of the concerns over climate change and energy security, the International Atomic Energy Agency (IAEA) has increased its outlook for nuclear power growth for the second year in a row.[2] The IAEA raised its high case scenario by 10%, and now sees its most optimistic scenario reaching 873 GWe of nuclear capacity by 2050, which is more than double the current level of 390 GWe.

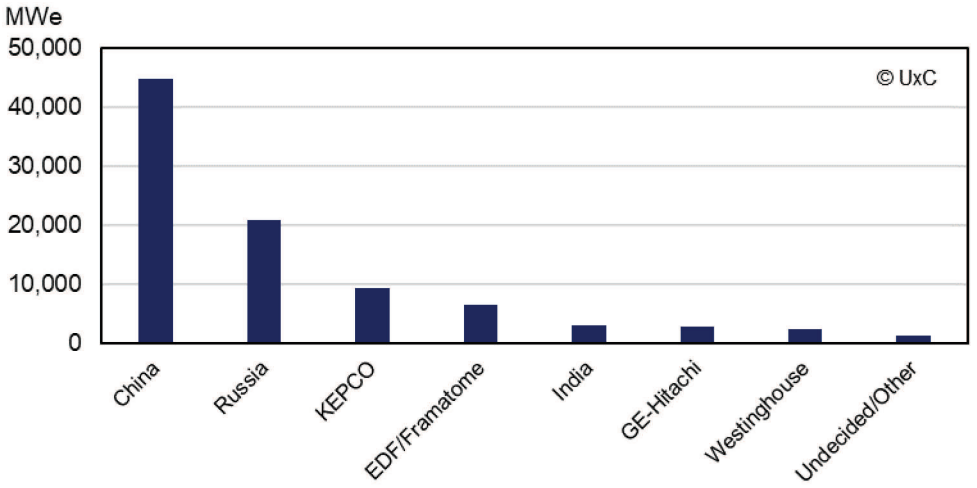

Figure 1. New Reactor Vendor Selections through 2030

Supply Issues: Russia's Role as a Nuclear Reactor and Fuel Supplier

While Russia's invasion has clearly boosted the desire to keep reactors operating and to construct new ones, it has also greatly complicated the picture for nuclear energy due to Russia's role on the supply side. As shown in Figure 1, Russia is one of the world's largest suppliers of reactors, with projects underway in Bangladesh, Belarus, China, Egypt, India, Iran, and Turkey as well as domestically in Russia. Russia's invasion of Ukraine and occupation of the Zaporizhzhia plant has not yet derailed this work but could still do so as well as impact plans for other new reactors.

Paradoxically, the rise in fossil fuel prices stemming from Russia's invasion of Ukraine can continue to fund Russian reactor construction around the world, if countries desire to look to Russia for their reactor needs. Thus, if nuclear power continues to grow due to higher natural gas and oil prices, Russia could be a beneficiary of this growth. One example of this is that Hungary is continuing to move forward with a plan to build two large Russian reactors at its Paks site, despite opposition by its EU neighbors.

Russia's status as a major nuclear fuel supplier also complicates the outlook for nuclear power. As shown in Figure 2, Russia through its state-controlled company Rosatom, accounts for around 40% of the world's uranium enrichment capacity, far greater than its share of world natural gas and oil supplies. It also accounts for a similar share of uranium conversion, which is another crucial step in the nuclear fuel cycle. Since most reactors are of the light water variety that require enriched uranium to operate, a stable enrichment and conversion supply is critical to future of nuclear power operations. Russia is also a major supplier of nuclear fuel assembly fabrication services for the VVER-type reactors that it has supplied and is building around the world.

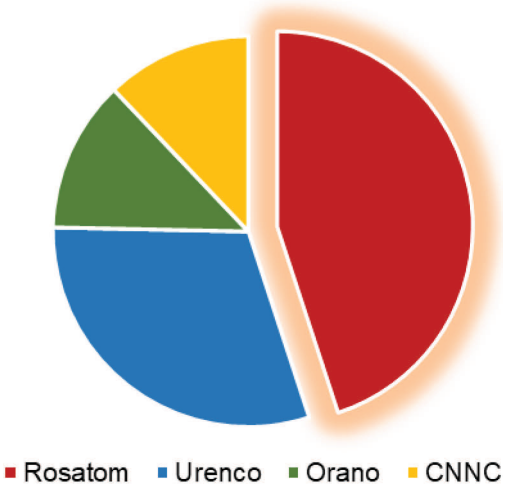

Figure 2. Global Enrichment Shares by Supplier Capacity

Concerns about Russia's role as an enrichment supplier have already had a marked impact on enrichment (or separative work unit – SWU) prices, as shown in Figure 3. Since the invasion, both the spot and long-term contract prices of non-Russian origin enrichment have increased notably. As of this writing, there are no restrictions on the importation of Russian nuclear fuel in the United States or Europe. However, individual utilities have opted to move away from Russian supplies. As most enrichment is sold under long-term contracts, prices for non-Russian supplies have risen dramatically as utilities have sought to secure long-term supplies from other Western suppliers. Uranium and conversion prices have also risen, and Russia is losing ground in the VVER fuel fabrication market.

Neither Russia nor Ukraine is a major source of uranium resources or production. However, Russia produces large amounts of uranium by underfeeding its enrichment plants (substituting enrichment for uranium in the make-up of the enriched product) and by enriching depleted uranium. Angarsk, one of its four enrichment plants, is devoted to enriching depleted uranium, and basically operates as a uranium mine.

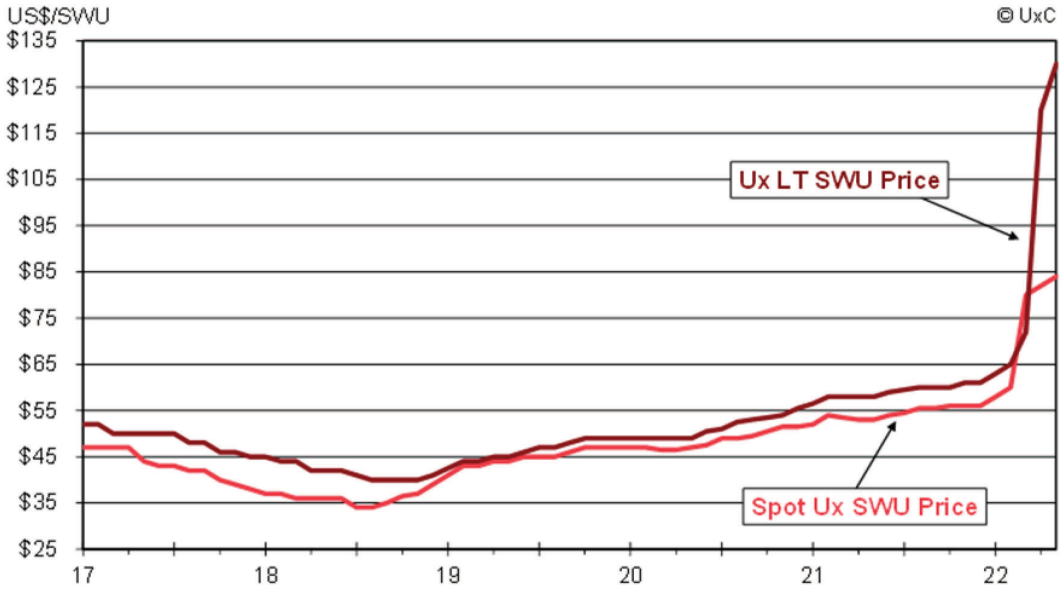

Figure 3. Spot and Long-Term Contract Enrichment Prices ($/SWU)

Perhaps more important to the uranium supply question is the fact that Kazakhstan, which accounts for 40% of the world's uranium production, is located next to Russia. The primary route to transport Kazakh uranium goes through Russia, although there is also an alternative route through the Caspian and Black Seas. Thus, it is possible that logistical issues caused by Kazakhstan's links with Russia could complicate international uranium shipments in the future.

Future Considerations

For nuclear power to grow robustly, Russia will need to continue as a nuclear reactor and fuel supplier, at least in the short to medium term. A bifurcated market has already developed in enrichment, conversion, and fuel fabrication and could develop in the sale of reactors. It may be the case that certain countries will continue to look to Russia for nuclear power plants and fuel in the future, and this could support a certain amount of growth. However, in the longer term, Russia risks losing market share in reactor and fuel sales as the war with Ukraine drags on.

To support timely nuclear power growth in the rest of the world, additional enrichment capacity must be added. The United States has already announced steps to make it independent of Russian nuclear fuel supplies by having the government augment market demand to stimulate new domestic production capability.[3] In addition, the U.S. Congress is considering legislation that would ban imports of Russian nuclear fuel. The United Kingdom is also taking steps to augment its domestic nuclear fuel supply.

If Russia is not seen as a reliable supplier of enrichment and other nations with enrichment plants do not expand their capacity, then countries embarking on nuclear power programs may feel compelled to pursue their own domestic enrichment programs for supply security reasons. This consideration would slow down the expansion of nuclear energy as it would take time for countries to develop and construct enrichment facilities, if this were even possible. It would also raise proliferation concerns as more countries would be developing enrichment capacity, making it more difficult to monitor and safeguard enrichment activities.

Stable sources of enrichment supply thus must be made available as a prerequisite to a robust expansion of nuclear energy worldwide, especially if the high levels currently forecast by the likes of the IAEA are to be realized. Expansion beyond current capacity is needed even if Russia's current capacity is fully utilized. With less reliance on Russia, which is anticipated, even more expansion of non-Russian enrichment capacity will be necessary, along with uranium and conversion capacity to support this. Countries, such as France and the United States that currently have enrichment facilities and seek to make reactor sales must look to build capacity sufficient not for just their own needs, but to support additional nuclear power growth worldwide. Importantly, enrichment is also a resource hedge, as enrichment and uranium are substitutes, so expansion of enrichment capacity using more advanced and efficient technology can underpin nuclear fuel supplies and support the introduction of advanced reactors whose fuel requires higher enrichments.[4]

Conclusion

Because of its invasion of Ukraine and the resulting reactions, Russia's role in the nuclear energy space is likely to decline in the future, especially when it comes to nuclear fuel. This decline is likely to be more dramatic if the war is protracted and/or if damage is done to Ukrainian reactors. Over the short to medium term, Russia will likely continue to supply nuclear fuel to Western countries, as no restrictions currently exist and Russia has not threatened to withhold supplies. However, if restrictions are placed on Russian nuclear fuel, or if Russia decides to stop supplying the United States and/or Europe, nuclear fuel prices would rise dramatically. This reaction could create the kind of fuel uncertainty that could undermine the expansion of nuclear power worldwide. Under any scenario, Western countries will need to expand enrichment capacity to ensure adequate supplies for nuclear power growth, particularly where this growth is in the form of advanced reactors that require higher levels of enrich-

ment to operate. Conversion and uranium supplies must also expand and remain sufficiently diverse to assure nuclear fuel supply security.

Footnotes

[1] Before the invasion, Ukraine had decided to move away from Russia as a supplier of nuclear reactors and fuel.

[2] International Atomic Energy Agency. IAEA Projections for Nuclear Power Growth Increase for Second Year Amid Climate, Energy Security Concerns. September 22, 2022.

[3] Bloomberg News. US Redoubles Efforts to End Dependence on Russian Nuclear Fuel, September 28, 2022.

[4] The importance of enrichment to nuclear fuel supplies is discussed more fully in Hsieh and Combs (2021). Enrichment's Critical Role in Nuclear Fuel Supplies. IAEE Energy Forum, First Quarter 2021, 44-47.

James Smith receives the IAEE Past President Award in Houston, Texas at the USAEE/IAEE North American Conference
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