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Chairman Kean, Ranking Member Keating, members of the subcommittee, thank you for the opportunity to testify today on the nuclear security, energy security, and energy policy implications of Russia's Rosatom corporation, and potential efforts to limit its reach.

Let me begin by saying that most sanctions against Rosatom, however intuitively appealing, will neither constrain Russia significantly, nor will they address the current nuclear fuel imbalance that the world faces. In fact, any attempt to sanction Rosatom's nuclear fuel subsidiaries without having the capacity to fill the gap in supply would disrupt markets in ways that make life more difficult for Western nuclear industry players while precipitating a sharp increase in nuclear fuel prices, thus boosting Rosatom's revenue. Some sanctions, if applied incautiously, could even threaten the safety and security of nuclear power plants in Europe.

The good news is that other measures to limit Rosatom are underway and beginning to show some success. Moreover, there are signs that Rosatom's once prominent role in the nuclear industry may already be in decline. A few well-chosen steps to ensure healthy global competition in the nuclear industry could redress imbalances in fuel accessibility and security while limiting Rosatom's reach. It will take a few years to finish building out the alternatives, but those years can be directed at better positioning the US for long-term competition in an era of expected demand increase for nuclear power.

To understand options going forward, it is useful to review Rosatom's relationships with the EU, the rest of the world, its own government, and the IAEA... and the changes evident in each of these areas. First, and significantly, in 2022, Rosatom and its affiliates accounted for a stunning 16.9% of Europe's natural uranium, 22.35% of the EU's conversion services, and 30% of its enrichment services.¹ Russia's outsized role in nuclear power is reflected in EU statistics. Consequently, when the European Union passes its 13th package of sanctions against Russia in late February 2024, likely on the anniversary of Russia's invasion of Ukraine, neither nuclear materials nor Rosatom will feature in the sanctions package.² In spite of Europe's remarkable turn-around on natural gas, Russian nuclear fuel dependence has proven to be too great a challenge to eliminate thus far.

This is not purely a European problem. Rosatom counts 54 countries among its customers, and between 2000-2015, it supplied roughly half of all international agreements regarding nuclear power plant construction, reactor and fuel supply, and decommissioning or waste. Rosatom has an especially strong presence in two aspects of nuclear fuel production - conversion and enrichment, where it controls 38% and 46% of global capacity and sanctioning that supply would

¹ Euratom Supply Agency Annual Report 2022, European Union 2023, Table 3: Origins of uranium delivered to EU utilities in 2022, p. 15, and pages 15, 18 and 25.

² Nuclear sanctions have not been included in any of the EU sanctions packets so far. See Marina Lorenzini, "Cutting power: How creative measures can end the EU's dependence on Russian Nuclear Fuel," *Bulletin of the Atomic Scientists*, May 3, 2023 <https://thebulletin.org/2023/05/cutting-power-how-creative-measures-can-end-the-eus-dependence-on-russian-nuclear-fuel/#post-heading>

pose a particular challenge to the US and Europe.³ In addition, Eastern European countries operating Russian-origin VVER reactors face certain technological barriers to diversification in fuel assembly fabrication.

Understandable dissatisfaction with Rosatom persists on both sides of the Atlantic. Steps have already been taken in the US and the United Kingdom to sanction some subsidiaries of Rosatom, but the sanctions have been limited, and to date the nuclear fuel subsidiaries have not been affected. Ukrainian Minister of Energy German Galushchenko reasonably asks how a company that illegally operates the Zaporizhzhya Nuclear Power Plant (ZNPP) can be tolerated as a player in European and US markets.⁴ U.S. as well as European policymakers share concern at Rosatom's dominance of key aspects of the nuclear fuel chain because of its role in managing the stolen ZNPP facility, its closeness to the Kremlin, and the Kremlin's obvious willingness to weaponize other energy sectors in recent years. Furthermore, Rosatom is responsible for maintaining Russia's nuclear arsenal, and concern also persists about Rosatom's role in helping other Russian sectors evade sanctions, such as in microchips and electronics. Nevertheless, these concerns do not fully offset Europe's fundamental dependence on Rosatom.

Rosatom's European Reach

Prior to the Russia's war on Ukraine, the relationship with Rosatom was well-integrated into the European Union. Of the 100 reactors in use in the European Union,⁵ 18 reactors located in five EU countries are of Russian or Soviet-design and have varying levels of built-in reliance on Rosatom.⁶ Europe is home to successfully retrofitted Soviet-era reactors and to reactors that (having been begun during the Soviet era) were completed after the Soviet collapse.⁷ The company and its subsidiaries are involved in reactor maintenance, fuel supply, and waste disposal. This poses a particular vulnerability in European energy security.

Within the first week of the full-scale invasion of Ukraine by Russia, with European Union airspace closed to Russian airlines, a Russian cargo airline was exempted from the ban to deliver nuclear fuel for Slovakia's reactors. Despite some European outrage, a month later another cargo airline was granted permission to deliver fuel to Hungary's reactors.⁸ Although facilities can

³ Data from Kacper Szulecki and Indra Overland, "Russian nuclear energy diplomacy and its implications for energy security in the context of the war in Ukraine," *Nature Energy*, Volume 8, April 2023, pages 413-421.

⁴ Atlantic Council Webinar, "Building US nuclear energy independence: The Russia connection" February 8, 2024.

⁵ World Nuclear Association, "Nuclear Power in the European Union," WNA Information Library, Updated January 2024, <https://world-nuclear.org/information-library/country-profiles/others/european-union.aspx>

⁶ Six reactors in the Czech Republic, four in Slovakia, four in Hungary, two in Bulgaria and two of five reactors in Finland are Russian-designed reactors that operate with Russian fuel. Nuclear power accounts for 33 to 52% of electricity production in those countries. See Ashutosh Pandey, "Why EU sanctions don't include Russian nuclear industry," July 19, 2023, *DW*, <https://www.dw.com/en/russia-nuclear-industry-eu/a-66275352>

⁷ Rosatom currently expects to remain involved in completion of two reactors in Hungary that are already in process, and is in arbitration with Finland regarding the termination of the contract to build Fennovoima. Rosatom contracted to construct the reactor in December 2013, and was in the process of licensing the construction when Russia invaded Ukraine. Finland terminated the Fennovoima contract on May 2, 2022, citing risks for the project caused by the war in Ukraine. See "Fennovoima cancels Hanhikivi 1 contract with Russia," *World Nuclear News*, 03 May 2022 <https://www.world-nuclear-news.org/Articles/Fennovoima-cancels-Hanhikivi-1-contract-with-Russia>

⁸ Ashutosh Pandey, "Why EU sanctions don't include Russian nuclear industry," July 19, 2023, *DW*, <https://www.dw.com/en/russia-nuclear-industry-eu/a-66275352>

store up to three years' worth of fuel supplies on site, the contracts are typically structured for regular replenishment, and these states feared that sanctions might leave them unable to power their reactors. Hence, uncertainty about the Russo-Ukraine war led many power plants to order additional fuel.⁹

With the invasion of Ukraine, diversification was recognized as a strategic necessity for all EU member states in the REPowerEU Plan adopted in May 2022.¹⁰ Based on its Ukraine and East European experience, Westinghouse took the lead, establishing a consortium that subsequently received co-funding from the EU in July 2023. The “Accelerated Program for Implementation of Secure VVER Fuel Supply” (APIS) consortium has 36 months of funding to make the fuel transition to European-supplied fuel possible for Russian-designed reactors in Europe.¹¹ All EU members with such reactors, with the exception of Bulgaria, have joined the consortium.¹²

In addition to diversification efforts, expanding nuclear power production is on the agenda of several European states. Since the overall percentage of electricity generated by each Russian power plant is a reasonable measure of vulnerability,¹³ increasing the number of plants offers a measure of security, particularly in an era of rising electricity demand. With that in mind, Ukraine, the Czech Republic, Slovakia, Bulgaria and Hungary are already working to expand their nuclear power production, while Poland has been progressing since 2020 towards construction of its first nuclear power plant.¹⁴ In this new generation of power plants, Bulgaria, Ukraine, Poland, and the Czech Republic are opting to turn to new suppliers. Only Hungary is persisting with an expansion of Rosatom's presence.¹⁵

Rosatom and the U.S.

There is no getting around the fact that Rosatom is embedded in the United States' domestic nuclear fuel supply chain. Although US fuel rods are not manufactured by Rosatom, through its subsidiary TENEX, Rosatom supplies a shocking 20% of the low-enriched uranium used in U.S. power plants.¹⁶ This resource dependence originated after the collapse of the Soviet Union with the Megatons to Megawatts program (1995-2013), which was designed to purchase uranium

⁹ Substitution was not an available option. Although it is possible to mix fuel rods from different sources in a reactor, doing so requires complex engineering and licensing, and efforts in the 2000s yielded mixed results. Westinghouse experienced fuel deformation problems in 2009 at the Temelin NPP. See Yanliang Pan, “Managing the Atomic Divorce: The challenges of East Central Europe's nuclear decoupling from Russia,” *The Electricity Journal* Vol 36, January 2023, <https://doi.org/10.1016/j.tej.2023.107241>

¹⁰ WNS Staff, “Nuclear included in EU's repowering plan,” *World Nuclear News*, 20 May 2022 <https://world-nuclear-news.org/Articles/Nuclear-included-in-EU-s-repowering-plan>

¹¹ The EU has contributed \$11 million to the program. See “EU picks Westinghouse-led project for VVER fuel supply,” *Nuclear Newswire*, July 12, 2023 <https://www.ans.org/news/article-5166/eu-picks-westinghouseled-project-for-vver-fuel-supply/>

¹² Russian designed reactors are located in Bulgaria, the Czech Republic, Finland, Hungary, Slovakia and Ukraine.

¹³ Kacper Szulecki and Indra Overland, “Russian nuclear energy diplomacy and its implications for energy security in the context of the war in Ukraine,” *Nature Energy*, Volume 8, April 2023, page 415

¹⁴ Nuclear Newswire Staff, “Ex-Im Bank, Poland sign MOU on US energy investment,” *Nuclear Newswire*, Dec 21, 2020 <https://www.ans.org/news/article-2489/exim-bank-poland-sign-mou-on-us-energy-investment/>

¹⁵ Nuclear Newswire Staff, “Czech Republic to build 4 new reactors,” *Nuclear Newswire*, February 1, 2024 <https://www.ans.org/news/article-5737/czech-republic-to-build-4-new-reactors/>

¹⁶ John Kotek, “Nuclear Energy Industry Committed to Secure Fuel Supply,” *Nuclear Energy Inst.*, June 16, 2022

from Russia as it downsized its nuclear weapons arsenal.¹⁷ The project achieved an important U.S. strategic goal by reducing the number of nuclear weapons in Russia’s arsenal. At the same time, the blending down of highly enriched uranium made both conversion and enrichment less essential. In an environment in which the nuclear industry was treated as just another commercial sector, the U.S. was poised to lose out.

Rosatom’s outsized role was exacerbated by the U.S. failure to innovate its enrichment processes. U.S. nuclear reactors continued to use an energy-intensive gas diffusion technology while other market players moved to more competitive centrifuge technologies. Enrichment capability declined and US production fell between 1985 and 2015 from 27.3 million SWU per year to zero.¹⁸ Meanwhile, the Joint Stock Company TENEX, which acted for the Russian government in the Megatons to Megawatts program, established longer term ties to the US industry and continued to operate (with imposed limits) after the close of the original program. TENEX and other companies out-competed the US in conversion as well as enrichment, and the only American facility capable of uranium conversion was placed on “idle standby” in 2018, due to forecasts that predicted global oversupply.¹⁹

The good news is that the rebuilding of US conversion and enrichment is already underway, driven by dramatically improved market conditions as well as by strategic efforts to make the HALEU (High Assay, Low Enriched Uranium) needed for next-generation reactors. While the production of HALEU is a separate problem from providing fuel for conventional reactors, and it will take several years to complete building the infrastructure, it represents a rejuvenation of the industry. The new generation of US enrichment is reliant on state-of-the art centrifuge technology, and is counting on sustained US government support to resolve the infamous “chicken and egg” problem whereby Generation IV reactors won’t be built unless fuel is securely available, but fuel capacity won’t be developed unless producers are confident of demand.

But Rosatom poses a problem beyond nuclear fuel supply. In addition to its substantial role in the U.S. and European nuclear energy sectors, Rosatom has a dramatic portfolio of nuclear power projects around the world. Currently involved in about half of the 53 active nuclear power plant constructions taking place globally,²⁰ Rosatom’s largest investments and projects include one in Egypt valued at \$30 billion, and the \$20 billion Akkuyu project in Turkey, which is scheduled to begin producing power this year.²¹ In the case of Turkey, Rosatom applied (for the first time) a build-own-operate model, which will entitle it to remain the majority owner of

¹⁷ See a history of the program, Centrus Website, “Megatons to Megawatts,” <https://www.centrusenergy.com/who-we-are/history/megatons-to-megawatts/#:~:text=The%20Megatons%20to%20Megawatts%E2%84%A2,for%20American%20nuclear%20power%20plants>.

¹⁸ SWU - Separative Work Units, is a measure of enrichment services. For details of US SWU capacity, see Paul Day, “US ramps up advanced fuel production capabilities,” *Reuters*, February 16, 2023. <https://www.reuters.com/business/energy/us-ramps-up-advanced-fuel-production-capabilities-2023-02-16/>

¹⁹ The facility was the Honeywell Metropolis Works Facility, marketed by ConverDyn. The facility has received an extension of its operating license as of 2021. See WNN Staff, “US conversion plant gears up for next 40 years,” *World Nuclear News* 14 April 2021, <https://www.world-nuclear-news.org/Articles/US-conversion-plant-gears-up-for-next-40-years>

²⁰ Jane Nakano, “The Changing Geopolitics of Nuclear Energy: A look at the United States, Russia, and China” CSIS 2020, page 6.

²¹ Szulecki and Overland, page 414.

the 4-reactor complex with a guaranteed price on electricity sales. The model was attractive to Turkey because Rosatom bore all the risks in finance, construction and operation. The model is particularly concerning to other NATO members because, although Turkey retains the regulatory rights, Russia will manage the facility, is entitled to provide physical security to the facility, and is training an entire generation of plant operators.

Rosatom’s Competitive Edge: Rise and Fall

Rosatom’s dramatic success in developing markets results from a recent history of consolidation and success that was difficult to predict 15 years ago. In 2011, the future of nuclear energy looked rather grim. The disaster at Fukushima dampened demand for fuel and for nuclear power. The US-Russia “Megatons to Megawatts” program was winding down, but over its lifetime had converted 500 metric tons of highly enriched uranium to low-enriched uranium, and had thereby served to flood the uranium market, so non-Russian producers (especially America) were struggling. In that same time period, Rosatom – established in 2007 as a company fully owned by the Russian state - was first beginning to experience success. Rosatom’s Director, Sergei Kirienko had been appointed to head the ailing Russian nuclear power agency with the mandate to reorganize the industry.

During his eleven-year leadership of Rosatom, Kirienko – who is a businessman rather than a nuclear engineer – transformed the sector. He established a vertically and horizontally integrated state corporation, administratively separated nuclear power from nuclear weapons, and committed to making the civilian arm of the company pay for itself without government handouts. Realizing that Russia’s demand for nuclear electricity was unlikely to grow rapidly, and that the only growth market for nuclear power was the developing world, Kirienko set out to design a “full-service package,” that would enable Rosatom to offer finance, fueling and services in addition to construction of reactors. This gave Rosatom a significant economic and commercial advantage.²²

The fact that Rosatom could provide a one-stop shop for construction, fuel, training, maintenance, decommissioning, spent fuel reprocessing and regulatory support in addition to generous finance packages, made it especially appealing to nations pursuing their first nuclear power plant.²³ Rosatom also sought to be a reliable and relatively transparent player, pursuing heightened cooperation with the IAEA to improve its reputation. -But the export-led model also constitutes a vulnerability. Kirienko was able to approach cost recovery of the civilian nuclear side of Rosatom because he could secure favorable construction contracts and generous state-backed loans to customers. But over time Rosatom lost its privileged status. In in 2016, the Russian Deputy Finance Minister announced a budget-cutting decision to suspend loans to foreign countries, (explicitly including nuclear construction).²⁴ Use of the National Wealth Fund to underwrite nuclear projects abroad ceased, changing the math for Rosatom.

²² For a discussion of Rosatom’s history, see Thane Gustafson, “The Revival of Russian Nuclear Power,” Chapter 6 in *Klimat: Russia in the Age of Climate Change*, Harvard University Press, 2021. Pages 131-152.

²³ Nakano, page 14

²⁴ Nakano, page 27

As Russia pulled back from its global financial packages, a new competitor, China, emerged, prepared to take the lead through its colossal infrastructure investments. While China still lags in international nuclear construction, and remains constrained both by its inability to accept spent fuel and its less-developed relationship with the IAEA,²⁵ it has a long-term advantage. Unlike Russia, the Chinese nuclear power sector is growing at a rate that makes economies of scale possible without exports, and China is leading in Small Modular Reactors. Russia's declining reputation in the world, as well as diminished government support for Rosatom's projects abroad, may point towards the ascendance of the China National Nuclear Corporation (CNNC) over Rosatom.

Safety and Security Concerns

If Rosatom is not yet clearly in decline, Russia's reputation in nuclear energy is. Criticisms of Rosatom are justified, as it has engaged in what has been described as “nuclear piracy.”²⁶ But there is one incontrovertible argument against sanctions: through its sustained collaboration with the IAEA, Rosatom plays an essential role in keeping Russian nuclear engagement—and the world—safer.

First, Rosatom continues to engage with — and listen to — IAEA officials. Rosatom's Director-General Alexey Likhachev — who would certainly be a candidate for individual sanctions - met with IAEA Director General Rafael Grossi six times between March 2022 and April 2023. Although Grossi was regularly frustrated by the fragile situation at the Zaporizhzhya NPP facility, he repeatedly noted how much he valued the opportunity to negotiate directly with Rosatom's leadership. Rosatom has responded to some IAEA safety concerns at Zaporizhzhya, bringing in 9 mobile diesel fuel boilers to supplement the existing 20 diesel backup generators, and completing a Russian-built structure to protect key facilities from shelling.²⁷ As a result of negotiations through the IAEA, Russia has also complied with the Ukrainian demand that the facility not be used to generate electricity, a measure that both enhances safety and reduces the gains to Russia of occupying the facility.

Second, using sanctions to isolate Rosatom from the international community of nuclear operators is bad for global safety and security. We need look no further than the example of the tragedy of Chernobyl, which was magnified by the isolation of the Soviet Union's nuclear energy cadre. Following the collapse of the Soviet Union, the World Association of Nuclear Power Operators and other professional agencies made it a high priority to better integrate post-Soviet plant operators and leaders into the professional nuclear power community to raise standards and promote a culture of safety.

²⁵ China is not a member of the IAEA Vienna Convention on Civil Liability for nuclear Damage, but is dramatically increasing its cooperation with the IAEA. See WNN, “IAEA strengthens cooperation with China,” World Nuclear News, 23 May 2023, <https://www.world-nuclear-news.org/Articles/IAEA-strengthens-cooperation-with-China>

²⁶ Ali Alkis and Bethany Goldblum, “Lessons from Zaporizhzhia: How to protect reactors against ‘nuclear piracy,’” *Bulletin of the Atomic Scientists*, September 20, 2023 <https://thebulletin.org/2023/09/lessons-from-zaporizhzhia-how-to-protect-reactors-against-nuclear-piracy/#post-heading>

²⁷ Charles Digges, “Rosatom's role in the war in Ukraine,” Bellona Working Paper 2023, Bellona Foundation, Vilnius, p. 15

Finally, imposing sanctions on Rosatom could reduce its willingness to collaborate on the development of higher technical and safety standards in global nuclear power. Following the collapse of the Soviet Union, the international nuclear community had an opportunity to view – and to begin to mitigate – the disastrous lack of safety culture in the Soviet nuclear industry. Russia is a member of the IAEA Vienna Convention on Civil Liability for Nuclear Damage precisely because it was a prerequisite for international assistance to its poorly-maintained reactors in the 1990s. Rosatom has also been a partner of the Nuclear Energy Agency of the OECD since 2013, in recognition of its outsized role in provision of nuclear electricity in OECD states. Especially in a world in which an accident or incident anywhere affects confidence in nuclear power everywhere, keeping Rosatom – and Russia – tightly engaged in the community of nuclear professionals is a nuclear safety imperative.

The Way Forward—Managed Competition

Sanctions on Rosatom would do more harm than good. To limit Rosatom’s reach without creating market instability or providing Russia easy opportunities to manipulate shortages, it is time to bring in new players with untapped capacity to leverage innovation and public-private partnerships, to support capacity-building in states that seek nuclear power but do not have it, to include national security considerations in development of the sector at home, and to regain a leadership role in the world for US and Western nuclear energy technology.

France’s efforts to bring Kazakhstan’s large reserves of uranium directly to Western markets without routing the material through Russia, and its efforts to develop new uranium mines in Central Asia, is an important example of recent cooperation.²⁸ Westinghouse’s leadership in the APIS effort to speed transition to European sources for Russian-designed reactors is another. US support of a domestic industry to produce HALEU is yet another.

Rosatom is sometimes a company seeking profit, and sometimes a tool of the Russian state. In either case, it is better moderated within the IAEA than outside it. Reducing Rosatom’s relative role in world nuclear energy production is a goal that can be best accomplished by expanding the field of viable, competent nuclear producers. With China rising in the sector, the discipline of managed competition will serve us well for the next contest over the future of nuclear energy.

²⁸ The French nuclear company, Orano, has been operating mines in Kazakhstan since 2006. The uranium had been sent through Russia for processing, but in recent months Kazakhstan has proven that it can use the Middle Corridor to transport uranium directly to Europe and Canada. An EU consortium has recently committed 10 billion euros to strengthen the Middle Corridor for expanded exports of materials, including nuclear materials. See Toghrul Ali, “French Connection: Macron’s Nuclear Deals in Central Asia,” Caspian Policy Center, November 17, 2023 <https://www.caspianpolicy.org/research/energy-and-economy-program-cep/french-connection-macrons-nuclear-deals-in-central-asia>