NUCLEAR MATERIAL MANAGEMENT TRENDS: PAST AND FUTURE

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The purpose of the amended Convention on the Physical Protection of Nuclear Material (CPPNM),[1] adopted in 2005, is to "achieve and maintain worldwide effective physical protection" of nuclear material and facilities used for peaceful purposes.[2] The convention's text implicitly recognizes that nuclear security is a dynamic field by including a provision that allows for a review of the convention "in the light of the then prevailing situation" not less than every five years should the majority of states parties so request.[3] As the first review of the amended CPPNM approaches, it is important for the international community to reflect on how trends in quantities, locations, and uses of nuclear material have changed since 2005, and how that then influences states parties' interpretation and implementation of the convention. States parties should also consider how future trends create the imperative to regularly review implementation of the convention.

The number of states with weapons-usable nuclear materials (highly enriched uranium and plutonium) has declined by half. However, global amounts of those materials have remained largely static and, in some states, quantities have actually increased. As climate change and a focus on sustainable development in the developing world drive interest in nuclear energy, and as novel opportunities for energy generation are developed through advanced nuclear reactors, a future in which nuclear materials are used by more actors is increasingly plausible.

This kind of future will pose new challenges and opportunities for nuclear security, but they are not unmanageable if states have a forum in which to regularly exchange views on how they are approaching them. While these kinds of discussion occur at the International Atomic Energy Agency, the review process for the amended CPPNM provides a unique forum to discuss mutual legal obligations rather than simply voluntary commitments and can be an important forum in which to address these challenges and opportunities. The international community should use the opportunity afforded by the amended CPPNM's regular review conference provision to its fullest extent.

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[1] When referring to the original, unamended convention, "CPPNM" or "original CPPNM" will be used. The document adopted in 2005 to amend the original CPPNM will be referred to as "the Amendment." The amended version of the convention, which entered into force in 2016 and is binding on states that have ratified the Amendment, will be referred to as "the amended CPPNM." When referring to the treaty regime as a whole, which encompasses both the original CPPNM and amended CPPNM, "CPPNM regime" will be used.

[2] "Nuclear Security – Measures to Protect Against Nuclear Terrorism: Amendment to the Convention on the Physical Protection of Nuclear Material", *International Atomic Energy Agency (IAEA),* GOV/INF/2005/10-GC(49)/INF/6 (CPPNM Amendment), September 6, 2005, Article 1A, at https://www.iaea.org/About/Policy/GC/GC49/Documents/gc49inf-6.pdf.

[3] Ibid., Article 16

I. Current nuclear materials holdings and use

A review of the number of countries with weapons-usable nuclear materials, the quantities of those materials, and of nuclear energy production in 2005 versus today demonstrates how predictions and trends can change.

In 2005, there was significant concern about the quantity of weapons-usable nuclear materials around with world, with over 40 states possessing one kilogram or more of highly enriched uranium (HEU) or plutonium.[4] The global stockpile of HEU totaled approximately 1,725 tons, and the global stockpile of separated plutonium was approximately 500 tons.[5]

This concern led to a global push to reduce, and where possible, eliminate weapons-usable nuclear materials. These efforts were largely effective, as demonstrated by the success of efforts like the U.S. Department of Energy's National Nuclear Security Administration's reactor conversion, material reduction, and physical protection assistance programs. HEU minimization efforts have been very successful, but that success means opportunities for complete removals of HEU from additional states are limited. Today, the number of states with weapons-usable nuclear material is down to 22 countries. Notably, of these 22 countries, nine have nuclear weapons programs and most others face significant technical or political challenges to eliminating their remaining materials stocks.

Meanwhile, reductions in global stocks of weapons-usable nuclear materials have plateaued. The International Panel on Fissile Materials has estimated there are approximately 1,340 tons of HEU in these 22 countries. This quantity has been steadily shrinking since the mid-1990s, primarily due to the end of new production of weapons materials by the P-5 countries, and to reductions in Russian and U.S. holdings of excess nuclear weapons material. That trend has leveled out in recent years[6] and Russia has begun producing HEU for export to civilian research reactors.[7]

The story of plutonium is less optimistic, as the lack of progress on plutonium disposal has been disappointing. Approximately 520 tons of separated plutonium exist in the United States, Russia, Japan,

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[4] There are currently 22 countries possessing one kilogram or more of weapons-usable nuclear materials. The following 21 countries plus Taiwan that previously possessed one kilogram or more of weapons-usable nuclear materials have removed all materials since 2005: Greece (2005), Republic of Korea (2007), Bulgaria (2008), Latvia (2008), Portugal (2008), Libya (2009), Romania (2009), Taiwan (2009), Chile (2010), Serbia (2010), Turkey (2010), Austria (2012), Mexico (2012), Sweden (2012), Ukraine (2012), Czech Republic (2013), Vietnam (2013), Hungary (2013), Uzbekistan (2015), Argentina (2016), Indonesia (2016), Poland (2016). See "Civilian HEU Reduction and Elimination Database," NTI, at https://www.nti.org/analysis/reports/civilian-heu-reduction-and-elimination/; "Global Fissile Material Report 2015," IPFM, 2015, at http://fissilematerials.org/library/gfmr15.pdf. Jamaica, which already had less than one kilogram of HEU, removed all of its HEU in 2015. See "NTI Nuclear Security Index: Building a Framework for Assurance, Accountability, and Action," NTI, January 2016, p. 34, fn 8, at https://ntiindex.org/wp-content/uploads/2016/02/NTI_2016-Index_021116.pdf.

[5] "Global Fissile Material Report 2006." International Panel on Fissile Materials, September 1, 2006. http://fissilematerials.org/publications/2006/09/global_fissile_mater_2.html.

[6] "Global Fissile Material Report 2015." International Panel on Fissile Materials, December 21, 2015. http://fissilematerials.org/blog/2015/12/ipfm_releases_gfmr2015.html

[7] "Production of New Highly Enriched Uranium in Russia for the FRM-II in Germany." IPFM Blog, November 8, 2017. http://fissilematerials.org/blog/2017/11/production_of_new_highly_.html.

France, and the United Kingdom, which is an increase of 20 tons from 2005.[8] This figure is expected to continue to grow as some countries increase plutonium production related to weapons programs, and others continue to separate plutonium for spent fuel management purposes. The need to secure plutonium will continue for many years, even as states begin to implement plutonium disposition processes, such as dilution and underground disposal, and plutonium production from used reactor fuel continues to outpace its reuse.

The outlook on nuclear facilities has also been mixed. In 2005, there was general optimism about the future of nuclear energy. In 2005, 440 nuclear power plants were in operation worldwide and 24 units were under construction.[9] Observers anticipated growth in nuclear power generation, and there were discussions about a "nuclear renaissance." While the number of nuclear power plants has increased since 2005, it has done so only slightly. There are currently 447 operational civil nuclear power reactors in 30 countries around the world, with a further 52 plants under construction.[10] In addition to power reactors, 236 research reactors are operational, and an additional 23 are planned.[11] Finally, thirteen countries operate uranium enrichment facilities while five operate civilian reprocessing facilities that separate plutonium from spent fuel.[12]

While the number of countries with, and the total quantity of, weapons-usable nuclear material has clearly decreased, and the number of nuclear power plants has not increased as much as previously anticipated, it is still clear that nuclear materials will continue to be transported, handled, processed, and stored for the foreseeable future.

II. Challenges and opportunities for the future

Both challenges and opportunities appear on the horizon for nuclear security. One potential new trend would be an increase in global quantities of nuclear material that will require more security rather than less. Increased demand both for traditional low enriched uranium (LEU) fuel, and for new kinds of nuclear fuel, will require additional transportation of nuclear material, and may put pressure on the existing norm against the spread of enrichment technology. Several advanced reactors being developed around the world are planned to be fueled with LEU in the 5-20% range, leading to an increased demand for high-assay LEU, which is not yet commercially produced. Licensed high-density LEU fuel to replace HEU in some research reactors remains elusive, leading to continued demand for HEU. Russia's renewed production of HEU encourages those states still using HEU in their reactors to keep using them, and

[8] "International Panel on Fissile Materials." International Panel on Fissile Materials, February 12, 2018. http://fissilematerials.org/.
[9] Annex I. Accessed February 7, 2020. https://www-pub.iaea.org/MTCD/Publications/PDF/cnpp2007/pages/AnnexI/AnnexI.htm.
[10] IAEA Power Reactor Information System, 2020. https://pris.iaea.org/PRIS/WorldStatistics/OperationalReactorsByCountry.aspx
[11] IAEA. RRDB Search. Accessed February 7, 2020. https://nucleus.iaea.org/RRDB/RR/ReactorSearch.aspx?filter=0.
[12] "International Panel on Fissile Materials." International Panel on Fissile Materials, February 12, 2018. http://fissilematerials.org/.

attempts to undermine the norm against building new HEU-based research reactors may increase their numbers.

The development of advanced nuclear reactors creates an opportunity to incorporate security considerations during the design phase of these reactors, and of the new fuel cycle facilities that will be required to support them. These reactors range in size from residential generators to megawatt-scale, and are being designed to be safer, cheaper, and more flexible than current models. They also use different kinds of fuel, and many are designed to be located underground. Because they differ from the well understood light-water model around which current security concepts are designed, security experts need to be involved now to understand and guide these new designs and the new fuel cycle facilities they will need. Similarly, the security aspects of decommissioning reactors and fuel cycle facilities will become more pressing with the anticipated shutdown of dozens of reactors in the coming decades.

All of these developments warrant a shift in perspective from threat reduction to risk management. Approaches to nuclear security will need to evolve, moving from a view of material reduction as the solution to nuclear security to a focus on long-term sustainable stewardship of nuclear materials, including capacity building, training and education, and strengthened security culture. This will require engagement with regulators and discussions about regulations; development and sharing of good practices; fostering responsibility among operators for nuclear security; incorporating security by design into new reactors; strengthening of international treaties, institutions, and norms; and engagement of national champions around the world. More forums in which countries can discuss how they are managing these evolutions will be vital to sustainable risk management.

III. Role of CPPNM Amendment review conferences in managing nuclear material

In the face of these changes, the global nuclear security architecture should be ready to respond to these challenges in order to maintain rigorous nuclear security standards. The amended CPPNM, including its review process, should become a foundational component of that architecture. This is why it is important to use the opportunity of the 2021 Review Conference to establish the will of member states to hold future review conferences, as envisioned in Article 16 of the amended Convention.

The amended CPPNM review process provides a unique opportunity to address the ongoing challenges of securing nuclear material. As the only legally binding treaty for nuclear security, the amended CPPNM is a cornerstone of the international nuclear security architecture. The wisdom of the drafters in calling for the review of the convention to take place “in the light of the then prevailing situation” and the option to do so at intervals of not less than five years enables the convention to keep up with the evolving nuclear landscape without requiring further amendments. Unlike IAEA meetings or conferences, reviews of the amended CPPNM have a legal mandate that affords a consistency and longevity that other venues lack.

Considering the changes in nuclear material holdings and nuclear facilities between 2005 and now, as well as predictions about future trends, it is clear there is a need for sustained focus on nuclear security and a readiness to adapt. The international community can support efforts to maintain a high level of nuclear security around the world by using the review conference to engage in dialogue about best practices. In fact, doing so is encouraged by Articles 5.4 and 5.5 of the amended convention, which call for cooperation and consultation between parties and the IAEA to obtain guidance "on the design, maintenance and improvement of systems of physical protection" of nuclear material and nuclear facilities.

Regular review conferences provide opportunities to routinely take a holistic view of states' nuclear security practices, the role of the IAEA's nuclear security guidance, and other important topics, all with a view to assessing the effectiveness of the convention's implementation and how states are adapting to "the then prevailing situation." Regular review conferences can also provide a venue to look ahead to potential challenges and new opportunities for nuclear security and to proactively identify strategies to keep up with the changing needs and realities of the world.

IV. Conclusion

The trends in nuclear materials, facilities, and use outlined above clearly demonstrate that states have had to adapt and must continue to adapt their nuclear security practices to change. States that continue to possess nuclear material will need to consider how to manage that material so that it remains secure in the long term and in an evolving world. In the lead up to the first review of the amended CPPNM, states should consider how to make the most of the opportunity before them to work together to accomplish the central goal of improving national and operational capacities for, commitment to, and implementation of long-term stewardship of nuclear materials, and to acknowledge there will be a need to continuously adapt together to reflect new and unpredictable trends. There is much work still to be done, but this opportunity to strengthen the international nuclear security architecture is too important to miss.