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Governance of nuclear energy in outer space

*by Alexander Q. Gilbert**

I. Introduction

Space nuclear energy is on the verge of a renaissance.

Until recently, only the former Union of Soviet Socialist Republics (Soviet Union), the Russian Federation (Russia),[1] and the United States had launched space nuclear power systems (SNPS), with the last fission reactors launched during the Cold War and modern nuclear activities in space limited to the use of radioisotope power systems (RPS).[2] However, in the last decade, both the People's Republic of China (China) and India have launched RPS-powered missions as part of their lunar exploration goals.[3] Multiple states, including France, Korea and the United Kingdom are developing RPS.[4] Many countries are also developing space fission reactors.[5] As soon as 2028, the United States (US) Department of Defense (DOD) and National Aeronautics and Space Administration (NASA) may launch the first nuclear rocket into space, marking the first modern launch of a space reactor.[6] Beyond state ambitions, there is also a large and growing commercial interest in developing and flying SNPS for various exploration and commercial objectives.

Also fuelling renewed interest in space nuclear energy, the falling cost of space access is driving a global push to develop a sustained lunar surface presence for scientific and economic purposes.[7] Nuclear energy is uniquely suited to power interplanetary transportation, robotic and crewed exploration, and space mining. This is especially true on the Moon, where nuclear power sources can enable spacecraft to survive the lunar night, operate in shadowed craters and power high-energy applications like *in-situ* resource utilisation or crewed habitats. There have been 84 known missions utilising SNPS, some of which powered the most ambitious missions in space history, including Lunokhod, Apollo

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1. Although Russia is the successor nation to the Soviet Union, they are treated as separate countries for the purposes of this article and care has been taken to provide correct attribution where a clear delineation can be made.
2. Gilbert, A.Q. (forthcoming), "Nuclear for Space Propulsion and Surface Power", in Foss, A. and N. Stauff (eds.), *New Directions in Nuclear Energy: Innovation and Opportunities in Fission and Fusion for Global Decarbonization*, Woodhead Publishing, Cambridge, publication expected in 2025.
3. *Ibid*.
4. International Space Exploration Coordination Group (ISECG) (2023), *Report of the Nuclear Power and Propulsion Gap Assessment Team*, Version 2.1, ISECG, available at: www.globalspace exploration.org/wordpress/wp-content/isecg/NPP_GAT_report_July%2027%202023a.pdf.
5. *Ibid*.
6. NASA, Press Release, "NASA, DARPA Will Test Nuclear Engine for Future Mars Missions", NASA News Release, (24 Jan. 2023).
7. Gilbert, A.Q. (forthcoming), *supra* note 2.

and Chang'e.[8] Novel SNPS technologies offer mission planners heat, electricity and propulsion for the new era of lunar and deep-space exploration.

National and international governance of space nuclear technologies is critical to promote safe and secure applications yet is underdeveloped compared to other areas of space and nuclear law. In 2019, the United States initiated a major effort to reform its approach to space nuclear regulation with the issuance of National Security Presidential Memorandum-20 (NSPM-20).[9] Although international and national approaches such as NSPM-20 provide a basic framework, new policies and norms are needed to ensure safe, sustainable use of SNPS generally, and space fission reactors particularly. The first-time involvement of commercial actors in the development and use of SNPS calls for a new governance paradigm.[10] To date, all missions have been done by governments and for governments – the emergence of new space companies offering commercial SNPS provides an impetus to clarify and formalise space nuclear governance. Further complicating matters, governments are turning to commercial launch providers to transport SNPS both into and in space, and national space agencies are courting international partners for SNPS technologies and joint missions.

Major accidents involving SNPS underscore the need for effective governance of nuclear power in the new space age. These accidents have already shaped international space law and international nuclear law. The 1978 crash of the Soviet Union's reactor-powered Cosmos 954 in Canada was the first test of liability elements of space law.[11] The crash was a contributing factor in the development of two conventions on radiological accidents: the Assistance Convention and the Early Notification Convention.[12] More recently, an active communications satellite and a decommissioned Soviet reactor in a disposal orbit collided in 2009, the first ever collision between two satellites and a major factor aggravating space debris risks in Earth's orbit.[13]

Previously published articles on the subject of nuclear in space evaluated safety, legal and other issues related to the use of nuclear power in space, generally noting the lack of a dedicated governance framework.[14] Many were based on issues that emerged in the 1980s from the operations of space reactors launched by the Soviet Union and nearly all such analyses pre-date the modern space sector, including the addition of new states with

8. Wiley, J. and A.Q. Gilbert (2023), "Coming in Hot? A Retrospective Review of Nuclear Spacecraft End-of-Life Strategies", *Transactions of the American Nuclear* Society, Vol. 129, No. 1, American Nuclear Society, Westmont, Illinois, pp. 31-32.
9. *Presidential Memorandum on Launch of Spacecraft Containing Space Nuclear Systems*, NSPM-20, (20 Aug. 2019).
10. Locke, J.W. and B. Lal (2020), "Emergence of a Commercial Space Nuclear Enterprise", *Nuclear Technology*, Vol. 206, No. 8, American Nuclear Society, Westmont, Illinois, pp. 1109-1119.
11. Dembling, P.G. (1978), "Cosmos 954 and the Space Treaties", *Journal of Space Law*, Vol. 6, No. 2, University of Mississippi School of Law, University, Mississippi, p. 129.
12. Harvey, S. (2020), "Ensuring Safety on Earth from Nuclear Sources in Space", International Atomic Energy Agency (IAEA), www.iaea.org/newscenter/news/ensuring-safety-on-earth-from-nuclear-sources-in-space. See also Convention on Early Notification of a Nuclear Accident (1986), IAEA Doc. INFCIRC/335, 1439 UNTS 276, entered into force 27 Oct. 1986 (Early Notification Convention); Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (1986), IAEA Doc. INFCIRC/336, 1457 UNTS 134, entered into force 26 Feb. 1987 (Assistance Convention).
13. Johnson, N. (2009), "The Collision of Iridium 33 and Cosmos 2251: The Shape of Things to Come", presented at the 60th International Astronautical Congress, Seoul, Korea, 16-19 October 2009, NASA Johnson Space Center, Report No. JSC-CN-18971.
14. Barco, A. et al. (2020), "Radioisotope Power Systems in Space Missions: Overview of the Safety Aspects and Recommendations for the European Safety Case", *Journal of Space Safety Engineering*, Vol. 7, No. 2, International Association for the Advancement of Space Safety (IAASS), Noordwijk, Netherlands, pp. 137-149; Qizhi, H. (1986), "Towards a New Legal Regime for the Use of Nuclear Power Sources in Outer Space", *Journal of Space Law*, Vol. 14, p. 95, University of Mississippi School of Law, University, Mississippi; Voegeli, N. (2007), "Space Nuclear Reactors: History and Emerging Policy Issues", *The Nonproliferation Review*, Vol. 14, No. 1, James Martin Center for Nonproliferation Studies, Monterey, California, pp. 163-175.

SNPS capability, near-term plans to launch fission reactors, and the recent commercial plans to design, build and operate SNPS.[15] Today, the nuclear and space industries are both heavily-regulated, modern industries. Governments consider both sectors strategic priorities, play a large role in funding technological development and commercialisation, and have national activities largely driven by international norms of governance.[16]

This article expands on previous analyses by evaluating the potential implications of the recent increase in space capabilities, with a particular focus on issues related to commercial nuclear-powered missions and the exploration of celestial bodies. This analysis encompasses elements of international space law, nuclear law and space nuclear guidance. Finally, this article looks to governance of SNPS by the European Union, Russia, China and the United States, analysing recent legal and regulatory developments that facilitate first-time commercial utilisation.

II. Nuclear energy technologies for space missions

Energy is one of the primary constraints when planning space missions.[17] Electricity is needed to power instruments, computers and communications; heat is needed for thermal management; and propulsion is needed to move spacecraft considerable distances. Mission planners must make energy decisions taking into account the volume and mass constraints of launching vehicles and spacecraft. To meet these energy needs, there are currently three types of power sources available: chemical, solar and nuclear.[18]

Chemical energy in the form of hydrocarbons is most useful for propulsion, enabling launch vehicles to break free from Earth's gravity. However, the lack of ready resupply in space means that hydrocarbons or chemical fuel cells are only useful for very short durations as a mass of large fuel supplies is prohibitive. In their absence, solar is the power source of choice for most space missions. Most crewed and robotic space activities occur in Earth orbits, where abundant sunlight makes solar power the default and ubiquitous power source.[19] Given Earth's distance to the sun, Earth orbits receive a significant amount of solar energy and eclipses by Earth's shadow are of relatively short duration (usually approximately 45 minutes or less). Batteries and thermal management can readily handle this. Missions heading to deep space, the areas beyond Earth's orbit such as the Moon or other planets, can also rely on solar in certain situations. When orbiting or flying by a celestial body in the inner solar system, there is enough sunlight for solar to work, albeit requiring panels with large surface areas and careful orientation towards the sun. However, solar radiance drops off with the square of distance, so solar power becomes

15. See e.g. Young, A.J. (1986), "Legal and Techno-Political Implications of the Use of Nuclear Power Sources in Outer Space", *The Rutgers Computer & Technology Law Journal*, Vol. 12, Rutgers University, New Brunswick, Connecticut, p. 305 (discussing the social and techno-political implications of expanded SNPS); Aftergood, S. (1989), "Towards a Ban on Nuclear Power in Earth Orbit", *Space Policy*, Vol. 5, No. 1, London School of Economics and Political Science, London, pp. 25-40 (proposing a ban on the use of space reactors due to dangers of space debris); Tan, D. (2000), "Towards a New Regime for the Protection of Outer Space as the 'Province of All Mankind'", *Yale Journal of International Law*, Vol. 25, p. 145 (noting that little progress had been made to establish international governance of SNPS); MacAvoy, J.J. (2004), "Nuclear Space and the Earth Environment: The Benefits, Dangers, and Legality of Nuclear Power and Propulsion in Outer Space", *William & Mary Environmental Law and Policy Review,* Vol. 29, No. 1, pp. 191-233 (describing the limited legal barriers in international law to SNPS).
16. Lovering, J., L. King and T. Nordhaus (2017), "Commercial Spaceflight: Case Study No. 1 in How to Make Nuclear Innovative", The Breakthrough Institute, www.thebreakthrough.org/articles/commercial-spaceflight-case-study.
17. Wertz, J.R. et al. (eds.) (2011), *Space Mission Engineering: The New SMAD,* Space Technology Library, Vol. 28, Microcosm Press, Hawthorne, California, pp. 47, 641.
18. *Ibid.,* pp. 48-49, 527, 641-642, 659.
19. Wiley, J. and A.Q. Gilbert (2023), *supra* note 8.

increasingly difficult at and beyond Mars.[20] Further, celestial bodies can produce complex shadow environments that make solar power inconsistent or even unreliable in orbit or on the surface. For example, the European Space Agency's (ESA's) Philae lander ended its mission to a comet's surface because a poor landing prevented ideal solar orientation, undermining power generation on the spacecraft.[21] Accordingly, spacecraft heading to deep space often rely on nuclear power options.

Nuclear power offers unique advantages for deep-space missions, as well as for specialised applications in Earth orbits.[22] SNPS provides consistent, high-density power, independent of solar energy availability. These traits make nuclear energy attractive for missions to the outer planets, for long-term operations on planetary surfaces, and for high-energy applications such as mining and *in-situ* resource utilisation (ISRU). From a system volume and mass perspective, SNPS can outperform comparable solar and chemical energy sources for many deep-space applications.[23]

However, nuclear power has trade-offs for space applications. Radioactive decay and fission rely on radioactive materials that are either rare in nature or manmade. All nuclear power types pose radiological risks to mission equipment, personnel and the space environment, requiring shielding, operational procedures and regulatory oversight.[24] Further, heat production from nuclear power requires thermal management to shed excess heat in space environments and SNPS may require special waste storage or decommissioning.

To better understand available nuclear technologies and their applications for SNPS, the following sections look at the primary types of SNPS, design considerations and mission histories, identify SNPS capabilities, evaluate the new phenomenon of commercial SNPS developers, and assess the potential for nuclear supply chains in space through space resource extraction.

1. Nuclear energy technologies for space missions

SNPS is a broad umbrella term covering a wide range of nuclear technologies for space applications, including RPS, fission reactors (both surface and orbital), nuclear rockets and, eventually, nuclear fusion.[25] Importantly, the term includes not just power applications but also heat applications.

RPS are the smallest type of SNPS.[26] The predictable natural decay of certain radioactive materials produces small quantities of heat for decades or even longer. Such materials can be packaged into heat sources, which provide containment and thermal output. This heat can work directly in a radioisotope heater unit (RHU), contributing to a spacecraft's thermal management system to enable operations in extreme cold temperatures.[27] Small amounts of electricity can also be produced by adding power conversion to a radioisotope heat source. Radioisotope thermoelectric generators (RTGs) are the historical backbone of RPS, providing tens to hundreds of watts electric with solid state conversion at a relatively low efficiency (approximately 5%). Stirling radioisotope

20. Levine, J.S., D.R. Kraemer and W.R. Kuhn (1977), "Solar Radiation Incident on Mars and the Outer Planets: Latitudinal, Seasonal, and Atmospheric Effects", *Icarus*, Vol. 31, No. 1, Elsevier, Amsterdam, pp. 136-145.
21. ESA (2016), "Philae Found!" European Space Agency: Science & Exploration, www.esa.int/Science_Exploration/Space_Science/Rosetta/Philae_found.
22. Gilbert, A.Q. (forthcoming), *supra* note 2.
23. *Ibid*.
24. *Ibid*.
25. *Ibid*.
26. *Ibid*.
27. Rinehart, G.H. (1997), "Light Weight Radioisotope Heater Unit (LWRHU) Production for the Cassini Mission", American Institute of Physics (AIP) Conference Proceedings, Vol. 387, No. 1, pp. 1375-1380.

generators have been the subject of significant space agency research as they can reach higher conversion efficiencies and thus power output for a given amount of radioisotope.[28]

Historically, RPS-powered spacecraft compose approximately half of all SNPS missions, including all missions beyond Earth's orbit.[29] Most missions have used RTGs or RTGs augmented by RHUs, but some have solely used RHUs. While there are several candidate radioisotope fuels for an RPS unit, the primary radioisotope of choice, historically, is plutonium-238 (Pu-238), due to its high-power density, long half-life, and relatively low gamma and neutron radiation, providing it with a high specific power (watts electric per kilogram).[30] The only other radioisotope that flew historically was polonium-210, which supported several Soviet lunar landers as an RHU. While Pu-238 has been the standard fuel for decades, recent research has expanded to explore alternative radioisotopes.[31] Such radioisotopes, including americium-241 (Am-241), strontium-90 (Sr-90), tritium (H-3) and cobalt-60 (Co-60), lack the specific power of Pu-238 but provide other advantages such as higher availability, lower cost or different half-lives.

The new space era is bringing significant demand for new RPS technologies due to deep-space ambitions. NASA recently conducted a survey of the civil space sector and found that the number one technology shortfall facing the United States was the ability to "survive and operate through lunar night".[32] The two-week long lunar night causes lunar surface temperatures to crash as low as 100 degrees Kelvin, which kills spacecraft. In 2023 and 2024, respectively, India and Japan made history by becoming the fourth and fifth countries to soft-land on the lunar surface. The American company Intuitive Machines became the first private company to accomplish the feat. All three landers died due to the extreme thermal conditions. RPS can provide the basis for landers, rovers and more complicated lunar architectures to survive through the lunar night and perhaps operate in permanently shadowed regions – the location of frozen volatiles like water. More broadly, expanded RPS supply can support more frequent and a wider variety of deep-space science missions.[33]

Fission power reactors have constituted about half of all SNPS missions and were primarily flown by the Soviet Union for military purposes during the Cold War. Like their terrestrial cousins, space reactors harness nuclear fission to create heat, which is then converted into electricity. Unlike terrestrial reactors, however, space reactors are generally small.[34] Historical systems produced up to five kilowatts-electric and utilised only highly enriched uranium (HEU). Modern systems range from ten kilowatts-electric to one megawatt-electric and include designs using either HEU or high-assay low enriched uranium (HALEU). For surface applications, fission reactors provide a steady, high-output power source capable of supporting habitats, resource extraction and scientific operations in extreme lunar or Martian environments where sunlight is inconsistent or unavailable.[35] Although not a primary research focus, such reactors can also provide thermal heat for industrial processes.

28. Wilson, S.D. (2023), "Development of Stirling Convertors for Radioisotope and Fission Power Systems", presented at Nuclear and Emerging Technologies for Space (NETS), Idaho Falls, Idaho, 7-11 May.
29. Wiley, J. and A.Q. Gilbert (2023), *supra* note 8.
30. National Research Council (2009), *Radioisotope Power Systems: An Imperative for Maintaining US Leadership in Space Exploration*, National Academies Press, Washington, DC, p. 43.
31. Gilbert, A.Q. (forthcoming), *supra* note 2.
32. NASA (2024), *Civil Space Shortfall Ranking July 2024*, NASA, Washington, DC, p. 8.
33. Lee, Y.H. et al. (2014), "*Enabling Future Low-Cost Small Spacecraft Mission Concepts Using Small Radioisotope Power Systems*", presented at the International Conference on Space Operations (SpaceOps 2014), Pasadena, CA, 5-9 May.
34. El-Genk, M.S. (2009), "Deployment History and Design Considerations for Space Reactor Power Systems", *Acta Astronautica*, Vol. 64, Nos. 9-10, International Academy of Astronautics, Elsevier, Amsterdam, pp. 833-849.
35. Gilbert, A.Q. (forthcoming), *supra* note 2.

Regarding propulsion, nuclear thermal propulsion (NTP) reactors can directly heat a propellant and expel it, promising greater fuel efficiency and shorter transit times than chemical systems.[36] Nuclear electric propulsion (NEP), alternatively, uses a power reactor combined with an electric engine. Both NTP and NEP are being developed for crewed missions to Mars and beyond.[37] Comparably, fusion power, while still in experimental stages, can provide even more efficient space propulsion due to its potential to generate immense thrust with relatively low fuel mass.

2. State plans for SNPS missions

By 2024, the governments of China, India, Russia, the Soviet Union and the United States had each separately launched SNPS technologies.[38] Each of these countries has or had active space nuclear development programmes and mission plans. Notably, the joint NASA-ESA Ulysses mission was powered by a US-supplied and owned RTG.[39] Interest in developing indigenous SNPS capability has continued to expand, with initial efforts from the ESA, Korean Aerospace Research Institute and Indian Space Research Organisation, primarily focused on radioisotope technology.[40] The current and planned activities of China, Russia and the United States are worth examining in depth, both for their breadth and their fission reactor ambitions.

The United States is the current leader in SNPS technologies, with an active civil space programme supported by Pu-238 RPS and many research and development projects focused on advanced SNPS.[41] Most US flagship space missions have used Pu-238 RPS, including the Apollo missions, Mars rovers and giant planet missions. The US Department of Energy (DOE) and NASA jointly work together to develop, fabricate and utilise Pu-238 for major science missions. At least five such missions are active (in part reflecting the longevity of RPS power): Voyager 1, Voyager 2, New Horizons, Curiosity and Perseverance. The United States plans to launch the RTG-powered quadcopter Dragonfly to explore Saturn's moon Titan for life in the mid-2020s.[42] The country is also providing Pu-238 RHUs as a contribution to ESA's Rosalind Franklin Mars rover. Beyond planned missions, the country is actively bolstering its Pu-238 supply chain and designing a new Pu-238 RTG for missions beginning in the 2030s.

Further, the United States is actively pursuing multiple space reactor technologies, the furthest along being the Demonstration Rocket for Agile Cislunar Operations (DRACO) project, a joint venture between Defense Advanced Research Projects Agency (DARPA) and NASA, which has received more than USD 500 million in cumulative funding.[43] Consisting of a HALEU-fuelled NTP system, DRACO would be the first ever NTP system demonstrated

36. NASA (2023), *Mars Transportation Assessment Study (MTAS)*, NASA, Washington, DC, p. 8.
37. *Ibid.*, p. 8-10.
38. Gilbert, A.Q. (forthcoming), *supra* note 2.
39. ESA (n.d.), "Ulysses Overview", ESA, www.esa.int/Science_Exploration/Space_Science/Ulysses_overview.
40. Gilbert, A.Q. (forthcoming), *supra* note 2.
41. Holmes, L.M. and A.M. Calomino (2022), *NASA Utilization of Space Nuclear Systems for Robotic and Human Exploration Missions: Response to EO 13972: Promoting Small Nuclear Reactors for National Defense and Space Exploration*, Technical Report No. 20210025352, NASA Langley Research Center, Hampton, Virginia.
42. Barnes, J.W. et al. (2021), "Science Goals and Objectives for the Dragonfly Titan Rotorcraft Relocatable Lander", *The Planetary Science Journal*, Vol. 2, No. 4, p. 130.
43. Kaldon, L.K. et al. (2024), "Current Status of NASA"s Fission Surface Power Project", paper presented at the 75th International Astronautical Congress, IAC-24-C3.3.4, International Astronautical Federation, Milan, Italy, 14-18 October; Peakman, A. and B. Lindley (2023), "A Review of Nuclear Electric Fission Space Reactor Technologies for Achieving High-Power Output and Operating with HALEU Fuel", *Progress in Nuclear Energy*, Vol. 163, Elsevier, Amsterdam, p. 104815; Thomas, D. (2024), "Nuclear Thermal Propulsion – Progress and Potential", *Journal of Space Safety Engineering*, Vol. 11, No. 2, IAASS, Noordwijk, Netherlands, pp. 362-373.

in orbit and the first reactor launched in the modern era.[44] NASA is also partnering with the private sector for its Fission Surface Power project, which is designing a reactor to provide at least 40 kilowatts-electric on the lunar surface, nominally to support space mining operations.[45]

The Soviet Union and Russia, its successor country, are the second primary historical SNPS users. The Soviet Union used nuclear fission power on more than 30 satellites launched in the 1960s, 1970s and 1980s.[46] Intended primarily for short-duration weather and military reconnaissance missions, these reactors used thermoelectric or thermionic technology to produce electricity from HEU.[47] Following operation, these Soviet nuclear-powered satellites ejected their reactors (and nuclear material) into high orbits above 700 kilometres, often referred to as "graveyard" orbits.[48] The launch of Soviet reactors and rapid space weapons proliferation during the 1980s briefly prompted concerns about a large increase in space nuclear reactors (SNRs) and led to calls for an international ban, as well as for potential orbital remediation operations.[49] Beyond reactors, two early Soviet navigation satellites, Cosmos 84 and Cosmos 90, may have used RTGs and two lunar landers, Lunokhod-I and Lunokhod-II, utilised RHUs to survive the cold of the long lunar night. In the modern era, Russia has attempted two RPS missions both of which suffered failures and, although there is less publicly available information, the State Atomic Energy Corporation (Rosatom) has worked on a nuclear-reactor powered rocket engine to provide electricity and thrust for deep-space missions.[50]

In the mid-2010s, China entered both the RPS-club and the space-nuclear club, with two lunar missions, Chang'e 3 and Chang'e 4.[51] While there is limited publicly available technical information about these missions, both reportedly used RHUs for their rovers and RTGs for their landers,[52] and the RPS were reportedly powered by Pu-238 provided by Russia.[53] China Aerospace Science and Technology Corporation has indicated that it is researching a nuclear-powered space shuttle, with a breakthrough expected before 2040.[54] More broadly, China is developing space reactors for lunar surface and propulsion applications.

3. The Commercial plans for SNPS missions

The global space sector is on the verge of an unprecedented boom. Economic development, technological proliferation and key innovations, like reusable rocketry, are expanding space access and reducing cost. Commercial revenue for the global space sector totalled USD 445 billion in 2023, 5.4% higher than in 2022, and government expenditures totalled

44. Thomas, D. (2024), *supra* note 43.
45. Kaldon, L.K. et al. (2024), *supra* note 43.
46. Wiley, J. and A.Q. Gilbert (2023), *supra* note 8, p. 32.
47. El-Genk, M.S. (2009), *supra* note 34.
48. Griaznov, G.M. et al. (1992), "Radiation Safety of the Space Nuclear Power Systems and Its Realization on the Satellite Cosmos-1900", in *Space Nuclear Power Systems 1989: Proceedings of the 6th Symposium*, Vol. 2, Albuquerque, New Mexico 8-12 Jan. 1989, pp. 453-456.
49. Johnson, N.L. (1986), "Nuclear Power Supplies in Orbit", *Space Policy*, Vol. 2, No. 3, Elsevier, Amsterdam, pp. 223-233.
50. Hendrickx, B. (2019), "Ekipazh: Russia's Top-Secret Nuclear-Powered Satellite", The Space Review, www.thespacereview.com/article/3809/1.
51. Li, T. et al. (2023), "Comprehensive Modeling and Characterization of Chang'E-4 Radioisotope Thermoelectric Generator for Lunar Mission", *Applied Energy*, Vol. 336, Elsevier, Amsterdam, p. 120865.
52. Ye, P. et al. (2017), "An Overview of the Mission and Technical Characteristics of Chang'e-4 Lunar Probe", *Science China Technological Sciences*, Vol. 60, No. 5, Springer Publishing, New York, pp. 658-667; Peng, W.X. et al. (2014), "Active Particle-induced X-ray Spectrometer for CHANG'E-3 YuTu Rover Mission and its First Results", paper presented at the 45th Lunar and Planetary Science Conference, 17-21 March, Abstract 1699, Lunar and Planetary Institute, Houston.
53. Jones, A., (2019), "China, Russia to cooperate on lunar orbiter, landing missions", SpaceNews, https://spacenews.com/china-russia-to-cooperate-on-lunar-orbiter-landing-missions.
54. Chen, S., "China's Nuclear Spaceships Will Be 'Mining Asteroids and Flying Tourists' as It Aims to Overtake US in Space Race", *South China Morning Post* (17 Nov. 2017).

over USD 125 billion, up 11%.[55] Even with this growth, the commercial space industry remains in its relative infancy. The revenue for the satellite manufacturing and the launch industry, for instance, doubled between 2021 and 2023 and numerous companies are emerging globally to provide launch services.[56] Increasingly, the US government is relying on commercial space companies for launch and other services.[57] NASA has shifted its model from owning spacecraft produced by commercial entities to contracting for services. [58] Several key programmes have helped NASA contractors develop key capabilities, including launch services for International Space Station (ISS) resupply and for human-capable launch craft.[59]

The commercial sector can play a key role in developing space nuclear power technologies for the next generation of space exploration and use. Private companies are developing all classes of space nuclear technologies (e.g. radioisotope, fission, fusion), mirroring the "new space" trend in the space sector of a shift from government-led to commercial-led technology development. Commercial entities are able to lower technology risks while making services available to both governments and the private sector.[60] Over time, commercialisation of space nuclear power systems could reduce costs:

> Based on the cost reductions for rockets developed privately versus those developed by government, it can be assumed that development costs of a commercial space reactor could be anywhere from 10% to 50% of the cost of a government developed space reactor. For a reactor concept like KiloPower this could mean a cost in the 10's of millions instead of 100's of millions.[61]

Potential commercial applications for space nuclear power systems include transportation, orbital towing, space mining, in-space manufacturing and in-space power production (like space-based solar power).[62] Of these, SNPS technologies may be most relevant to support space mining.

Once purely the domain of science fiction, the ability to successfully mine celestial bodies may be a reality within the next few years. The discovery of significant water resources on the Moon, which could be used to produce fuel for in-space refuelling, has the potential to spur a Moon mining rush.[63] Companies such as AstroForge and Karman+ have spent tens of millions of dollars developing technologies to mine asteroids.[64] The nature of space mining operations would require significant amounts of both heat and

55. Space Foundation, Press Release, "Space Foundation Announces $570B Space Economy in 2023, Driven by Steady Private and Public" (18 July 2024).
56. *Ibid*.
57. Hubbard, S. (2013), "The State of New Space", *New Space*, Vol. 1, No. 3, Mary Ann Liebert, Inc. Publishers, New Rochelle, New York, pp. 1-3.
58. Canis, B. (2016), "Commercial Space Industry Launches a New Phase", Congressional Research Service Report R44708, US Congress, Washington, DC.
59. Bowen, M. (2019), "In Search of a SpaceX for Nuclear Energy", Nuclear Innovation Alliance, Washington, DC.
60. Hardin, L.A. (2014), "United States Nuclear Rocket Company", paper presented at the Nuclear and Emerging Technologies for Space Conference, 24-26 February, Report M14-3297, NASA Marshall Space Flight Center, Stennis Space Center, Mississippi.
61. Poston, D.I. and P.R. McClure (2017), "White Paper – Use of LEU for a Space Reactor", Report LA-UR-17-27226, Los Alamos National Laboratory, Los Alamos.
62. Wood, L.W. and A.Q. Gilbert (2022), "Space-based Solar Power as a Catalyst for Space Development", *Space Policy*, Vol. 59, Elsevier, Amsterdam, p. 101451.
63. A recent study provided evidence that surface water ice exists near the poles of the Moon. Li, S. et al. (2018), "Direct evidence of surface exposed water ice in the lunar polar regions", *Proceedings of the National Academy of Sciences*, Vol. 115, No. 36, pp. 8907-8912; see also Strickland, E. (2019), "The coming moon rush: Technology, billionaires, and geopolitics will all help get us back to the moon, but they won't be enough to let us live there indefinitely", *IEEE Spectrum*, Vol. 56, No. 7, pp. 22-25.
64. Scoles, S. (2024), "In the Race for Space Metals, Companies Hope to Cash In", Undark, https://undark.org/2024/05/08/asteroid-mining-space-metals (accessed 17 Apr. 2025).

electricity at the lowest possible mass with the highest reliability, which nuclear power systems may be able to provide.[65]

In terms of space nuclear power, a 2019 survey found at least nine companies are directly developing space nuclear systems, working on related technologies or have technology that can be readily adapted.[66] Given that the United States has invested almost USD 700 million in public private partnerships to develop SNPS technologies between 2019 and 2024, as well as other early stage investments internationally, the total number of private companies developing SNPS is undoubtedly much higher.[67]

4. Off-world nuclear supply chain

In the long term, demand for nuclear fuels beyond Earth's orbit could lead to the nuclear fuel supply chain moving off world.[68] As launch presents the highest risks to the public, off-world production can reduce terrestrial safety risks.[69] Further, if humans establish a permanent presence in space, indigenous production of natural resources is likely to be necessary. Natural uranium, thorium and other fission fuels exist throughout the solar system, including the Moon, Mars and potentially even uranium's namesake, Uranus.[70] Whether they exist in high enough concentrations at accessible locations for economic extraction is uncertain. Asteroids are unlikely to have significant quantities of fissile or fertile ores.[71] Large deposits of Helium-3 on the Moon have long been identified as a potential source of fuel for nuclear fusion reactors, both in space and terrestrially.[72] Other fusion fuels likely exist in recoverable quantities on planets, moons and asteroids throughout the solar system. However, resource extraction raises key legal issues and risks and could become a major non-proliferation concern. A lack of resource data and the complexity of processing radioactive ores into usable nuclear fuels remain technical barriers.

Beyond the potential extraction of nuclear fuels themselves, there is an important relationship between space mining ambitions and nuclear energy technologies.[73] The energy requirements of space mining could drive demand for nuclear power on planetary surfaces, both reactors for high-energy processing applications and radioisotopes for rovers and other robotic equipment. NASA's Fission Surface Power project is nominally slated to power its ISRU pilot plant.[74] Further, the growth of space-based nuclear propulsion could lead to greater in-space refuelling requirements, potentially driving demand for water mined from the lunar surface or asteroids.

65. Kornuta, D. et al. (2019), "Commercial Lunar Propellant Architecture: A Collaborative Study of Lunar Propellant Production", *REACH*, Vol. 13, Article 100026, Elsevier, Amsterdam.
66. Locke, J.W. and B. Lal (2020), *supra* note 10.
67. Gilbert, A.O, H.S. Desai and J. Matthews (2024), "Commercial nuclear innovation 'new space' age", Nuclear Newswire, American Nuclear Society, www.ans.org/news/article-5875/commercial-nuclear-innovation-new-space-age.
68. Bruhaug, G. and W. Phillips (2024), "Nuclear Fuel Resources of the Moon: A Broad Analysis of Future Lunar Nuclear Fuel Utilization", *NSS Space Settlement Journal*, Issue 5, National Space Society, Cocoa, Florida, available at: https://space.nss.org/wp-content/uploads/NSS-JOURNAL-Nuclear-Fuel-Resources-of-the-Moon-2021-June.pdf.
69. Gilbert, A.Q. (2023), "Lifecycle mission safety for space nuclear systems", *Journal of Space Safety Engineering*, Vol. 10, No. 4, Elsevier, Amsterdam, pp. 467-473.
70. Yamashita, N. et al. (2010), "Uranium on the Moon: Global distribution and U/Th ratio", *Geophysical Research Letters*, Vol. 37, No. 10., American Geophysical Union Publications, Washington, DC; Bazilevskii, A.T. et al. (1981), "Evaluation of the thorium and uranium contents of Martian surface rock – A new interpretation of Mars-5 gamma-spectroscopy measurements", *Geokhimiia*, Jan. 1981, Elsevier, Amsterdam, pp. 10-16.
71. Cannon, K.M., M. Gialich and J. Acain (2023), "Precious and Structural Metals on Asteroids", *Planetary and Space Science*, Vol. 225, Article 105608, Elsevier, Amsterdam, p. 2, Fig. 2.
72. Simko, T. and M. Gray (2014), "Lunar Helium-3 Fuel for Nuclear Fusion: Technology, Economics, and Resources", *World Futures Review*, Vol. 6, Issue 2 SAGE Publications, pp. 158-171.
73. Gilbert, A.Q. (forthcoming), *supra* note 2.
74. Klein, A. et al. (2020), "Operational Considerations for Fission Reactors Utilized on Lunar In-Situ Resource Utilization Missions: A Report to the Nuclear Power & Propulsion Technical Discipline Team", NASA Contractor Report, Document ID 20205009307, Langley Research Center.

III. Governance issues for space nuclear energy

Nuclear power's radiological risks present notable design challenges and impact public acceptance of the technology. These risks also present unique issues that should inform potential governance. In this section the most pertinent of these issues are considered: (1) protection of public health and safety and the terrestrial environment; (2) space safety and sustainability; (3) protection of astronauts and the space environment; (4) decommissioning and equipment end-of-life in space; and (5) security and safeguards.

1. Protection of public health and safety and the terrestrial environment

The primary public health and safety concerns with space nuclear power arise from radiological risks to people or environments on Earth from certain types of accidents.[75] There have been at least 14 major anomalies or accidents involving space nuclear power systems, representing a surprisingly high 16% of space nuclear missions as of the time of this writing.[76] There are three primary scenarios: spaceport accidents (pre-launch), launch failures and unplanned re-entry. A pre-launch explosion of a rocket containing nuclear materials, burn-up of nuclear materials during re-entry, or impact of compromised nuclear systems could cause environmental release of radiation or the spread of radiation-contaminated debris.[77] Radioactive materials can pose a direct public health hazard through dose exposure, inhalation or consumption, while environmental contamination could cause significant cleanup challenges and costs.

Historically, most incidents involving SNPS were tied to the risk to terrestrial populations or the environment. Following an aborted launch in 1964, the SNAP-9A RTG on the navigational satellite Transit-5-BN-3 burned up during re-entry, distributing its PU-238 into the upper atmosphere.[78] Originally, US RTGs were designed to break up during such an accident, to dilute radiological effects; however, the US DOE subsequently redesigned RTGs to stay intact during launch to prevent pollution and allow for recovery.[79] After four years without an RTG-powered mission launch, the United States tried to launch the Nimbus-B-1 weather satellite in 1968. Despite another aborted launch, the RTG survived; it crashed into the Atlantic Ocean and was eventually recovered from the seabed.[80] Its fuel was recovered and used in the subsequent Nimbus III mission. During launch, Russia's Mars 96 mission failed to reach orbit and was subsequently lost on or near Chile (the RTG was never found).[81]

The unplanned re-entry of several nuclear-powered missions further highlights the risks of environmental releases of radiation or concentrated radiation hazards. Following the accident on Apollo 13, the RTG on the lunar module re-entered the atmosphere and crashed into the Pacific Ocean, settling 20 000 feet (6 096 metres) below sea level in the Tonga Trench. The US has since monitored the area and has not detected any major radiological releases, likely indicating the RTG survived re-entry intact.[82] More dramatically, the Soviet satellite

75. Gilbert, A.Q. (2023), *supra* note 69.
76. Wiley, J. and A.Q. Gilbert (2023), *supra* note 8; Bennett, G.L. (1992), "Soviet space nuclear reactor incidents – Perception versus reality", in *Space Nuclear Power Systems 1989: Proceedings of the 6th Symposium*, Vol. 1, Orbit Book Co., Inc., London.
77. Launius, R. (2008), "Powering Space Exploration: U.S. Space Nuclear Power, Public Perceptions, and Outer Planetary Probes", presented at AIAA Conference, Session EPEH-3: Historical Perspectives on Space Power Technology Development and Use, 28-30 July.
78. US Atomic Energy Agency (1972), *Global Inventory and Distribution of Pu-238 from SNAP-9A*, Report No. HASL-250, NSA-26-022783; Krey, P.W. (1967), "Atmospheric Burnup of a Plutonium-238 Generator", *Science*, Vol. 158, No. 3802, pp. 769-771.
79. Barklay, C., R. Hoffman, G. Pohl, and B. Williams (2023), "A Novel Design Approach for Post-Reentry Impact Survivability of Radioisotope Thermoelectric Generator Fuel", as presented at the 2023 IEEE Aerospace Conference, 4-11 March.
80. US DOE (1987), *Atomic Power in Space: A History*, DOE/NE/32117--H1, DE87 010618.
81. Wiley, J. and A.Q. Gilbert (2023), *supra* note 8.
82. *Ibid*.

Cosmos 954 lost control and crashed in the Canadian wilderness in 1978. The burn-up led to a significant spread of radioactive debris across a wide area and required a joint US-Canada recovery effort named Operation Morning Light.[83] The loss led to the Soviet Union designing a better method to boost the SNPS satellite and eject the fuel core at end-of-life, but a subsequent failure of that system led to Cosmos 1402 re-entering over the ocean. Two of the three accidental SNPS re-entries occurred over the ocean, approximating the share of global ocean coverage and the general probability of re-entry location for future space missions.

Thankfully, significant public health threats have, to date, been avoided due to the type and location of these incidents, but any potential governance must give due consideration to the potential risks.

2. Space safety and sustainability

Space debris is rapidly emerging as a serious threat to the safe and economic operation of government and commercial space missions.[84] The continued cost reduction in satellite launch costs, as well as the emergence of mega-constellations, has led to substantially more controlled and uncontrolled space objects.[85] There are tens of thousands of space objects or space debris larger than ten centimetres.[86] Given the increasing amount of space debris and the high relative velocities of objects in space, collisions can damage or destroy satellites in Earth's orbit. Beyond unintentional collisions, the proliferation of anti-satellite (ASAT) weaponry poses space debris risks. Various nations have direct ascent ASAT technologies, and weapons tests over the last 15 years have created thousands of pieces of trackable space debris.[87] Debris from weapon tests, or actual use of such weapons, could threaten all satellites in low-Earth orbit (LEO), including the ISS, the several dozen decommissioned reactors in disposal orbits and future SNPS-powered satellites.

SNPS missions are both threatened by space debris and are a potential source of space debris themselves. In 2009, an Iridium satellite collided with the decommissioned Cosmos 2251 satellite, creating more than 2 000 pieces of space debris, increasing total space debris by more than 10%.[88] This debris is not expected to come down for decades or centuries.[89] Cosmos 2251 did not carry a SNPS but it was in a disposal orbit used by dozens of other fission reactors, underscoring the potential intersection of space nuclear safety and space debris. Other relatively minor incidents also highlight this intersection. The United States' first and only launched space nuclear reactor-powered mission (SNAP-10A) has been identified as the source of at least 51 space debris objects, though no radiological release has been identified.[90] Following the introduction of the fuel core ejection approach in response to Cosmos 954, 16 Soviet BUK reactors were observed leaking sodium-potassium (NaK) coolant, creating thousands of pieces of space debris ranging from 100 microns to 5 centimetres.[91] While the debris resulting from partial or complete destruction of a nuclear-powered satellite is unlikely to pose radiation risks to terrestrial populations, the

83. US DOE (1978), *Operation Morning Light: Northwest Territories, Canada, 1978; A Non-Technical Summary of US Participation*, Report No. NV-198, US Government Printing Office.
84. NASA Office of Inspector General (2021), *NASA's Efforts to Mitigate the Risks Posed by Orbital Debris*, Report No. IG-21-011.
85. Grotch, S.E. (2022), "Mega-Constellations: Disrupting the Space Legal Order", *Emory International Law Review*, Vol. 37, No. 1, Emory University, Atlanta, p. 101.
86. *Ibid*.
87. Krepon, M. and J. Thompson (eds.) (2013), *Anti-Satellite Weapons, Deterrence and Sino-American Space Relations*, Stimson Center, www.stimson.org/2013/anti-satellite-weapons-deterrence-and-sino-american-space-relations (accessed 15 Apr. 2025).
88. Weeden, B. (2010), "2009 Iridium-Cosmos Collision Fact Sheet", Secure World Foundation, https://swfound.org/media/6575/swf_iridium_cosmos_collision_fact_sheet_updated_2012.pdf. (accessed 15 Apr. 2025).
89. *Ibid*.
90. Stokely, C.L. and E.G. Stansbery (2008), "Identification of a Debris Cloud from the Nuclear Powered SNAPSHOT Satellite with Haystack Radar Measurements", *Advances in Space Research*, Vol. 41, Issue 7, Elsevier, Amsterdam, pp. 1004-1009.
91. El-Genk, M.S. (2009), *supra* note 34.

large sizes of historical reactors and the NaK coolant in historical SNPS make them particular debris concerns.[92]

3. Protection of astronauts and the space environment

Beyond the risks of creating space debris that threatens other space missions in orbital locations, the use of nuclear power sources could also threaten the surface environment of planetary bodies or astronaut operations. Although space environmental protection remains in its infancy, planetary protection is a key principle underlying existing government missions to celestial bodies.[93] Protection of undiscovered life, untapped space resources or other celestial resources is critical. A radiological accident involving a space nuclear power source could contaminate astronomical bodies for decades or centuries. Cleanup, if even possible, would likely be cost-prohibitive in many cases. Beyond astronaut safety and general contamination risks, the use of space nuclear power sources may require special procedures for missions to restricted bodies.[94]

4. Decommissioning and equipment end-of-life in space

SNPS require safe disposal and/or decommissioning after use. As of late 2023, the final destinations of the nuclear materials and power systems of the 84 spacecrafts utilising SNPS were:[95]

- deorbit to Earth: 13
- LEO disposal orbit with long-term re-entry: 43
- planetary surface (Moon, Mars, Titan): 21
- atmospheric disposal at gas giant: 2
- solar system ejection: 5

Of these, all existing decommissioned space reactors are in LEO disposal orbits, where they will reside for hundreds or thousands of years.[96] The relatively high accident rate and expected long-term increases in space debris even in higher orbits could make such graveyard orbits less feasible in the future; alternative deep-space storage may be required. Missions to other celestial bodies, particularly surface missions, require other end-of-life storage options such as *in-situ* storage or gas giant re-entry.[97] Although *in-situ* storage may work for some initial missions, like the Apollo or Chang'e landers, plans for large-scale activities on the lunar surface may require more dedicated policy solutions.

5. Security and safeguards

SNPS supply chains and mission activities may lead to unique security and safeguards considerations. Established protocols such as secure handling, transport and storage of nuclear materials are largely applicable to SNPS fuel fabrication, transportation and other

92. Gafarov, A.A. (1993), "The Problem of Space Nuclear Power Sources Collisions with Artificial Space Objects in Near-Earth Orbits", *AIP Conference Proceedings*, Vol. 271, Issue 1, AIP Publishing, Melville, New York, pp. 99-103.
93. Wiley, J. (2024), "Too Hot to Handle? Planetary Protection Concerns for Nuclear Space Missions to Planetary Surfaces, Proceedings of the 75th International Astronautical Congress, Milan, Italy, 14-18 October.
94. Shotwell, R.F. et al. (2019), "Can an Off-Nominal Landing by an MMRTG-Powered Spacecraft Induce a Special Region on Mars When No Ice Is Present?", Astrobiology, Vol. 19, No. 11, Mary Ann Liebert, Inc. Publishers, New Rochelle, New York.
95. Gilbert, A.Q. (forthcoming), *supra* note 2.
96. Wiley, J. and A.Q. Gilbert (2023), *supra* note 8.
97. El-Genk, M.S. (2010), "On End-of-Life Storage Options of Space Reactor Power Systems", Proceedings of the Fourth IAASS Conference: Making Safety Matter, Huntsville, Alabama, 19-21 May.

supply chain activities within national jurisdictions.[98] However, the unique nature of space activities, including overflight of many countries, remote (and often autonomous) operations and activities beyond territorial jurisdictions, could pose unique issues.

Generally, there are two categories of unusual risk when it comes to security considerations: accidental re-entry during or after launch, and during operations in deep space.[99] If a launch failure occurs or a spacecraft re-enters, the launching state could lose control of nuclear materials or the reactor core. Considering conventional orbital paths, such materials could be lost over almost any country on Earth.[100] In orbit, spacecraft are susceptible to both physical threats and intentional interference, including anti-satellite (ASAT) weaponry. SNPS missions also face unique cybersecurity vulnerabilities. With the rise of offensive cyber capabilities, nation-state and non-state actors may target SNPS systems for disruption, sabotage or piracy.[101] A cyber breach could compromise mission control and navigation, with potentially severe safety and environmental consequences. Further, most space reactors and RPS-powered spacecraft are designed to operate autonomously, a control mode that is not widely practiced for terrestrial reactors, further elevating the cybersecurity risk as it relates to control systems.[102]

Once launched, SNPS fuel may also raise unique nuclear safeguards issues, particularly regarding HEU or oversight of non-weapons state ownership of nuclear materials subject to international non-proliferation controls. The historical Soviet and US SNRs, as well as NASA's demonstration Kilopower reactor, used HEU for fuel.[103] As HEU can be readily used in a nuclear weapon, non-proliferation efforts over the last 20 years focused on reducing the use of HEU in civilian applications. The development of HALEU terrestrial reactors and supply chains for climate change mitigation has thus enabled commercial space reactor ambitions by opening HALEU design options for space reactors. While still concerning, the loss of HALEU in a launch accident or re-entry would be less pressing than an HEU core.

IAEA safeguards for non-weapons states in space may pose novel enforcement and implementation issues. Physical monitoring may be impractical, requiring remote monitoring technologies. Safeguards may require the tracking and accountability of materials in exotic space environments, especially in the event of an accident or unintended deviation from a mission plan.

IV. International space nuclear law

Given the breadth of issues, many different aspects of international law govern, or could govern, the expanded use of nuclear power in space. Designing, supplying, launching, operating and decommissioning a nuclear power system for outer space activities can involve aspects of space law, nuclear law and broader international law. This section reconciles these diverse areas of international law to identify state responsibilities as they relate to state and state-authorised space nuclear missions in outer space.

98. Gilbert, A.Q. (2023), *supra* note 69.
99. Voss, S.S. (2020), "Nuclear Security Considerations for Space Nuclear Power: A Review of Past Programs with Recommendations for Future Criteria", *Nuclear Technology*, Vol. 206, No. 8, pp. 1097-1108.
100. Pardini, C. and L. Anselmo (2022), "The Kinetic casualty risk of uncontrolled re-entries before and after the transition to small satellites and mega-constellations", *Journal of Space Safety Engineering*, Vol. 9, No. 3, Elsevier, Amsterdam, pp. 414-426.
101. Falco, G. (2018), "Cybersecurity Principles for Space Systems", *Journal of Aerospace Information Systems*, Vol. 16, No. 2, pp. 1-9.
102. Trask, D., M. MacDonald and C. Jung (2014), *Cyber Security for Remote Monitoring and Control of Small Reactors*, AECL Report No. AECL-CW-66510-CONF-001, Atomic Energy of Canada Limited, Chalk River, Canada.
103. McClure, P.R. et al. (2018), *White Paper – Comparison of LEU and HEU Fuel for the Kilopower Reactor*, Los Alamos National Laboratory Report No. LA-UR-18-29623, Los Alamos National Laboratory, Los Alamos, NM.

Space nuclear power governance at the national and international levels involves overlapping governance from both space law and nuclear law, and is influenced by treaties, national statutes and the ongoing development of customary international law. Use of soft law based on international law principles and national enforcement can develop space law norms.[104] Space law faces a key constraint governing commercial space applications moving forward: It governs the conduct and relationship of nations, not individuals or companies. When evaluating national-level laws, a key factor is evaluating whether laws apply only to actions occurring within the nation's physical jurisdiction, to actions by nationals anywhere or to actions by nationally-authorised entities in outer space.[105] Enforcement of international space law is a challenge as, even if an issue involves two private entities, it can be an international matter.

1. Space Law

In many ways, "space law *is* international law".[106] Space is inherently international; orbiting objects can cross multiple jurisdictions in minutes. Following the launch of Sputnik, the Soviet Union, the United States and other countries began working to establish international space governance. There are four multilateral international treaties that comprise global space law:[107]

- Outer Space Treaty (OST)
- Rescue Agreement
- Registration Convention
- Space Liability Convention

Together, these conventions establish the international legal framework for space activities beyond customary international law. However, as this framework was established in the early years of human space exploration, it is not necessarily designed for today's space activities, particularly in relation to commercial space activities.[108] Rather, the framework establishes general principles.

104. Urban, J.A. (2016), "Soft Law: The Key to Security in a Globalized Outer Space", *Transportation Law Journal*, Vol. 43, No. 1, University of Denver, Denver, pp. 33-50; Byrd, L.C. (2022), "Soft Law in Space: A Legal Framework for Extraterrestrial Mining", *Emory Law Journal*, Vol. 71, No. 4, Emory University, Atlanta, p. 801.
105. Abrams, B. (2014), "First Contact: Establishing Jurisdiction over Activities in Outer Space", *Georgia Journal of International & Comparative Law*, Vol. 42, No. 3, University of Georgia, Athens, Georgia, p. 797.
106. Anderson, S.W., K. Christensen and J. LaManna (2019), "The Development of Natural Resources in Outer Space", *Journal of Energy & Natural Resources Law*, Vol. 37, No. 2, International Bar Association, London, pp. 227-258.
107. United Nations (UN) Committee on the Peaceful Uses of Outer Space (COPUOS) (2018), "Status of International Agreements Relating to Activities in Outer Space" presented at 1 January 2018, Legal Subcommittee, Fifty-seventh session, A/AC.105/C.2/2018/CRP.3, Vienna, 9-20 April; Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (1967), 610 UNTS 205, entered into force 10 Oct. 1967 (Outer Space Treaty or OST); Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (1968), 672 UNTS 119, entered into force 3 Dec. 1968 (Rescue Agreement); Convention on Registration of Objects Launched into Outer Space (1975), 1023 UNTS 15, entered into force 15 Sept. 1976 (Registration Convention); Convention on International Liability for Damage Caused by Space Objects (1972), 961 UNTS 187, entered into force 1 Sept. 1972 (Space Liability Convention).
108. Beck, B. (2009), "The Next, Small, Step for Mankind: Fixing the Inadequacies of the International Space Law Treaty Regime to Accommodate the Modern Space Flight Industry", *Albany Law Journal of Science & Technology*, Vol. 19, No. 1, Albany Law School, Albany, New York, pp. 1-36.

The OST establishes the primary legal basis for national activities in space, declaring that space is the "the province of all mankind" and prohibiting signatories from claiming outer space or celestial bodies as national territories. Critically, the OST defines one of the key principles of space law: that of the launching state.[109] A launching state is the country that puts a space object into orbit, and which retains jurisdiction over and responsibility for that object. The OST does not directly address the use of nuclear power for space, but it specifically prohibits states from placing weapons of mass destruction into orbit around the Earth, or other celestial bodies, or otherwise stationing them in space. Further, the OST prohibits "harmful contamination" and requires state-to-state consultation for state activities that constitute "harmful interference" with another state's activities. The terms lack clear definitions and application in the OST but nevertheless pose potential constraints on space nuclear activity. The OST may be interpreted to require member states to establish regulatory programmes to oversee commercial nuclear applications in space, with the states assuming liability for activities unless domestic legislation channels it to private actors.[110]

All subsequent space treaties focus on managing specific issues regarding national interactions in space. Building on Articles 5 and 8 of the OST, the Rescue Agreement obliges states parties to provide assistance to astronauts in distress, return them to the launching state in the event of a crash and to assist launching states in recovering space objects that return to Earth.[111] In effect, the rescue agreement would oblige signatories to return spacecraft utilising nuclear power systems that crash in their territory. The Registration Convention provides for specific procedures for launching states to register their space objects.[112] The Convention on Space Liability governs liability claims arising from cross-border damages resulting from space launches. The Space Liability Convention, building on Article 7 of the OST, makes a launching state (1) strictly liable for compensation for damage caused by space objects that crash on Earth and (2) liable for damages in space resulting from fault.[113]

The Space Liability Convention outlines procedures to settle claims for any such terrestrial or extraterrestrial damages. To date, the settlement process outlined in the convention has not been used.[114] Due to provisions of absolute liability, damage caused by SNPS returning to Earth are generally likely to be covered.[115] However, obtaining relief under the convention may prove difficult in cases where no party is damaged, as exemplified by the Apollo 13's RTG ditching in international waters, or cases where damage is hard to establish, as in the launch failure of the Russian Mars 1996 mission. The 2009 collision between Iridium 33 and Cosmos 2251 illustrates the challenges of liability for in-space incidents. Although the Soviet Union was the launching state for Cosmos 2251, Iridium 33 was not registered, as it was supposed to be under the Registration Convention.[116] Accordingly, it is unclear which nation was the launching state for Iridium 33. Russia

109. Hameed, H. (2018), "The Concept of Launching State in Democratized NewSpace", in Blount, P.J. et al. (eds.), *Proceedings of the International Institute of Space Law 2018*, International Institute of Space Law, Eleven International Publishing, Netherlands, pp. 61-71.
110. St. John, D. (2012), "The Trouble with Westphalia in Space: The State-Centric Liability Regime", *Denver Journal of International Law & Policy*, Vol. 40, No. 4, University of Denver, Denver, Colorado, p. 686.
111. Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, (1968), 672 UNTS 119, entered into force Dec. 3, 1968.
112. Convention on Registration of Objects Launched into Outer Space (1975), 1023 UNTS 15, entered into force 15 Sept. 1976.
113. Convention on International Liability for Damage Caused by Space Objects, (1972) 961 UNTS 187, entered into force 1 Sept. 1972.
114. The damages resulting from the 1978 crash of Cosmos 954 in Canada were paid by the Soviet Union following an out-of-convention settlement. Wirin, W.B. (1985), "The Sky is Falling: Managing Space Objects", in International Institute of Space Law (ed.), *Proceedings of the Twenty-Seventh Colloquium on the Law of Outer Space*, International Astronautical Federation, Lausanne, Switzerland, 7-13 October 1984.
115. Space Liability Convention, *supra* note 107, Art. II.
116. Weeden, B. (2010), *supra* note 88.

provided the launch vehicle that was launched from Kazakhstan for a US-based company.[117] Beyond the issue of ownership, the Space Liability Convention does not provide a legal definition for fault; this limitation makes space debris a particularly challenging problem for the Space Liability Convention.[118] Perhaps illustrative of this reality, the liability from the Iridium-Cosmos collision was settled outside of the Convention's procedures.[119]

A fifth major space treaty, the Moon Agreement, has been signed and ratified by 16 nations.[120] Overall, the Moon Agreement could potentially apply greater constraints to activities involving space nuclear power. However, the treaty's members are not major spacefaring nations, and the agreement is explicitly rejected by many major space powers, so the practical implications are limited.

The OST and its accompanying treaties provide for the general principles of state activities in space, but the governance of specific activities is generally handled by non-binding frameworks.[121] While non-binding governance mechanisms are soft law, they provide frameworks for co-operation, transparency and responsible behaviour. As SNPS technology advances, such mechanisms can ensure the safe and sustainable use of nuclear power in space absent dedicated space nuclear guidance.

The primary intergovernmental co-ordinating body for space activities is the UN COPUOS, which consists of member state representatives.[122] It plays a key role in establishing non-binding guidelines, such as the "Long-Term Sustainability Guidelines for Outer Space Activities", which provides best practices for minimising space debris.[123] COPUOS has a working group dedicated to SNPS and consults with the IAEA on space nuclear safety. A primary recent area of focus of the COPUOS working group on SNPS is reconciling SNPS applications and orbital debris risks.[124]

As national ambitions for lunar activities have grown, so has international co-ordination. Two major agreements are developing to guide lunar activities: the US-led Artemis Accords and the Chinese/Russian-led International Lunar Research Station.[125] Together, these two approaches have attracted membership from all major space powers and over 50 countries. Neither instrument explicitly addresses space nuclear power, but their principles of co-operation, such as safety zones, could be extended to do so.[126]

Finally, "planetary protection" is a distinct policy consideration for deep-space exploration and may impose implicit requirements on SNPS missions.[127] Developed by

117. *Ibid*.
118. Wang, T. (2016), "A Liability and Insurance Regime for Space Debris Mitigation", *Science & Global Security*, Vol. 24, No. 1, Taylor & Francis, pp. 22-36.
119. Weeden, B. (2010), *supra* note 88.
120. Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (1979), 1363 UNTS 3, entered into force 11 July 1984 (Moon Agreement).
121. The specific non-binding approach to space nuclear is discussed in detail below.
122. United Nations Office for Outer Space Affairs (UNOOSA) (2025), "Committee on the Peaceful Uses of Outer Space (COPUOS)", UNOOSA, www.unoosa.org/oosa/en/ourwork/copuos/index.html (accessed 15 Apr. 2025).
123. United Nations Office for Outer Space Affairs (UNOOSA) (2021), *Guidelines for the Long-Term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space*, A/AC.105/C.1/2017/CRP.12, United Nations.
124. Committee on the Peaceful Uses of Outer Space, Scientific and Technical Subcommittee (2017), "National Research on Space Debris, Safety of Space Objects with Nuclear Power Sources on Board, and Problems Relating to Their Collision with Space Debris", A/AC.105/C.1/2017/CRP.12.
125. Neef, R. (2021), "Artemis Accords: A New Path Forward for Space Lawmaking?", *Adelaide Law Review*, Vol. 42, No. 2, Adelaide Law School, Adelaide, South Australia, pp. 569-580.; Wu, X. (2023), "The International Lunar Research Station: China's New Era of Space Cooperation and Its New Role in the Space Legal Order", *Space Policy*, Vol. 65, Elsevier, Amsterdam, p. 101537.
126. Gilbert, A.Q. (2023), "Implementing Safety Zones for Lunar Activities under the Artemis Accords", *Journal of Space Safety Engineering*, Vol. 10, No. 1, Elsevier, Amsterdam, pp. 103-111.
127. Wiley, J. (2024) *supra* note 93.

COPUOS and national space agencies, planetary protection aims to prevent biological contamination of celestial bodies. These standards are primarily focused on protecting planets from Earth-borne microbes but could evolve to manage radiological contamination or radiation from space nuclear systems.

2. Nuclear law

Alongside space law, nuclear law forms the other essential legal foundation for regulating SNPS. International and national nuclear law has evolved into an independent academic discipline, with a focus on several key areas: nuclear non-proliferation, commercial operations and liability for nuclear accidents. While space law primarily addresses state responsibilities in space, nuclear law has historically concentrated on ensuring the safe, secure and peaceful use of nuclear technology, promoting trade, preventing the spread of nuclear weapons and addressing issues of nuclear liability. As space nuclear technologies become more prominent, understanding how these nuclear legal frameworks apply – or fail to apply – to space activities is critical for developing coherent governance structures. The OST's principle to extend international law into outer space means that state obligations related to nuclear technologies will apply in space as on Earth, at least when allowed by the specific nuclear treaty.

The major multilateral nuclear treaties break into two buckets when it comes to SNPS:[128]

- Broadly applicable treaties that clearly apply:[129]
  - Treaty on the Non-Proliferation of Nuclear Weapons (NPT)
  - Convention on Early Notification of a Nuclear Accident (Early Notification Convention)
  - Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (Assistance Convention)
- Treaties that are explicitly limited to terrestrial activities:[130]
  - Convention on Nuclear Safety (CNS)
  - Paris Convention on Third Party Liability in the Field of Nuclear Energy (Paris Convention)
  - Vienna Convention on Civil Liability for Nuclear Damage (Vienna Convention)

128. Note that some less high-profile treaties or agreements, like the Code of Conduct, may apply to terrestrial SNPS activities and extend limited obligations or expectations to space activities.
129. Treaty on the Non-Proliferation of Nuclear Weapons (1968), IAEA Doc. INFCIRC/140, 729 UNTS 169, entered into force 5 Mar. 1970 (NPT); Early Notification Convention, *supra* note 12; Assistance Convention, *supra* note 12.
130. Convention on Nuclear Safety (1994), IAEA Doc. INFCIRC/449, 1963 UNTS 293, entered into force 24 Oct. 1996 (CNS); Convention on Third Party Liability in the Field of Nuclear Energy of 29 July 1960, as amended by the Additional Protocol of 28 January 1964, by the Protocol of 16 November 1982 and by the Protocol of 12 February 2004, entered into force 1 Jan. 2022, consolidated text available at: NEA (2024), "Convention on Third Party Liability in the Field of Nuclear Energy of 29 July 1960, as amended by the Additional Protocol of 28 January 1964, by the Protocol of 16 November 1982 and by the Protocol of 12 February 2004", NEA Doc. NEA/NLC/DOC(2017)5/FINAL (Paris Convention or PC); Vienna Convention on Civil Liability for Nuclear Damage (1963), IAEA Doc. INFCIRC/500, 1063 UNTS 266, entered into force 12 Nov. 1977 (Vienna Convention or VC): Protocol to Amend the 1963 Vienna Convention on Civil Liability for Nuclear Damage (1997), IAEA Doc. INFCIRC/566, 2241 UNTS 302 (the revised Vienna Convention or RVC); Convention on Supplementary Compensation for Nuclear Damage (1997), IAEA Doc. INFCIRC/567, 36 ILM 1473, entered into force 15 Apr. 2015 (CSC).

- Protocol to Amend the 1963 Vienna Convention on Civil Liability for Nuclear Damage (Revised Vienna Convention)
- Convention on Supplementary Compensation (CSC)

The most relevant governing document on the deployment of space nuclear power systems stems from the landmark NPT. The NPT establishes strict controls over the development, transfer and use of nuclear materials, particularly nuclear-weapons-related materials. The launching states responsible for missions utilising SNRS must thus adhere to non-proliferation obligations. In the case of nuclear weapons states, like the China, Russia and the United States, the restrictions can be handled easily through domestic law. Non-weapons states, however, would likely require some sort of IAEA safeguards and oversight as it relates to SNPS technology development, supply chain/manufacturing and potentially in-space operations. Restrictions on HEU derive from proliferation concerns – thus the largest impact of the NPT may be on encouraging the development of HALEU-fuelled space reactors, which are especially enabling for commercial ambitions and for non-weapons states.

Given the catalytic role of the Cosmos 954 re-entry into Canada, it is no surprise that the Early Notification Convention and Assistance Convention would apply to SNPS. The language of the treaties is broad in requiring states to provide early notification and/or offer assistance in the event of a risk or actual occurrence of transboundary radiological pollution.[131] In the context of space nuclear power, there is a strong argument these conventions would apply if a radiological incident involving a space nuclear system threatened human health or the environment on Earth. These conventions require states to notify the international community promptly and provide assistance when requested.[132] This would be particularly relevant in the event of a launch failure or the unplanned re-entry of a nuclear-powered spacecraft.

Finally, there are the set of treaties that do not apply to SNPS because they are explicitly limited to terrestrial land-based installations, namely the CNS and the three liability conventions. Legal scholarship for floating nuclear power plants, maritime commercial nuclear propulsion and terrestrial transportable reactors has previously pointed out the lack of applicability of these treaties to novel reactor applications, including space reactors.[133] In practice, the lack of applicability of the CNS may not matter much given the overriding focus on launch and mission safety for SNPS in international guidance and national implementation (discussed below).

Comparably, the fact the liability conventions do not apply to SNPS poses a potential governance hurdle, especially as it relates to peaceful trade in SNPS technologies. While the complexity of nuclear liability is beyond the scope of this article, it can suffice to point out that the liability conventions facilitate trade in nuclear material, enriched fuel, fabricated fuel and other important parts and components. Thus, the lack of governing conventions could chill international nuclear trade for fuel, materials and components for SNPS, and may require a reliance on domestic nuclear supply chains. Nevertheless, the principle of strict liability for nuclear operators in the Vienna and Paris Conventions (and implied to an extent in the CSC) is potentially consistent with the Space Liability Convention's strict liability for launching state damages to Earth. Therefore, the nuclear and space liability conventions are readily reconcilable, at least at the international level. Despite the lack of coverage of space nuclear power in liability conventions, customary

131. Early Notification Convention, *supra* note 12, Art. II.; Assistance Convention, *supra* note 12, Art. II.
132. *Ibid*.
133. "This analysis starts from the general assumption that a special system of liability of nuclear operators should apply to TNPPs as opposed to the ordinary law of tort, and that it should be based on either existing relevant international conventions or domestic legislation in line with the basic principles of these conventions." IAEA (2013), *Legal and Institutional Issues of Transportable Nuclear Power Plants: A Preliminary Study*, IAEA Nuclear Energy Series No. NG-T-3.5, IAEA, Vienna, p. 78; McIntosh, S. (2022), "Nuclear Liability and Post-Fukushima Developments", in IAEA (ed.), *Nuclear Law: The Global Debate,* IAEA, Vienna, p. 252.

international law creates obligations to prevent and compensate nuclear damage.[134] To the extent that nuclear damages would occur that are not covered by space law (OST and Space Liability Convention) customary international law could apply.

Beyond the specific conventions, a significant notable difference between international space law and international nuclear law is that the IAEA serves as an important body for international co-operation in the nuclear field. The IAEA has established frameworks for nuclear safety, security, safeguards, and non-proliferation across civilian and commercial nuclear activities. It develops standards and provides technical assistance. Space law lacks an equivalent international body with the same authoritative scope. Although the COPUOS oversees certain aspects of space activities, it does not possess the same capacities as the IAEA in nuclear governance.

In practice, much of the "practice" of space nuclear law is likely to come through the IAEA, especially as it relates to the pillars of nuclear law: safety, security, safeguards and liability. This is especially true with commercial actors developing SNPS and with non-weapons states pursuing SNPS technologies.

3. Space nuclear law

Although elements of space law and nuclear law address issues related to SNPS, there are no binding international treaties that specifically govern space nuclear power. In many cases, historical precedent from state space nuclear missions may have established specific norms or expectations, such as end-of-life *in situ* on planetary surfaces. The international community has established two non-binding instruments that provide specific guidance:

- The United Nations' *Principles Relevant to the Use of Nuclear Power Sources in Outer Space* (NPS Principles), passed by the UN General Assembly in 1992.[135]
- The COPUOS-IAEA *Safety Framework for Nuclear Power Source Applications in Outer Space* (IAEA Safety Framework), issued in 2009.[136]

Following the 1978 re-entry of Cosmos 954, the UN began significant discussions on SNPS safety with COPUOS serving as the primary forum.[137] The NPS Principles recognise the important role of SNPS in national space activities but emphasise the importance of minimising the use of radioactive materials and reactors in space solely to missions that require it.[138] It covers topics such as international law, safety criteria, safety assessments and notifications of disputes. Specific requirements include specific altitudes for disposal orbits, safety features for RPS technologies and a dose limit in accident scenarios.[139]

134. "Nuclear activities are included in the general obligation resulting from customary international law, which entails State responsibility 'to ensure that activities within their [a State's] jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.'" Kiss, A. (2006-2007), "State Responsibility and Liability for Nuclear Damage", *Denver Journal of International Law & Policy*, Vol. 35, No. 1, University of Denver, Denver, Colorado, pp. 67-83.
135. United Nations General Assembly (UNGA) (1992), "Principles Relevant to the Use of Nuclear Power Sources in Outer Space", UN Doc. A/RES/47/68, adopted on 14 Dec. 1992 (NPS Principles).
136. United Nations Committee on the Peaceful Uses of Outer Space and IAEA (2009), "Safety Framework for Nuclear Power Source Applications in Outer Space", UN Doc. A/AC.105/934, adopted on 19 May 2009.
137. Bennett, G.L., J.A. Sholtis Jr. and B.C. Rashkow (1989), "United Nations Deliberations on the Use of Nuclear Power Sources in Space: 1978-1987", in El-Genk, M.S. and M.D. Hoover (eds.), *Space Nuclear Power Systems 1988*, Orbit Book Company, Cocoa, Florida, Chap. 13.
138. NPS Principles (1992), *supra* note 135, Principle 3.
139. *Ibid*.

The principles were not without controversy, particularly from the United States, which disagreed with multiple technical elements.[140] Among other things, the United States pushed to remove a prohibition on space nuclear propulsion, a requirement for defence-in-depth and a prohibition of pre-launch testing of SNPS. Not all US concerns were waylaid, however, and the United States notably does not consider itself bound to the principles. Its official stance is that it recognises the principles but holds that its approach to space nuclear safety is sufficient to meet the intent of the principles, if not the specific elements.

Developments over the last decade may require further modernisation. For example, section 2.c of the NPS Principles states "nuclear reactors shall use only highly enriched uranium 235 as fuel"; this guidance would prohibit the use of HALEU reactors.[141] It also runs counter to the post-9/11 focus on reducing civil uses of HEU. Another technical issue for the NPS Principles is that, as written, they do not apply to all uses of nuclear energy in outer space.[142] Rather, they are just concerned with power sources, like RTGs or fission surface reactors. RHUs, NTP and reactors for just thermal heat may thus be excluded.

In 2009, the IAEA and the COPUOS jointly issued the *Safety Framework for Nuclear Power Source Applications in Outer Space*. This framework offers more detailed technical guidance for the SNPS missions, with a particular focus on guiding states in adopting a regulatory framework for space nuclear safety. The IAEA Safety Framework emphasises the importance of risk assessments, regulatory review and safety evaluations throughout the entire lifecycle of a space nuclear mission. It outlines key responsibilities for states and other entities involved in space nuclear power and is generally well regarded.[143] Per a recent COPUOS Working Group (WG) document:

> The Safety Framework is widely accepted and has proved valuable to member States when developing and/or applying their national systems for ensuring the safe use of [SNPS] in outer space. Its usefulness has also been acknowledged and accepted by other member States and international intergovernmental organisations that are not currently involved in utilising NPS in space, as they consider the safe use of such applications. No significant challenges in implementing the guidance provided in the Safety Framework have been identified, although several Working Group members A/AC.105/C.1/L.413 2/4 V.23-22767 have expressed the view that, as more than a decade has passed since its adoption, the Framework could usefully be supplemented with additional guidance. The guidance could address developments including the potential involvement of non-governmental and commercial entities in a variety of space NPS missions and the need to take account of the guidance being developed on the long-term sustainability of space activities.[144]

140. Bennett, G.L. (1995), "A Technical Review of the UN Principles on the Use of Nuclear Power Sources in Outer Space", paper presented at the 46th International Astronautical Congress, Oslo, Norway, 2-6 October.
141. *Ibid*.
142. "*Affirming* that this set of Principles applies to nuclear power sources in outer space devoted to the generation of electric power on board space objects for non-propulsive purposes, which have characteristics generally comparable to those of systems used and missions performed at the time of the adoption of the Principles." Bouvet, I. (2004), "Use of Nuclear Power Sources in Outer Space: Key Technology Legal Challenges", *Journal of Space Law*, Vol. 30, University of Mississippi School of Law, Oxford, Mississippi, p. 203 (emphasis added).
143. Summerer, L., et al. (2015), "The International Safety Framework for Nuclear Power Source Applications in Outer Space – Useful and substantial guidance", *Acta Astronautica*, Vol. 111, International Academy of Astronautics, Elsevier, Amsterdam, pp. 89-101.
144. *Ibid*.

Although the IAEA framework provides a comprehensive approach to nations setting up their regulatory infrastructure, it primarily serves as a technical reference rather than a regulatory instrument. It leaves the implementation to individual states, but it does not provide significant safety guidance for commercial developers or novel mission designs. It also primarily focuses on safety for terrestrial populations. The most recent working plan indicates specifically: "There is still a need for further work on the safety aspects of space NPS applications, particularly nuclear fission reactors and new types and uses of radioisotope power systems".[145]

4. Additional areas of international law

Beyond core areas of space law, nuclear law and space nuclear law, missions involving SNPS could face obligations derived from broader areas of international law. As with the application of international nuclear law to SNPS, the specific obligations deriving from such legal realms remain relatively understudied. Nevertheless, the OST's application of international law to state activities in outer space extends discrete state obligations to the space domain. A comprehensive review is beyond the scope of this article, but two discrete areas, environmental treaties and international humanitarian law (IHL), are worth briefly examining.

Environmental treaties or related governance mechanisms may establish various requirements on SNPS missions, especially as they relate to radiological risks and end-of-life practices. In general, there is considerable debate about the application of environmental laws to outer space itself.[146] This derives from legal definitions of the natural environment in different instruments, such as the "human environment" requirement in the US National Environmental Policy Act. The Espoo Convention on Environmental Impact Assessment in a Transboundary Context [147] may create requirements tied to the risk of radiological pollution for its signatories.[148] Multiple treaties tied to environmental concerns may restrict the potential for disposal of SNPS in international domains:

- The London Convention[149] forbids dumping in international waters, though the practice of re-entering large space objects at Point Nemo was not anticipated by the convention and the Convention does not extend its obligations explicitly to spacecraft.[150]
- The Antarctica Treaty explicitly forbids the disposal of radioactive materials, though (politics aside) the legality of an intentional disposal re-entry may not be clearly forbidden, with similar "incidental disposal" arguments like those for space objects regarding the London Convention.[151]

IHL, or the law of armed conflict, would also apply to SNPS when used for military activity or for commercial activity that, even indirectly, supports military activity. In recent years there has been considerable development of legal thought about IHL for space activities.

145. *Ibid*. p. 2.
146. Gilbert, A.Q. and M. Vidaurri (2021), "Major Federal Actions Significantly Affecting the Quality of the Space Environment: Applying NEPA to Federal and Federally Authorized Outer Space Activities", *UC Davis Environmental Law & Policy Journal*, University of California at Davis, Davis, California, Vol. 44, p. 233.
147. Convention on Environmental Impact Assessment in a Transboundary Context (1991), 1989 UNTS 310, entered into force 10 Sept. 1997 (Espoo Convention).
148. NEA (2016), "The Application of the Espoo Convention on Environmental Impact Assessment in a Transboundary Context to Nuclear Energy-Related Activities", *Nuclear Law Bulletin*, No. 97, OECD Publishing, Paris, pp. 63-70.
149. London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1972), 1046 UNTS 120, entered into force 30 Aug. 1975 (London Dumping Convention).
150. De Lucia, V. and V. Iavicoli (2019), "From Outer Space to Ocean Depths: The 'Spacecraft Cemetery' and the Protection of the Marine Environment in Areas Beyond National Jurisdiction", *California Western International Law Journal*, Vol. 49, p. 345.
151. The Antarctic Treaty (1959), 404 UNTS 71, entered into force 23 June 1961.

Generally, IHL recognises states' rights to self-defence but binds military activities to various rules including proportionality. Protocols 1[152] and 2[153] of the Geneva Conventions have specific prohibitions on intentional targeting of nuclear facilities, in large part due to concerns about excessive human casualties or environmental damage.[154] However, these specific provisions are not necessarily recognised by state parties.

V. US governance of space nuclear energy

The US government remains the primary modern launcher of space missions globally. Further, it has the most developed commercial space industry, which may soon include commercial nuclear-powered space services. Its overall policy framework for space nuclear power will thus shape the long-term path of global governance of space nuclear technologies. An examination of US law and regulation as it relates to the use of space nuclear power can therefore be informative.

Rather than a comprehensive overview of all federal or state laws impacting nuclear-powered missions; the sections below highlight the most relevant parts of US federal domestic law as they relate to governance issues and to the implementation of international obligations.

1. *Federal statutory framework for space activities*

The United States governs the nuclear and space sectors through a multi-agency approach depending on the activities, the specific policy issue and the relevant actors. Generally, federal law expressly pre-empts state or local laws when it comes to either radiological safety or space activities.[155]

For activities involving nuclear technologies and materials, the US Nuclear Regulatory Commission (NRC) and DOE are the primary governing bodies.[156] The NRC is exclusively responsible for regulation of commercial actors using nuclear technologies for peaceful purposes, as well as federal agencies in certain circumstances (such as NASA material possession as a spaceport).[157] The NRC directly oversees reactor licensing and regulation and is responsible for byproduct material licensing (such as radioisotope fuels) in about one-third of states.[158] The other two thirds of states implement the NRC's regulation as "Agreement States".[159] The DOE authorises most civil applications of peaceful nuclear technology and has historically played the central role in developing, producing and providing space nuclear technologies to NASA.[160] In some instances, the DOD may directly authorise its own nuclear activities related to utilisation facilities (i.e. reactors).[161]

Regarding space, the United States employs three main governance regimes depending on the application. The DOD authorises defence activities while NASA authorises civil

152. Protocol Additional to the Geneva Conventions of 12 August 1949, and Relating to the Protection of Victims of International Armed Conflicts (Protocol I) (1977), 1125 UNTS 3, entered into force 7 Dec. 1978.
153. Protocol Additional to the Geneva Conventions of 12 August 1949, and Relating to the Protection of Victims of Non-International Armed Conflicts (Protocol II) (1977), 1125 UNTS 609, entered into force 7 Dec. 1978.
154. Lamm, V. (2003), "Protection of Civilian Nuclear Installations in Time of Armed Conflict", *Nuclear Law Bulletin*, No. 72, OECD Publishing, Paris, pp. 23-42.
155. Pacific Gas & Electric Co. v. State Energy Resources Conservation & Development Commission, 461 US 190 (1983); 51 United States Code (USC) 50901 *et seq*.
156. Atomic Energy Act of 1954, 42 USC 2011 *et seq*. (AEA).
157. 10 CFR 30.3(a).
158. US NRC (2024), "Agreement States", NRC, www.nrc.gov/agreement-states.html (accessed 15 Apr. 2025).
159. *Ibid*.
160. 51 USC 50901 *et seq*.
161. AEA, *supra* note 156, sec. 91(b).

activities such as science and exploration. Commercial activities are overseen by three federal regulators who oversee domain-specific regulation.[162] The Federal Aviation Authority's (FAA) Office of Commercial Space Transportation (AST) is responsible for licensing launches and re-entries in the United States and exerts jurisdiction over US persons launching or re-entering space objects internationally. The Federal Communications Commission (FCC) regulates spectrum use for satellites and deep-space objects, effectively making it a regulator of satellite orbits (since location of a satellite is tied to spectrum requirement).[163] The National Oceanic and Atmospheric Administration's Office of Space Commerce licenses Earth observation. As will be discussed below, US law is generally considered to have a mission authorisation and continuing supervision gap for activities beyond these three areas.

Other federal agencies are involved as needed and co-ordinate with the space authorisers and space regulators. For example, the FAA AST formally consults in an interagency process when reviewing launch licence and payload review applications.[164] Additionally, in 2017, the National Space Council was re-established to provide executive oversight of interagency activities.[165] Recognising the important role of nuclear energy in planned space activities, the DOE was added to the Council in 2020.[166] The Department of State plays a critical role both in providing information to US agencies about US international obligations and in advocating for US space positions in bodies such as COPUOS.

2. Launch authorisation through National Security Presidential Memorandum-20 (NSPM-20)

The US framework for SNPS technologies has evolved over time.[167] Presidential Directive/NSC-25 (PD/NSC-25) issued in 1977 formalised many requirements and has governed most historic US space nuclear missions. However, the emergence of the commercial space industry in the early 2010s and broader space regulatory reforms led to their reconsideration in the late 2010s. The Commercial Lunar Propellant Architecture described PD/NSC-25 as:

> Established by Presidential Directive/NSC-25 [69], an ad hoc Interagency Nuclear Safety Review Panel (INSRP) consists of the Department of Defense (DoD), DOE, NASA, the Environmental Protection Agency and a technical advisor from the Nuclear Regulatory Commission. INSRP oversees and reviews three (partially) concurrent safety reports that coalesce into the final approval (or disapproval) for nuclear launch: Safety Analysis Review, Safety Evaluation Report, and Environmental Impact Statement (EIS)—with only EIS having any legislative backing through the National Environmental Policy Act. Historically, approval for launch has ranged from four to eight years, and […] the poorly defined, non-legislative process is difficult to plan for in a commercial entity.

In particular, the PD/NSC-25 process was perceived as being both redundant for Pu-238 systems (whose safety had been established by dozens of reviews and design modifications

162. Lindbergh, R. (2018), *Commercial Space: Federal Regulation, Oversight, and Utilization*, Congressional Research Service Report No. R45416, Congressional Research Service, Washington, DC.; Dempsey, P.S. (2016), "National Laws Governing Commercial Space Activities: Legislation, Regulation, & Enforcement", *Northwestern Journal of International Law & Business*, Vol. 36, No. 1, Northwestern University, Chicago, p. 1.
163. Civil and commercial use of spectrum is co-ordinated through the National Telecommunications and Information Administration (NTIA). The FCC and NTIA co-ordinate with the International Telecommunications Union for international management of spectrum.
164. 14 CFR 450.41(b).
165. Executive Order No. 13,803, 82 *Federal Register* (Fed. Reg.) 31429 (July 7, 2017).
166. Executive Order No. 13,906, 85 Fed. Reg. 10031 (Feb. 20, 2020).
167. US NRC (2023), *Safety Review Process for Space Nuclear System Launches: RIL 2023-06 Literature Review*, NRC, available at: www.nrc.gov/docs/ML2322/ML23226A004.pdf.

over six decades) and poorly suited to handling the wide variety of novel SNPS technologies in development.[168]

Accordingly, the Presidential Memorandum on Launch of Spacecraft Containing Space Nuclear Systems, formerly known as National Security Presidential Memorandum-20 (NSPM-20), was issued in 2019 and provides the current governing framework.[169] This memorandum substantially updated the executive branch's process for approving government launches and provided clear guidance for commercial regulation of private space launches with SNPS. NSPM-20 primarily focuses on launch safety but effectively serves as the keystone regulatory framework for US SNPS by "plugging in" to other regulatory requirements.

NSPM-20 features four key design features:[170]

- **Performance-based safety guidelines.** NSPM-20 establishes "safety guidelines" for all SNPS missions, providing clear design targets and performance parameters. The first guideline is that a mission must demonstrate compliance with all other US laws, which serves as a hook for reactor and material licensing, as well as relevant NEPA reviews. The other three guidelines are specific performance-based hazard National Environmental Policy Act (NEPA) levels, which require that the risk of specific radiation doses to the maximally exposed member of the public be limited below specific frequencies. The risk thresholds (both dose and probability) approximate the safety standards for DOE facility safety analyses.
- **Interagency Nuclear Safety Review Board (INSRB).** The previous process for safety reviews in PD/NSC-25 had each mission empanel an INSRP for every SNPS launch, composed of representatives from seven agencies. The INSRP was both a technical review body and a safety authoriser, with its approval required for a mission to launch. The ad hoc nature of the INSRP led to significant controversy about its utility. NSPM-20 revises the system by creating the INSRB, which, like the INSRP, is composed of members of seven agencies and provides technical feedback to the launch authorisation authority but, unlike the INSRP, does not function as a safety authoriser.
- **Review Tiers.** NSPM-20 creates Review Tiers to allow safety reviews to be right-sized to specific safety risks or policy considerations. Tier 1 is the lowest level of review. Tier 2 is the middle level and requires INSRB technical review for government missions. Criteria for a mission to be Tier 2 include high material activity, the use of a fission reactor or probabilistic hazard criteria that are loosely tied to the safety guidelines. Tier 3 is the final review level and applies to missions with the highest probabilistic hazard analysis and to fission reactors utilising HEU. Tier 3 government missions require Presidential authorisation.
- **Three authorisers, one framework.** NSPM-20 provides standardised criteria with the safety guidelines and Review Tiers for all three launch authorisers in the United States (DOD, NASA and AST). This enables a standardised safety framework across US SNPS missions, benefiting technology development. NSPM-20 is technically not binding on AST absent formal rulemaking, but NSPM-20 provides significant guidance to AST on establishing a commercial launch approval pathway, as well for associated DOD or NASA authorisations tied to a commercial launch (such as

168. Buenconsejo, R.S. et al. (2019), *Launch Approval Processes for the Space Nuclear Power and Propulsion Enterprise*, IDA Science & Technology Policy Institute, IDA Doc. D-10910, Institute for Defense Analyses, Washington, DC.
169. Presidential Memorandum, "Launch of Spacecraft Containing Space Nuclear Systems", 84 Fed. Reg. 45347 (20 Aug. 2019) (superseding Presidential Policy Directive-4 and modifying National Security Council Presidential Directive-25), available at: https://trumpwhitehouse.archives.gov/presidential-actions/presidential-memorandum-launch-spacecraft-containing-space-nuclear-systems.
170. *Ibid*, secs. 3-5.

spaceport activity authorisation). Notably, AST can request INSRB review of missions in any Review Tier but is not required to do so, even for missions in Tier 2 or 3.

NSPM-20 has been well received in the United States by federal agencies, commercial SNPS developers and the broader space sector.[171] Its use of performance-based standards facilitates novel SNPS designs.

Beyond NSPM-20, two additional executive actions related to improving SNPS capabilities and regulatory frameworks were issued in 2020. Space Policy Directive-6 (SPD-6) issued in December 2020 establishes a National Strategy for Space Nuclear Power and Propulsion (SNPP), aiming to deploy safe, effective and scalable space nuclear systems. In addition to providing specific direction regarding technological development, it also provides some regulatory guidance. First, it indicates that AST's Payload Review process, part of its broader launch licensing framework, can be used for an SNPS to obtain launch approval, separate from a launch vehicle licence application.[172] Second, it indicates that a disposal orbit can be used for fission reactors.[173] Although intended to mirror the technical requirements in the UN NPS, the actual language on disposal orbits created a much more stringent altitude requirement that may be overly restrictive.[174]

The other executive action, Executive Order (EO) 13972, further builds on NSPM-20 and SPD-6 by directing the DOE and NASA to accelerate SNPP development and outline clear standards for handling and deploying such systems.

3. Agency implementation of SNPS executive orders

Federal agencies have undertaken significant implementation activities to respond to the directives of NSPM-20, SPD-6 and EO 13972. While the Mars 2020 mission did notably adopt some NSPM-20 practices, it was largely conducted under the PD/NSC-25 system. Accordingly, no mission has yet undergone the full NSPM-20 process, but ongoing missions like Dragonfly, Rosalind Franklin and DRACO are under agency review.

NASA and six other federal agencies formally convened the INSRB, establishing it with a charter.[175] In line with its new nature as a standing body, the INSRB issued a "Playbook" to provide guidance on its plans for conducting Safety Evaluation Reports as part of its role as a technical safety reviewer.[176] Further, NASA has revised its procedures for space nuclear launch authorisation, as memorialised in NASA Procedural Requirements (NPR) 8715.26.[177] The new rules incorporate the high-level requirements of NSPM-20 and provide the specific approval pathways for the agency's space missions. A 2021 NASA white paper evaluating its approach to launch approval provides good insight into how federal agencies account for many complex international and national legal requirements.[178] In examining NASA's revised nuclear flight safety programme, the article identified at least 46 requirements from

171. Chang, Y. (2021), "Considerations for Implementing Presidential Memorandum-20 Guidelines for Nuclear Safety Launch Authorization for Future Civil Space Missions", *Nuclear Technology*, Vol. 207, No. 6, pp. 844-850.
172. Space Policy Directive-6, "National Strategy for Space Nuclear Power and Propulsion" (16 Dec. 2020), sec. 4(e).
173. *Ibid*, sec. 3(a)(iii).
174. See Alfonsi, A. and M. Eades (2022), "A Technical Interpretation of the SPD-6 Radioactivity Limited 'Sufficiently High' Disposition Orbit Lifetime for a Space Fission Reactor", paper presented at NETS-2022, Cleveland, Ohio, 8-12 May, pp. 154-158.
175. INSRB (2022), *Charter of the Interagency Nuclear Safety Review Board*, Ver. 2, Interagency Nuclear Safety Review Board.
176. INSRB (2023), "Playbook: Non-binding Guidance for INSRB and Its Counterparts", Revision 2, INSRB.
177. NASA (2022), *Procedural Requirements NPR 8715.26: Nuclear Flight Safety*, NASA, effective 3 Feb. 2022, expiration 3 Feb. 2027.
178. Forsbacka, M.J. and D.M. Helton (2023), "Evolution of NASA's Nuclear Flight Safety Program to Infuse Risk Leadership and Assurance Framework Concepts", *Journal of Space Safety Engineering*, Vol. 10, No. 1, pp. 95-102.

at least 10 treaties, national laws, regulations and agency procedures. In line with the US stance, the article did not identify any requirements from the UN NPS Principles but rather indicated the rest of the process would be compatible. A NASA Handbook document provides more details on the implementation of NPR 8715.26.[179]

The DOD issued its revised procedures for nuclear launch authorisation in Department of the Air Force Manual (DAFMAN) 91-110.[180] While adopting the NSPM-20 performance-based guidelines, DAFMAN 91-110 is notable for also establishing a "radiological risk constraint" (RRC) requirement that necessitates additional safety analysis. A 2020 article in the *Journal of Space Engineering* explains the rationale behind this additional requirement.[181] In short, NSPM-20 was derived from nuclear safety standards and focuses on dose.[182] The RRC is designed to convert radiological hazards into space safety practices, which is a probabilistic measure of risk of fatalities.[183] Beyond the RRC, it is worth noting that DAFMAN 91-110 also applies to non-DOD users of DOD ranges.[184] This underscores the integrated nature of the space sector in the United States, with most commercial missions launching from NASA or DOD ranges. The standardised approach of NSPM-20 to different types of launch authorises facilities the ready application of these DAFMAN 91-110 requirements to non-DOD missions.

AST's formal regulatory requirement for commercial launch approval is that payloads containing radionuclides must be reviewed and approved on a "case-by-case" basis. Specifically, 14 CFR 450.45(e)(6) states:

> The FAA will evaluate the launch or re-entry of any radionuclide on a case-by-case basis and issue an approval if the FAA finds that the launch or reentry is consistent with public health and safety, safety of property, and national security and foreign policy interests of the United States. For any radionuclide on a launch or reentry vehicle, an applicant must—
>
> (i) Identify the type and quantity;
>
> (ii) Include a reference list of all documentation addressing the safety of its intended use; and
>
> (iii) Describe all approvals by the Nuclear Regulatory Commission for pre-flight ground operations.

AST recently streamlined its launch licensing process from multiple chapters into 14 CFR Part 450, but the revisions did not substantially change this requirement compared to the earlier regulations.

In 2023, AST issued Advisory Circular (AC) 450.45-1, which provides guidance for applicants wishing to obtain approval through a launch licence or payload review for a SNPS launch.[185] AC 450.45-1 provides guidance for both a SNPS mission designer and a launch vehicle to understand their respective requirements for launch approval. The AC is

179. NASA (2023), *Measurement System Identification: NASA Handbook NASA-HDBK-8715.26 – Information and Best Practices Related to NASA Nuclear Flight Safety for Space Flights Involving Space Nuclear Systems*, NASA, available at: https://nodis3.gsfc.nasa.gov.
180. Department of the Air Force (2022), *Department of the Air Force Manual 91-110: Nuclear Safety Review and Launch Approval for Space or Missile Use of Radioactive Material*, Air Force Safety Center, available at: https://static.e-publishing.af.mil/production/1/af_se/publication/dafman91-110/dafman91-110.pdf.
181. Glissman, M. et al. (2020), "United States Air Force Radioisotope Material Launch Approval Requirements", *Journal of Space Safety Engineering*, Vol. 7, No. 2, IAASS, Noordwijk, Netherlands, pp. 150-157.
182. *Ibid*.
183. *Ibid*.
184. Department of the Air Force (2022), *supra* note 180, sec. 1.2.1.4.
185. US Department of Transportation, FAA (2023), *Advisory Circular AC 450.45-1: Launch and Reentry of Space Nuclear Systems*, AC 450.45-1, available at: www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID.

non-binding, and AST indicates that it only provides one approach to compliance with regulations, inviting other approaches. As indicated by AC 450.45-1 and broader AST statements, NSPM-20's safety guidelines are broadly considered as sufficient to meet a case-by-case review criterion.

4. National Environmental Policy Act (NEPA)

The United States' modern environmental law regime began with the 1970 passage of NEPA. A process statute, NEPA requires that government agencies consider the impacts of and alternatives to "major federal actions significantly affecting the quality of the environment" in an environmental impact statement (EIS).[186] For each major federal action, an agency must determine whether it qualifies as a categorical exclusion (CE). If not, an agency can either conduct an environment assessment (EA) to determine if there is a significant effect on the environment or proceed straight to conducting a full EIS. When conducting an EA, an agency will either determine a full EIS is necessary or will issue a Finding of No Significant Impact (FONSI).

NEPA applies to both government actions and private-sector actions authorised or otherwise approved by government, including space activities. A space launch, or the licensing thereof, is considered a major federal action.[187] Accordingly, NASA missions, DOD missions and commercial space launches authorised by the FAA often require an EA or EIS. Notably, the United States considers NEPA documents as public statements of hazards tied to a mission as requested in the UN NPS and often attaches final NEPA documentation to notifications of upcoming SNPS sent to COPUOS. NEPA also applies to significant federal actions related to terrestrial SNPS, such as ground testing or spaceport licensing.[188]

NASA conducted EISs for all SNPS missions approved under the PD/NSC-25 framework.[189] For example, the Cassini EIS determined that 1) NPS design limited risk of fuel releases during accidents and 2) an accident could release fuel at the spaceport, over parts of Africa within the flight path, or over indeterminate parts of the Earth.[190] The EIS Executive Summary describes the risks of a radiological release at launch as the primary environmental concern of the mission. Although NEPA litigation is well developed in other sectors, it has been used rarely in the space sector. There has been no major litigation related to NEPA for SNPS. The 1996 Cassini mission brought a brief lawsuit related to the potential for Earth re-entry, but the suit was dismissed before launch.

One key principle of NEPA is that agencies must consider alternative actions, including a no-action alternative. In the context of NPS systems, NEPA requires agencies to consider cancelling the mission, altering the nuclear technology utilised and evaluating the use of other power sources, such as solar. New Horizons' EIS considered alternative energy options, identifying technology and fuel limitations related to using other radioisotopes or

186. Gilbert, A.Q. and M. Vidaurri (2021), *supra* note 146.
187. *Ibid*.
188. The Kilopower test reactor did not require an explicit NEPA analysis because it was covered by the EIS for the facility it was tested within. Comparably, Idaho National Laboratory recently issued a proposed FONSI for DOE's planned MARVEL microreactor, which could indicate that CEs or less stringent EAs may be appropriate for most planned space nuclear activities. See: Butcher, L., J. Locke, and B. Lal (2020), "Regulations on Ground Testing Space Nuclear Systems", in NETS 2020, Knoxville, Tennessee, 6-9 April.
189. Chang, Y. (2018), "Nuclear Safety Launch Approval: Multi-Mission Lessons Learned", *Journal of Space Safety Engineering*, Vol. 5, No. 2, IAASS, Noordwijk, Netherlands, pp. 126-130.
190. NASA (1997), *Cassini Final Environmental Impact Statement*, NASA, Washington, DC, available at: https://assets.science.nasa.gov/dynamicimage/assets/science/psd/solar/2023/09/f/feis.png?w=980&h=1254&fit=clip&crop=faces%2Cfocalpoint.

obtaining more efficient RPS systems.[191] It explicitly determined that solar was unable to provide an alternative energy source.[192]

Following the spirit of NSPM-20 in streamlining SNPS regulatory processes (though not expressly mandated) NASA conducted a review of its SNPS NEPA process in 2021.[193] In looking at the missions reviewed under PD/NSC-25, the review found that even though all missions conducted full EISs, they would have all qualified for a FONSI had they been just EAs. Accordingly, both NASA and DOD have since modified their SNPS NEPA process to start with an EA. NASA completed a programmatic environmental assessment for missions using RHUs in 2021 and both the Dragonfly and DRACO missions received FONSIs in their respective EAs.[194]

Current interpretations by NASA and other federal space agencies generally limit the review of environmental impacts to the Earth's environment.[195] This means that potential space environmental impacts of SNRs, such as harmful contamination of the Moon or the creation of space debris, are not likely to be considered by federal agencies conducting an EIS. This interpretation is based on executive precedent but may not hold up to judicial scrutiny considering the statutory text, legislative history and judicial precedent related to how the presumption against extraterritoriality applies to NEPA. However, the scope and extent of EIS for extraterrestrial activities remains in its infancy – considering the relatively limited human uses of outer space and current lack of identified life, it is likely that most space nuclear activities would qualify for a CE or EA/FONSI for space activities even if NEPA were applied to outer space.

5. *Liability, insurance and indemnification*

In the United States, space missions using nuclear power sources may fall under two major liability regimes: (1) liability for nuclear materials and technologies and/or (2) liability for space missions.

Nuclear liability in the United States is governed by the Price-Anderson Act (PAA), an amendment to the enabling Atomic Energy Act of 1954.[196] The PAA was originally passed in response to concerns by private-sector contractors and nascent nuclear supply chain companies to facilitate their participation in government and commercial nuclear activities. The PAA works through two primary mechanisms: an indemnification scheme for DOE contractors and a mandated liability pooling insurance regime for the commercial nuclear industry. The DOE mechanism includes a specific waiver of sovereign immunity for civil damages from government nuclear activities.

The PAA does not specifically mention space-based nuclear power systems. Nevertheless, its provisions may apply in certain circumstances. The PAA covers all nuclear-related acts by the DOE, including the Pu-238 supply chain and relevant research and development activities at DOE facilities. To ensure indemnification coverage of NASA's Pu-238 missions, the DOE usually retains title to US space nuclear systems aboard NASA

191. NASA (2005), *Final Environmental Impact Statement for the New Horizons Mission*, NASA, Washington, DC, available at: www.nasa.gov/wp-content/uploads/2018/04/nh-feis_vol1_0.pdf.
192. *Ibid*.
193. Eppig, B. et al. (2021), "NASA's Approach to Nuclear National Environmental Policy Act Compliance", paper presented at NETS 2021, 26-30 April.
194. NASA (2020), *Programmatic Environmental Assessment of Launches Involving Radioisotope Heater Units (RHUs)*, NASA, Washington, DC; DARPA (2023), *Environmental Assessment for the Demonstration Rocket for Agile Cislunar Operations (DRACO) Mission*, DARPA, Arlington, Virginia, available at: www.nasa.gov/wp-content/uploads/2024/01/draco-final-ea-oct2023.pdf; NASA (2022), *Environmental Assessment for the Dragonfly Mission*, NASA, Washington, DC, available at: www.nasa.gov/wp-content/uploads/2015/04/dragonfly_public_draft_ea_april_2022.pdf.
195. Gilbert, A.Q. and M. Vidaurri (2021), *supra* note 146.
196. Price-Anderson Nuclear Industries Indemnity Act of 1957, 42 USC 2210 (Price-Anderson Act or PAA).

spacecraft. For example, the DOE retained title to the RTG for the New Horizons mission.[197] The most recent Memorandum of Understanding between NASA and the DOE on Pu-238 RPS describes this in more detail:

> DOE hereby indemnifies NASA for liability for nuclear incidents under Section 170d. of the Atomic Energy Act of 1954, 42 USC §2210(d), as amended, including the amendments made thereto by the Price-Anderson Amendments Act of 2005, Public Law 109-58 (the Act). The provisions of the clause set forth in 48 C. F. R. 952.250-70, Nuclear Hazards Indemnity, shall apply to this MOU […] the term "contract location" means the property and facilities owned and/or operated by NASA and the Jet Propulsion Laboratory whereon radioisotope power systems are present. NASA agrees to modify this Article to include herein any Nuclear Hazards Indemnity clause promulgated by DOE to implement the Act. [198]

Given the plans for novel SNPS technologies and the substantial role of the private sector in their development and utilisation, liability issues likely pose the biggest policy gap in the US space nuclear governance framework. NASA does not have explicit indemnification authorities equivalent to the PAA to cover systems procured from commercial vendors. The US DOD has indemnification authorities under P.L. 85-804 for nuclear activities, but it requires a convoluted procurement process that has previously received scrutiny from the Government Accountability Office.[199] Establishment of a NASA indemnification authority, clarity on DOD indemnification requirements and other activities are likely needed to guide federal procurement of commercial SNPS.

There is more complexity and uncertainty for commercially launched and/or commercially operated SNPS. Such an analysis requires reconciling domestic nuclear liability and space liability. Although commercial PAA indemnification may apply to a space reactor at the spaceport before launch, it will not apply during and after space launch given the switch in jurisdiction from NRC to FAA. Insurance in the United States universally excludes coverage for nuclear damages due to the existence of PAA, meaning that commercial entities may not readily be able to get third-party space insurance.[200]

The launch vehicle-centric nature of FAA's space launch regulatory scheme has shaped its approach to indemnification, codified in 14 CFR Part 440. In effect, the FAA has a combined liability and insurance scheme for commercial launch vehicle providers. This scheme is intended, at least in part, to meet US obligations under the Space Liability Convention should an accident of a commercial US launch vehicle impact a third-party state.[201] The most relevant portion requires launch vehicle providers to cover a certain amount based on a calculation call "maximum probable loss" (MPL).[202] Launch vehicle providers either need to purchase third-party liability insurance in the amount of MPL or cover it through other financial assurance mechanisms.[203] Amounts more than the MPL are indemnified by the federal government up to a limit of several billion.[204]

197. NASA (2005), *supra* note 191.
198. NASA and US DOE (2016), "Memorandum of Understanding between the National Aeronautics and Space Administration and the Department of Energy Concerning Radioisotope Power Systems" available at: www.nasa.gov/wp-content/uploads/2015/01/nasa_doe_mou_energy_related_space_activities.pdf.
199. United States Government Accountability Office (GAO) (2024), *Defense Contracting: DOD Should Encourage Greater Use of Existing Expertise to Review Indemnification Requests*, GAO-24-106403, GAO, Washington, D.C.
200. Ampovska, M. (2017), "Nuclear Insurance Pools Worldwide: The Role in the Nuclear Law", *Balkan Social Science Review*, Vol. 9, University Goce Delcev, Štip, Macedonia pp. 7-21.
201. Dempsey, P.S. (2011), "Liability for Damage Caused by Space Objects Under International and National Law", *Annals of Air & Space Law*, Vol. 37, McGill University, Montreal, Canada, pp. 333-369.
202. 14 CFR 440.
203. 14 CFR 440.9.
204. 14 CFR 440.19.

Major questions remain about how liability will operate for commercial missions given these conflicting schemes. The insurance coverage for a launch provider may be sufficient to meet its Part 440 requirements but may not necessarily cover nuclear damage from a SNPS payload. Further, the insurance requirement is levied on the launch vehicle, not the payload, so reconciliation between private-sector actors on third-party damages would likely be required. Critically, even should a reconciliation occur, Part 440 only applies to the launch portion of a space mission and does not cover in-space liability or liability should a SNPS accident re-enter following the conclusion of launch operations. In such cases, the United States, as launching state, would have at fault or strict liability under the OST and Space Liability Convention, but currently does not have a clear mechanism which it transfers that liability to a commercial SNPS operator. Perhaps even more complicated, the United States is the primary global commercial launch provider: A future scenario could easily portend a foreign SNPS payload on a US launch vehicle resulting in multiple "launching states", with attendant complications in international and national liabilities.

6. Export controls

To meet its international treaty obligations, protect national security and to promote foreign policy goals such as minimising nuclear proliferation, the United States controls exports of nuclear goods, services and technology to foreign countries. A multi-agency licensing regime governs the export of nuclear goods and technologies from the United States to other countries:

- NRC regulates the export of reactors, technologies and materials under 10 CFR Part 110.[205]
- NNSA regulates the export of nuclear technology and assistance under 10 CFR Part 810.[206]
- The Department of Commerce regulates exports of "dual use" nuclear-power-related technologies through its Export Administration Regulations.[207]
- The Department of State's Directorate of Defense Trade Controls regulates SNPS and components through its International Traffic in Arms Regulations.[208]

These overlapping authorities create a complex labyrinth for both physical export of SNPS and for information exchange, such as safety reviews. For example, any SNRs built in the United States and exported abroad would likely require one or more export licences from each of these entities. Given the substantial international interest in SNPS capabilities for both civil and commercial lunar activities, these export controls may substantially burden US industry if not optimised. Additional legislation or implementing regulations are likely necessary to clarify the application of export controls to foreign missions launched from the United States.

7. The domestic mission authorisation and continuing supervision gap

Article VI of the OST requires that launching states "authorize and continually supervise" the space activities of their nationals, such as private citizens or corporations.[209] The existing commercial space regulatory scheme in the United States only provides for three primary regulators. Activities outside of their jurisdiction, such as a lunar mine or space reactor, do not have a clear mission authoriser or supervisor. For the United States to meet its Article VI obligations, current SNPS missions in the United States may be limited to

205. 10 CFR 110.
206. 10 CFR 810.
207. US Department of Commerce and FAA (2017), *Introduction to US Export Controls for the Commercial Space Industry* (2nd ed.), FAA, Washington, DC, available here: www.faa.gov/about/office_org/headquarters_offices/ast.
208. 22 CFR 120-130.
209. OST, *supra* note 107.

NASA or DOD customers, who have the ability to authorise and supervise missions either directly or via contract. While the application of extraterritorial jurisdiction under US law is beyond the scope of this article, the Atomic Energy Act provides the NRC with both territorial jurisdiction and personal jurisdiction, much as AST is empowered to regulate international space launches by US persons.[210] Accordingly, the NRC may be able to authorise and supervise US persons using SNPS, but existing regulations do not allow for it. As documented in NUREG 1556, Vol. 20, the NRC generally considers its jurisdiction for space activities to end at the spaceport when AST jurisdiction takes over during launch.[211]

Mission authorisation has been an outstanding policy issue in the United States for almost a decade, originally emerging from the first wave of space mining startups. Each Presidential administration has taken a different approach to a new mission authorisation framework, while Congress has released proposals of its own.[212] Generally, these proposals either extend jurisdiction for authorisation and supervision to AST, to the Office of Space Commerce or split it between both. As of 2024, the question of whether to and how to fill the mission authorisation gap remains unanswered. Further, even if an explicit regulatory authority was defined, the nascent nature of space nuclear technologies and commercial applications raises questions about whether any existing federal agency has sufficient technical capabilities to oversee the whole SNPS mission lifecycle.

8. Space resources

It is possible, albeit in the longer term, that uranium and thorium resources could be found in economic quantities on the Moon, Mars or moons of the giant planets. Given current limitations in planetary science, significant amounts of science and prospecting are likely needed to occur to establish resource viability. Nevertheless, as Ziarnick (2015) points out, extensive human activities in space may one day lead to a drive for space mining of nuclear materials.[213]

In 2015, the United States passed the Commercial Space Launch Competitiveness Act, which codified the ability of American citizens or companies to own abiotic resources gathered in space.[214] The statute grants the right of ownership to all abiotic resources gathered, which implicitly includes source material like natural uranium or thorium. However, as described in section 5(g)., it is likely that a mission authorisation gap exists for space mining; there is no clear system for the US government to approve a proposed commercial space mining mission.[215]

The potential mining of nuclear materials in outer space raises nuclear proliferation concerns. Absent mission authorisation, such mining would conflict with existing international obligations and US policy to prevent the unregulated production of source material. Any space resources mission authorisation framework should thus consider appropriate provisions governing the extraction of nuclear materials. More broadly, space resources development may lead to the use of SNPS, so space mining licences or authorisations may include provisions related to the use of SNPS for that specific operation.

210. For a useful discussion of US extraterritorial jurisdiction as it relates to space activities see Gilbert and Vidaurri (2021), *supra* note 146.
211. NRC (2020), "Consolidated Guidance About Materials Licenses: Guidance About Administrative Licensing Procedures", NUREG-1556, Vol. 20, Rev. 1, NRC, Washington, DC.
212. Swope, C. (2023), *Mission Authorization: Decoding the Space Policy Dilemma*, Center for Strategic and International Studies, Washington, DC.
213. Ziarnick, B. (2015), *Developing National Power in Space: A Theoretical Model*, McFarland & Company, Jefferson, North Carolina.
214. Commercial Space Launch Competitiveness Act, Pub. L. 114-90. The Act did not explicitly provide for Article VI mission authorisation and continuing supervision for US persons to gather abiotic resources, only to own them if they somehow had. For further discussion see Anderson, S.W., K. Christensen and J. LaManna (2019), *supra* note 106.
215. Anderson, S.W. et al. (2023), "Policy, Legal Processes and Precedents for Space Mining", in J.S. Lewis (ed.), *Handbook of Space Resources*, Springer Publishing, New York, pp. 1109-1161.

VI. Comparative governance of space nuclear energy

As other nations develop space nuclear power systems, they are also developing their regulatory frameworks for launch approval and other relevant authorisations. However, these systems are less mature than the US system. In most cases they are government authorisation processes for government activities and are not established for non-governmental actors like commercial entities. This section provides an overview of space nuclear governance in China, Europe and Russia. In general, these cases indicate the value of international soft law guidance, the interagency and sometimes international co-ordination involved for a single SNPS launch, and the ongoing maturation of the national legal frameworks.

1. *China*

China's approach to governing SNPS activities remains in its early years. Filings with the UN indicate that China followed the IAEA-COPUOS Safety Framework guidance in an ad hoc manner for its first two SNPS launches, Chang'e 3 and 4. The UN filing regarding the Chang'e 3 launch provides a good overview of the measures taken:

> Safety practices of space nuclear power sources were successfully carried out in Chang'E-3 (CE-3) mission. As for management aspects, regulations of space nuclear safety management were issued, a special coordination panel was formed, personnel safety measures were taken, an emergence response organisation and the whole emergency response system were established, all kinds of levels of safety training and safety rehearsals were performed. As for technical aspects, safety design of space nuclear power sources was done, special safety experiments and tests were carried out, and radiation doses were measured.[216]

Further, the filing indicates the launch followed the guidance of both the Safety Framework and the UN Principles.[217]

Nevertheless, the approaches to safety and approval of SNPS launches during Chang'e 3 and 4 were first-time activities and "there is still no long-term national space NPS safety mechanism" in China.[218] Multiple academic papers, both before and after NSPM-20 modernisations, call for China to draw inspiration from the comprehensive approach of the United States to an established space nuclear safety and regulatory framework.[219] These highlight both the procedural elements and the technical expertise of the US

216. Government of China (2016), "Safety Practices of Space Nuclear Power Sources in China", UN Doc. A/AC.105/C.1/2016/CRP.12, Conference room paper submitted to the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space, Vienna, 16 Feb. 2016.
217. UN COPUOS does not have a public filing of notice of the Chang'e 3 or 4 consistent with Principle 4.3. of the UN Principles. For example, see: Government of the Russian Federation (2023), "Note verbale dated 4 Aug. 2023 from the Permanent Mission of the Russian Federation to the United Nations (Vienna) addressed to the Secretary-General", UN Doc. A/AC.105/1297, Committee on the Peaceful Uses of Outer Space, Vienna; Government of the United States (2020), "Note verbale dated 28 July 2020 from the Permanent Mission of the United States of America to the United Nations (Vienna) addressed to the Secretary-General", UN Doc. A/AC.105/1233, Committee on the Peaceful Uses of Outer Space, Vienna.
218. Liu, J. et al. (2020), "Suggestions for China on establishing safety mechanisms for space nuclear power source applications", *Chinese Science Bulletin*, Vol. 65, No. 10, Science in China Press, Beijing, pp. 875-881.
219. *Ibid.* See also: Yin, Y. and J. Long (2014), "The US Outer Space Nuclear Power Sources Security Mechanism and Its Implication for China", *Journal of Beijing Institute of Technology (Social Sciences Edition)*, Vol. 2, Beijing Institute of Technology, Beijing, pp. 105-111; Hu, W. et al. (2017), "Advances of Safety Research on Nuclear Space Power Sources", *Journal of Deep Space Exploration*, Vol. 4, No. 5, Beijing Institute of Technology, Beijing, pp. 453-465.

approach. Overall, China's recent launches and academic commentary indicate a high level of interest in implementing the approach of the IAEA-COPUOS Safety Framework.

2. European governance

Europe is actively developing its approach to space nuclear safety and launch approval, with the additional complexity of needing to work across transnational laws and national implementing laws. The need for a European safety framework was initially identified by the European Working Group on Nuclear Power Sources for Space in 2005.[220] Initial efforts closely mirrored the timing and efforts of the IAEA-COPUOS Safety Framework. The work culminated in 2018 with ESA releasing an initial safety policy for SNPS that governs ESA missions, "ESA Safety Policy on the Use of Nuclear Power Sources".[221] The policy implements all levels of guidance outlined in the IAEA-COPUOS Safety Framework: governance, management and technical approaches.[222] It consists of key safety principles including (but not limited to):

- protection of people and the environment;
- launch approval process;
- reducing risk as low as reasonably achievable;
- lifecycle mission management;
- endorsement by ESA member states.

As an international intergovernmental organisation, ESA's policy is binding on ESA personnel but does not directly govern space nuclear launch safety. Rather, it provides significant guidance to national governments responsible for direct governance of nuclear activities and effectively creates a mechanism for ESA's governance to interface with a state's responsibilities. More broadly, ESA's status as an intergovernmental agency could create some unique challenges when it comes to implementation of the space treaties, particularly the Space Liability Convention.[223]

The first European missions expected to be governed by European launch approval processes are expected to occur in the 2030s out of French Guiana.[224] Accordingly, French laws regarding nuclear and space safety will apply to the nuclear launch authorisation process. For purposes of the OST and other space treaties, France would thus be considered a launching state, although other additional European nations could be considered additional launching states for ESA missions. Initial efforts started in 2018 on the "Nuclear Launch Safety Authorisation Process" (NLSAP), which initially focuses particularly on the technical approaches to evaluate the safety of novel RPS designs, with significant progress

220. Summerer, L. and F. de Winne (2005), "Considerations of Safety and European Options Regarding Nuclear Power Sources for Space", presented at *1st IAASS Conference: Space Safety, a New Beginning*, Nice, France, 25-27 October.
221. ESA (2019), "Implementation of the Guidelines Provided for in the International Safety Framework for Nuclear Power Source Applications in Outer Space for ESA Space Missions – The ESA Safety Policy on the Use of Nuclear Power Sources", UN Doc. A/AC.105/C.1/2019/CRP.10, Committee on the Peaceful Uses of Outer Space, Scientific and Technical Subcommittee, ESA, Vienna, pp. 1-2.
222. Interestingly, the IAEA-COPUOS Safety Framework specifies that its guidance applies to governments and not necessarily intergovernmental organisations like ESA. Nonetheless, ESA's approach adopts the framework nevertheless, with provisions for harmonisation with the governance of specific launch activities by its member states. See *Ibid.*, pp. 4.
223. Barco, A. et al. (2020), *supra* note 14, pp. 144.
224. Note that ESA's Rosalind Franklin rover is being launched under the United States launch approval framework.

being made to date.[225] Lattwein et al. describe this system as consisting of three parts:[226]

- A "ground" phase where regulation is consistent with "any other radioactive sealed source" and handled by the French Nuclear Safety Authority (now, following a reorganisation on 1 January 2025, the French Authority for Nuclear Safety and Radiation Protection [*Autorité de Sûreté Nucléaire et de Radioprotection*, or ASNR]);
- A "launch" and an "orbital" phase where the French space agency (*Centre national d'étude spatiales* – CNES) is the nuclear safety authority, with technical assistance from the French nuclear regulator (*Institut de Radioprotection et de Sûreté Nucléaire* [IRSN], now the ASNR).

As CNES, ESA and IRSN (ASNR) work through establishing this framework, they are using both the UN Principles and the US framework as benchmarks.[227] Nevertheless the specific methodologies borrow heavily from the French approach to terrestrial facility safety.[228] Although Europe is beginning to explore development of space fission reactors, this initial approach is primarily focused on RPS. Further, the initial efforts by ESA solely apply to civil space missions, although the launch approval processes developed by CNES and other French authorities may be precedential for future commercial launch activities from French Guiana.

3. *Russia*

Russia's framework for SNPS safety and authorisation is derived from procedures originally established during the Soviet era.[229] This consists of multiple government agencies responsible for various parts of the design, mission planning and launch approval for a SNPS mission. Key elements include:

- Russian Government Decree No. 1039, dated 15 August 1997, is the primary dedicated governing document and provides for notifications of executive authorities and local governments, as well for some emergency response planning.[230]
- The Federal System for Space Technology Certification is responsible for certifying that a specific RPS meets safety requirements and that its use would be consistent with the UN Principles.[231]

225. ESA (2024), "Implementation of the guidelines from the international safety framework for nuclear power source applications in outer space for ESA space missions – Preliminary Nuclear Launch Safety Authorisation Process (NLSAP)", UN Doc. A/AC.105/C.1/2024/CRP.24, Conference room paper submitted to the United Nations Committee on the Peaceful Uses of Outer Space, Vienna, 1 Feb. 2024.
226. Lattwein, F. et al. (2024), "Ensuring the Safety of European Space Missions with Radioisotope Power Systems", paper presented at the NETS Conference, Santa Fe, New Mexico, 6-10 May.
227. *Ibid*.
228. *Ibid*.
229. Cook, B.A., R.G. Lange and A.A. Pustovalov (1994), "A Comparison of the Launch Approval Processes used in the US and Russia for Nuclear Power Space Exploration Missions", AIP Conference Proceedings, Vol. 301, No. 1, AIP, Washington, DC, pp. 875-878.; Chernykh, I.A. (2017), "Soft Law Realisation in the Context of 'Principles Relevant to the Use of Nuclear Power Sources in Outer Space': Case Study the Russian Federation, the United States of America and the European Union States", *RUDN Journal of Law*, Vol. 21, No. 3, pp. 44.
230. Government of the Russian Federation (2023), "Note verbale dated 4 August 2023 from the Permanent Mission of the Russian Federation to the United Nations (Vienna) addressed to the Secretary-General", UN Doc. A/AC.105/1297.
231. Government of the Russian Federation (2020), "Experience in the practical application of the Principles Relevant to the Use of Nuclear Power Sources in Outer Space and the Safety Framework for Nuclear Power Source Applications in Outer Space", UN Doc. A/AC.105/C.1/L.388, Working paper submitted to the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space, Vienna, 16 Sept. 2020.

- An RPS is governed by usual radiation safety authorities for non-launch activities, including regulations consist with IAEA Transportation Regulations.[232]
- The RPS is subjected to a rigorous testing regime to support certification.

Overall, the available documents indicate a priority on meeting the goals for the UN Principles, with a lesser degree on matching the Safety Framework approach (since Russia has an existing framework).

VII. Conclusion: the final frontier of international nuclear law

The rapid increase in lunar activities and commercial space ambitions mean that nuclear power sources are poised to play a major role in the new age of space exploration. Nuclear power could well be the foundation of the lunar and Martian economies, enabling a sustained and sustainable presence for the global community. Such an expansive view of SNPS applications entails new state and commercial actors, advanced technologies and new destinations. This represents a significant departure from historical SNPS missions, which were exclusively state-led by the largest superpowers.

Existing international space and nuclear law offers a sufficient structure for early experimentation with novel SNPS technologies. While old, the space treaties were designed as general principles and are flexible enough to incorporate the unique elements of nuclear law. Nevertheless, space law (unlike nuclear law) was not originally meant to govern commercial actors and trade, so careful attention will be needed by states to develop governing structures for national SNPS activities. The non-binding UN Principles and IAEA-COPUOS Safety Framework provide sufficient guidance for initial safety governance, especially for state activities. Indeed, the examples of newcomer space nuclear entities like ESA and China relying upon both the UN Principles and the Safety Framework indicate the influential power of soft law in building strong international safety norms, particularly with only limited state practice to emulate. More policy and guidance may be needed for specific activities, such as end-of-life, security and proximity operations. Emergent space agreements such as the Artemis Accords and International Lunar Research Station provide promising venues for such adaptive governance.

The United States, as a leader in space nuclear governance, has developed a proactive framework that facilitates commercial nuclear launches and includes robust safety guidelines, even for novel technologies and actors. NSPM-20 and its associated regulatory framework is an experiment in risk-informed, technology-inclusive, performance-based regulation, with little of the bureaucratic overhang that traditional national nuclear regulators have. As the United States continues to develop implementing guidance and gain experience, it is well suited to share its lessons learnt with the international community.

Perhaps the most challenging extant and pressing issue in international and national law for SNPS is liability, with its attendant insurance and indemnification implications. While the OST and Space Liability Convention establish a foundation for addressing damages caused by space objects, they do not adequately cover the complexities introduced by commercial SNPS missions. This is especially true when involving supply chains and mission operators from multiple states, or for intergovernmental entities such as ESA. The current nuclear liability treaties are limited to terrestrial reactors and thus do not address liability-related trade barriers. In the United States, the PAA and P.L. 85-804 systems provide indemnification for some government activities, but NASA may be unable to directly procure commercial SNPS, greatly impairing US science capabilities. More worryingly, third-party liability and lack of insurance for private entities could hinder the growth of commercial space nuclear ventures and limit international trade in peaceful SNPS technologies. Clarifying and modernising liability provisions, particularly as they

232. IAEA (2016), *Regulations for the Safe Transport of Radioactive Material*, IAEA Safety Standards Series, Specific Safety Requirements, No. SSR-6 (Rev. 1), IAEA, Vienna.

pertain to launches, in-space operations and re-entry risks, will be necessary to build a responsible and resilient commercial SNPS sector.

Ultimately, the growth of the space sector and potential establishment of permanent human settlements on the Moon, Mars and beyond may depend on the availability of space nuclear technologies. Such ubiquitous use may require much more than the current legal framework. Handling the unique concerns of SNPS may require a dedicated branch of law: space nuclear law. A hybrid of both space law and nuclear law, such a final frontier of law would enable the expansive and permissive use of space nuclear systems, unlocking the solar system to human activities.

New-build nuclear power plant contracts and nuclear third-party liability: Contractor zero liability for net zero?

*By Ephraim Wittman**

"We don't get to net zero by 2050 without nuclear power in the mix."

United States (US) Special Climate Envoy John Kerry[1]

I. Executive summary

The International Energy Agency (IEA) has stated that nuclear energy can help address both growing energy needs and climate goals, two desperately needed pillars for balancing economic growth while achieving net zero carbon emissions (net zero).[2] Due to the well-known risks and benefits of harnessing nuclear energy, the International Atomic Energy Agency (IAEA) has formulated an 11-point series or principles of nuclear law,[3] two of which are: (1) *responsibility* for safety primarily falls on the operator (for nuclear energy production), and (2) adequate *compensation* needs to be readily available if a nuclear incident leading to nuclear damage occurs.[4]

To address both responsibility and compensation, there are three major international convention regimes that address nuclear third-party liability (the Conventions): the Convention on Third Party Liability in the Field of Nuclear Energy (Paris Convention or PC), the Vienna Convention on Civil Liability for Nuclear Damage (Vienna Convention or VC) and the Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage (Revised Vienna Convention or RVC), and the Convention on Supplemental Compensation

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1 Valdmanis, R., S. Mcfarlane and V. Volcovici (2022), "At COP27, nuclear power industry vies for bigger role in decarbonizing planet", Reuters, www.reuters.com/business/cop/cop27-nuclear-power-industry-vies-role-decarbonizing-planet-2022-11-09.

2. IEA (2022), *Nuclear Power and Secure Energy Transitions*, IEA, p. 7, https://iea.blob.core.windows.net/assets/016228e1-42bd-4ca7-bad9- a227c4a40b04/NuclearPowerandSecureEnergyTransitions.pdf (accessed 23 Apr. 2025).

3. Stoiber, C. et al. (2003), *IAEA Handbook on Nuclear Law*, IAEA, Vienna, p. 5.

4. *Ibid,* pp. 7-8.

for Nuclear Damage (CSC).[5] These Conventions, while creating a special regime for nuclear energy, follow the traditional tort risk allocation model of strict liability imposed on persons conducting unusually hazardous or "abnormally dangerous" activities.[6] Strict liability lowers the burden of proof to only causation between the nuclear incident and the resulting nuclear damage, meaning intention[7] to commit nuclear damage or even just negligence per se is not required to assign liability, primarily, to the operator.[8] While there are limited exceptions to this imposition of strict liability,[9] in practice, it is this author's experience that many contractors are requiring additional indemnification by contract, thereby creating a different and more rigorous standard of liability on the operator than that imposed by the Conventions as enacted in domestic law, even to the extent that gross negligence and wilful misconduct caused by such contractors or their employees remains the operator's responsibility. While the general rule of contracts is freedom of contract,[10] meaning the parties can agree to whatever they wish as a lynchpin of market-based economics,[11] certain reasons for why a contract or parts of a contract would be unenforceable in this instance may apply, such as illegality and public policy grounds.[12]

As discussed below, it is common practice in the industry for broad-based indemnities to be offered by each party to the other in a contract in case of death, injury, illness and property damage, but this has traditionally been limited to non-nuclear damage. Where in traditional power projects the risk of nuclear damage is zero, nuclear-based construction, operations and maintenance contracts will need to address both non-nuclear and nuclear damage. Therefore, careful drafting is required to avoid sweeping nuclear and non-nuclear damage under one regime or creating a situation in which the same actions and same origins of damage trigger different liability regimes. The matter becomes more complicated when the carefully crafted Conventions and ensuing domestic legislation are disposed of in commercial agreements in favour of zero liability for the contractor and/or its employees.

As a separate challenge, while construction court cases publicly available are legion, the number of nuclear third party liability (NTPL) court cases is limited,[13] and domestic law

5. Convention on Third Party Liability in the Field of Nuclear Energy of 29 July 1960, as amended by the Additional Protocol of 28 January 1964, by the Protocol of 16 November 1982, and by the Protocol of 12 February 2004, entered into force 1 Jan. 2022, consolidated text available at: Nuclear Energy Agency (NEA) (2024), "Convention on Third Party Liability in the Field of Nuclear Energy of 29 July 1960, as amended by the Additional Protocol of 28 January 1964, by the Protocol of 16 November 1982 and by the Protocol of 12 February 2004", NEA Doc. NEA/NLC/DOC(2017)5/FINAL; Vienna Convention on Civil Liability for Nuclear Damage (1963), IAEA Doc. INFCIRC/500, 1063 UNTS 266; Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage (1997), IAEA Doc. INFCIRC/566, 2241 UNTS 302, entered into force 4 Oct. 2003; Convention on Supplementary Compensation for Nuclear Damage (1997), IAEA Doc. INFCIRC/567, 36 ILM 1473, entered into force 15 Apr. 2015. The "Vienna Conventions" will hereinafter refer to the Vienna Convention and the revised Vienna Convention jointly.
6. See Legal Information Institute (LII) (n.d.), *"Strict liability"*, Wex, www.law.cornell.edu/wex/strict_liability, (accessed 23 Apr. 2025); LII (2022), "Abnormally dangerous activity", Wex, www.law.cornell.edu/wex/Abnormally_dangerous_activity, (accessed 23 Apr. 2025)
7. Incidentally, intention arising to wilful misconduct is one of the exceptions to operator strict liability as referenced further below.
8. Stoiber, C. et al. (2003), *supra* note 3, p. 111.
9. PC, *supra* note 5, Articles 6(c), (e) and (f); VC and RVC, *supra* note 5, Articles V.2, V.7; CSC, *supra* note 5, Annex, Articles 3.6, 10.
10. See, generally, Irakli, T. (2017), "The Principle of Freedom of Contract, Pre-Contractual Obligations Legal Review English, EU and US Law", *European Scientific Journal*, Vol. 13, No. 4, European Scientific Institute, Kocani, Macedonia, pp. 62-71.
11. Weber, D. (2013), "Restricting the Freedom of Contract: A Fundamental Prohibition", *Yale Human Rights and Law Journal*, Vol. 16, New Haven, Connecticut, p. 52.
12. See e.g. United Arab Emirates (UAE) Federal Law No. 5 of 1985, concerning the issuance of the civil transactions of the United Arab Emirates (UAE Civil Code) Articles 129 and 210.
13. Magnus, U. (2022), "Recognition and enforcement of foreign judgments on civil liability for nuclear damage", *Nuclear Law Bulletin*, No. 106, OECD Publishing, Paris, pp. 7-20.

tends to mimic the language of the Conventions where they are incorporated.[14] There is therefore no actionable data to determine whether, as a matter of illegality, public policy or otherwise, such provisions on contractors removing their liability for nuclear damage would be struck down if a case was actually litigated.[15] At least under common law systems, this uncertainty is leaving a legal grey area for courts to decide whether, if a nuclear incident leads to nuclear damage, the will of the parties to the contract will overcome the strictures of the Conventions, both as enacted in domestic law and as supplemented by domestic legal restrictions on limiting liability in contract.[16]

Additionally, as more reactors are under construction or planned as a part of plans to achieve net zero, the lack of clarity from the courts and the contractual manoeuvring of contractors to ensure no liability due to their or their employees' gross negligence or wilful misconduct causing nuclear damage arising from or connected to a nuclear incident is leading to a higher risk profile for both operator and contractor if a new contractual regime of zero liability channelling moves to the operator in all instances. To compound matters, while NTPL has traditionally been covered by insurance either up to the limits of the Conventions or to limits established by the laws of several states,[17] there is little reason for an insurer to take on liability for gross negligence as a concept, and none for wilful misconduct, especially for NTPL. This means that coverage for a nuclear incident leading to nuclear damage caused by gross negligence or wilful misconduct likely falls outside of the required scope of coverage for insurers, leading to a thwarting of the intention of the Conventions and a potential shortfall for victims in the unlikely event of a nuclear incident leading to nuclear damage caused by gross negligence or wilful misconduct.

This article illustrates the need to return to the bargained-for exchange confines of the Conventions in actual practice, which will save time and money for the parties, and continue to protect and, if necessary, compensate third parties as intended as per the Conventions.

II. Introduction

At the time of writing, a search on Google for the term "nuclear renaissance" produces over 22 million results. Further review of the search results leads to proponents and detractors of nuclear power proclaiming the merits of or denouncing nuclear energy, and stating that the renaissance is here, is nearly upon us, or will not happen.[18] Amid the jumble of newspapers, thinktanks, academics and bloggers debating whether the world is experiencing a nuclear renaissance, according to the World Nuclear Association (WNA), as of April 2025, there are approximately 66 reactors under construction to complement the current 440 reactors operating in 31 countries and Chinese Taipei, with an additional 85 reactors planned and over 300 proposed.[19] About 30 countries have started or are looking

14. UAE Federal Law by Decree No. 4 of 2012, concerning civil liability for nuclear damage.
15. The NEA has produced a very helpful, though perhaps non-exhaustive, review of nuclear-related case law from March 1987 through August 2024, which does not contain any cases covering this article's purpose. NEA (2025), *"Nuclear Law Case Chart"*, OECD Publishing, Paris, available at: www.oecd-nea.org/upload/docs/application/pdf/2025-04/nuclear_law_case_chart_april_2025.pdf.
16. E.g. the United Kingdom's Unfair Contract Terms Act of 1977 (c. 50).
17. Some national laws provide for unlimited nuclear liability on the operator, but even where there is unlimited liability under the law, insurance will only cover up to an established limit.
18. See e.g. The Economist (2023), "America aims for nuclear-power renaissance", The Economist, www.economist.com/united-states/2023/06/25/america-aims-for-nuclear-power-renaissance; Stepansky, J. (2022), "No nuclear power 'renaissance' as Europe wrestles energy crisis", Al Jazeera, www.aljazeera.com/news/2022/10/6/europe-sees-shift-in-attitudes-no-nuclear-power; Lake, J.A. (2006) "The Renaissance of Nuclear Energy", *Journal of Economic Perspectives*, Vol. 20, No. 2, American Economic Association, Nashville, pp. 14-18.
19. WNA (2024), "Plans for New Reactors Worldwide", WNA, https://world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide.aspx (accessed 23 Apr. 2025).

to implement nuclear power programmes,[20] and with new builds come new construction and operations and maintenance contracts, all of which, from this author's experience, lead to questions, or to positions on NTPL that may not comport with the Conventions or with domestic law.

Unfortunately (or fortunately), to date there have been no cases at the International Court of Justice or at the Permanent Court of Arbitration on the issue of NTPL, which perhaps is not surprising given that under the Conventions, commercial contracts and the dispute resolution process for NTPL would, with limited exceptions, be under the jurisdiction of the relevant court where the nuclear incident occurred.[21]

Moving to domestic courts does not provide any more clarity. While writing on the enforcement of foreign judgments with respect to NTPL, Dr Magnus of the University of Hamburg analysed several cases from different jurisdictions, including Japan and the United States, with respect to the Fukushima Daiichi Nuclear Power Plant accident.[22] None of the cases involved the actions of a contractor, let alone where a contractor's gross negligence or wilful misconduct led to a nuclear incident and where the contractor is seeking indemnification from the operator.[23] Additionally, in a survey of English case law based upon the Nuclear Installations Act of 1965, an act that purportedly complies with the Paris Convention, the authors concluded that there were also no cases with respect to contractor indemnification.[24] Moreover, they noted that an indemnity towards a supplier (or its employees as individuals who would actually fall into the exception) for intentional acts would be void under English law as indemnification for criminal acts is not allowed.[25]

As discussed in greater detail below, while the trend of zero liability channelling appears to be a welcome trend from outside counsel and suppliers,[26] it is not tenable and, in the unlikely event of a nuclear incident, liability is most likely to be placed on the individual concerned as a matter of law, rather than the company, thereby making this concession unnecessary and ineffective.[27]

The purpose of this article is to review, comment on and analyse the effects of the trend in nuclear goods and services commercial contracting towards zero liability channelling from suppliers to operators, even where express exceptions under the Conventions would otherwise allow or explicitly allocate the risk of nuclear damage to a person other than the operator. To address this point, section III will begin with a brief discussion on NTPL and exceptions to NTPL as provided under the Conventions, followed by an analysis of the traditional role of insurance and the gaps in coverage created by the exceptions in the Conventions, some commentary on Fukushima Daiichi with respect to insurance and costs, with a final discussion on how to define gross negligence and wilful misconduct.

20. WNA (2024), "Emerging Nuclear Energy Countries", WNA, https://world-nuclear.org/information-library/country-profiles/others/emerging-nuclear-energy-countries.aspx.
21. PC, *supra* note 5, Article 13; RVC, *supra* note 5, Articles 4.7, 11 ; CSC, *supra* note 5, Annex Article 2.4.
22. Magnus, U. (2022), *supra* note 13, pp. 7-20.
23. *Ibid*.
24. Thomas, A. and R. Heffron (2012), *"Third Party Nuclear Liability: The Case of a Supplier in the United Kingdom"*, Electricity Policy Research Group (EPRG) Working Paper 1205, EPRG, Cambridge.
25. *Ibid*, p. 23.
26. Fork W. and A. Frank (2023), "Nuclear Project Development: Contracting Issues in Context", presentation at the International School of Nuclear Law, NEA and University of Montpellier, Montpellier, France, 31 August 2023.
27. NEA (2024), "Exposé des Motifs of the Paris Convention as amended by the Protocols of 1964, 1982 and 2004", adopted by the Contracting Parties to the Paris Convention on 18 Nov. 2016, NEA Doc. NEA/NLC/DOC(2020)1/REV1/FINAL, pp. 15-16, 30; IAEA (2020), *The 1997 Vienna Convention on Civil Liability for Nuclear Damage and the 1997 Convention on Supplementary Compensation for Nuclear Damage – Explanatory Texts*, IAEA International Law Series, No. 3 (Rev. 2), IAEA Doc. STI/PUB/1906, IAEA, Vienna (Explanatory Texts).

Section IV reviews certain domestic laws on how risk for nuclear damage is allocated and in what amount, followed by commercial contracting trends in section V, which is based upon this author's experience as a lawyer working on both the contractor and operator side of a nuclear installation. The sixth and final section will discuss the implications of zero liability channelling from suppliers with an examination of the Cooper case from the United States as a potential foretelling of the futility of zero liability channelling for nuclear liability claims.

III. What is nuclear third-party liability?

On this author's first day after joining the operator of a prominent nuclear programme, the general counsel started his introduction by saying a phrase heard even today – "nuclear is special". There is an understanding within the industry and by nuclear experts everywhere that the special nature of nuclear means, in part, that irrespective of precautions taken, nuclear incidents can occur. If a nuclear incident leading to nuclear damage does occur, responsibility must be clearly and swiftly allocated, and third parties suffering such damage must be compensated under certain scenarios due to the potential negative effects of ionising radiation and the possibility of transboundary damage.[28]

NTPL has therefore developed into a special, nearly worldwide regime designed to address the unique nature of nuclear and utilises five principles consistent throughout the Conventions:[29] (1) strict and (2) exclusive liability (i.e. legal channelling) on the operator with respect to third parties; (3) mandatory amounts of financial security; (4) up to a certain minimum as provided in the Conventions (or a greater amount as established under domestic law); and (5) a generous statute of limitations on claims for nuclear damage. This is the balance of trying to ensure that the production of nuclear energy remains viable (affordable) while ensuring victims can be compensated for the potentially wide-ranging effects of nuclear damage.[30]

Two other principles or acknowledgements regarding nuclear damage present in the Conventions are critical to addressing key potentialities and management of nuclear damage claims: the possibility of transboundary nuclear damage and the resulting cross-border claims. For these two points, under the Conventions, jurisdiction over nuclear damage claims remains with the designated court of the country in which the nuclear incident took place. These claims are therefore subject to such country's laws while remaining enforceable in foreign jurisdictions, and every person affected by nuclear damage should be compensated irrespective of their nationality or residency status in the country where the nuclear incident occurred.[31]

The above sums up the key principles of the Conventions but, as these principles have been analysed in exhaustive detail in a number of notable papers and articles,[32] this next section instead focuses on certain exceptions to operator liability as provided for in the Conventions, a brief consideration of insurance as the typical mechanism for coverage of the financial security requirement under the Conventions, Fukushima Daiichi and its use as a trendsetter for claims, and finally, an examination of the exceptions and what they would mean in the context of the domestic law of certain countries.

28. Stoiber, C. et al. (2003), *supra* note 3, p. 107; Schwartz, J. (2022), "Liability and compensation for third party damage resulting from a nuclear incident", in NEA (ed.), *Principles and Practice of International Nuclear Law*, OECD Publishing, Paris, p. 409.
29. *Ibid*., pp. 411-416.
30. It should be noted that some states, such as Germany, Japan and Switzerland, have decided to enact domestic legislation that leaves liability uncapped for nuclear damage. See NEA (n.d.), "Nuclear Liability", NEA, www.oecd-nea.org/jcms/pl_31319/nuclear-liability. The ramifications of this approach, as best evidenced by Fukushima, are addressed below.
31. Schwartz, J. (2022), *supra* note 28, pp. 417-418.
32. E.g. Stoiber, C. et al. (2003), *supra* note 3, pp. 107-116; Thomas, A. and R. Heffron (2012), *supra* note 24, pp. 3-9.

1. *Exceptions to operator liability under the Paris Convention*

While Article 3 of the Paris Convention places liability for nuclear damage arising from a nuclear incident[33] on the operator, Article 6 of the PC provides a clear statement that liability on the operator is only triggered in accordance with the PC. The ensuing text in Article 6 then provides certain exceptions to the operator's liability, which, while quite limited, provide an important and carefully crafted and negotiated balance of responsibility for when, as a matter of common sense and fairness, the operator should not be liable for nuclear damage.

Specifically, Article 6(c)(i) of the PC states that the liability of a person (individual) intending to and causing nuclear damage is not obviated with respect to nuclear damage affecting the nuclear installation, and any property thereon, "to be used in connection" with the nuclear installation.[34] While this statement alone does not remove liability per se from the operator, it should be noted that Article 3 itself states that the operator is liable for damage "other than" that described above, meaning that if the operator is not liable and the liability of the person(s) who intentionally caused nuclear damage is not removed, it is clear that such person(s), as the only causal influence, is(are) the only person(s) liable.[35] To reinforce this point, Article 6(c)(ii) removes liability on the operator for nuclear damage except for as provided in the PC, meaning that nuclear damage to the nuclear installation and associated property would be, under normative principles of law, the responsibility of the person intending to cause such damage, and not the operator. This same article also refers to Article 9, which is much more explicit in removing liability from the operator and clarifying that the liability removed from the operator is transferred to the person(s) who causes a nuclear incident leading to nuclear damage due to "armed conflict, hostilities, civil war, or insurrection".[36] Article 6(e) creates an additional exception for nuclear damage liability that, in part, builds upon the circumstances under which intent to cause nuclear damage is no longer limited to certain enumerated exceptions like those provided in Article 6(c). In this instance, the operator is not responsible for compensating the person who either intentionally, or through gross negligence, caused the nuclear damage, but the operator remains liable for all other third parties.[37]

In other words, pursuant to Article 6, the operator is not liable for nuclear damage affecting the nuclear installation or that is caused by an act of armed conflict, hostilities, civil war or insurrection, nor for damages sustained by individuals who intentionally, or through their gross negligence, caused the nuclear damage.

Finally, Article 6(f) of the PC states that the parties to a contract can agree therein for the operator to have the right of recourse against a person (individual or company)[38] who intended to and did cause nuclear damage. This does not remove liability from the operator towards third parties and, unlike in Article 6(c)(i), the right of recourse is founded in contract law, not tort law. The right of recourse can, by agreement, be expanded to include the employer of the person who intentionally caused the damage. This right of recourse would be effectuated by the operator compensating third parties for their damages and

33. Or nuclear substances at the installation or in carriage as further described in Article 4 of the Paris Convention, but these circumstances are not addressed further for the purposes of this article. PC, *supra* note 5.
34. *Ibid.*, Article 6(c)(i).
35. *Ibid.*, Article 3(a).
36. *Ibid.*, Article 9.
37. There is no definition of gross negligence in the PC, meaning that the national law of the country having jurisdiction would need to have this concept for the exception to apply.
38. While the PC, the VC and the RVC have explanatory documents that elaborate on the conventions focus on the liability of individuals and not the companies they work for, this liability could arguably be expanded by contract or national law). See IAEA (2020), Explanatory Texts, *supra* note 27; NEA (2020), "Exposé des Motifs of the Brussels Supplementary Convention as amended by the Protocols of 1964, 1982 and 2004", adopted by the Contracting Parties to the Brussels Supplementary Convention on 23 Dec. 2010, NEA Doc. NEA/NLC/DOC(2017)4/FINAL

then the operator seeking recovery against the person(s) who caused the nuclear damage, or their employer, pursuant to the contract.

What are the differences then? Under the first exception, the person intending to cause nuclear damage takes on full liability, including towards third parties, rather than the operator, but only for certain types of enumerated damage. This means that any other type of nuclear damage unrelated to the nuclear installation and associated property, or all other damage would still be the responsibility of the operator even if caused by a person intending to create nuclear damage unless falling under the remaining exceptions to operator liability (e.g. war). Under the second exception, the person intending to cause nuclear damage or committing gross negligence, which then causes nuclear damage, is unable to recover from the operator for nuclear damage to himself and his associated property, but the operator remains liable towards all other third parties. Finally, under the third exception, parties agreeing in a contract to take responsibility for nuclear damage will be responsible to reimburse the operator (through recourse) who remains liable towards third parties for nuclear damage.

2. Exceptions to operator liability under the Revised Vienna Convention

The PC and the VC and RVC operate as separate regimes and are linked via the 1988 Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention (Joint Protocol).[39] There are many similarities, including with respect to exceptions to operator liability. Article II(5) of both the VC and the RVC states that the operator is liable except as provided in the conventions, and Article IV of the VC and the RVC makes such operator liability "absolute" while mimicking most of the exceptions already listed in the PC: (1) where provided in national law, gross negligence and/or wilful misconduct of a person leading to nuclear damage removes operator liability to compensate such person for the nuclear damage suffered;[40] (2) there is no liability on the operator if the operator proves nuclear damage occurred from "armed conflict, hostilities, civil war, or insurrection;"[41] (3) there is no liability on the operator for nuclear damage to the nuclear installation and associated property;[42] (4) a person intending to cause nuclear damage to the nuclear installation or associated property does not have liability removed by virtue of nuclear damage occurring to the same;[43] and (5) the operator retains the right of recourse against a person who intended to cause nuclear damage, or as expressly covered by contract.[44]

3. Exceptions to operator liability under the Convention on Supplementary Compensation

The CSC is a free-standing instrument, where states can join by being members of the PC, VC or RVC. The CSC also permits countries to develop their domestic nuclear liability legislation in line with the Annex of the CSC in order to become a contracting party to the CSC without joining the PC, VC or the RVC.[45] There are also a couple of notable expansions of the exceptions listed such as granting the rights of recourse to all contracting parties if

39. Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention (1988), IAEA Doc. INFCIRC/402, 1672 UNTS 293, entered into force 27 Apr. 1992 (Joint Protocol).
40. Compare VC, *supra* note 5, Article IV(2) and RVC, *supra* note 5, Article IV(2) with PC, *supra* note 5, Article 6(e).
41. Compare VC, *supra* note 5, Article IV(3)(a) and RVC, *supra* note 5, Article IV(3) with PC, *supra* note 5, Article 9.
42. Compare VC, *supra* note 5, Article IV(5)(a) and RVC, *supra* note 5, Article IV(5) with PC, *supra* note 5, Articles 6(c)(i) and 3(a).
43. Compare VC, *supra* note 5, Article IV(7)(a) and RVC, *supra* note 5, Article IV(7) with PC, *supra* note 5, Article 6(c)(i).
44. Compare VC, *supra* note 5, Article X(a) and RVC, *supra* note 5, Article X(a), with PC, *supra* note 5, Article 6(f).
45. CSC, *supra* note 5, Articles 1(b) and 2.

such right is granted pursuant to the PC, VC or RVC,[46] and the right of contracting parties to absolve the operator from liability for nuclear damage caused by "a grave natural disaster of an exceptional character".[47] This would leave open then the possibility that liability would still arise for the operator under the PC, VC or RVC but not with expanded compensation as provided under the CSC.

4. *Insurance coverage for financial liability under the Conventions*

As mentioned earlier, one of the key points of nuclear law is the compensation principle. This principle establishes the right of persons affected by nuclear damage to be compensated, and this is done through the NTPL regime by the operator and/or the state establishing some type of financial security as provided in the Conventions or in similar provisions in national law, with the state acting as a backstop in several jurisdictions.[48] According to the IAEA, most of the coverage of this financial security is through insurance, providing a more affordable option for the industry.[49]

Messrs. Reitsma and Tetley have listed five necessary points for an insurance contract to be viable: (1) utmost good faith; (2) an insurable interest; (3) fortuity; (4) indemnity; and (5) subrogation.[50] Utmost good faith requires full disclosure to the insurer of the known risks that a reasonable person knew or should have known. An insurable interest means the product or item insured is owned by the person seeking insurance coverage. Fortuity was not particularly clear in the article cited, but one Canadian court defined fortuity as an insured event that arises "unlooked for, unexpected, or not intended by the insured";[51] in other words, an event is fortuitous if it could not have been known that it would arise. Indemnity means that the amount insured is payable to the beneficiary upon raising the claim, and subrogation means that the insurer can step in on behalf of the insured upon indemnifying the insured and pursue the actual person who caused the damage.[52]

Insurance coverage for NTPL has worked from the early days of nuclear since "principles of insurance apply equally to nuclear as to motor insurance".[53] Insurance covers both installation and associated property (i.e. on-site), one of the exclusions of operator liability under the Conventions, and NTPL is covered under a separate insurance policy.[54] Due to the extremely hazardous and potentially costly risk associated with nuclear damage, for the most part, insurance pools or groups of insurance companies have been formed to dilute and re-appropriate the risk among themselves and through re-insurance. Also, just like with separate on-site policies, insurance companies have exclusive coverage for "radioactive contamination" (i.e. nuclear damage) coming through these on-site and NTPL policies to the exclusion of other types of insurance (e.g. life insurance, Erection All Risks [EAR] policies) as a means of channelling cost to a certain amount.[55]

It should be noted that while insurance remains the primary means of covering the financial security requirements of the Conventions, some utilities opt to make their own insurance companies, hire a managing general agent outside of the insurance pools, or use

46. *Ibid.*, Article 9.1.
47. *Ibid.*, Article 3.5(b), Annex.
48. Compare PC, *supra* note 5, Articles 10 and 11 with VC, *supra* note 5, Articles VII and VIII, RVC, *supra* note 5, Articles VII and VIII and CSC, *supra* note 5, Annex, Article 5. See generally WNA (2021), "Liability for Nuclear Damage", https://world-nuclear.org/information-library/safety-and-security/safety-of-plants/liability-for-nuclear-damage.aspx (accessed 10 Apr. 2025).
49. Stoiber, C. et al. (2003), *supra* note 3, p. 114.
50. Reitsma S. and M. Tetley (2022), "Insurance of Nuclear Risks", in NEA (ed.), *Principles and Practice of International Nuclear Law*, OECD Publishing, Paris, p. 446.
51. Graham, R. (2022), "Fortuity as an Essential Element of "All-Risk" Insurance Policies", JSS Barristers, https://jssbarristers.ca/litigation-law-firm/insights/fortuity-as-an-essential-element-of-all-risk-insurance-policies.
52. Reitsma, S. and M. Tetley (2022), *supra* note 50, p. 446.
53. *Ibid.*, p. 452.
54. *Ibid.*, p. 451.
55. *Ibid.*, pp. 447-448, 452.

capital markets to provide financial coverage; however, these options are not common, with insurance still providing more than 80% of all NTPL coverage as of 2022.[56]

While some countries have not signed onto either the PC, the VC or the RVC, leaving it to domestic legislation to provide instructions on liability and coverage for both on-site and NTPL, coverage in those countries appears to be quite similar in approach to the Conventions. In the United States, the Price-Anderson Nuclear Industries Indemnity Act of 1957 (Price-Anderson Act or PAA) establishes three tiers of liability, with insurance coverage of about USD 15 billion for the first two tiers and Congress deciding on whether to issue additional funding if the first two tiers are fully depleted.[57] Japan has two laws governing nuclear liability, the Act on Compensation for Nuclear Damage and the Act on Indemnity Agreements for Compensation of Nuclear Damage.[58] Under the Compensation Act, Japan places unlimited liability on the operator but has implemented a separate state-backed insurance for "a grave natural disaster of an exceptional character",[59] defined as earthquakes and volcanic eruptions.[60] Finally, in China, which is a party to many nuclear-based conventions but not any of the Conventions,[61] there is a pool-based insurance system covering both first party and NTPL coverage for some, but not all, reactors.[62]

5. *Fukushima Daiichi*[63]

As the costliest nuclear incident to date,[64] the Fukushima Daiichi Nuclear Power Plant accident is worth mentioning in regard to how the Japanese nuclear industry and Japanese government have approached damages as this nuclear incident may be seen as a bellwether for future claims management and cost allocation in the unlikely occurrence of another level 7 nuclear event on International Nuclear Event and Radiological Scale (INES).

The Fukushima Daiichi Nuclear Power Plant experienced three partial core meltdowns following the earthquake and ensuing tsunami on 11 March 2011 when the residual heat removal system was damaged and submerged by a tsunami wave of about 15 metres.[65] Japanese law requires each operator to have approximately USD 1.5 billion in liability cover per site with a government indemnity covering the remainder.[66] The Japanese Atomic Energy Insurance Pool provided the Tokyo Electric Power Company (TEPCO) cover through mid-January 2012, but declined to renew its contract. In January 2012, TEPCO deposited

56. *Ibid*., pp. 450-451.
57. US NRC (2025), "Backgrounder on Nuclear Insurance and Disaster Relief", www.nrc.gov/reading-rm/doc-collections/fact-sheets/nuclear-insurance.html (accessed 12 May 2025).
58. Act on Compensation for Nuclear Damage (Act No. 147 of 1961) as amended by Act No. 19 of 2009 (Compensation Act); Insurance Business Act (Act No. 105 of 1995); Act on Indemnity Agreements for Compensation of Nuclear Damage (Act No. 148 of 1961), as amended by Act. 19 of 2009.
59. Compensation Act, *supra* note 58, sec. 3.
60. S. Reitsma and M. Tetley *supra* note 50, p. 459.
61. IAEA (2022), "Fact Sheets", IAEA Office of Legal Affairs, https://ola.iaea.org/Applications/FactSheets/Country/Detail?code=CN (accessed 10 Apr. 2025).
62. For information on how of other countries have established liability for nuclear damage, see WNA (2021), *supra* note 48.
63. See generally, NEA (2012), *Japan's Compensation System for Nuclear Damage: As Related to the TEPCO Fukushima Daiichi Nuclear Accident*, OECD Publishing, Paris.
64. Hornyak, T. (2018), "Clearing the Radioactive Rubble Heap that was Fukushima Daiichi, 7 Years On", Scientific American, www.scientificamerican.com/article/clearing-the-radioactive-rubble-heap-that-was-fukushima-daiichi-7-years-on.
65. WNA (2024), "Fukushima Daiichi Accident", https://world-nuclear.org/information-library/safety-and-security/safety-of-plants/fukushima-daiichi-accident.aspx (accessed 10 Apr. 2025)
66. Burns, S.G. and X. Vásquez-Maignan (2012), "Japan Nuclear Liability and Compensation" presentation at the International Radiation Protection Association, Glasgow, www.irpa.net/members/1415%201%20thu%20boisdale%20Vasquez-Maignan%20.pdf, slide 12 (accessed 23 Apr. 2025); World Nuclear News (WNN) (2009), "Japan revises nuclear liability laws", www.world-nuclear-news.org/Articles/Japan-revises-nuclear-liability-laws (accessed 23 Apr. 2025).

JPY 120 billion with the Tokyo Legal Affairs Bureau and sought cover from private-sector insurers.

In 2017, the Japan Agency for Natural Resources and Energy estimated the total cost of cleanup and restoration would be USD 190 billion, about double the initial estimate, with TEPCO, the operator, taking on the bulk of the cost.[67] But some private parties have estimated that the ultimate cost may rise to more than USD 600 billion over the life of decommissioning and restoration efforts.[68]

Though Japan is an unlimited liability regime,[69] the meagre amount covered by both private and public insurance was quickly exhausted with no possibility of reinstating private coverage. It stands to reason that other nuclear insurance pools in other situations will likely exercise the same option of declining future coverage, meaning that governments where the nuclear installations causing nuclear damage are located are likely going to have to foot the bill or decline certain coverage, and safety first is going to continue to be the best defence. But as seen in the next sub-section, exceptions to operators taking responsibility do exist in the Conventions and if these are triggered, there is likely no backstop other than the state to cover the potential damages.

6. Gross negligence and wilful misconduct

While Japan determined the Fukushima Daiichi Nuclear Power Plant accident was man-made, the liability imposed was not due to, or arising from, gross negligence or wilful misconduct and therefore remained with the operator (with the backing of the government). [70] While the cost for Fukushima Daiichi has ballooned to well beyond the capabilities of private insurance, and even some governments, the seven-scale nuclear incident classification system illustrates that it is not expected that every nuclear incident would be at the cost of an event like Fukushima Daiichi.[71] In other words, if insurance is normal for covering costs associated with NTPL, and the costs for such coverage are expected to be within the range of normal NTPL coverage,[72] there is a corresponding gap in coverage when the exceptions to operator liability are triggered, either because the financial security required by the Conventions does not cover the exceptions per se, or because such exceptions are uninsurable.[73]

67. *Ibid*.
68. Hornyak, T. (2018), *supra* note 64.
69. WNA (2024), *supra note* 65.
70. *Ibid*. See also Kurokawa K. et al. (2012), "The Official Report of the Fukushima Nuclear Accident Independent Investigation Commission", The National Diet of Japan, p. 16, available at: www.nirs.org/wp-content/uploads/fukushima/naiic_report.pdf (in which the Commission found that the Fukushima Daiichi Nuclear Power Plant accident ultimately resulted from collusion between the Japanese government, the nuclear regulators and TEPCO).
71. IAEA (n.d.), "International Nuclear and Radiological Event Scale (INES)", www.iaea.org/resources/databases/international-nuclear-and-radiological-event-scale (accessed 23 Apr. 2025).
72. The costs for TMI were within the range of insurance coverage. See US Government Accountability Office (GAO) (1981), "Financial and Operation Problems at Three Mile Island www.gao.gov/products/116665 (accessed 10 Apr. 2025); Insurance Information Institute (2011), "Insurance coverage for nuclear accidents", www.iii.org/article/insurance-coverage-nuclear-accidents (accessed 23 Apr. 2025).
73. See Yrulegui, J. (2021), "Three Steps Employers can take to avoid serious and willful misconduct liability", Yrulegui & Roberts, www.rjylaw.com/three-steps-employers-can-take-to-avoid-serious-and-willful-misconduct-liability; McAvoy, T. (2018), "Lawyer's Alleged Intentional Misconduct Excluded from Professional Liability Coverage", Hinshaw, www.hinshawlaw.com/newsroom-updates-lawyer-s-alleged-intentional-misconduct-excluded-from-professional-liability-coverage.html; Smit, M. (2012), "The exclusion of willful misconduct: are liability insurers aware of what they still cover?", Van Steenderen MainportLawyers, Lexology, www.lexology.com/library/detail.aspx?g=3fb49de5-2404-4815-a8d0-3d80229c93c0 (accessed 23 Apr. 2025).

Indeed, this appears to also be the intention of the Conventions. While the PC is silent in further explaining the buildup of the exceptions in the *Exposé de Motifs*, the explanatory notes to the RVC state:

> the issue of channeling of liability was briefly discussed at the beginning of the negotiations on the revision of the Vienna Convention and [...] the view was expressed, in that context, that a recourse procedure should be made available to operators in cases where nuclear damage is the result of fault on the part of the manufacturer, supplier, or carrier. However, that idea did not receive sufficient support and did not result in any amendment to the existing provisions.[74]

Also, in the 16th session of the amendment to the 1963 Vienna Convention, it was determined that Poland's proposal of unlimited liability for personal damage was "widely shared" but deemed to be not feasible.[75] It should be noted that there is no distinction in the Explanatory Texts to the RVC regarding supplier-caused nuclear damage (i.e. whether it comes from wilful misconduct, gross negligence, or just defects), meaning supplier liability as a whole appears to have been excepted from the exceptions, at least with respect to the Conventions.[76] It remains unclear if countries can feasibly exempt suppliers from liability pursuant to the intent of the Conventions, but the next section will look at different countries' domestic laws as they relate to both liability and nuclear liability.

As the focus of this article remains on exceptions to operator liability as a trend in contracting, specifically with respect to gross negligence and wilful misconduct, we must now identify what these terms generically mean. Ultimately, however, the definitions of these terms and the ensuing liability arising from their application will be determined by applicable domestic law and the courts of jurisdiction of the state where the nuclear incident occurs.

According to the Legal Information Institute:

> Gross negligence is a lack of care that demonstrates reckless disregard for the safety or lives of others, which is so great it appears to be a conscious violation of other people's rights to safety. Gross negligence is a heightened degree of negligence representing an extreme departure from the ordinary standard of care. Falling between intent to do wrongful harm and ordinary negligence, gross negligence is defined as willful, wanton, and reckless conduct affecting the life or property or another. Gross negligence is considered more harmful than ordinary negligence because it implies a thoughtless disregard of the consequences and the failure to use even slight care to avoid harming the life or property of another.[77]

This same source defines "misconduct" and "wilful'" separately, with the former being "wrongful or unlawful behavior"[78] and the latter being "... acts which are intentional, conscious, voluntary, and designed to achieve a particular result".[79] This latter definition gives different contextual definitions (based upon US law); however, one of these definitions is germane to our review – that of a wilful tort. A wilful tort is "... committed intentionally and consciously with the wish to harm another person. It is an act that is neither accidental nor due to negligence."[80]

74. Explanatory Texts, *supra* note 27, p. 46, n. 142.
75. *Ibid.*, n. 44.
76. Explanatory Texts, *supra* note 27.
77. LII (2022), "gross negligence", Wex, www.law.cornell.edu/wex/gross_negligence (accessed 23 Apr. 2025).
78. LII (2022), "misconduct", Wex, www.law.cornell.edu/wex/misconduct (accessed 23 Apr. 2025).
79. LII (2024), "willful", Wex, www.law.cornell.edu/wex/willful (accessed 23 Apr. 2025).
80. LII (2024), "willful tort", Wex, www.law.cornell.edu/wex/willful_tort (accessed 23 Apr. 2025).

Wilful torts can have counterparts in criminal law (e.g. assault and battery) where, rather than a private party seeking damages (i.e. money), prosecutors may impose fines or jail time.[81] Although this article does not address criminal torts in detail, certain jurisdictions do not allow recovery or indemnification where an act is classified as criminal,[82] meaning that such terms and conditions would be struck down as null and void, as discussed later in this paper.

Returning to the main premise, based upon the above definitions, gross negligence requires the culprit to have no care for the consequences of their actions, possibly then leading to harm as a result. However, gross negligence is also not necessarily defined in every jurisdiction[83], with one international law firm going as far as to say that it is not a common law concept.[84] In this author's experience, the term is still quite commonly used in cross-border commercial transactions and power projects, including nuclear power projects, meaning there is a disconnect between the statutory and often governing law of the contract and the cultural backgrounds of contract negotiation partners. In short, gross negligence may or may not be defined under the relevant jurisdiction where the nuclear incident occurs,[85] unless otherwise incorporated into domestic law because of the Conventions or for other purposes.[86] To the extent such language exists in contracts, as is the norm, but not in domestic law, courts will honour the language of the contract and look to interpret it accordingly.[87]

The term "wilful misconduct", however, and all its iterations, are common to many jurisdictions.[88] Under English law, it is defined as "… conduct by a person who knows that he is committing, and intends to commit a breach of duty, or is reckless in the sense of not caring whether or not he commits a breach of duty".[89] While the latter definition cited with respect to recklessness tracks better with gross negligence, the definition overall shows a wilful tort; it is the desire of the culprit to bring about the harm intended, and which as mentioned already above, under English law such liability would not be able to be excluded.

While the exact definitions in jurisdictions differ, the concepts appear to be synonymous in approach. In the United Arab Emirates, excluding liability for a "harmful act" is prohibited.[90] Japan does not allow indemnification of company directors for gross negligence or wilful misconduct[91] and courts in Japan will "likely" strike down liability

81. Luongo, S. and T. Bellwoar, (n.d.) "Criminal Cases vs. Civil Cases", LuongoBellwoar LLP, www.luongobellwoarlaw.com/resources-victims-crime/criminal-cases-vs-civil-cases (accessed 23 Apr. 2025).
82. Thomas, A. and R. Heffron (2012) *supra* note 24, p. 23.
83. Thomas Reuters (2024), "Glossary – Gross Negligence", Thomas Reuters: Practical Law, https://uk.practicallaw.thomsonreuters.com/2-381-1557 (accessed 23 Apr. 2025).
84. Goldberger, J. (2020), "Gross Negligence Revisited", Norton Rose Fulbright, https://nortonrosefulbright.com/en-me/knowledge/publications/c102bd41/gross-negligence-revisited, (accessed 23 Apr. 2025).
85. Fisher. D and L. Rhodes (2013), "Limitations on Liability Exceptions for Gross Negligence and Willful Misconduct and the Implications for Outsourcing Agreements", Mayer Brown Business and Technology Outsourcing Review, www.mayerbrown.com/en/perspectives-events/publications/2013/08/limitations-on-liability-exceptions-for-gross-negl, (accessed 23 Apr. 2025).; but see UAE Civil Code, *supra* note 12, Article 383.2.
86. UAE Federal Law by Decree by Law 4 (2012) *supra* note 14, Article 7.
87. Camerata Property v Credit Suisse Securities (Europe) Limited [2011] EWHC 479 (Comm).
88. DLA Piper (2023), "Enforceability of exclusions/limitations of liability indemnification", www.dlapiperintelligence.com/goingglobal/intellectual-property/index.html?t=commercial-contract-terms&s=exclusions-limitations (accessed 23 Apr. 2025).
89. De Beers UK Ltd v Atos Origin IT Services UK Ltd [2010] EWHC 3276 (TCC).
90. UAE Civil Code, *supra* note 12, Article 296.
91. Horiki, J. (n.d.), "The International Bar Association Company Director Checklist – Japan", TMI Associates, www.ibanet.org/document?id=Directors-Duties-Japan-22, pp. 15-16.

exemptions for gross negligence and wilful misconduct in construction contracts.[92] The United States laws on contracts vary from state to state, but in general liability exceptions for gross negligence and wilful misconduct are also impermissible.[93]

Now that we have generally defined gross negligence and wilful misconduct and have seen how many countries exclude recovery let alone indemnification for both gross negligence and wilful misconduct, we can see why under the Conventions the operator's normally strict liability for nuclear damage is removed and re-allocated in favour of the person who committed gross negligence or wilful misconduct. And while liability for nuclear damage is an independent regime, its origins are in tort law, meaning the Conventions did not reinvent the liability wheel to apportion both liability for nuclear damage and the associated exceptions arising from there. The next section will therefore dive into specific sections in the domestic law of several nations with respect to nuclear liability.

IV. Domestic law on nuclear liability

There are no publicly available cases on nuclear liability on the part of a contractor due to gross negligence or wilful misconduct. The law must therefore be taken as drafted with respect to nuclear liability in countries where such laws exist and then compared to general principles regarding gross negligence and wilful misconduct. This section examines domestic laws from a cross section of countries, including the United States as a non-party to the PC, the VC and RVC but a party to the CSC; the United Kingdom as a party to the PC but not the CSC; and the United Arab Emirates as a party to RVC and the CSC.

1. *The Price-Anderson Act (United States)*

The Atomic Energy Act of 1954 (AEA), an amendment to the 1946 AEA, was passed to, among other things, "… assure the proper management of source, special nuclear, and byproduct material."[94] While US nuclear law is a patchwork of different laws and regulations due to the differing roles of its government agencies – among them the US Department of Energy (DOE), the US Nuclear Regulatory Commission (NRC) and the Environmental Protection Agency – this article focuses on the amendment to the AEA that addresses nuclear liability, better known as the Price-Anderson Act or PAA.[95]

The PAA, found in section 170 of the AEA,[96] was created for two distinct purposes: (1) to encourage private participation in the nuclear sector by addressing how nuclear liability is managed; and (2) to ensure suitable funding and a cap for such liability.[97] The PAA apportions liability for nuclear damage to the operator (owner) and covers the same through two layers of insurance from both the private sector and each operator's

92. Inoue, A., D. MacArthur, and M. Yano (2021), "GAR Know-how Construction Arbitration", sec. 31, Anderson Mōri & Tomotsune, www.amt-law.com/asset/res/news_2021_pdf/publication_0023397_ja_001.pdf, p. 9.
93. Bates Jr., A. and R. Torres-Fowler, (2022) "GAR Know-how Construction Arbitration", Troutman Pepper, www.troutman.com/a/web/323264/GAR-Know-How-Construction-Arbitration-USA-September-2022.pdf. For more details on other jurisdictions that share a similar approach, including Sweden, Canada and Germany, please see the table compiled in PLC Cross-border (2010), "Excluding liability on international construction projects", Thomas Reuters: Practical Law, https://uk.practicallaw.thomsonreuters.com/0-503-6602.
94. US DOE (n.d.), "Atomic Energy Act and Related Legislation", DOE Office of Environment, Health, Safety & Security, www.energy.gov/ehss/atomic-energy-act-and-related-legislation.
95. Price-Anderson Nuclear Industries Indemnity Act of 1957, 42 USC 2210.
96. Atomic Energy Act of 1954, as amended, 42 USC 2011 et seq, sec. 170 (AEA).
97. NRC (2021), "*The Price Anderson Act: 2021 Report to Congress*", NUREG/CR-7293 (Agencywide Documents Access and Management System [ADAMS] Accession No. ML21335A064). available at: www.nrc.gov/docs/ML2133/ML21335A064.pdf.

contributions on a per-unit basis, with a cumulative value of more than USD 16 billion[98] if there is a "nuclear incident"[99] leading to "public liability",[100] including for an "extraordinary nuclear occurrence".[101] The NRC is to set the type and amounts to be covered[102] and can also require a waiver of any protections against liability otherwise afforded under federal or state law.[103] This waiver is counterbalanced by both the NRC and DOE offering indemnities to licensees and contractors respectively under sections 170(c) and (d).[104]

There is no reference in the PAA with respect to liability being removed from the operator under either gross negligence or wilful misconduct. Indeed, in the buildup to the 1988 amendment, this was a specific area of discussion with respect to DOE contractors, but in lieu of express liability for either of these normally exculpatory defences, Congress granted both the NRC and the DOE the authority to fine such contractors, including their employees, for violations of licence conditions and/or nuclear safety, among other things[105] at USD 100 000 per day per violation.[106] Also, section 223(b) of the AEA makes clear that a parallel regime of criminal liability will still be enforced against:

> Any individual director, officer, or employee of a firm constructing, or supplying the components of [a licensed facility] […] who by act or omission […] knowingly and willfully violates or causes to be violated, any section of this Act, any rule, regulation, or order issued thereunder, or any license condition, which violation results, or if undetected could have resulted, in a significant impairment of a basic component of such a facility…[107]

The result is the culpable party is subjected to fines and/or imprisonment for each violation. The AEA further defines basic component in the ensuing paragraph as "a facility structure, system, component [SSC] or part thereof" that affects safety, as it is unlikely for a nuclear incident to occur unless an SSC has been impacted. DOE contractors face similar provisions of criminal liability, including fines and imprisonment, in section 223c.

98. As of this writing. Holt, M. (2024), "Price-Anderson Act: Nuclear Power Industry Liability Limits and Compensation to the Public After Radioactive Releases", Congressional Research Service, https://crsreports.congress.gov/product/pdf/IF/IF10821.
99. "The term 'nuclear incident' means any occurrence, including an extraordinary nuclear occurrence, within the United States causing, within or outside the United States, bodily injury, sickness, disease, or death, or loss of or damage to property, or loss of use of property, arising out of or resulting from the radioactive, toxic, explosive, or other hazardous properties of source, special nuclear, or byproduct material…". AEA, *supra* note 97, sec. 11(q).
100. "The term 'public liability' means any legal liability arising out of or resulting from a nuclear incident or precautionary evacuation … except: (i) claims under State or Federal workmen's compensation acts of employees or persons indemnified who are employed at the site of and in connection with the activity where the nuclear incident occurs; (ii) claims arising out of an act of war; and (iii) whenever used in subsections a., c., and k., of section 170, claims for loss of, or damage to property which is located at the site of and used in connection with licensed activity where the nuclear incident occurs. Public liability also includes damage to property of persons indemnified … except property which is located at the site of and used in connection with the activity where the nuclear incident occurs." *Ibid*., sec. 11(hh).
101. "The term 'extraordinary nuclear occurrence' means any event causing a discharge or dispersal of source, special nuclear, or byproduct material from its intended place of confinement in amounts off-site, or causing radiation levels off-site, which the Nuclear Regulatory Commission or the Secretary of Energy, as appropriate, determines to be substantial, and which… has resulted or will probably result in substantial damages to persons off-site or property off-site … As used in this subsection, 'off-site' means away from 'the location' or 'the contract location …'". *Ibid*., sec. 11(j).
102. *Ibid*., pp. 131-132.
103. *Ibid*.
104. This is limited by both time and amount. AEA, *supra* note 97, secs. 170(c) and (d).
105. DOE (1999) "Report to Congress on the Price-Anderson Act", p. 24, available at: www.energy.gov/gc/articles/report-congress-price-anderson-act.
106. As adjusted for inflation. AEA, *supra* note 97.
107. *Ibid*., sec. 223(b).

The above is a prime example of economic channelling. In other words, though the operator remains strictly liable irrespective of who and how a nuclear incident arose, legal liability is still apportioned to the responsible person, meaning a separate regime for covering public liability costs remains with the operator as supported by insurance, other operators and the government, but the persons actually responsible for a nuclear incident will face their own civil and criminal penalties where applicable. This two-tiered approach has enabled consistency in the law with respect to liability being maintained for at least wilful misconduct and allowing some recovery by the government through an administrative system of fines.

While this has influenced, in particular, American contractors to seek zero nuclear liability in contracts, the American approach is not replicated in other jurisdictions as legal liability does not equate to strict economic liability. Indeed, the PAA does not actually remove liability for gross negligence and wilful misconduct per se; it just channels public liability costs to the operator as subsidised by multiple avenues of recovery (not just insurance), while creating an administrative regime of costly penalties for what would be considered an even greater scope of fault than for nuclear damage arising from or connected to gross negligence or wilful misconduct. The PAA also does not remove criminal liability, and subsequent restrictions on recovery, for the defendant imposed by insurers for the same.

2. The Nuclear Installations Act of 1965 (United Kingdom)

The Nuclear Installations Act of 1965 (NIA), as amended (in particular by the Nuclear Installations [Liability for Damage] Order 2016),[108] is the primary legislation governing, among other things, the licensing of nuclear reactors in the United Kingdom and apportioning liability for nuclear damage.[109] The NIA implements the PC, meaning it also captures the concepts of strict liability,[110] as interpreted by case law,[111] channelling liability towards the operator, mandatory compensation coverage (e.g. insurance), a statute of limitations for bringing claims, limits on total liability on the operator, jurisdiction of the relevant courts, with limited exceptions, determining governing law at the place of the nuclear incident and ensuring no preclusion of standing due to immigration status of the claimant.[112]

Liability exclusions on the operator are also present in the NIA for the numerous potential heads of claims available in accordance with the Conventions, including many of those already discussed such as in the case of hostile actions and liability transfer by agreement. But to understand these claims and how they are triggered, it is important to first note that the structure of the liability and recovery regime is predicated on a breach of duty by the operator, or in some instances, the Crown or Authority, which then gives rise to the right of recovery due to such breach.[113] An interesting note to observe with respect to exceptions to liability is that such liability is not necessarily transferred under the NIA to the person causing the damage (putting aside legal channelling and strict liability);[114] rather, compensation cannot be claimed for damage caused by acts by others done "maliciously or negligently",[115] because the operator did not breach their respective duties. There is a separate section that also reduces liability on the operator with respect

108. The Nuclear Installations (Liability for Damage) Order 2016, Statutory Instrument 2016 No. 562.
109. Nuclear Installations Act 1965 (c. 57) (NIA), secs. 1.1, 12-14.
110. *Ibid*., sec. 7.1.
111. Thomas, A. and R. Heffron (2012), *supra* note 24, pp. 10-13.
112. NIA, *supra* note 109, secs. 12.1, 15.1, 15.3, 16.1, 16B, 16C, 19.1 and 26.
113. See *Ibid*., secs. 7-10 (covering licenced sites, disposal sites, duties of the Authority and Crown, and foreign operators) and secs. 12-14 (right of recovery due to breach).
114. Liability is not excluded from such person by virtue of the NIA, but such liability would arise under other laws. *Ibid*., sec. 12.1(G).
115. *Ibid*., secs. 11H(3), 12.3A(a),12.3B(b).

to a person whose "act or omission" intended to cause harm or that acted with "reckless disregard for the consequences of such act or omission".[116]

Some liability experts do not believe that the legal theories of vicarious liability, principal liability and *respondeat superior* would apply in the case of nuclear damage, meaning only the individual who caused such damage would be liable.[117] They further argue that indemnification for wilful acts would be void under English law leaving liability on the perpetrator and no recourse at law or contract for payment of damages to victims.[118]

3. *Law By Decree 4 (2012) concerning civil liability for nuclear damage (United Arab Emirates)*

The United Arab Emirates is a relative newcomer to nuclear energy, but that has not stopped it from progressing at full speed in the procurement of four APR 1400 units from the Korea Electric Power Corporation (KEPCO), which now provide up to 25% of the United Arab Emirates' energy needs.[119] As a part of its debut into the world as a nuclear energy user, the United Arab Emirates acceded to the RVC and ratified the CSC with the former's concepts being adopted into domestic law by Law by Decree 4 (2012).[120] This decree, which unlike the PAA and NIA, is completely separate from its nuclear law, contains the same provisions and exceptions as the RVC, including on the operator potentially being exempt from strict liability if nuclear damage is caused by the gross negligence or wilful intent of another person, or by recourse by contract.[121] Thus, the operator is "solely liable" for nuclear damage up to SDR 450 million, which is to be covered by financial security, and distributed in accordance with the RVC.[122] Also, the time for bringing claims for nuclear damage is limited, and can only be heard in federal courts in Abu Dhabi.[123] As an interesting catchall, Article 12.2 states that anything not covered under this law will follow the requirements of the RVC, making this decree relatively shorter in length than the domestic legislation of other countries.[124]

The United Arab Emirates' implementing decree for the CSC is even pithier, giving just two substantive articles (3 and 4) to describe the rights of the United Arab Emirates and other contracting parties and responsibilities of the operator with respect to ensuring adequate funding via financial security or insurance.[125]

4. *Development of nuclear liability in commercial contracts*

Nuclear liability is just one type of liability found in commercial contracts for nuclear projects, but its principles are based upon the same concepts as one would find for non-nuclear power projects and even just normal commercial contracts for the sale and purchase of goods and services. There is no standard-form nuclear new-build contract, meaning either prominent international standard forms or bespoke agreements are required to be drafted to cover the gap between independent water and power plants and

116. *Ibid.*, sec. 13.7(a)(b).
117. Thomas, A. and R. Heffron, *supra* note 24, pp. 22-23.
118. *Ibid.*
119. ENEC (n.d.), "Barakah Nuclear Energy Plant", www.enec.gov.ae/barakah-plant (accessed 23 Apr. 2025).
120. Federal Law by Decree No. 4 of 2012, concerning civil liability for nuclear damage, available at: www.fanr.gov.ae/en/Lists/LawOfNuclear/Attachments/3/Federal-Law-by-Decree-No-4-of-2012-Concerning-Civil-Liability-for-Nuclear-Damage-English.pdf, (accessed 23 Apr. 2025).
121. *Ibid.*, Articles 7 and 11.
122. *Ibid.*, Articles 4, 5.1, 8.1 and 8.4. The UAE increased the amount from the VC's SDR 300 million.
123. *Ibid.*, Articles 10.3 and 12.7.
124. *Ibid.*, Article 12.2.
125. Federal Decree No. 51 of 2014 On the Ratification of the Agreement on Supplementary Compensation for Nuclear Damage, available at: www.lexismiddleeast.com/law/UnitedArabEmirates/Decree_51_2014 (accessed 23 Apr. 2025).

nuclear projects.[126] Though comparing the differences between the former and the latter is beyond the scope of this article, it will be useful to see how liability is treated as a part of this review on nuclear liability in commercial contracts, specifically with respect to indemnities. Due to the widespread use of English law as the typical law governing power projects and commercial transactions, all citations will be from English law in this section.

A. *What is an indemnity?*[127]

Recovery under a contract is usually through damages (i.e. money) with the aim of placing the aggrieved party in a position they would have been in if the contract had been performed.[128] Sometimes, damages are insufficient due to the special nature of the content of the contract (e.g. purchase of a one-of-a-kind vehicle or injunctions on disclosure of confidential information), in which case equitable relief is sought. Indemnities are another remedy existing usually independently of damages per se and equitable relief, because indemnities exist independently of primary obligations of both parties (i.e. are not a part of the reason for entering into a contract and are not therefore associated with a breach of primary obligations).[129]

Indemnities are also usually conditional (i.e. triggered by an event or series of events), and perhaps most importantly, create an obligation on the indemnifying party to protect the other party(ies) by paying a debt (on-demand claim) or damages (e.g. a claim by a third party) incurred by such party(ies) after the fact based upon final judgements.[130]

For purposes of nuclear liability, the Conventions do not provide indemnities per se; it is only recognised that strict and sole liability for NTPL must be channelled accordingly when there is no privity of contract. This typically occurs in commercial contracts by reference to the operator being responsible for nuclear damage as defined by the Conventions as enacted in local law. In other words, a party to a contract who is not the operator will rely upon the operator to indemnify such party if sued by a third party for nuclear damage impacting such third party. As seen in the next section, this follows typical indemnification practices under standard-form contracts with the caveats already discussed under the Conventions.

B. *Standard-form contracting*

The International Federation of Consulting Engineers' (FIDIC'S) 1999 Silver Book, one of many standard-form templates and a part of the rainbow suite of construction contracts, as amended,[131] is the FIDIC template dedicated to turnkey EPC contracting, a contractual style designed to maximise risk and reward for the contractor.[132] Like other construction contracts, it contains an indemnity provision in clause 17.1 that requires both the contractor and customer to indemnify the other for "bodily injury, sickness, disease, or death" and for the contractor to indemnify the customer for damage to property if certain

126. Fork, W. and A. Frank (2022), "Nuclear project development: the lawyer's perspective", in Nick, K.S. and S.G. Burns (eds.), *Principles and Practice of International Nuclear Law*, OECD Publishing, Paris, p. 502.
127. For additional resources on indemnities, see LexisPSL (n.d.), "Indemnities in commercial contracts", https://plus.lexis.com/uk/practical-guidance-uk/indemnities-in-commercial-contracts/?crid=de3ea6de-be5c-497f-aab0-a004b9ffa493&pddocumentnumber=1 (accessible with subscription).
128. British Westinghouse Electric and Manufacturing Co Ltd v Underground Electric Rlys Co of London Ltd (1912) AC 673, p. 689.
129. Yeoman Credit Ltd v Latter (1961) 1 WLR 828 (CA), 830-831 (Holroyd Pearce LJ); (1961) 2 All ER 294 at para. 296.
130. Total Transport Corporation v Arcadia Petroleum Ltd, The Eurus (1997) Lexis Citation 4619, (1997) All ER (D) 77.
131. International Federation of Consulting Engineers (FIDIC) (2022), Conditions for Contract for Construction, 2017 Edition (reprinted), FIDIC, Geneva (2017 Rainbow Suite).
132. FIDIC (1999), *Conditions of Contract for EPC/Turnkey Projects*, First Ed., FIDIC, Geneva (1999 Silver Book).

conditions are triggered and certain exclusions are not applicable. [133] There are two key takeaways from this provision, keeping in mind that FIDIC contracts are some of the most-used standard forms in the world today: (1) Even where the contractor is taking on a majority of the risk by design in the drafting of the Silver Book, a wilful act on the part of the customer negates the indemnification requirement; and (2) in the absence of express language to the contrary, if the Silver Book were used for a nuclear project, nuclear and non-nuclear damage would also be indemnified (and excluded) under the same principles as we see in the Conventions.[134]

Why the emphasis on this? The Conventions did not change indemnification principles, even in light of strict liability, as recognised by the exceptions listed in the Conventions. Zero liability channelling completely changes the risk mechanism from one where the parties can reach a fair allocation of risk and reward, to a chimera of unbalanced risk and potential gaps in compensation coverage for actual victims. Additionally, while it is unlikely that the Conventions' exceptions will be triggered in actual practice, as will be seen in the next section, we already have a preview where supporting principles of liability allocation in domestic law echoed resolution of the matter as per the Conventions.

5. *Implications of contractor zero liability*

Traditional wisdom and experience tell us that the risk of contract failure is lower when balanced between risk and reward in a way in which both the customer and the contractor are satisfied. As noted above, when using the FIDIC Silver Book, the more risk a contractor takes on, the more reward it is anticipated that they will receive. But whether a full, turnkey new build is at stake or simply scaffolding services incidental to the installation of equipment, an attachment to a nuclear project automatically grants protection to contractors for nuclear liability, based upon the Conventions, where applicable or, in the case of domestic law compatible with the Conventions. This protection has certain requirements, which, by contract, are sometimes (attempted to) being overruled through zero liability channelling, such as if nuclear damage is transboundary to a state which is not a member to the Conventions, and such contractor is sued in that state rather than the allocated venue required by the Conventions. In this instance, should a neighbouring country honour the wording of the contract and force the operator to indemnify such contractor in that foreign court in contravention to the Conventions and domestic law of where the nuclear installation is located, or should principles of comity, *forum non conveniens,* or even state sovereignty fill in the gaps where there is no binding international and domestic legal commitments?

There is no certainty that the operator of a nuclear installation in a contracting party to the Convention(s) would be found liable in the courts of a non-contracting party to the Conventions, or that a court of such non-contracting party would even necessarily accept jurisdiction over a nuclear damage claim. However, we can see from the seminal case of Cooper v. Tokyo Electric Power Co. Holdings Inc. that the issue can arise and cause uncertainty and needless litigation to reach the conclusion that the Conventions had already dictated: Redress should be sought in the place where the nuclear incident occurred.

The section below examines the arguments raised by the parties in Cooper and the procedural steps taken by the court until it (and the subsequent appellate level courts) reached a final conclusion.

133. *Ibid*., Clause 17.1(a)(b)

134. *Ibid*. The Silver Book also negates indemnification (or in the customer's case, requires it) for negligence (and not gross negligence) and breach of contract, but the concept of indemnification being negated or triggered follows the same principle as the Conventions albeit with a higher standard for gross negligence and additional procedural step of recourse after the operator takes responsibility for nuclear damage.

A. *The Cooper case (Part 1)* [135]

The United States and Japan were originally not party to any of the Conventions, but based upon the Annex to the CSC and their separate domestic law on nuclear liability, were able to join and ensure the CSC[136] came into force upon Japan's deposit of its acceptance on 15 April 2015. Prior to Japan becoming a party to the CSC, the Fukushima Daiichi Nuclear Power Plant accident occurred. US Navy sailors, who were part of a cleanup operation for the incident on behalf of the US government, allegedly suffered injury due to radiation exposure resulting from the incident.[137] In 2012, the sailors sued TEPCO in the federal district court of San Diego, California on grounds of injury due to TEPCO allegedly knowingly allowing the sailors to be exposed to radiation beyond acceptable limits.[138]

The case hinged mostly on procedural grounds, including whether the plaintiffs should have pursued filing a claim in Japan further to Japanese law governing claims for the Fukushima Daiichi incident. The first complaint was dismissed under the political question doctrine, which forbids federal courts "from resolving questions when doing so would require the judiciary to make policy decisions, exercise discretion beyond its competency, or encroach on powers the Constitution vests in the legislative or executive branches".[139] The plaintiffs filed a second amended complaint and TEPCO responded with a motion to dismiss, which was granted in part and rejected in part. Specifically, the court dismissed TEPCO's claims regarding: (1) lack of subject matter jurisdiction of the court due to the political question doctrine (i.e. the reasons for dismissal under the first complaint),[140] (2) failure to state a claim by the plaintiffs due to: (a) a lack of proximate causation,[141] (b) the applicability of the firefighter rule,[142] (c) a lack of duty of care owed towards the plaintiffs from TEPCO; [143] (d) a lack of a basis for establishing negligent misrepresentation; [144] (e) strict liability due to ultrahazardous activities being covered under other laws and not common law;[145] and (f) loss of consortium requiring a valid tort claim which is lacking.[146]

135. WMC Cooper v. Tokyo Electric Power Company, Inc., Case No. 12-CV-3032 JLS (WMC) (S.D. Cal. 2014) (Cooper 1). The six "parts" of the Cooper case, as presented in this article, refer to the six separate cases in which plaintiff Cooper attempted to recover for damages attributed to the Fukushima Daiichi Nuclear Power plant accident.
136. Gaspar, M. (2015), "Convention on Supplementary Compensation for Nuclear Damage Enters into Force", IAEA, www.iaea.org/newscenter/news/convention-supplementary-compensation-nuclear-damage-enters-force.
137. Cooper 1, *supra* note 135.
138. *Ibid.*
139. *Ibid.*, p. 2; Lampe, J. (2022) "The Political Question Doctrine: An Introduction (Part 1)", p. 1, https://crsreports.congress.gov/product/pdf/LSB/LSB10756.
140. The plaintiffs' focus on negligence and omissions by TEPCO removed the political question doctrine from consideration enabling a focus on the merits for the time when substantive claims would be considered. Cooper 1, s*upra* note 135, pp. 4-10.
141. The court found that the claims were "sufficiently pled" meaning that this element of the case could be adjudicated on its own merits. *Ibid.*, pp. 10-13.
142. The court found that the plaintiffs were not deemed to be "professional rescuers" as required for this rule to bar a claim from the plaintiffs. *Ibid.*, pp. 13-14.
143. The court found that TEPCO did not adequately address the argument from the plaintiffs that TEPCO owed each plaintiff a duty of care as individuals, separate from the US Navy. *Ibid.*, pp. 14-15.
144. The court and plaintiff agreed that this head of claim was not present, meaning the defence by TEPCO was moot. *Ibid.*, p. 15.
145. The court found that the CSC was not in force and that TEPCO failed to address the point raised by the plaintiff that the PAA does not apply to foreign corporations. *Ibid.*, pp. 17-18.
146. The court found that there were several valid tort claims raised, meaning TEPCO's response on consortium not applying due to no valid tort claims was incorrect. *Ibid.*, p. 18.

The court did, however, grant TEPCO's motion to dismiss on claims regarding: (1) strict liability[147] for design defects;[148] (2) intentional infliction of emotional distress;[149] and (3) the plaintiffs' reservation of John and Jane Doe[150] claims in an attempt to certify the case as a class action.[151]

Regarding point (e) on strict liability for ultrahazardous activities, this is the closest the district court gets in this hearing to addressing international law as directing the appropriate forum. At that time, while the United States was party to the CSC, Japan was not.[152] The court therefore found fault with TEPCO's response that the CSC requires Japan to be the right forum for adjudication (and yet, it was not in force).

Moving to domestic law, the court rejected TEPCO's argument of *forum non conveniens* – the argument that a better forum exists to adjudicate the matter.[153] To reach this conclusion the court weighed a number of factors required under the three-factor test of: (1) an alternative forum being available, and the balancing of (2) public and (3) private interests.[154] The court also rejected TEPCO's motion to dismiss due to international comity for similar reasons it had rejected the *forum non conveniens* argument.[155]

In short, in the absence of supervening legislation like the CSC, the US district court found that while both Japan and the United States had vested interests in the resolution of this matter, the United States had slightly stronger ones enabling the case to proceed on its merits.[156]

B. *The Cooper case (Part 2)*[157]

TEPCO filed a motion for reconsideration or, failing that, a certification for an interlocutory appeal[158] of the first judgement to the appellate court, citing a change in applicable law with respect to international comity and clear error in the district court's superseding causation analysis and dismissal of the firefighter rule. This motion essentially revisited the elements of the original claim at the district court level and, with respect to international comity, arose due to a change in law as a result of an appellate court ruling that came out two weeks after the first judgement[159]. This appellate court ruling modified the international comity test concerning countries' competing interests to hear the matter before their courts, requiring the court to consider: "(1) the location of the conduct in question, (2) the nationality of the parties, (3) the character of the conduct in question,

147. GE became a member of the lawsuit by virtue of it being the designer of the reactors at Fukushima Daiichi but, as GE's inclusion is not pertinent to this article, that aspect of the case is not discussed further herein.
148. The court ruled that the plant was not "placed on the market", an essential element required to establish this head of claim. *Ibid.*, pp. 15-16.
149. The court ruled that the harm occurred before the plaintiffs were in the vicinity of the harm and such harm was not aimed at the plaintiffs, two requisite points to establish this type of claim. *Ibid.*, pp. 16-17.
150. John and Jane Doe are pseudonyms frequently used in the American legal system to signify either a person who is not named, or a person who will be named in the future.
151. The court ruled that sufficient time had elapsed without plaintiffs successfully bringing a sufficient number of plaintiffs for this purpose. Cooper 1, *supra* note 135, pp. 18-19.
152. Ironically, Japan's accession to the CSC was the triggering event that caused it to come into force.
153. LII (2022), "*forum non conveniens*", Wex, www.law.cornell.edu/wex/forum_non_conveniens, (accessed 23 Apr. 2025).
154. Cooper 1, *supra* note 135, pp. 19-29 (citing Lueck v. Sundstrand Co., 236 F.3d 1137, 1142 (9th Cir. 2001)).
155. *Ibid.*, pp. 29-31.
156. *Ibid.*, pp. 31-33.
157. *Cooper v. Tokyo Electric Power Co., Inc.*, 166 F. Supp. 3d 1103 (S.D. Cal. 2015) (Cooper 2).
158. "An interlocutory appeal is an appeal of a non-final order issued during the course of litigation". LII (2023), "*interlocutory appeal*", Wex, www.law.cornell.edu/wex/interlocutory_appeal (accessed 23 Apr. 2025).
159. Cooper 2, *supra* note 157, p. 1116, citing Mujica v. AirScan, Inc., 771 F.3d 580 (9th Cir.2014).

(4) the foreign policy interests of the United States, and (5) any public policy interests".[160] The court agreed with TEPCO that this new analysis needed to be incorporated into the original ruling.[161]

Regarding clear error, the court again sided with TEPCO and agreed that supplemental arguments would be considered.[162] However, in its review of all arguments raised, the court still reached the same conclusions as provided in Cooper Part 1, with the exception of granting an interlocutory appeal, stating that "a controlling question of law exists"[163] with respect to the political question doctrine and the firefighter rule that could determine whether the district court actually has jurisdiction.[164] The appellate court then revisited all of TEPCO's and the plaintiff's claims in Part 3 of the Cooper case as provided below.

C. *The Cooper case (Part 3)*[165]

During TEPCO's 2017 appeal, the appellate court, with input from the Japanese government and the US State Department, finally opined on the effect of the CSC, as it had come into force in 2015.[166]

The government of Japan had not provided any opinion during the district court proceedings but filed an *amicus curiae*[167] brief for this appeal seeking dismissal of the case so that the plaintiffs could file in Japan.[168] Upon request by the court, the US State Department provided its own *amicus curiae* brief, which the court summarised as saying that "the district court did not err in allowing plaintiffs' claims to proceed for the time being. Specifically, the United States opines that allowing plaintiffs' lawsuit to continue in the United States is consistent with US efforts to promote the [CSC]."[169] TECPO argued that Article 13 of the CSC with respect to jurisdiction over nuclear incidents should apply retroactively to remove any question of jurisdiction that the US courts may have.[170]

It should be noted that while the parties acknowledged that Article 28 of the Vienna Convention on the Law of Treaties[171] forbids automatic retroactive application of a treaty to a matter, TEPCO posited a well-known US principle that procedural questions are not subject to restrictions on retroactive application as "jurisdictional provisions do not retroactively alter substantive rights, but only alter where plaintiffs can go to obtain prospective relief".[172] While this rule pertains to the retroactive application of US domestic laws regarding jurisdiction of its courts, TEPCO argued that the rule should apply to treaties as well, which the court did not accept based upon a plain reading of the text in the CSC.[173] Specifically, the appellate court said that: (1) the use of the present tense of "occurs" in Article 13 – "jurisdiction … shall lie only with the courts of the Contracting Party within which the nuclear incident occurs", precludes past incidents to be covered by the CSC; and that (2) the intention of the CSC is that the whole of the CSC applies and not just

160. *Ibid*., p. 1117.
161. *Ibid*.
162. *Ibid*.
163. *Ibid*., p. 1142.
164. *Ibid*.
165. *Cooper v. Tokyo Elec. Power Co.*, 860 F.3d 1193 (9th Cir. 2017) (Cooper 3).
166. *Ibid*.
167. Literally, friend of the court, used when a non-party to a suit has an interest in the outcome. LII (2022), "*amicus curiae*", Wex, www.law.cornell.edu/wex/amicus_curiae (accessed 23 Apr. 2025).
168. Cooper 3, *supra* note 165, p. 1199.
169. *Ibid*.
170. *Ibid*.
171. The United States is not a party to the Vienna Convention on the Law of Treaties (signed but not ratified) but has stated that considered to be customary international law and therefore binding on the United States. See *Ibid* at p. 1201 (citing Mora v. New York, 524 F.3d 183 (2nd Cir. 2008).
172. *Ibid*.
173. *Ibid*., p. 1202.

Article 13.[174] In other words, under the first point, the court concluded that only future nuclear incidents are captured by the CSC after the CSC came into force because the CSC by its drafting tense used is not to be applied retroactively. Under the second point, the court concluded that one cannot separate Article 13 from the remainder of the text, meaning agreement to the remaining text of the CSC not applying retroactively is fatal to TEPCO's argument that a part of the CSC (i.e. Article 13) alone applies.

The appellate court also addressed the international comity argument in large part by deferring to the US State Department due to the government of Japan's sudden interest in the Cooper case. [175] Specifically, the appellate court cited the State Department's own *amicus curiae* brief:

> The exclusive jurisdiction provision [of the CSC] forms part of a bargain in exchange for robust, more certain and less vexatious (e.g. the application of strict liability without need to establish fault) compensation for victims of a potential incident. United States policy does not call for advancing one element of this system in isolation from the other elements of the Convention's system. For these two inextricably interrelated interests to be fully realized, it is essential that the Convention be as widely adhered to internationally as possible. *Thus, broad international adherence to the Convention is the ultimate U.S. policy goal.*[176]

The court summarised the United States's position that US jurisdiction in this case should be kept because: "… faced with the reality that there is no guarantee of exclusive jurisdiction outside of the CSC, more countries will accede to the CSC, thus fostering the global liability regime the CSC was designed to create. Indirectly, this suit makes the case – and Japan has become the poster child – for why recalcitrant countries should join the CSC."[177] The court noted that encouraging adoption of the CSC was an important policy interest, and the district court did not abuse its discretion in weighing US and Japanese interest.[178] The court then reviewed the remaining claims raised and concluded that the district court should further ascertain whether the case should be dismissed under principles of comity, the political question doctrine or the claims raised under California law,[179] thereby setting up Cooper Part 4.

D. The Cooper case (Part 4)[180]

In light of the decision made during the interlocutory appeal, the US district court reviewed the case again to examine, among other things, how choice-of-law and international comity would (or should) lead to dismissal of the plaintiff's claims in favour of refiling in Japan. This time around, the district court ruled in favour of TEPCO with respect to choice-of-law, stating that, under California choice-of-law rules,[181] there is a true conflict of law between Japanese law and California law but that Japan has a greater interest.[182] One thing to note that helped sway the court in favour of TEPCO was the Japanese position on its Nuclear Damage Compensation and Decommissioning Facilitation Fund (NDF). The

174. *Ibid*., pp. 1203-1205.
175. Adjudicative comity is defined by the appellate court citing as a "discretionary act of deference by a national court to decline to exercise jurisdiction in a case properly adjudicated in a foreign state". *Ibid* at p. 1205 (citing In re Simon, 153 F.3d 991 [9th Cir. 1998]).
176. *Ibid*., p. 1208 (emphasis added).
177. *Ibid*.
178. *Ibid*., p. 1209.
179. *Ibid*., p. 1218.
180. Cooper v. Tokyo Elec. Power Co., Case No.: 12cv3032-JLS (JLB) (S.D. Cal. 2019) (Cooper 4).
181. The federal court is required by law to apply the choice-of-law rules in the state in which it sits. California follows a three-step governmental interest approach: (1) are the laws of competing jurisdictions different when applied to the same matter; (2) if yes, do both jurisdictions have an interest in resolving the matter themselves so that there is a true conflict between them; and (3) if yes, which state would be most 'impaired' if its law is not applied. *Ibid*., pp. 5-6 (citing Abogados v. AT&T, 223 F.3d 932, 934 (9th Cir. 2000)).
182. *Ibid*., pp. 5-6, 19-21.

Japanese government stated in its *amicus curiae* brief, as interpreted by the court, that applying American law "could result in inconsistent adjudication of claims, which would be 'highly corrosive to the integrity of the compensation system,' not only for reasons of fairness to the claimants, but also the continued viability of funding of the NDF".[183]

Finally, as a matter of international comity, now buoyed by its decision on the choice-of law issue, the district court found in favour of TEPCO, acknowledging the court's inability to distil the correct elements of Japanese law, [184] and because the Japanese government finally expressed an interest in such claims being resolved in Japan.[185]

E. The Cooper case (Parts 5 and 6)[186]

The plaintiffs in the Cooper case once again appealed the decision to the appellate court, but in review, the appellate court found in favour of TEPCO, thereby affirming the motion to dismiss. Not to be outdone, the plaintiffs appealed to the US Supreme Court, the final adjudicator in the United States, using a *writ of certiorari*, the most common way by which the Supreme Court reviews cases.[187] The US Supreme Court issued a non-descript order on 21 March 2021, denying *certiorari* and therefore rejecting the plaintiffs' attempts to have the United States courts hear their claims over Fukushima Daiichi radiation exposure. [188]

F. Contractor zero liability after Cooper

While the Cooper case took several years to conclude and caused the parties to incur perhaps tens of millions of dollars in legal fees and associated costs, it never proceeded to trial as only the preliminary motion to dismiss was examined at length by the courts. This means that the lengthy discovery process, or exchange of relevant documents and associated review, and a court presiding over the merits of the claims could have easily doubled (or more) the amount of time and costs[189] this case took to reach a decision that would have come to the same result had the parties agreed to follow the Conventions – the place where the nuclear incident occurs is where the courts will hear all claims.[190]

The United States did not initially help bring clarity to its position in its attempts to encourage countries to join the CSC, as it did not back dismissal at the appellate court level, even though Japan had already been a member of the CSC and, indeed, Japan's joining was the reason the CSC went into force two years prior. However, it was likely that Japan's strong insistence that all compensation cases be heard in Japan influenced the United States to take a softer position on jurisdiction, which helped the court rule in favour of TEPCO.[191]

183. *Ibid.*, p. 21.
184. *Ibid.*, p. 23.
185. *Ibid.*, pp. 23-25.
186. Cooper v. Tokyo Elec. Power Co., 960 F.3d 549 (9th Cir. 2020) (Cooper 5).
187. LII (2024), "*writ of certiorari*", Wex, www.law.cornell.edu/wex/writ_of_certiorari (accessed 23 Apr. 2025).
188. Cooper v. Tokyo Elec. Power Co., 592 US at ____, No. 20-730, slip op. (order denying certiorari), available at: www.supremecourt.gov/orders/courtorders/032921zor_nmip.pdf (accessed 23 Apr. 2025).
189. A 2010 study by several groups on Fortune 200 companies indicated that average litigation costs per company were USD 115 million per year in 2008, a significant increase of 73% since 2000. Lawyers for Civil Justice, Civil Justice Reform Group and US Chamber Institute for Legal Reform (2010), "Litigation Cost Survey of Major Companies", presented at the 2010 Conference on Civil Litigation, Duke Law School, Durham, North Carolina, 10-11 May, p. 2.
190. The plaintiffs did not deny that choice-of-law was a relevant factor to consider; they just wanted to it to be adjudicated during trial and not as a preliminary motion, among other things. Cooper 5, *supra* note 186, pp. 558-559.
191. *Ibid.*, p. 569 (noting that the United States provided a "measured response", voicing concern over the reasons provided by the district court for the decision but not arguing that California was the proper forum to exercise jurisdiction in the case).

How does this apply to zero contractor liability? As discussed above, the purpose of contractor zero liability is not to address claims made under the Conventions but potential claims in countries where transboundary nuclear damage has led to a contractor being sued in local courts by virtue of having worked both in the place where the nuclear incident occurred (or caused or contributed to the arising of the nuclear incident) and also in the country affected by nuclear damage. The Cooper case was straightforward in that TEPCO had admitted liability early on and no third parties were responsible for the nuclear damage (i.e. the operator was responsible for the damage and, pursuant to the local law, was strictly liable with the government of Japan providing excess funding required for claims).

Parties to the Conventions (or those with similar domestic law as the Conventions) will likely not be different in the event of nuclear damage but will seek to have exclusive jurisdiction over all claims, especially in instances where the exceptions in the Conventions are triggered. Cases therefore brought in foreign jurisdictions that run contrary to the Conventions will likely lead to stronger positions taken by parties to the Conventions as even in countries where there is limited liability on an operator, it is understood that the state is the ultimate payer in the event of claims. National sovereignty is unlikely to bend to a foreign court's ruling when costs for nuclear damage are allocated or extend beyond the Conventions' requirements as shown by the Cooper case, which was relatively straightforward. Likewise, foreign courts knowing about the Conventions, as in the case of Cooper, are unlikely to make a decision that therefore runs contrary to principles of international comity. This uncertainty and bringing claims in courts not suited for addressing nuclear damage claims ultimately negatively impacts the victims and prolongs their suffering and right to obtain compensation as it may take years for claims to be adjudicated and finally decided.

Moreover, we have already seen how jurisdictions treat gross negligence and wilful misconduct – each person committing either of these two may be civilly and criminally liable, and only in rare circumstances gross negligence may be covered by insurance but not for wilful misconduct. Domestic law codifying the Conventions will explicitly not permit responsibility to be placed on the operator, so choice-of-law decisions may become the norm in the unlikely event of a nuclear incident leading to transboundary nuclear damage in a non-party to the Conventions.

Admittedly, all of this is speculative, and will continue to be so without a real life matter for courts to parse through, but the Cooper case gives valuable insight into human nature and political will, and the necessary fact that once a country has agreed to a mechanism as found in the Conventions, it will not concede to foreign interference running contrary to the Conventions, especially when the reason for the nuclear damage is deemed to be the fault of the person seeking redress, and which fault (cause) may even be punishable under criminal law. Thus, if under a contract a contractor must be indemnified in a foreign court for nuclear damage, even if the victim is given damages in that foreign court, enforcement in the adjoining country where the nuclear incident occurred may not be entertained as contrary to the Conventions and domestic law – an ultimately detrimental and costly result, especially for the victims.

Commercial contracts are normally seen as valid and binding on all parties, but changes to NTPL running afoul of general principles of law and the Conventions are unlikely to be enforceable, meaning agreeing to this approach in commercial contracts not only takes more time to conclude, but potentially ends up being an exercise in futility. Therefore, a return to certainty in commercial contracts as found in the Conventions is necessary as nuclear energy must remain viable for the world to reach net zero.

CASE LAW

United States

Spent fuel storage litigation

As previously reported in *Nuclear Law Bulletin*, No. 111 in August 2023, the United States (US) Court of Appeals for the Fifth Circuit vacated a licence the NRC issued to Interim Storage Partners, LLC (ISP), authorising the construction and operation of a facility in Texas to receive and store spent nuclear fuel in above ground canisters and casks for a licence term of up to 40 years.[1] In March 2024, the Fifth Circuit denied a petition for a rehearing of that decision.[2]

On 12 June 2024, the US Solicitor General (on behalf of the US Nuclear Regulatory Commission [NRC]) sought review of the Fifth Circuit's decision by filing a "petition for a *writ of certiorari*" with the US Supreme Court. The Supreme Court granted the petition in October 2024. The case is currently scheduled for oral argument in March 2025. In short, the two questions presented in the case are: (1) whether the Fifth Circuit erred in exercising jurisdiction over the challenge to the issuance of the licence, given that none of the challengers to the NRC's issuance of the licence to ISP had successfully intervened as parties in the NRC licensing proceeding; and (2) whether the Fifth Circuit erred in concluding that the NRC lacks legal authority to issue licences to temporarily store spent nuclear fuel away from the reactor site where the fuel was generated. A decision from the Supreme Court is anticipated by June or July of 2025.

Diablo Canyon "timely renewal" exemption

On 29 April 2024, the US Court of Appeals for the Ninth Circuit issued a decision upholding the legality of an exemption that the US NRC had previously issued to the operator of the Diablo Canyon Power Plant in San Luis Obispo County, California.[3] The exemption concerned the timing of the operator's application to renew the facility's licences, and the legal effect of the receipt of that licence renewal application, given the unique circumstances.

As explained in the Court's decision,[4] the Diablo Canyon nuclear plant consists of two reactor units that have been in operation since the 1980s. In 2009, the operator (Pacific Gas & Electric Company – PG&E) applied to renew the licences for both units for an additional 20 years of operation.[5] However, this licence renewal application was withdrawn in 2018, based on a resource planning decision that concluded that continued operation of the two units was not necessary to meet California's projected energy demand requirements. PG&E

1. Texas v. NRC, 78 F.4th 827 (5th Cir. 2023); *see also* NEA (ed.) (2024), *Nuclear Law Bulletin*, No. 111, OECD publishing, Paris, pp. 76-78.
2. Texas v. NRC, 95 F.4th 935 (5th Cir. 2024); *see also* NEA (ed.) (2024), *Nuclear Law Bulletin*, No. 112, OECD publishing, Paris, pp. 37-38.
3. San Luis Obispo Mothers for Peace v. NRC, 100 F.4th 1039, 1049 (9th Cir. 2024) (SLOMFP).
4. *Ibid.*, pp. 1046-1049.
5. The Atomic Energy Act of 1954, as amended (AEA), authorises the NRC to grant an initial licence to operate a commercial nuclear up to 40 years. 42 *United States Code* (USC) 2133(c). These licences can then be renewed one or more times for additional terms not to exceed another 20 years. 10 *Code of Federal Regulations* (CFR) 54.31(b).

thus planned to retire the reactors upon the expiration date of their licences – November 2024 for Unit 1, and August 2025 for Unit 2. But in September 2022, the state of California reversed this decision through legislation, based in part on climate change impacts and significant projected electricity reliability challenges. This legislation directed PG&E and other state actors to take all actions necessary to extend operation of the Diablo Canyon reactor units beyond their 2024 and 2025 expiration dates.

Shortly thereafter, in October 2022, PG&E submitted a request to the NRC to either resume review of the licence renewal application that had been withdrawn in 2018 or, in the alternative, grant PG&E an exemption from the NRC's "timely renewal" rule provided PG&E submitted a new and updated licence renewal application by the end of 2023. "Timely renewal" refers to a provision of the federal Administrative Procedure Act (APA) that provides certain protection to the holder of any federal licence seeking renewal – so long as that licence holder submits a "timely and sufficient application" to renew the licence "in accordance with agency rules". [6] The licence holder can continue to engage in the licensed activity until the federal agency takes final action on the renewal application.[7] The NRC's regulations implementing this APA provision require nuclear power reactor licensees to submit a renewal application at least five years before the expiration of the licence in order to receive this "timely renewal" protection.[8] PG&E sought an exemption from this five-year deadline because more than five years had already passed by the time California reversed the prior decision to retire the two reactors.

The NRC determined in March 2023 that it could not resume review of PG&E's previously withdrawn licence application but granted PG&E's alternative request for an exemption from the five-year timely renewal deadline. [9] NRC regulations authorise the issuance of exemptions from regulatory requirements if certain established criteria are met, including (among others) that issuance of the exemption is not contrary to law, will not present "an undue risk to the public health and safety" and that "special circumstances" warranting the exemption are present.[10] The NRC concluded that granting the timely renewal exemption – which would allow PG&E to continue operating the reactors past their licence expiration date if the NRC's review of the licence renewal application was still ongoing – would not create any undue risk to public health and safety because the terms of the current licence would remain in force and the NRC would continue to conduct all regulatory inspection and oversight activities. The NRC also concluded that the five-year "timely renewal" deadline in its regulations was discretionary and could lawfully be adjusted in an individual case, and that California's legislative reversal of the decision to retire Diablo Canyon due to climate change impacts and serious electricity reliability challenges constituted "special circumstances" justifying an exemption.[11]

Multiple organisations representing members living in the vicinity of Diablo Canyon filed a consolidated challenge of the NRC's exemption decision in the Ninth Circuit, arguing that the NRC's decision was inconsistent with the Atomic Energy Act (AEA) and the National Environmental Policy Act (NEPA) and that the decision to grant the exemption was not supported. The Ninth Circuit rejected these arguments. Specifically, the Court found that although the AEA limits an initial licence term for a nuclear power reactor to 40 years, which can only be renewed for an additional licence term through a formal licence renewal proceeding, the NRC's granting of a timely renewal exemption was lawful and did not itself constitute a renewal of the licence.[12] Because the exemption was not a licence renewal, the Court also held that the NRC was not required to hold a hearing on

6. 5 USC 558(c).
7. *Ibid.*
8. 10 CFR 2.109(b).
9. *See generally* Pacific Gas and Electric Company; Diablo Canyon Power Plant, Units 1 and 2, 88 *Federal Register* (Fed. Reg.) 14395 (8 Mar. 2023).
10. 10 CFR 50.12.
11. 88 Fed. Reg. at 14397-14398.
12. SLOMFP, *supra* note 3, p. 1056.

the decision to issue the exemption.[13] Additionally, the Court held that the NRC was not required, as the petitioners argued, to commit to completing the licence renewal proceeding prior to the expiration date of the licences.[14] Lastly, the Court held that the NRC had reasonably concluded that granting the exemption would not result in undue risk to public health and safety or any significant unevaluated environmental impact and the agency's determination that "special circumstances" were present in the individual case was reasonably supported.[15]

PG&E submitted its application to renew both licences in November 2023. As of this writing, the NRC anticipates that it will issue a final decision on the application by August 2025.

13. *Ibid*. Section 189a of the AEA requires the NRC to provide an opportunity for a hearing in any proceeding for the "granting, suspending, revoking, or amending" of a licence. 42 USC 2239(a).
14. SLOMFP, *supra* note 3, pp. 1056-1057.
15. *Ibid*., pp. 1057-1058.

NATIONAL LEGISLATIVE AND REGULATORY ACTIVITIES

France

General legislation, regulations and instruments

Law No.2024-450 of 21 May 2024 on the organisation of the governance of nuclear safety and radiation protection to meet the challenge of the relaunching the nuclear industry[1]

The main purpose of the Law on the organisation of nuclear safety and radiation protection governance is to create, as of 1 January 2025, the French Authority for Nuclear Safety and Radiation Protection (*L'Autorité de Sûreté Nucléaire et de Radioprotection* – ASNR), which is the new independent administrative authority born out of the merger of the Nuclear Safety Authority (*L'Autorité de Sûreté Nucléaire* – ASN) and its technical support organisation, the Nuclear Safety and Radioprotection Institute (*L'Institut de Radioprotection et de Sûreté Nucléaire* – IRSN). The mission of the ASNR is to provide general expertise, research and training in nuclear safety and radiological protection. Its mandate is to monitor national and international research activities in nuclear safety and radiological protection and make proposals or recommendations on research needs. The ASNR should also contribute to parliamentary work, inform the public and ensure transparency in these fields.

As an independent authority, the ASNR, as was the case with its predecessor, the ASN, is tasked with regulatory oversight, nuclear licensing and radiological protection. It should establish rules and regulations to clearly separate the processes for review, expertise and research on one side and decision making by its collegial body, the "*Collège*", on the other.

The ASNR is also in charge of the permanent monitoring of radiological protection and surveillance of the environment and of people exposed to ionising radiation.

Although the ASNR inherits most of the IRSN's missions, the provision and operation of delayed-reading dosimeters is transferred to the Atomic Energy and Alternative Energies Commission (CEA). The CEA replaces the IRSN as the employer of staff whose missions have been transferred to the Ministry of Defence, namely those staff who provide technical support to public authorities in the fields of: i) nuclear safety and radiological protection for defence-related nuclear facilities and activities; ii) security of nuclear installations and transport of nuclear materials or sources of ionising radiation; iii) non-proliferation, control and centralised accounting of nuclear materials; and iv) prohibition of chemical weapons.

Beyond this reform, the Law of 21 May 2024 also aims to:

- Adapt public procurement rules related to nuclear projects, including projects related to the construction of facilities for research activities linked to the peaceful use of nuclear energy, processing of radioactive waste or fuel, and decommissioning of facilities where nuclear substances are or have been stored; and
- Make amendments to the missions of the CEA and place it under the authority of the Prime Minister. The CEA is now charged with advising the government on issues related to nuclear energy and national security, science and technology, civil

1. Law No. 2024-450 of 21 May 2024 on the organisation of the governance of nuclear safety and radiation protection to meet the challenge of relaunching the nuclear industry, *Official Journal of the French Republic* (JORF) No. 117, 22 May 2024, Text No. 3.

nuclear activities (including challenges associated with power generation and fuel cycle), and to provide expertise and control services to the government on defence-related issues.

Before it was promulgated, this law was reviewed by the Constitutional Council, especially regarding the revocation of the dual system that separated the expertise role of the IRSN from the decision-making authority that rested with the ASN. In its Decision No. 2024-868 DC of 17 May 2024, the Constitutional Council stated that the law complied with the Constitution since the ASNR must maintain, in its rules and regulations, a clear distinction between the expertise and the decision-making roles.

Nuclear installations

Decree No. 2024-296 of 29 March 2024 defining the concept of immediate vicinity in the context of accelerating measures for procedures related to nuclear new build near existing nuclear sites and making various procedural adaptations[2]

Law No. 2023-491 of 22 June 2023 on accelerating procedures related to nuclear new build near existing nuclear sites and to the operation of existing facilities establishes a fast-track procedure for the construction of new nuclear reactors, including small modular reactors (SMRs), or of certain facilities for the interim storage of nuclear fuel, if and when:

- The facility is to be built in the immediate vicinity or within the perimeter of an existing Basic Nuclear Installation (*Installation nucléaire de base* – INB); and
- The creation permit request is filed within 20 years following the promulgation date of the law (i.e. by 23 June 2043).

This decree clarifies the term "immediate vicinity", which needs to fulfil two cumulative requirements:

- The project will be located within the Emergency Planning Zone (*Plan particulier d'intervention* – PPI) when it exists; and
- The perimeter of the facility is less than 500 metres away from the existing INB in sea-side communities and less than 5 kilometres away in other communities.

As an exception, a nuclear reactor that does not fulfil both cumulative criteria may, under certain conditions, still be considered as being in the immediate vicinity of an INB, taking into account its specific technical characteristics or the specific geographical characteristics of the selected site.

Nuclear safety and radiological protection (including nuclear emergency planning)

Order of 15 May 2024 relating to the prevention of radon risk and the implementation of radon zones and of associated checks in the context of the reinforced framework for the protection of workers[3]

The order establishes the applicable modalities to acknowledge the risk associated with the exposure of workers to ground-emitted radon gas, i.e. gas that directly emanates from rocks, or indirectly from water circulating among rocks or among material extracted from rocks. The order requires employers to establish a traceable action plan and to take

2. Decree No. 2024-296 of 29 March 2024 defining the immediate vicinity notion in the context of measures for speeding up procedures related to the construction of nuclear new build close to existing nuclear sites and making various procedural adaptations (JORF No. 77, 31 March 2024, Text No. 38).
3. Order of 15 May 2024 relating to the prevention of radon risk and the implementation of a radon zone and of associated checks in the context of the reinforced framework for the protection of workers (JORF No. 134, 6 June 2024, Text No. 9).

measures to reduce exposure when the concentration of radon in the atmosphere of the workplace exceeds the reference level of 300 bq/m^3 as a yearly average. If, within a maximum period of three years, the employer fails to implement the reduction measures or fails to reduce the concentration of radon below the reference level, the employer must implement a "radon zone" and take reinforced measures.

If the level exceeds 1 000 bq/m^3 as a yearly average, the employer must immediately take measures to reduce the concentration of radon below that level within 12 months.

Nuclear security

Order of 14 May 2024 related to the protection of sources of ionising radiation against malicious acts for activities under the remit of the Ministry of Defence[4]

This order defines technical and organisational protection provisions that must be taken by persons responsible for nuclear activity related to defence that involves a risk of exposing people to ionising radiation in order to protect sources of ionising radiation and/or bundles of radioactive sources against malicious acts.

A malicious act is defined as theft, misappropriation, wilful deterioration of a source of ionising radiation or any other act aiming to intentionally cause risks or danger.

The order applies to nuclear activities undertaken:

- within sites under the authority of the Defence Minister;
- within nuclear facilities or activities related to defence; and
- for the transport of radioactive substances under the authority of the Defence Minister sent to or from these sites or facilities.

Slovak Republic

International co-operation

Bilateral meeting between the Nuclear Regulatory Authority of the Slovak Republic (ÚJD SR) and the Polish Atomic Agency (PAA)

A meeting between ÚJD SR and the PAA was held on 11-12 April 2024 in Tomášov, Slovak Republic. The meeting participants provided information about the significant activities of their respective nuclear safety authorities that have been undertaken since the last bilateral meeting. They also discussed recent issues in their countries relating to nuclear regulatory and legislative frameworks, the safety of nuclear installations and developments related to international affairs.

Quadrilateral + meeting between the Czech Republic (Czechia), Finland, Hungary, Poland, the Slovak Republic and Slovenia

A meeting between Czechia, Finland, Hungary, Poland, the Slovak Republic and Slovenia, referred to as the Quadrilateral + meeting, was held on 14-15 May 2024 in Balatonfüred, Hungary. The agenda of the meeting comprised of discussions related to recent developments in national frameworks and regulatory bodies, incidents at nuclear power plants and related enforcement actions, pre-licensing of new nuclear power plants (including SMRs), fuel diversification issues, European Union (EU) and international issues of common interest, and the status of common EU projects.

4. Order of 14 May 2024 related to the protection of sources of ionising radiations against malicious acts regarding activities under the remit of the Ministry of Defence (JORF No. 117, 22 May 2024, Text No. 32).

Bilateral meeting between Austria and the Slovak Republic

A meeting between Austria and the Slovak Republic was held on 17-18 June 2024 in Voderady, Slovak Republic. The partners informed each other about current developments in the field of nuclear safety and radiation protection, activities of their respective regulatory authorities and other relevant institutions, commissioning and operation of nuclear installations, amendments to legislation, as well as developments in the field of radiation monitoring. The topics discussed also included emergency preparedness, decommissioning of nuclear installations and an issue regarding a new nuclear power plant under in the Slovak Republic.

The Slovak Republic's delegation, led by the Chairperson of the ÚJD SR, Marta Žiaková, was composed of representatives of ÚJD SR, the Public Health Authority of the Slovak Republic, the Ministry of Economy of the Slovak Republic, the Ministry of Environment of the Slovak Republic, the Ministry of Interior of the Slovak Republic, the Ministry of Foreign and European Affairs of the Slovak Republic, the National Nuclear Fund, the company Slovenské elektrárne, a.s., the company Jadrová a vyraďovacia spoločnosť, a.s., and the company Jadrová energetická spoločnosť Slovenska, a. s. The meeting provided a beneficial opportunity for discussion and information sharing, principally regarding details of the Slovak nuclear programme.

General legislation, regulations and instruments

Act No. 161/2024 Coll. amending and supplementing Act No. 143/1998 Coll. on civil aviation (Aviation Act) and on amendments and supplements to certain acts, as amended, and on amendments to certain acts

Act No. 161/2024 Coll. amended provisions regarding physical protection of nuclear installations, as governed by Act No. 541/2004 Coll. on the peaceful use of nuclear energy (the Atomic Act) and on changes and amendments to certain laws, as amended. These amended provisions introduce enhanced protection of nuclear installations against the entry of unauthorised persons. Entry to restricted areas within nuclear installations is allowed only to persons with verified integrity and reliability. For this purpose, members of the Police Corps of the Slovak Republic are entitled to request from the General Prosecutor's Office of the Slovak Republic excerpts from the criminal records of persons seeking authorisation. The process of handling such a request is stipulated in the Act No. 299/2024 Coll. amending and supplementing the Act of the National Council of the Slovak Republic No. 171/1993 Coll. on the Police Corps, as amended, and on amendments and supplements to certain acts.

Nuclear Regulatory Authority of the Slovak Republic (NRA SR) Draft decree amending and supplementing the Decree of the NRA SR No. 431/2011 Coll. on a quality management system, as amended

The NRA SR prepared a draft decree (the Draft Decree) amending and supplementing the Decree of the NRA SR No. 431/2011 Coll. on a quality management system, as amended, based on the enabling provision of section 25(6) of the Atomic Act.

The quality management system is one of the key system tools for verifying the licensee's approach to the use of nuclear energy to achieve the highest possible level of nuclear safety and reliability in terms of quality assurance, process approach and the documentation of the quality management system itself. This system must be permanently maintained and improved by the licence holder.

The submitted Draft Decree responds to current trends in the world, especially in procurement of components for the nuclear sector. It is necessary to emphasise that these trends have a major impact on the quality of services and goods from the supply chain. This trend reflects the decline in the quality of suppliers of components used in the peaceful use of nuclear energy, as well as the low quantity of available components. It is necessary for legislation in the Slovak Republic to capture and reflect these trends.

However, despite, or precisely because of, the use of the so-called "commercial grade items", this does not mean that the NRA SR will not ensure an increase in the level of nuclear safety in its approach.

It is necessary to note that this issue has already been partially regulated via legislation, namely in Decree of the NRA SR No. 56/2006 Coll. (Decree No. 56/2006) on details concerning requirements for quality system documentation of the authorisation holder, as well as details concerning quality requirements for nuclear installations, details concerning quality requirements for classified equipment and details concerning the scope of their approval, which was replaced by the currently valid Decree of the NRA SR No. 431/2011 Coll. Decree No. 56/2006, section 7, paragraph 7 defines the term "commercial facility" stating these "facilities could not be used for systems categorised into safety classes I and II". The term "process of demonstrating the usability of a commercial facility as the selected facility" (Commercial Grade Dedication Process) was also defined in section 7, paragraph 8. Decree No. 56/2006 clearly defined the obligations of the licensee when, after successfully demonstrating the demonstration process, the commercial facility was considered to be the selected facility.

During the demonstration process and for all activities performed on this equipment after its delivery, the licence holder must possess and ensure the development of a quality plan for the selected equipment in accordance with the current requirements defined in Decree of the NRA SR No. 431/2011 Coll., as amended.

In view of the above, it was determined that the previously defined and existing requirements need to be revised, and new ones incorporated into an amendment to Decree No. 431/2011 Coll. as soon as possible. The necessity of this amendment reflects the changes resulting from the current conditions in the world and regarding the method of introducing commercial-grade products into practice. To elaborate on this issue in more detail, the NRA SR plans to issue a safety guide as a non-legislative recommendation document, which can serve as a guide for the licence holder.

Slovenia

General legislation, regulations and instruments

Research and development strategy for 2025-3035

The Slovenian Nuclear Safety Administration, in co-operation with the Ministry of Science, Higher Education, and Innovation, has prepared a proposal for a Research and Development Strategy for the Safe Use of Nuclear Energy and Sources of Ionising Radiation for the period 2025-2035 (the Strategy).

The aim of the Strategy is to strengthen and systemise research and development in the field of the safe use of nuclear energy and other sources of ionising radiation in Slovenia. The adoption of the Strategy is necessary in view of the challenges posed by the existing nuclear and radiation facilities in Slovenia, the planned construction of a new repository for low- and intermediate-level radioactive waste, as well as the possible expansion of the nuclear programme and the development of new technologies for small modular reactors. The Strategy also addresses innovations in the development of new technologies using radiation sources in medicine, industry, research and other related areas of nuclear and radiation safety.

The Strategy provides an overview of the current state of research and development, defines a vision and sets out the objectives to be achieved in this field. It also identifies the research areas in which it will be implemented, taking into account the risks involved. Another important element is the further strengthening of the knowledge already achieved in the field, both in terms of technical infrastructure and know-how. The Strategy proposes actions to achieve the objectives. A key implementing document foreseen in the Strategy will be the Research and Development Programme for 2025-2035.

Nuclear safety and radiological protection (including nuclear emergency planning)

New rules on radiation and nuclear safety factors

New rules on radiation and nuclear safety factors were adopted at the end of June 2024 and entered into force on 24 July 2024.[5] These rules are in line with the key International Atomic Energy Agency (IAEA) standards, the most recent requirements of the Western European Nuclear Regulators Association (WENRA) Reference Levels of 2020, the recommendations of the IAEA's Integrated Regulatory Review Service (IRRS) mission on the legislative and regulatory framework for nuclear and radiation safety, held in April 2022, and the European Directive on Nuclear Safety.

Compared to the previous valid rules, the changes concern the design bases, where some new more detailed requirements are given in line with the IAEA Standards regarding the content of the application for a licence to store or treat radioactive waste for the purposes of the compulsory national public service for radioactive waste management and the design requirements for human factors and human-machine interface. The requirements were also updated for cybersecurity in nuclear installations, the management system, and the design bases for nuclear power plants, irradiation facilities or particle accelerators. Design requirements for internal hazards and for external hazards due to human activities were added based on Western European Nuclear Regulators' Association (WENRA) safety reference levels.[6]

Moreover, a new annex was added, setting out the requirements for the pre-operational tests programme and the requirement for approval of the pre-operational test programme in the construction permit procedure.

New rules on the safety assurance of radiation and nuclear facilities

New rules on the safety assurance of radiation and nuclear facilities were adopted in March 2024 and became valid on 13 April 2024.

The changes to the rules concern new chapters on management and control of facility systems, special requirements for core and fuel in nuclear power plants and research reactors and other programmes aligned with the requirements of IAEA Standards. The revised Emergency Preparedness chapter is aligned with the rules on the content and preparation of protection and rescue plans. In addition, the requirements for daily, quarterly and annual reporting of a nuclear power plant, and for annual reporting of a research reactor, have been updated. A new annex on annual reporting of a radioactive waste management facility has also been provided. The requirements for ageing management and technological obsolescence have been updated based on more recent WENRA reference levels. Furthermore, the related recommendations of the IRRS mission have been implemented in the new rules.

5. "*Pravilnik o dejavnikih sevalne in jedrske varnosti* [Rules on radiation and nuclear safety factors]", *Uradni list Republike Slovenije* [Official Gazette of the Republic of Slovenia], No. 56/24.
6. See WENRA (2021), *Report: WENRA Safety Reference Levels for Existing Reactors 2020*, available at: www.wenra.eu/sites/default/files/publications/wenra_safety_reference_level_for_existing_reactors_2020.pdf.

Switzerland

General Legislation

Proposal of the Swiss Federal Council to lift the ban on construction of new nuclear power plants in Switzerland – Opening to consultation

The Swiss population voted by referendum in 2017 to phase out nuclear energy. On 16 February 2024, the people's initiative "Electricity for all at all times (Stop the blackout)" was filed before the Federal Chancellery. Although not expressly mentioned, the purpose of the initiative was to lift the ban on construction of new nuclear power plants in Switzerland. The Federal Council agrees with the initiative's authors that the general conditions of energy supply have evolved since the 2017 popular vote. However, it rejected the initiative, reasoning that lifting the ban on construction of new nuclear power plants is to be lifted by amending the Nuclear Energy Act (NEA, Classified Compilation (CC) 732.1). Consequently, the Federal Council will recommend that the Federal Chambers reject the initiative, and the Federal Council will submit an indirect counterproposal aimed at lifting the ban on construction of new nuclear power plants. The counterproposal would require the revocation of some provisions of the Nuclear Energy Act.

The consultation process is expected to end in April 2025. Final deliberation and adoption of the proposal by the Parliament could be expected around mid-2026. A possible referendum consultation could then be held in 2027.

Nuclear safety and radiological protection (including nuclear emergency planning)

Technology Monitoring of Nuclear Energy

The Swiss Federal Office of Energy (SFOE) monitors nuclear energy developments as part of the Federal Council's reporting to the Federal Assembly. The legal basis for this mandate lies in Article 74a of the Nuclear Energy Act of 21 March 2003 (NEA; CC 732.1). Because the monitoring of nuclear energy had not been updated since 2017, in the spring of 2023 the SFOE commissioned a separate study on the state of development of nuclear energy technology. The report, *Technology Monitoring of Nuclear Energy*,[7] was published in English by SFOE in 2024 and includes an executive summary provided in German, French, Italian and English. Authors from the Federal Institute of Technology (Eidgenössische Technische Hochschule – ETH) are solely responsible for the content of the report, which provides an overview of nuclear energy status in Switzerland and worldwide.

Radioactive waste management

General licence requests concerning a deep geological repository and an encapsulation plant for fuel elements

On 19 November 2024, the National Co-operative Society for Radioactive Waste Storage (Nagra) filed two licence applications to the SFOE, along with corresponding support documents, for the construction of a deep geological repository (DGR) for radioactive waste and for an encapsulation plant for fuel elements. As announced in 2022, Nagra proposes to build the DGR in the siting region "North Lägern" (Canton Zürich) and the encapsulation plant on the site of the present centralised interim repository in Würlingen (Canton Argovie). The competent authorities of the Swiss Confederation have reviewed the

7. Manera, A. and A. Pautz (eds.) (2024), *Technology Monitoring of Nuclear Energy,* SFOE Energy Research and Cleantech, Bern, Switzerland, available at: www.bfe.admin.ch/bfe/de/home/news-und-medien/publikationen.exturl.html/aHR0cHM6Ly9wdWJkYi5iZmUuYWRtaW4uY2gvZW4vcHVibGljYX/Rpb24vZG93bmxvYWQvMTE4Mzg=.html.

applications to ensure that all legally required documents have been provided. The applications will be published in early summer 2025. The in-depth review follows.

The general licence application consists of a security report and a safety report, as well as a report on the reasons for selecting the particular site. It also contains an Environmental Impact Assessment report and a Land-Use Planning Compliance (LPC) report. For each application, Nagra proposes the installation site (size and siting of the main facilities) and demonstrates its safety. Regarding the DGR, Nagra proposes the maximum capacity of the repository, exclusion criteria, as well as the provisional underground protection zone around the repository site. Towards the end of the current decade, both general licences, the report on the outcomes of Step 3 of the sectoral plan – which is the final step in the site selection process – as well as the updated project briefs should be submitted simultaneously to the Federal Council for approval. The general licence will then have to be validated by the Federal Assembly, whose decision may be subject to an optional referendum.

United States

General legislation, regulations and instruments

The Accelerating Deployment of Versatile, Advanced Nuclear for Clean Energy Act of 2024 (ADVANCE Act)

On 9 July 2024, the President signed into law the ADVANCE Act, which was passed in the United States (US) Congress with significant bipartisan support.[8] The ADVANCE Act requires the US Nuclear Regulatory Commission (NRC) to take a number of actions, particularly in the areas of licensing of new reactors and fuels, while maintaining the NRC's core safety and security mission. The ADVANCE Act affects a wide range of NRC activities, including by supporting the recruitment and retention of the NRC workforce, adding flexibility in the NRC's budgeting process, enhancing the regulatory framework for advanced reactors and fusion technology, and requiring initiatives to support the NRC's efficient, timely and predictable reviews of licence applications.

Key provisions of the ADVANCE Act include:

- Requiring the NRC to continue supporting international regulatory co-operation and assistance activities relating to nuclear technologies and licensing activities (ADVANCE Act section 101);
- Placing new restrictions on the NRC's issuance of domestic licences to possess or own certain nuclear fuel (section 102);
- Creating a requirement for the NRC to notify appropriate committees of the US Congress if it issues a licence to export certain nuclear material or items to a country that has not ratified an Additional Protocol to its safeguards agreement with the International Atomic Energy Agency, or has not ratified or acceded to the amendment to the Convention on the Physical Protection of Nuclear Material (section 103);
- Requiring the US Department of Energy (DOE) to review and update, as appropriate, its process for determining a country's status as a "generally authorized destination" for purposes of its regulations (10 *Code of Federal Regulation* [CFR] Part 810) requiring approval of the transfer of certain unclassified nuclear technology and assistance to foreign nationals (section 105);

8. Public Law No. 118-67, 138 Stat. 1447.

- Implementing changes to how the NRC recovers fees from licensees and other entities, including establishing a lower hourly rate for advanced reactor applicants and pre-applicants (sections 101, 201, and 204);
- Amending the Atomic Energy Act (AEA) to include a new definition for "fusion machine" and codify into law radioactive material produced by fusion machines as byproduct material (section 205);
- Requiring the NRC to evaluate potential changes to its regulations, guidance or policies to promote efficient, timely and predictable licence application reviews for nuclear facilities at brownfield sites and retired fossil fuel sites (section 206);
- Requiring the NRC to establish a new combined licence application review procedure to allow the NRC to expedite the review process for qualifying applicants (section 207);
- Requiring the NRC to develop risk-informed and performance-based strategies and guidance for the licensing and regulation of microreactors (section 208);
- Where certain criteria are met, discontinuing application of the AEA's prohibitions against issuing nuclear reactor licences to an entity "owned, controlled, or dominated" by a foreign person, corporation or government (section 301);
- Requiring the NRC to establish a nuclear energy traineeship subprogramme as part of the University Nuclear Leadership Program to meet critical mission and nuclear workforce needs (section 402);
- Enhancing the NRC's preparedness to review requests for regulatory approval of advanced nuclear fuel, including enhanced co-ordination with the US Department of Energy (section 404);
- Requiring the NRC to update its mission statement to specify that the licensing and regulation of radioactive materials and nuclear energy for civilian purposes be conducted in a manner that is efficient and does not unnecessarily limit: (1) the civilian use of radioactive materials and deployment of nuclear energy; or (2) the benefits of civilian use of radioactive materials and nuclear energy technology to society (section 501);
- Strengthening the NRC's workforce through additional pay and hiring authorities (section 502); and
- Requiring the NRC to establish techniques and guidance to support efficient, timely and predictable reviews of nuclear reactor licence applications (section 505).

The ADVANCE Act requires the NRC to submit various reports to the US Congress, which the NRC is in the process of preparing. The NRC is also engaging with external stakeholders where appropriate and has created a publicly available implementation status dashboard to document the agency's progress towards meeting key milestones.[9]

Environmental protection

Final generic environmental impact statement (GEIS) for licence renewal

On 6 August 2024, the NRC issued a final rule amending its environmental review regulations, codified in Part 51 of Title 10 of the CFR, governing the review of an application for the renewal of the operating licence for a nuclear power plant.[10]

9. NRC (n.d.), "ADVANCE Act (Accelerating Deployment of Versatile, Advanced Nuclear for Clean Energy Act of 2024: Implementation Status Dashboard", NRC, www.nrc.gov/about-nrc/governing-laws/advance-act.html#dashboard.
10. 89 *Federal Register* (Fed. Reg.) 61466 (6 Aug. 2024).

The AEA and NRC regulations allow for the renewal of an operating licence for a term not to exceed an additional 20 years of operation, with no limitations on the number of times a licence may be renewed. Separate from the NRC's safety evaluation of a licence renewal application, NRC regulations require applicants for a renewed operating licence to prepare an environmental report that evaluates the potential impacts to the environment of facility operation for an additional 20 years. This environmental report informs the environmental impact statement (EIS) that the NRC is required to prepare under the National Environmental Policy Act (NEPA). To streamline the preparation of a licence renewal EIS and document the systematic approach the NRC uses to evaluate environmental impacts, the NRC issued a final rule in 1996 which codified the conclusions of a GEIS accompanying the rule for licence renewal (LR GEIS). The LR GEIS defines the environmental impacts of licence renewal that would essentially be the same at all nuclear power plants (or a subset of plants with similar characteristics). These "generic" impacts are referred to as "Category 1" issues that are not required to be evaluated further on a plant-specific basis. Environmental impacts that are not generic and could differ at plants are referred to as "Category 2" impacts and must be evaluated by the applicant and the NRC on a plant-specific basis. The LR GEIS was last updated in 2013.

As directed by the Commission in a series of adjudicatory orders from 2022, the NRC's most recent final rule concerning environmental impacts associated with power reactor licence renewal expands the scope of the LR GEIS to cover subsequent licence renewal (i.e. a period of extended operation from 60 years to 80 years) as well as initial licence renewals (a period of extended operation from 40 years to 60 years). In addition, the revised LR GEIS adds two issues related to climate change, revises some of the findings on ground water to reflect experience from cooling canals at a coastal plant and re-categorises severe accidents as a Category 1 issue. As a result of these and other changes, the LR GEIS redefines the number and scope of the environmental issues that must be addressed by the NRC and licence applicants. These changes are based primarily on the lessons learnt and knowledge gained from review of initial licence renewal applications and subsequent licence renewal applications. The final rule includes 80 total environmental issues, 20 of which require plant-specific analysis. A dedicated interdisciplinary team of experts worked exclusively on the rulemaking in line with Commission directive to complete the rulemaking in just over two years to allow the NRC to use the LR GEIS in subsequent licence renewal proceedings.

Draft GEIS for nuclear reactors

On 4 October 2024, the NRC published a proposed rule that would amend its regulations governing the environmental review of new nuclear reactor applications under NEPA.[11] In conjunction with the proposed rule, the NRC staff prepared a draft "Generic Environmental Impact Statement for Licensing of New Nuclear Reactors" (NR GEIS), which uses a technology-neutral framework to determine which potential environmental impacts would be common to the construction, operation and decommissioning of new nuclear reactors that meet specified plant and site parameters.

This proposed rule would codify the generic findings of the NR GEIS into a new appendix to 10 CFR Part 51. Similarly to the model for power reactor licence renewal described above, issues for which the NRC has made a generic conclusion regarding the potential environmental impacts of issuing a permit or licence for a new reactor are categorised as "Category 1" issues. These conclusions can then be adopted by both the applicant and the NRC staff without further project-specific analysis, provided that the new nuclear reactor and proposed site meet or are bounded by the values and assumptions used to develop the NR GEIS and that there is not any new and significant information that changes the codified generic analysis. Environmental issues for which a generic finding regarding the respective environmental impacts cannot be reached are classified as "Category 2" issues that require further environmental evaluation with project-specific information. The proposed rule states that the Commission intends to review the conclusions in the NR GEIS on a 10-year cycle and update it as necessary.

11. 89 Fed. Reg. 80 797 (4 Oct. 2024).

If finalised, the proposed rule is intended to streamline and improve the efficiency of the environmental reviews for future nuclear reactor applicants by eliminating the need to repeatedly reproduce the same analyses for issues that are expected to be generic for many new nuclear reactors, thus allowing applicants and the NRC staff to focus review efforts on issues that can only be resolved once a site is identified. As of this writing, the NRC is accepting public comments on the proposed rule and the NR GEIS.

Licensing and regulatory infrastructure

Part 53 proposed rule

The NRC is in the process of developing a new technology-neutral regulatory framework for licensing reactors, which could include advanced reactors and non-light water reactors, referred to as "Part 53".[12] This rule – required by the Nuclear Energy Innovation and Modernization Act to be finalised no later than 31 December 2027[13] – is intended to provide future commercial nuclear power plant applicants with a technology-neutral, alternative regulatory framework that utilises risk-informed and performance-based techniques to ensure an equivalent level of safety to that of operating commercial nuclear plants licenced under current NRC regulations developed primarily for large light-water reactor technology. In March 2024, the Commission approved a draft proposed rule and directed the NRC staff to publish the rule for a public comment period after making certain edits and addressing clarifications.[14]

On 31 October 2024, the NRC published the proposed rule for public comment.[15] The Part 53 proposed rule contains technology-inclusive, high-level safety criteria that serve as the overall performance standards of the regulatory framework (Subpart B). Other subparts of the proposed rule then define how specific activities during the various stages of the life cycle of a commercial nuclear power plant contribute to satisfying these performance standards. These include:

- Specific requirements for the design of a nuclear power plant and how supporting analyses must demonstrate the performance standards are satisfied (Subpart C);
- Siting requirements to ensure that licensees and applicants assess what impact external hazards may have on the plant and what potential adverse health and safety impacts the plant may have on nearby populations (Subpart D);
- Construction and manufacturing requirements that largely reflect current requirements but with limited updates to better accommodate the possible factory fabrication of manufactured reactors (Subpart E);
- Requirements for the operations phase of a commercial power plant to ensure safety during all modes of normal operation and unplanned events, including requirements for plant structures, systems and components, plant personnel and operator staffing, and plant programmes including (among others) radiation control, physical protection and emergency response (Subpart F); and
- Decommissioning requirements (Subpart G).

The proposed rule also includes proposed revisions to current NRC "Fitness for Duty" regulations in 10 CFR Part 26, that would create a technology-inclusive, risk-informed and performance-based approach for the application of drug and alcohol testing and fatigue management requirements for facilities licenced under Part 53. These changes are, in part,

12. See NEA (ed.) (2023), *Nuclear Law Bulletin*, No. 110, OECD Publishing, Paris, p. 79.
13. Public Law No. 115-439, 132 Stat. 5565.
14. NRC (2024), "Proposed Rule: Risk-Informed Technology-Inclusive Regulatory Framework for Advanced Reactors (RIN 3150-AK31)", SRM-SECY-23-0021 (ADAMS Accession No. ML24064A039), available at: www.nrc.gov/docs/ML2406/ML24064A039.pdf.
15. Risk-Informed, Technology-Inclusion Regulatory Framework for Advanced Reactors, 89 Fed. Reg. 86918 (31 Oct. 2024).

intended to provide flexibility because of the anticipated wide variety of staff sizes for advanced commercial nuclear plants, as well as the geographically remote locations in which they may be sited. The proposed rule also includes proposed revisions to current NRC physical protection regulations in 10 CFR Part 73, and would establish a new technology-inclusive, consequence-based approach for a range of security areas, including physical security, cybersecurity and access authorisation for commercial nuclear reactors.

As of this writing, the NRC has extended the public comment period through February 2025. The NRC currently expects to provide a draft final rule to the Commission for its approval by May 2026.

Simplified mandatory hearing procedures and issuance of Kairos Hermes 2 Construction Permits

On 21 November 2024, the NRC issued construction permits to Kairos Power LLC, authorising the construction of the Hermes 2 Demonstration Plant in Oak Ridge, Tennessee.[16] The permits allow construction of the two-unit test reactor facility on a site adjacent to another previously approved non-power test reactor of similar design. The purpose of the Hermes 2 facility is to demonstrate Kairos Power's high-temperature advanced nuclear technology, which uses tri-structural isotropic (TRISO) particle fuel in pebble form along with fluoride salt coolant.

The issuance of the construction permits is notable because it involved the NRC's first use of a new, streamlined "mandatory" hearing process. The AEA requires the NRC to conduct a hearing before issuing licences authorising the construction of certain types of nuclear facilities. These are referred to as "mandatory" hearings because the NRC must hold the hearing prior to issuing the licence, regardless of whether any interested person requests one. Generally speaking, the types of proceedings for which the "mandatory" hearing requirement applies are proceedings for the issuing of a combined construction and operating licence, a construction permit for a reactor for an industrial or commercial purpose or a testing facility; an early site permit for a reactor for industrial or commercial purposes; or a licence for the construction and operation of a uranium enrichment facility.[17] The NRC has conducted "mandatory" hearings for decades, through which the Agency has determined the sufficiency of the NRC staff's technical and environmental review of applications typically through oral presentation, witness testimony and extensive written briefing. In February 2024, the NRC Chair directed the NRC's Office of the General Counsel to develop proposals to revise this process to gain efficiencies while still maintaining public engagement and transparency.[18] In July 2024, the Commission approved the use of simplified hearing procedures,[19] which were used in the Hermes 2 proceeding, involving solely written submissions rather than an oral evidentiary hearing.

16. Kairos Power LLC (Hermes 2 Test Reactor Facility), CLI-24-03, 100 NRC (21 Nov. 2024).
17. *See* 42 USC 2239(a)(1)(A) (requiring the NRC to hold a hearing on each application for a construction permit for commercial or industrial purposes, or for research and development activities), 2235(b) (requiring the Commission to hold a hearing prior to issuing a combined construction and operating licence), and 2243(b)(1) (requiring the Commission to conduct a single hearing with regard to the licensing of the construction and operation of a uranium enrichment facility).
18. Memorandum to Brooke P. Clark, from Christopher T. Hanson, Chair (7 Feb. 2024), "Revisiting the Mandatory Hearing Process at the U.S. Nuclear Regulatory Commission", (ADAMS Accession No. ML24038A023) available at: www.nrc.gov/docs/ML2403/ML24038A023.pdf.
19. Memorandum to Brooke P. Clark, General Counsel, from Carrie M. Safford, Secretary (18 July 2024), "Revising the Mandatory Hearing Process at the U.S. Nuclear Regulatory Commission", SECY-24-0032 (ADAMS Accession No. ML24200A044), available at: www.nrc.gov/docs/ML2419/ML24199A077.pdf.

Nuclear security

Proposed rule on alternative physical security requirements for advanced reactors

On 9 August 2024, the NRC published a proposed rule that would amend its regulations to provide certain alternative, risk-informed, performance-based physical security requirements for advanced nuclear reactors, which includes light-water small modular reactors, or non-light water reactors.[20] Current NRC physical protection regulations for nuclear power reactors in 10 CFR Part 73 are designed to protect plant features needed to provide fundamental safety functions, such as maintaining reactor core cooling to prevent significant core damage, against the design basis threat of radiological sabotage. When compared to operating large light-water reactors, many advanced reactor designs have smaller power outputs and correspondingly smaller inventories of fission products available for potential release, and some advanced reactor designs may also include attributes that could result in smaller and slower releases of fission products following the loss of certain safety functions. The proposed rule recognises that some advanced reactor designs may warrant different methods for meeting the NRC's physical security requirements, commensurate with the potential radiological consequences resulting from radiological sabotage.

This proposed rule would retain the current security framework (10 CFR 73.55) to protect against radiological sabotage but would create specific voluntary, risk-informed and performance-based alternative physical security requirements for advanced reactors licensed under current NRC regulations. These alternative physical security requirements are intended to (1) enhance regulatory effectiveness by providing greater stability, predictability and clarity in the licensing process for implementing physical security for advanced reactors; (2) reduce requests for exemptions from certain physical security requirements by advanced reactor applicants; (3) consider technological advancements in reactor designs and their associated design features impacting the possible loss of safety functions from malicious acts and any resulting consequences; and (4) provide alternatives for meeting certain physical security requirements commensurate with the potentially lower risks posed by advanced reactors.

As of this writing, the public comment period on the proposed rule has closed, and the NRC is considering the comments received as part of the decision to finalise the rule.

20. 89 Fed. Reg. 65226 (9 Aug. 2024).

INTERGOVERNMENTAL ORGANISATION ACTIVITY

Euratom Atomic Energy Community (Euratom)

Euratom Community activities

Practical Arrangements with the International Atomic Energy Agency (IAEA) on Emergency Preparedness and Response

The Directorate General for Energy of the European Commission (DG ENER) and the IAEA signed "Practical Arrangements on Cooperation in the area of Response to Nuclear and Radiological Incidents and Emergencies" in the margins of the 68th IAEA General Conference (16-20 September 2024) (the Practical Arrangements). The Practical Arrangements further reinforce existing co-operation between the Commission and the IAEA and include a detailed process for early notification and rapid information exchange during radiological incidents and emergencies. They are expected to significantly enhance the emergency preparedness and response capabilities of both organisations, leading to better protection for citizens during nuclear emergencies.

In the case of a radiological emergency potentially affecting the European Union (EU), DG ENER is responsible for the urgent exchange of information on the basis of Council Regulation 87/600/Euratom.[1] To this end, it operates the European Community Urgent Radiological Information Exchange (ECURIE) system, the EU's early warning system that is used to alert the 27 EU member states, Montenegro, the Republic of North Macedonia, Norway, Switzerland and Serbia, as well as the European Union Radiological Data Exchange Platform (EURDEP), which makes radiological monitoring data from most European countries available on a routine daily basis and in real-time in emergencies.

Besides the EU emergency arrangements, a system of notification and warning in case of a nuclear or radiological incident or accident has been created at the international level, under the auspices of the IAEA, based on the Convention on Early Notification of a Nuclear Accident,[2] to which the Euratom Community, represented by the European Commission, is contracting party.

The IAEA operates the Unified System of Information Exchange in Incidents and Emergencies (USIE) and the International Radiation Monitoring Information System (IRMIS). In addition, it provides the Emergency Preparedness and Response Information Management System (EPRIMS). This web-based tool enables IAEA member states to share information on Emergency Preparedness and Response matters. EPRIMS also comprises a database that provides technical data on nuclear reactors, which can be used to advise decision-making processes during emergencies.

The legally non-binding Practical Arrangements set the general rules for co-operation between the respective EU and IAEA early warning and information exchange IT systems. This includes a detailed process for early notification and rapid information exchange,

1. Council Decision 87/600/Euratom of 14 December 1987 on Community arrangements for the early exchange of information in the event of a radiological emergency, *Official Journal of the European Union* (OJ) L 371 (30 Dec. 1987), pp. 76-78.
2. Convention on Early Notification of a Nuclear Accident (1986), IAEA Doc. INFCIRC/335, 1439 UNTS 276, entered into force 27 Oct. 1986 (Early Notification Convention).

crucial in ensuring a swift and co-ordinated response. They will also allow EURDEP to make available radiological data managed by the IAEA from the European Union (EU) Candidate and other European countries who have agreed to make their routine and emergency data available to DG ENER. Finally, the European Commission may have access to information contained within the EPRIMS.

Euratom Nuclear Safety Directive implementation: Second topical peer review on fire protection at nuclear installations

Recognising that co-operation between EU member states can provide added value in terms of nuclear safety, transparency and openness towards stakeholders, as well as delivering continuous improvements, the amended Nuclear Safety Directive[3] introduced a European system of Topical Peer Reviews (TPR) that commenced in 2017 and takes place at least every six years thereafter. The purpose of the TPRs is to jointly examine topics of importance to nuclear safety, to exchange experience, and to identify opportunities to improve nuclear safety in both the installations concerned and at the European level.

The European Commission welcomed the European Nuclear Safety Regulators Group's (ENSREG's) publication of the summary report[4] and 22 country review reports[5] of the second topical peer review (TPR II) under the Directive, which addressed the topic of fire protection at nuclear installations. In total, licensees and regulatory authorities as well as technical safety organisations (TSOs) from 22 countries (18 EU countries, plus Switzerland, Türkiye, Ukraine and the United Kingdom) participated in the peer review. The process comprised a self-assessment of the national approaches to fire protection, followed by a peer review of the reports by approximately 50 nominated experts in the field. In addition, a number of site visits to nuclear research reactors were conducted to allow for information exchange on fire safety arrangements and to experience fire protection measures in practice.

The TPR II process looked at the participating countries' fire safety analyses and fire prevention and protection strategies aiming to implement safety improvements to ensure the safety of their nuclear installations. The review found that national regulatory frameworks for fire protection in nuclear installations vary significantly across countries and facility types with some focusing on nuclear safety goals, and others on conventional fire safety. More than 100 findings are reported as national "areas for improvement" or "good performances", mostly focusing on nuclear power plants.

Some examples of good practice include the use of technologies, such as thermographic cameras for fire detection, and the conduct of experimental tests to gain knowledge of fire behaviour and to improve fire safety tools. While the review did not identify any major deficiencies in European approaches to regulate and implement fire safety, amongst the common challenges found were a lack of a centralised repository of past events affecting all installation types to facilitate the sharing of experience, and the need to develop guidance to translate high-level objectives for safety analysis into more practical requirements.

The ENSREG peer review process foresees that national authorities develop action plans during 2025 to describe the measures planned to respond to the country-specific findings. The Commission, whose duty it is to monitor the implementation of the Directive, will continue to follow the closure of the national actions and support ENSREG's activities to follow-up the TPR II findings.

3 Council Directive 2014/87/Euratom of 8 July 2014 amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations, OJ L 219 (25 July 2014) (2014 amended Nuclear Safety Directive).

4. ENSREG (2022), *2nd Topical Peer Review – 'Fire Protection': Board's review of the national selections of nuclear installations to be reported on in the national assessment reports*, ENSREG, Brussels, available at: www.ensreg.eu/sites/default/files/attachments/tpr_ii_boards_review_of_national_selections.pdf.

5. These country review reports can be found at: www.ensreg.eu/country-specific-reports-tpr-2.

International Atomic Energy Agency

Nuclear safety

Convention on Nuclear Safety (CNS)

The Agency facilitated the Third Extraordinary Meeting of the Contracting Parties to the Convention on Nuclear Safety, which was held in Vienna, Austria, on 3-4 September 2024. The focus of the meeting was to consider a proposal aimed at balancing the effectiveness and efficiency of the CNS processes, building on the outcomes of a working group established for the purpose of developing such proposals at the Joint Eighth and Ninth Review Meeting. At the meeting, Contracting Parties adopted 13 out of 16 proposals, such as those concerning more streamlined Country Group session times, optimised time allocation, and the categorisation of Contracting Parties based on their nuclear programme.

The Agency hosted the Organizational Meeting for the Tenth Review Meeting of the Contracting Parties to the CNS, which was held in Vienna, Austria, on 5 September 2024. The meeting was presided by the President of the Joint Eighth and Ninth Review Meeting. At the Review Meeting, a number of preparatory decisions related to the conduct of the upcoming Review Meeting were taken and agreed by consensus. The Contracting Parties, in particular, elected the officers for the Tenth Review Meeting, to be held on 13-26 April 2026, and decided on the establishment and composition of seven Country Groups. The Review Meeting decided to hold one topical session on "Strengthening national regulatory capabilities, taking into account new and innovative technologies and effective nuclear knowledge management".

Convention on Early Notification of a Nuclear Accident (Early Notification Convention) and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (Assistance Convention)

On 3-7 June 2024, the Agency held the 12th Meeting of the Representatives of Competent Authorities identified under Early Notification and Assistance Conventions. The main objectives of the Meeting were to share information on national emergency preparedness and response arrangements and challenges, and to discuss the implementation of the Conventions.

Denials and delays of shipment of radioactive material

The Agency facilitated an Open-Ended Meeting of Legal and Technical Experts on a Non-Binding Instrument on the Facilitation of Safe and Secure Transport of Radioactive Material, held at the IAEA's headquarters in Vienna, Austria, on 15-18 July 2024. Member states participants of the meeting recommended that interested member states should continue consultations on this issue.

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention)

The Agency hosted a Workshop for the incoming and outgoing Officers of the Joint Convention in Vienna, Austria, on 25-26 June 2024. During the Workshop, the Review Meeting process was described in detail, including key documents, and the outgoing officers shared their experiences and lessons learnt with the incoming officers.

Outreach on the CNS

The Agency facilitated a virtual Educational Workshop on the CNS on 1-5 July 2024. The Workshop was focused on Contracting Parties that recently joined the CNS or have difficulties to fulfil their obligations under the Convention – especially embarking ones

such as Albania, Armenia, Bangladesh, Ghana, Indonesia, Saudi Arabia and Zimbabwe – to enhance their participation in the peer review and their understanding of their obligations.

In addition, a Workshop for Representatives of Permanent Missions to the IAEA to provide assistance and educational information on the CNS, its review process and on fulfilling obligations under the CNS was held on 8 July 2024.

Nuclear security

Outreach on the Convention on the Physical Protection of Nuclear Material (CPPNM) and its Amendment (A/CPPNM)

The Agency continued to promote further adherence to and full implementation of the CPPNM and its Amendment (A/CPPNM) through regional workshops – for Asia and the Pacific in Lao People's Democratic Republic in August 2024, and for Latin America and the Caribbean in Brazil in October 2024. In addition, the Agency convened the annual technical meeting of CPPNM and A/CPPNM points of contact on 19-20 November 2024. This was the tenth such meeting of points of contact, and it gave participants the opportunity to discuss experiences, lessons learnt and challenges in implementing the CPPNM and the A/CPPNM. Immediately following the points of contact meeting, the Agency held a technical meeting on 21-22 November to promote the universalisation of the A/CPPNM. This event allowed parties to the A/CPPNM, parties to the original CPPNM only and non-parties to exchange views and experiences with a view to supporting universal adherence to the CPPNM and A/CPPNM.

Nuclear liability

The 24th regular meeting of the International Expert Group on Nuclear Liability (INLEX) took place at IAEA headquarters on 28-30 May 2024. At the meeting, the Group discussed, *inter alia*, the geographical scope of the 2004 Paris Convention, the 1963 and 1997 Vienna Conventions and the Convention on Supplementary Compensation for Nuclear Damage (CSC). Further, the Group discussed the understanding of the term "for use" provided in the 2014 IAEA Board of Governors resolution (GOV/2014/63, derestricted 6 September 2017) on the exclusion of small quantities of nuclear material from the scope of the 1963 and 1997 Vienna Conventions and the CSC, and the related 2016 Organisation for Economic Co-operation and Development (OECD) Nuclear Energy Agency (NEA) Steering Committee decision. In addition, the Group discussed the compensation of radiation exposures under the international nuclear liability regimes, nuclear liability in situations of armed conflict as well as the operator's right of recourse under the nuclear liability conventions and the current liability limits of the Contracting Parties to the 1963 Vienna Convention.

On 27 May 2024, a Workshop on Civil Liability for Nuclear Damage for diplomats from member states was held at IAEA headquarters with the assistance of members of INLEX. The purpose of the workshop was to provide the diplomats with an opportunity to gain further knowledge about the international legal framework on nuclear liability.

A 20th anniversary INLEX publication, entitled *International Expert Group on Nuclear Liability (INLEX): A Collective View on the First Two Decades*, was published in May 2024. The publication recalls the work of the Expert Group over the last two decades and aims in particular to raise awareness and facilitate understanding of the importance of the issues of liability and the need for a global regime.

The Fourth Meeting of the Contracting Parties and Signatories to the CSC was held on 18-21 June 2024 at IAEA headquarters. Some 60 representatives from 14 Parties and Signatories (Argentina, Australia, Canada, Ghana, India, Indonesia, Japan, Lebanon, Lithuania, Morocco, Peru, Philippines, the United Arab Emirates and the United States of America) and 18 invited observer countries (Armenia, Brazil, Bulgaria, China, Estonia, Finland, Germany, Kenya, Mexico, Myanmar, Paraguay, Poland, Singapore, South Africa, Spain, Thailand, the United Kingdom and Uruguay), as well as invited observers from nuclear suppliers, insurers, lenders, the EU and the NEA, all participated in the Fourth Meeting. The

Fourth Meeting provided an opportunity to build on the momentum created by the Third Meeting and focused on efforts to expand CSC membership and to provide guidance on the operation of the CSC. During the Fourth Meeting, representatives of the invited observer and signatory countries shared their perspectives on the factors that have influenced their consideration of the CSC. Issues related to the implementation of the CSC, including national nuclear liability frameworks, were considered, as was the operationalisation of the CSC's international fund. The Fourth Meeting also considered the relationship of the CSC with the Paris and Brussels Supplementary Conventions. The Meeting elected the new Bureau of the Fifth Meeting, which is planned to be held in an in-person format at IAEA headquarters in 2025. The Agency once again acted as the Secretariat to support the Fourth CSC Meeting.

Legislative assistance

The Agency continued to provide legislative assistance to member states to support the establishment of an adequate and comprehensive national nuclear legal framework and to promote adherence to the relevant international legal instruments. The Agency provided such assistance through national workshops and awareness-raising activities. Specific bilateral legislative assistance was also provided to several member states through written comments and advice on the preparation of national nuclear legislation.

In addition, the Agency conducted the first advanced inter-regional training course on nuclear law for all IAEA member states in Belgrade, Serbia, from 28 October to 8 November 2024. This event enabled 33 lawyers and officials from 29 countries to gain further knowledge in nuclear law.

The Agency also held four regional and subregional workshops for English-speaking member states in Africa in Cairo, Egypt, in July 2024; for Pacific Island member states in Vienna, Austria, in September 2024; for French-speaking member states in Africa in Abidjan, Côte d'Ivoire, in November 2024; and for member states in Asia and the Pacific in Manila, the Philippines, in December 2024.

The Agency also continues to implement the pilot University Partnership Programme on Nuclear Law, launched by the IAEA Director General during the First International Conference on Nuclear Law: The Global Debate in April 2022. Through this Programme, the Agency is supporting the establishment of postgraduate courses in nuclear law at the six participating academic institutions in Argentina (University of Buenos Aires), Brazil (Nuclear Engineering Institute of the National Nuclear Energy Commission), Egypt (Alexandria University), Jamaica (University of the West Indies), South Africa (University of the Witwatersrand) and the United Arab Emirates (Khalifa University of Science and Technology). In May 2024, the University of Buenos Aires became the first university to launch its postgraduate course. The other five institutions are expected to launch their courses in early 2025.

68th Regular Session of the IAEA General Conference

The 68th Regular Session of the IAEA General Conference was held in person, at IAEA headquarters in Vienna, Austria, on 16-20 September 2024.

This year, approximately 2 671 delegates registered to attend the General Conference from 150 of the IAEA's 178 member states and from international organisations, non-governmental organisations and the media. A total of 111 side-events took place during the week, highlighting the innovative work underway at the IAEA and in member states using nuclear technology and its applications.

Resolutions of the Conference

A number of resolutions were adopted by the Conference. As in previous years, resolution GC(68)/RES/8 on Nuclear and Radiation Safety as well as resolution GC(68)/RES/9 on Nuclear Security include sections addressing the legal-related aspects of nuclear safety and

security. All resolutions adopted during the 68th Regular Session of the General Conference are available on the IAEA website.[6]

- Nuclear and Radiation Safety (GC(68)/RES/8)[7]

Regarding the CNS, the General Conference urged "all Member States that have not yet done so, especially those planning, constructing, commissioning or operating nuclear power plants, or considering a nuclear power programme, to become Contracting Parties to the CNS".[8]

The Conference likewise urged "all Member States that have not yet done so, particularly those managing radioactive waste or spent fuel, to become Contracting Parties to the Joint Convention". [9]

The Conference stressed "the importance of CNS and Joint Convention Contracting Parties fulfilling their respective obligations stemming from these Conventions and reflecting these in their actions to strengthen nuclear safety and in particular when preparing National Reports, and actively participating in peer reviews for CNS and Joint Convention Review Meetings".[10]

In addition, the Conference requested "the Secretariat to provide full support for the CNS and Joint Convention Review Meetings, and to consider addressing their outcomes in the Agency's activities, as appropriate and in consultation with Member States".[11]

The Conference further urged "all Member States that have not yet done so to become Contracting Parties to the Early Notification Convention and the Assistance Convention" and stressed "the importance of Contracting Parties fulfilling the obligations stemming from these Conventions, and actively participating in regular meetings of the Representatives of Competent Authorities".[12]

In this context, the Conference requested "the Secretariat, in collaboration with regional and international organizations and Member States, to continue its activities to promote the importance of conventions concluded under the auspices of the IAEA and to assist Member States upon request with adherence, participation and implementation as well as strengthening of their related technical and administrative procedures".[13]

With respect to the Code of Conduct on the Safety and Security of Radioactive Sources, its supplementary Guidance on the Import and Export of Radioactive Sources, and its supplementary Guidance on the Management of Disused Radioactive Sources, the General Conference encouraged "all Member States to make political commitments to the voluntary and non-legally binding Code of Conduct on the Safety and Security of Radioactive Sources, its Guidance on the Import and Export of Radioactive Sources, and its Guidance on the Management of Disused Radioactive Sources, and to implement these, as appropriate, in order to maintain effective safety and security of radioactive sources throughout their life cycle". The Conference also requested "the Secretariat to continue supporting Member States in this regard and to promote these instruments".[14]

6. IAEA (2024), "68th IAEA General Conference (2024) Resolutions and Decisions", www.iaea.org/about/governance/general-conference/gc68/resolutions (accessed 28 Jan. 2025).
7. IAEA (2024), Nuclear and Radiation Safety: Resolution adopted on 20 September 2024 during the eleventh plenary meeting, IAEA Doc. No. GC(66)/Res/5, available at: www.iaea.org/sites/default/files/gc/gc68-res8.pdf (access 28 Jan. 2025).
8. *Ibid.*, para. 17.
9. *Ibid.*, para. 18.
10. *Ibid.*, para. 19.
11. *Ibid.*, para. 20.
12. *Ibid.*, para. 21.
13. *Ibid.*, para. 22
14. *Ibid.*, para. 23.

Similarly, the Conference encouraged member states "to apply the guidance of the Code of Conduct on the Safety of Research Reactors at all stages in the lifetime of research reactors, including planning" and "to exchange their regulatory and operating information and experience with regard to research reactors".[15] In this context, the Conference requested the Secretariat "to continue to support Member States, upon request, in [the] application of the guidance of the Code of Conduct on the Safety of Research Reactors".[16]

Regarding civil liability for nuclear damage, the General Conference encouraged "Member States to give due consideration to the possibility of joining the international nuclear liability instruments, as appropriate, and to work towards establishing a global nuclear liability regime".[17]

In this context, the Conference requested "the Secretariat, in coordination with the NEA when appropriate, to assist Member States, upon request, in their efforts to adhere to any international nuclear liability instruments concluded under the auspices of the IAEA or the NEA, taking into account the recommendations of the INLEX in response to the IAEA Action Plan on Nuclear Safety".[18]

In addition, the Conference recognised "the valuable work of INLEX", took note "of its recommendations and best practices on establishing a global nuclear liability regime, including through the identification of actions to address gaps in and enhance the existing nuclear liability regimes", encouraged "the continuation of INLEX, especially for its support for the IAEA's outreach activities to facilitate the achievement of a global nuclear liability regime" and requested "that INLEX, via the Secretariat informs Member States on a regular and transparent basis about the work of INLEX and its recommendations to the Director General".[19]

- Nuclear Security (GC(68)/RES/9) [20]

In the context of nuclear security, the Conference affirmed "the central role of the Agency in strengthening the nuclear security framework globally and in coordinating international activities in the field of nuclear security, while avoiding duplication and overlap".[21]

The Conference welcomed "the ICONS 2024: Shaping the Future, where ministers, policymakers, senior officials and nuclear security experts gathered for comprehensive discussions and deliberations with the aim to strengthen nuclear security worldwide" and further called "upon the Secretariat to continue to organize ICONS every four years".[22]

The Conference also encouraged "all Parties to the CPPNM and its 2005 Amendment to fully implement their obligations thereunder" and encouraged "States that have not yet done so to become party to this Convention and its Amendment". It further encouraged "the Agency to continue efforts to promote further adherence to the Amendment with the aim of its universalization". In this context, the Conference reminded "all Parties to inform the depositary of their laws and regulations which give effect to the Convention without further delay", and requested "the Director General of the IAEA, as the depositary, to continue communicating such information to all Parties".[23]

15. *Ibid.*, para. 24.
16. *Ibid.*, para. 26.
17. *Ibid.*, para. 35.
18. *Ibid.*, para. 36.
19. *Ibid.*, para. 37.
20. IAEA (2024), Nuclear Security: Resolution adopted on 20 September 2024 during the eleventh plenary meeting, IAEA Doc. No. GC(68)/RES/9, available at: www.iaea.org/sites/default/files/gc/gc68-res9.pdf (accessed 23 Apr. 2025).
21. *Ibid.*, para. 1.
22. *Ibid.*, para. 9.
23. *Ibid.*, para. 14.

The Conference requested "the Secretariat to take the Outcome Document of the 2022 Conference of the Parties to the Amendment to the CPPNM into consideration in line with the States Parties' respective legal obligations, in convening a follow-on Conference, in line with Article 16.2 of the Convention" and welcomed "an update on the substantive and organizational preparations of the follow-on Conference".[24]

IAEA treaty event

The 14th Treaty Event was held on the sidelines of the 68th Regular Session of the General Conference, providing member states with a further opportunity to deposit their instruments of ratification, acceptance or approval of, or accession to, the treaties deposited with the Director General. These included those related to nuclear safety, security and civil liability for nuclear damage. During the course of this event, Liberia deposited a number of key instruments: an instrument of acceptance of the Agreement on the Privileges and Immunities of the International Atomic Energy Agency, instruments of accession to the Convention on Early Notification of a Nuclear Accident, the Convention on Assistance in the Case of a Nuclear Accident and Radiological Emergency, the Convention on Nuclear Safety, and an instrument of accession to the CPPNM and acceptance of its Amendment. In addition, South Africa marked its commitment to regional co-operation by joining the African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA).

CSC side event

A further side event on the margins of the General Conference was held to promote the expansion of the membership of the CSC. The event highlighted the important role of the CSC as the basis for a global nuclear liability regime, which is essential for realising the full potential of nuclear energy to provide clean, affordable and secure energy. The event aimed to raise awareness and a broader understanding of the CSC and the benefits of the global regime which the CSC strives to achieve.

The event was co-sponsored by the United States, together with Argentina, Canada, Ghana, India, Japan, Lithuania, Morocco, Romania and the United Arab Emirates.

OECD Nuclear Energy Agency

Meeting of the Working Party on Legal Aspects of Nuclear Safety (WPLANS)

The WPLANS met in person and online on 17-18 September 2025 to discuss the legal aspects of nuclear safety. The meeting was attended by 30 participants representing 16 NEA member countries, 2 non-NEA member countries, the European Union (EU) and the International Atomic Energy Agency (IAEA).

The meeting featured discussions on numerous subjects, including legal issues related to long-term operation/lifetime extension, with a presentation provided by Korea; legal challenges to licensing decisions, with a presentation by the United States; legal issues related to radioactive waste management, with presentations by Canada and the Netherlands; national developments in the legal aspects of nuclear safety, with presentations by the Netherlands, Poland, Slovenia, the Slovak Republic and Switzerland; and licensing and regulation of small modular reactors, with a presentation by the United States. The meeting also included a *tour de table* with countries providing updates to information they originally provided in the 2019 Report *Legal Frameworks for Long-Term Operation of Nuclear Power Reactors*. A breakout session was also held to confer on development of the 2025 small modular reactor workshop, including discussions on a draft agenda, potential speakers and an approach to pre-workshop activities.

24. *Ibid.*, para. 15.

Meeting of the Working Party on Nuclear Liability and Radioactive Waste Disposal Facilities (WPLDF)

The WPLDF met in person and online on 19 September 2024 to discuss the application of the nuclear liability regimes to deep geological repositories and other radioactive waste disposal facilities. The meeting was attended by 26 participants representing 13 NEA member countries, 2 non-member countries, the EU, the IAEA and the nuclear insurance industry.

The meeting featured presentations on national developments in legal and regulatory frameworks applicable to radioactive waste disposal facilities by Czechia, Spain, Sweden and the United Kingdom, as well as a presentation by an expert from the nuclear insurance industry on the topic of insurance challenges related to radioactive waste facilities. A follow-up session on near-surface disposal facilities and nuclear liability was held to build upon discussions from the previous WPLDF meeting, with participants considering possible paths forward regarding the applicability of the conclusions of the report on *Deep Geological Repositories and Nuclear Liability*.

Roadmaps to New Nuclear 2024

On 19-20 September 2024, the NEA and the Government of Sweden co-hosted Roadmaps to Nuclear 2024, in which government ministers, CEOs and other leaders and experts in nuclear energy gathered to find concrete solutions to achieve net zero carbon emissions targets by rolling out new nuclear projects more quickly. A statement was jointly issued by 21 countries represented at the event, highlighting their commitment to nuclear technology as a reliable, low-carbon energy source and pledging to work together to fully unlock its potential. Organisations representing the global nuclear industry also released a joint statement, as did the NEA Committee on Nuclear Regulatory Activities comprised of nuclear safety regulatory leaders from NEA member countries. The regulators called for further strengthening co-operation among regulatory authorities.

The next edition of Roadmaps to New Nuclear will be held in 2025 and co-chaired by the Government of Korea.

NEA Global Forum on Nuclear Education, Science, Technology and Policy (Global Forum on Nuclear Education)

On 21-22 November 2024, the Council of Advisors for the NEA Global Forum on Nuclear Education met at NEA headquarters in Paris to receive progress updates from its seven working groups, each tasked with tackling a specific issue impacting nuclear education. Official observer organisations, including the IAEA, EC and the European Nuclear Education Network also attended the meeting and reported on their own educational initiatives.

The Council looked ahead to the Global Forum Symposium, planned for 30 September – 2 October 2025 and to be hosted by the University of Michigan. The head of the Nuclear Engineering and Radiological Science Department for the University Michigan provided an overview of the draft programme for the Symposium.

The NEA Global Forum's Rising Stars Workshop, held on 25-26 November 2024 at the European Commission Joint Research Centre (JRC) in Karlsruhe, Germany, offered professional development and mentoring sessions for female rising stars in science, technology, education and policy. Participants from 32 academic and research institutions across 12 countries had the opportunity to share their research through presentations and poster sessions and received a tour of the JRC research facilities.

Meeting of the Contracting Parties to the Paris Convention (CPPCs)

The CPPCs met virtually on 11 December 2024, with 16 participants from 10 countries in attendance. The attendees discussed the application of the Paris Convention and the Brussels Convention Supplementary to the Paris Convention to nuclear incidents occurring, or nuclear damage suffered, on the high seas or in international airspace.

The meeting also featured a resumed discussion on the criteria for applying the reciprocity principle laid out in Article 2(a)(iv) of the Paris Convention, as well as updates from participating CPPCs on their respective national legislative and administrative processes and the status of financial securities following the entry into force of the 2004 Protocols. The Spanish delegation also presented on specific issues related to the implementation of the Joint Protocol and on matters related to the interpretation of the Recommendation of the Steering Committee for Nuclear Energy on Nuclear Substances in Transit.

2024 International School of Nuclear Law

The 23rd edition of the ISNL course was held in Montpellier, France, from 26 August to 6 September 2024, bringing together a diverse group of 59 participants representing 41 countries. The rigorous two-week programme provides participants with an in-depth look at the legal framework and major issues affecting the peaceful use of nuclear energy. Activities consist of lectures, group assignments and panel discussions touching on all aspects of international nuclear law, including nuclear safety, management of spent fuel and radioactive waste, environmental protection, transport, nuclear security, non-proliferation, safeguards, nuclear liability and international trade. The programme was delivered by nearly 30 renowned specialists in nuclear law from international organisations, governments, academia and private industry.

Since 2001, the ISNL has attracted nearly 1 300 participants from 118 countries, and, through a partnership with the University of Montpellier, has awarded over 600 University Diplomas in International Nuclear Law. Many participants have gone on to become experts in the nuclear law field, with some returning to the programme as lecturers.

NEA publications of interest

Since the publication of *Nuclear Law Bulletin* No. 112, the NEA has issued a number of publications of interest. *TEPCO Fukushima Daiichi NPS Accident: 10-Year Reflection, Now and the Way Forward* published in July 2024, presents a Summary Report of the International Conference on Regulators' Views and Priorities on Nuclear Safety and Radiation Protection. The conference endeavoured to bring together regulatory officials from around the world to discuss a number of topics, including developments in national regulatory frameworks after the Fukushima Daiichi Nuclear Power Plant accident, the reassessment of safety requirements related to natural hazards, trust-building and transparency, and the involvement of women in the nuclear field.

SMRs for Mining: Opportunities and Challenges for Small Modular Reactors, published in September 2024, presents the first of a series of NEA case studies that assess the opportunities and challenges for SMRs to support decarbonisation of hard-to-abate industrial sectors, informed by direct engagement with stakeholders in the mining sector. The case study highlights the potential for SMRs to enable sustainable and cost-effective means to mine the critical materials necessary for the global clean energy transition.

NEWS BRIEFS

25th Nuclear Inter Jura Congress in Warsaw, 2024

The 25th Nuclear Inter Jura Congress was held in Warsaw, Poland, on 3-7 November 2024 at the Hotel Crowne Plaza. Hosted by the International Nuclear Law Association (INLA) jointly and in co-operation with the Lower Silesian Institute for Energy Studies (DISE Energy). It was the first time the bi-annual series was held in Poland. The theme of the Congress was "[t]he renaissance of new nuclear projects – in search of new approaches to legal challenges and regulatory effectiveness", and its aim was to foster research on legal issues related to the peaceful uses of nuclear energy and encourage the exchange of information pertinent to the nuclear sector.

INLA Congresses are a premier international event in nuclear law that bring together representatives of government, regulatory authorities, nuclear specialists, legal professionals, academics and others involved in nuclear law. The 5-day conference included 17 sessions with over 110 presenters and panellists, including law professors, PhD students, researchers, corporate lawyers, public interest litigators, diplomats, government officials, representatives from the OECD Nuclear Energy Agency (NEA), the International Atomic Energy Agency (IAEA), the European Commission, the ITER organisation, and representatives from operators, regulatory boards, research institutes and insurance companies.

The opening session set the stage for a week of engaging sessions and networking opportunities. Participants were welcomed by the president of INLA, the president of DISE Energy and the president of Poland's National Atomic Energy Agency (PAA) before being treated to keynote addresses from Mr Miłosz Motyka, Undersecretary of State for the Ministry of Climate and Environment of the Republic of Poland, Mr William D. Magwood, IV, Director-General of the NEA, Ms Anna Clunes, British Ambassador to Poland, Mr Étienne de Poncins, Ambassador of France to Poland, and Ms Peri Lynne Johnson, Legal Advisor and Assistant Director-General for the IAEA.

The sessions that followed addressed Poland's nuclear ambitions and national energy strategy; challenges and potential solutions in the financing of nuclear power plants; the landscape of international nuclear trade and new-build projects; interconnected issues of nuclear security and non-proliferation; new approaches to legal challenges and regulatory effectiveness; the evolving environment of safety and regulation in the nuclear industry; the balancing of responsibility and risk in nuclear liability insurance; regulatory frameworks to ensure safe, secure and efficient nuclear transport; issues of legal compliance in waste management and radiation protection; the development and integration of women in the nuclear energy sector; the boosting of local economies and cultivation of a robust nuclear supply chain; and quality assurance and accreditation challenges for suppliers. Additionally, several sessions focused on aspects of advanced nuclear technologies such as small modular reactors (SMRs), advanced modular reactors (AMRs) and fusion-based technologies. These sessions focused on vendors' perspectives on the implementation of SMRs and AMRs; the opportunities and potential dangers of standardisation of regulatory frameworks for advanced nuclear technologies; overcoming regulatory impediments; insights and analysis into the international and European legal frameworks for the development of advanced nuclear technologies; legal challenges in implementing advanced nuclear technologies; and legal frameworks for nuclear fusion.

The final papers submitted at the Congress can be viewed at: www.dise.org.pl/en/papers. Once published, the final proceedings can be downloaded from: www.inla-association.org/proceedings.

The next INLA Congress will take place in Wales on 18-22 October 2026.

2025 International Nuclear Law Essentials (INLE)

The 12th edition of the INLE will take place in Paris, France, from 3-7 March 2025. The five-day INLE course is designed to provide participants with a practical and comprehensive understanding of the various interrelated legal issues relating to the safe and peaceful use of nuclear energy. This intensive course in international nuclear law addresses the needs and interests of lawyers working in either the public or the private sector but will also be of interest to scientists, engineers, policymakers, managers and other professionals working in the nuclear field. Renowned specialists in nuclear law from international organisations, governments, academia and private industry will deliver the INLE's intensive programme, which consists of a series of lectures, case studies and panel discussions. More information on the course and how to apply is available at www.oecd-nea.org/law/inle.

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The following articles are featured in this issue: "New-build nuclear power plant contracts and nuclear third-party liability: Contractor zero liability for NetZero?" by Ephraim Wittman and "Nuclear governance and the final frontier: Regulating nuclear energy in outer space" by Alexander Q. Gilbert.

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