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Nuclear Conundrum - Navigating the evolving Landscape of Laws and Policies

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New opportunities and challenges are continually developing in response to trends and changes on a worldwide scale in the field of nuclear law and policy. The expanding use of nuclear weapons and technology, the growing interest in nuclear energy production, and the shifting geopolitical landscape are some of the major issues that are now affecting this sector. The necessity to ensure that the spread of nuclear weapons and technology is properly managed and prevented represents one of the main challenges in the field of nuclear law and policy. To do this, strong security protections must be put in place, and there must be strong international laws and agreements that control the use of these technologies. Additionally, there is rising concern regarding the security of nuclear power plants and the requirement to guarantee that they are run in a way that reduces the possibility of mishaps and radioactive material leaks. The need to reconcile the conflicting interests of several stakeholders, including the government, the commercial sector, and civil society, is another new problem in nuclear law and policy. This entails guarding the public's interests while simultaneously ensuring that nuclear technology's advantages are realized and that the creation of new nuclear technologies is promoted. This necessitates a complex and multifaceted strategy that takes into account the various demands and viewpoints of each stakeholder. Finally, the topic of nuclear law and policy is significantly being impacted by the shifting geopolitical context. Effective international collaboration and coordination are becoming more and more important as new countries become nuclear powers and as current powers continue to enhance their nuclear capabilities. Along with the negotiation of new treaties and accords that support international stability and security, this entails the development of universal norms and frameworks for the regulation of nuclear activity.

Keywords: *policy, technology, treaty, nuclear activity.*

INTRODUCTION

Overview of the current state of Nuclear Law and Policy: With the steady emergence of new technologies and innovations, the subject of nuclear law and policy is always changing. These developments could fundamentally alter how we produce and use nuclear energy, as well as how we dispose of nuclear waste and stop the spread of nuclear weapons. They also bring up several legal and policy issues that need to be resolved. Maintaining the most urgent new challenges in the industry to properly comprehend and negotiate the quickly evolving terrain of nuclear operations and conduct, is important.

Explanation of the need for discussion on the emerging issues of this field: The handling of nuclear waste is one of the most important issues in nuclear law and policy. It is necessary to properly store and dispose of radioactive waste streams from nuclear power generation for hundreds of thousands of years, including spent fuel.[1] The way that waste is now managed, including the use of deep geological repositories and dry cask storage,[2] is still up for discussion. Reprocessing and transmutation are two emerging technologies and approaches to waste management that may hold promise as solutions. However, several legal and policy issues, such as those relating to liability and safety, and security, are also raised by these novel techniques.[3]

[1] 'Radioactive Waste Management | Nuclear Waste Disposal - World Nuclear Association' (*World-nuclear*.org, January 2022) <https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-wastes/radioactive-waste-management.aspx#:~:text=Nuclear%20power%20is%20characterized%20by%20the%20very%20large,therefore%20must%20be%20carefully%20managed%20as%20hazardous%20material> accessed 31 January 2023

[2] 'Dry Cask Storage' (*NRC Web*, 09 January 2023) <https://www.nrc.gov/waste/spent-fuel-storage/dry-cask-storage.html> accessed 31 January 2023

[3] Friederike Frieß & Wolfgang Liebert, 'Inert-Matrix Fuel for Transmutation: Selected Mid- and Long-Term Effects on Reprocessing, Fuel Fabrication and Inventory Sent to Final Disposal' (2022) 145 Progress in Nuclear Energy <https://doi.org/10.1016/j.pnucene.2021.104106> accessed 31 January 2023

The creation and use of small modular reactors (SMRs) is another recent development in the area of nuclear legislation and policy.[4] Smaller, more adaptable, and simpler to construct than conventional large-scale nuclear power facilities, SMRs are a new type of nuclear reactor. They may offer a secure and dependable supply of low-carbon energy, especially for isolated or off-grid areas.[5] SMRs, however, also brings up a variety of legal and policy challenges, such as concerns about security, safety, and licensing.

The use of SMRs also raises concerns about the potential effects on the nuclear industry as it currently exists and the contribution of SMRs to the achievement of global energy and climate goals.[6] Another crucial new topic in the area of nuclear law and policy is nuclear non-proliferation. The proliferation of nuclear weapons poses a serious threat to the security and stability of the world. Numerous international treaties and regimes have been established to stop the spread of nuclear weapons and materials to address this issue. But when new actors enter the international scene and new technologies continue to evolve, non-proliferation efforts face fresh difficulties. These include concerns like the potential for cyberattacks on nuclear plants such as, in September, a cyberattack on the Kudankulam Nuclear Power Plant (KKNPP) in Tamil Nadu, India that has been confirmed by Nuclear Power Corporation of India (NPCIL)[7] and the potential for new technology to pave the way for the production of nuclear weapons. Such as, a significant accomplishment has been achieved by burying sophisticated electronic sensors in hardened metal shells at the tip of an increasing number of American ballistic missiles in weapons engineering. This development could pave the way for a reduction in the size of the

[4] 'NRC Certifies First U.S. Small Modular Reactor Design' (*Energy.gov* 2023) <https://www.energy.gov/ne/articles/nrc-certifies-first-us-small-modular-reactor-design> accessed 31 January 2023

[5] 'U.S. Approves First Small Modular Nuclear Reactor, Beginning New Era for Atomic Energy' (*Vice.com* 23 January 2023) <https://www.vice.com/en/article/3ad9gw/us-approves-first-nuclear-reactor> accessed 31 January 2023

[6] Gokul Iyer et al., 'Implications of Small Modular Reactors for Climate Change Mitigation 1' (2014) 45 Center for International & Security Studies at Maryland <https://spp.umd.edu/sites/default/files/2019-07/Implications%20of%20SMRs%20for%20Climate%20Change%20Mitigation.pdf> accessed 31 January 2023

[7] Debak Das, 'An Indian Nuclear Power Plant Suffered a Cyberattack. Here's What You Need to Know.' (*Washington Post*, 4 November 2019) <https://www.washingtonpost.com/politics/2019/11/04/an-indian-nuclear-power-plant-suffered-cyberattack-heres-what-you-need-know/> accessed 31 January 2023

country's nuclear arsenal, however, can cause concern regarding security to other nations.[8] International cooperation is yet another important new topic that is emerging in the field of nuclear law and policy. Although nuclear energy has the potential to be a dependable and secure source of low-carbon energy, it is currently the largest carbon-free baseload energy source, accounting for nearly 20% of the US's total electricity production and 55% of low-carbon production, which prevents over 520 MMT of carbon emissions.[9] Additionally, approximately 440 commercial reactors are operating in 30 nations, and another 300 reactors worth $1.6 trillion are scheduled to be built over the next 15 years. Therefore, nuclear energy will undoubtedly be a significant source of energy. In addition, it will be crucial for creating jobs, expanding export opportunities, and bolstering energy security in addition to being a clean energy source.

It also raises several international concerns, such as how to manage radioactive waste and stop the spread of nuclear weapons. International cooperation is required to handle these concerns efficiently. International collaboration in the area of nuclear law and policy, however, faces further difficulties as a result of the ongoing transformation of the world's political and economic landscape. The former UN high commissioner for human rights, Mary Robinson agreed with this by saying that for the whole of humanity, the Doomsday Clock is sounding an alarm. He further said that we are on the brink of a chasm, but the world leaders are not working at enough pace to secure a tranquil and livable planet. Even so, the SASB estimated that if we let the new Start (the last remaining treaty on nuclear weapons between Russia and the US) expire in 2026, then certainly the race of hoarding of nuclear arms will start. China has already begun to expand its nuclear program, North Korea is stepping up its missile tests, Iran is getting closer to developing nuclear weapons, and the US, India, and Russia are all modernizing their arsenals.[10]

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[8] R. Jeffrey Smith, 'The US Nuclear Arsenal Is Becoming More Destructive and Possibly More Risky' (*Center for Public Integrity*, 29 October 2021) <https://publicintegrity.org/national-security/future-of-warfare/nuclear-weapon-arsenal-more-destructive-risky/> accessed 31 January 2023

[9] 'International Nuclear Energy Policy and Cooperation' (*Office of Nuclear* Policy, 2023) <https://www.energy.gov/ne/international-nuclear-energy-policy-and-cooperation> accessed 31 January 2023

[10] ''Doomsday Clock' update triggered by Ukraine conflict' (*RT International*, 24 January 2023) <https://www.rt.com/news/570427-doomsday-clock-moves-closer-to-midnight/> accessed 31 January 2023

The field of nuclear law and policy is always evolving due to the rapid appearance of new technology and advances. These innovations may significantly change how we generate and use nuclear energy, as well as how we eliminate nuclear waste and prevent the proliferation of nuclear weapons. They also raise several unresolved legal and policy challenges. Understanding and navigating the rapidly shifting landscape of nuclear operations and behavior requires keeping up with the most pressing new issues in the field, such as nuclear waste management, small modular reactors, nuclear non-proliferation, and international collaboration.

NUCLEAR WASTE MANAGEMENT

Overview of current waste management practices: Nuclear power generation produces a variety of radioactive waste streams, including spent fuel, which must be safely stored and disposed of for hundreds of thousands of years.[11] The management of this waste is a critical issue in the field of nuclear law and policy. Currently, there are two main approaches to managing nuclear waste: storage in dry casks and deep geological repositories.[12] It is possible to store spent nuclear fuel in massive casks made of steel and concrete using the dry cask storage technique. These containers are made to keep radioactive materials from discharging and to protect against the elements and other outside influences. As dry casks are only intended to last a few decades, dry cask storage is a very short-term solution. Despite this, it is frequently employed in many nations as a temporary storage option while long-term alternatives are being developed.

Despite the difficulties, presently, dry cask storage has several benefits that have emerged recently.[13] The extensible nature of dry storage, according to Prakash Narayan, chief technical officer of Orano, is another benefit. To support the ongoing, long-term operation of the nuclear facility of nuclear energy, dry storage offers another important advantage when combined with

[11] Radioactive Waste Management | Nuclear Waste Disposal - World Nuclear Association (n 1)
[12] 'Spent Fuel Storage Options: Challenges and Solutions Joint Event Nuclear Fuel Cycle and Materials Section & Research Reactors Section' (*IAEA*, 22 September 2021) <https://nucleus.iaea.org/sites/connect/SFMpublic/Docs%202/IAEA%20Presentation%20on%20Spent%20Fuel%20Storage_GC65_SFM_RRs.pdf> accessed 31 January 2023
[13] 'Dry Cask Storage Systems' *(Stanford*, 23 June 2017) <http://large.stanford.edu/courses/2017/ph241/huang1/> accessed 31 January 2023

modular, extensible storage. The US has adopted a different stance and believes that the usage of storage casks is secure and safe, despite the UK's claims to the contrary. Nuclear power stations currently have about 70,000 tonnes of fuel, including US fuel, stored in temporary storage pools and casks. Since it was originally introduced four decades ago, dry nuclear technology is becoming more and more common. However, there are some issues with its use as well, including the risks of transporting hazardous nuclear waste for dry storage, the need for workers to be exposed to high levels of radiation, and the potential for canisters to open and leak their contents.[14] Deep geological repositories, on the other hand, are designed as a long-term solution for the disposal of nuclear waste.

These repositories are typically located deep underground, in rock formations that are stable and unlikely to be affected by surface activities. The waste is placed in specially designed containers and then buried in the repository. These repositories are intended to provide safe storage for hundreds of thousands of years until the radioactive materials have decayed to safe levels.[15]

Discussion of new technologies and methods for waste management: While deep geological repositories and dry cask storage are now the most popular approaches to handling nuclear waste, new approaches and technologies are being researched that may provide better options. Nuclear reprocessing is one of the most interesting of these.[16] This technique is used to chemically separate the radioactive waste from the valuable components of spent nuclear fuel, such as plutonium. The amount of waste that needs to be stored or disposed of can be decreased by recycling the separated materials and using them to make fresh fuel. Nuclear transmutation

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[14] Yoana Cholteeva, '"Wet" vs "Dry": The Pros and Cons of Two Storage Methods for Nuclear Waste' (*Power Technology*, 21 December 2020) <https://www.power-technology.com/features/wet-vs-dry-the-pros-and-cons-of-two-storage-methods-for-nuclear-waste/> accessed 31 January 2023

[15] 'Deep Geological Repositories' (*Canadian Nuclear Safety Commission*, 2021) <https://nuclearsafety.gc.ca/eng/waste/deep-geological-repositories.cfm#:~:text=A%20deep%20geological%20repository%20is,result%20in%20a%20geological%20repository> accessed 31 January 2023

[16] 'Nuclear Reprocessing: Dangerous, Dirty, and Expensive' (*Union of Concerned Scientists*, 05 April 2011) <https://www.ucsusa.org/resources/nuclear-reprocessing-dangerous-dirty-and-expensive#:~:text=Reprocessing%20is%20a%20series%20of,also%20to%20make%20nuclear%20weapons> accessed 31 January 2023

is another technique that is being developed. This is a technique for altering the properties of radioactive waste to make it less dangerous and more suited for disposal. Although this technology is still in its infancy, it has the potential to greatly reduce the volume and danger of nuclear waste.

Analysis of legal and policy challenges surrounding waste management: While new approaches to managing nuclear waste have the potential to provide better solutions, they also present several legal and political difficulties. The concern for safety and security is one of the most important of these. To safeguard the people and the environment from the potential discharge of radioactive materials, nuclear waste must be stored and disposed of safely. Before being implemented, new waste management techniques and technologies must undergo extensive testing and evaluation to guarantee their security and safety. The problem of liability in waste management presents another legal and policy concern. The task of managing nuclear waste can last for hundreds of thousands of years. To hold accountable parties for the secure storage and disposal of nuclear waste, it is critical to make sure that there are clear and enforceable liability regimes in place.

The Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management,[17] the Euratom Waste Directive, and the IAEA's Fundamental Safety Principles[18] all establish the fundamental precondition that the license holder has the primary responsibility for ensuring the safety of radioactive waste management and that the State in which the waste originates has the ultimate responsibility for ensuring that programs are prepared for the handling (including disposal) of radioactive waste. Through legislation and regulations that define the functions, accountability, and reporting structures of the pertinent entities, these commitments are put into effect in each Member State.[19]

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[17] 'Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management' (*IAEA*, 25 July 2014) <https://www.iaea.org/topics/nuclear-safety-conventions/joint-convention-safety-spent-fuel-management-and-safety-radioactive-waste> accessed 29 January 2023

[18] 'Safety Standards' (*IAEA*, 18 February 2019) <https://www.iaea.org/resources/safety-standards> accessed 29 January 2023

[19] 'Status and trends in Spent Fuel and Radioactive Waste Management' (*IAEA* 2020) <https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1963_web.pdf> accessed on 31 January 2023

The adoption of innovative waste management technologies and techniques also brings up questions of cost and funding. It's crucial to make sure that new technologies and approaches are economically viable and that the expenses are distributed fairly because their development and implementation might be costly. In the area of nuclear law and policy, the management of nuclear waste is a crucial topic. The way that waste is now managed, including the use of deep geological repositories and dry cask storage, is still up for discussion. Reprocessing and transmutation are two emerging technologies and approaches to waste management that may hold promise as solutions. These new approaches also bring up several legal and regulatory difficulties, including those related to cost, funding, liability, safety, security, and security. The long-term safety, security, and economic viability of the management of nuclear waste must be ensured.

SMALL MODULAR REACTORS

A. Overview of SMRs and legal framework

Nuclear power stations known as small modular reactors (SMRs) are intended to be lighter and more adaptable than conventional nuclear power plants. Typically, they are referred to as reactors with a power output of less than 300 MWe. SMRs have a wide range of uses, including the production of hydrogen, process heat, and electricity.[20] They can be used in many different contexts, like as off-grid applications and remote places. SMRs are subject to the same safety, security, and nonproliferation rules as conventional nuclear power plants in terms of the legal framework, but because of their smaller size and various deployment choices, there can be certain legal issues that need to be taken into account.

B. Discussion of the advantages and disadvantages of the SMRs from a legal perspective

SMRs have several advantages over conventional nuclear power stations from a legal standpoint. The potential for more flexible deployment choices, which may make it simpler to

[20] 'Small Nuclear Power Reactors' (*World Nuclear Association*, January 2023) <https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/small-nuclear-power-reactors.aspx> accessed 30 January 2023

secure the required permissions and clearances, is one of the key benefits. Additionally, the smaller size of SMRs might result in fewer safety and environmental issues, which could simplify the legal process.[21] SMRs do, however, also have several drawbacks. Apart from the generation of large-scale spent fuel, restricted power production is one of the key drawbacks, which may make them less suited for large-scale electricity generation and necessitate a different legal strategy.[22] Additionally, because SMR technology is still in its infancy, there is a dearth of operational experience and a larger degree of legal uncertainty around their deployment. Additional research and development are still required to solve the safety and security issues associated with SMRs and the corresponding regulatory regulations.

C. Analysis of the current state of the SMRs and their licensing regime

SMR technology is still in its infancy; numerous prototypes and demonstration projects are either being built or are in the planned phases.[23] Additional research and development are still required to address the legal, safety, and security issues linked to SMRs. To enable the deployment of SMRs, legislative and policy frameworks are also required. For the proper deployment of SMRs, a variety of regulatory concerns must be taken into account. For instance, the addition of intrinsic safety measures and multi-module deployment configurations all have unique failure modes and effects that are still under regulatory investigation. Additionally, modifications to the fuel and/or coolant will necessitate higher departures from established licensing standards and may necessitate the development of a significant amount of new expertise within nuclear safety regulatory organizations.[24] The use of a flexible regulatory

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[21] 'Benefits of Small Modular Reactors (SMRs)' (*Office of Nuclear Energy*, 2023) <https://www.energy.gov/ne/benefits-small-modular-reactors-smrs#:~:text=Small%20modular%20reactors%20offer%20a,security%20compared%20to%20earlier%20designs> accessed 30 January 2023

[22] 'Small Modular Reactors Produce High Levels of Nuclear Waste' (*Stanford News*, 30 May 2022) <https://news.stanford.edu/2022/05/30/small-modular-reactors-produce-high-levels-nuclear-waste/#:~:text=These%20materials%20become%20radioactive%20when,composition%20of%20their%20waste%20streams > accessed 30 January 2023

[23] 'GE Hitachi Signs Contract for the First North American Small Modular Reactor' (*GE News*, 2022) <https://www.ge.com/news/press-releases/ge-hitachi-signs-contract-for-the-first-north-american-small-modular-reactor> accessed 30 January 2023

[24] International Atomic Energy Agency, 'Lessons Learned in Regulating Small Modular Reactors' (*IAEA*, 2022) <https://www.iaea.org/publications/15149/lessons-learned-in-regulating-small-modular-reactors> accessed 30 January 2023

philosophy permits a designer to suggest how their concept will achieve each performance standard. It could be difficult for some SMR features to comply with general safety criteria. For instance, the current international framework for the transfer of nuclear materials may face difficulties if major components of a reactor, which includes the reactor core, are manufactured in a factory or through other means. Emerging challenges include the level of regulatory participation in the manufacturing process as well as the issue of global licensing of modules and specific components.

Due to the utilization of shared systems and the movement of construction and production from on-site to factories, multi-module SMR designs may necessitate special considerations for nuclear safety.[25] Compared to traditional nuclear power plants, these differences may have an impact on the timing and location of initial plant testing. These modifications may have an impact on the future SMR licensing stages and provide difficulties for the conventional licensing method. International cooperation could assist in resolving these issues for national and international regulatory systems, for instance by creating an international forum to coordinate the creation of specialized methods for licensing classes of SMRs for nations actively exploring them. Each country makes sure that safety requirements are in keeping with its own national interests and current regulatory practice while maintaining public confidence in the regulatory body's decisions. However, regulatory organizations from all over the world might collaborate to license a certain design. The level of transnational convergence attained through the Multinational Design Evaluation Programme (MDEP) framework is a notable example of this.[26]

There are several potentials to reach a higher level of regulatory harmonization, particularly in the three levels of regulatory harmonization for the legal framework through national governing bodies, licensing and regulatory guidelines maintained by atomic regulatory bodies, as well as codes and standards established within the standing industrial practice. Each level will face several difficulties, and although total harmonization is unrealistic, especially at the heads of

[25] Hidayatullah H & Ors, 'Design and Technology Development for Small Modular Reactors – Safety Expectations, Prospects and Impediments of Their Deployment' (2015) 79 Progress in Nuclear Energy 127 <https://www.sciencedirect.com/science/article/abs/pii/S0149197014002972> accessed 30 January 2023

[26] 'NEA Multinational Design Evaluation Programme (MDEP)' (*NEA*, 2018) <https://www.oecd-nea.org/mdep/> accessed 30 January 2023

government level, it is frequently possible to pinpoint some areas where streamlining can be accomplished. International cooperation is required for that. The deployment of various SMR designs in multiple countries without significant adjustments to comply with national rules could be facilitated by the harmonization of licensing requirements and licensing processes for SMRs. As a result, harmonization will be crucial in promoting the economies of series, which are necessary for this technology to be competitive and profitable.[27]

D. Major global and local instruments governing the SMRs.

The Convention on Nuclear Safety (CNS) and the 2009 Euratom Safety Directive,[28] as updated in 2014, both apply to "nuclear installations." Nuclear installations, in the words of CNS, "are some ground commercial nuclear power plants within its control" (Article 2(i)).[29] As the aforementioned definition primarily applies to "land-based" nuclear power facilities, it is unclear if floating SMRs and other mobile SMRs would fall under its purview.

How to define "Nuclear Power Plant" is the second area that is unclear. Though one might argue that micro SMRs would not be included in this,[30] a clear picture is still required. Applying CNS requirements to SMRs in the future won't be onerous for nuclear power countries because they have already created CNS; however, it might be for newcomers. For instance, Article 7 states that a legal and governmental framework must be established and maintained to oversee the security of nuclear installations; Article 8 calls for the establishment of a governmental body and the provision of sufficient authority, resources, and personnel to enable it to carry out its duties; and Articles 11(1) and 11(2) specify the need to secure adequate financial resources and qualified personnel, respectively.

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[27] 'Small Modular Reactors: Challenges and Opportunities' (*NEA*, 23 March 2021) <https://www.oecd-nea.org/jcms/pl_57979/small-modular-reactors-challenges-and-opportunities?details=true> accessed 30 January 2023

[28] *Ibid*

[29] 'Convention on Nuclear Safety 1994' (*IAEA*, 1994) <https://www.iaea.org/sites/default/files/infcirc449.pdf > accessed 31 January 2023

[30] 'Code of Conduct on the Safety of Research Reactors' (*IAEA*) <https://www.iaea.org/topics/nuclear-safety-conventions/convention-nuclear-safety> accessed 31 January 2023

Environmental preservation and public engagement are two more issues. However, in the case of CNS, additional legal procedures are needed to interpret the definition of activities covered by the Convention on Access to Information along with the Public Participation in Decision-Making and Access to Justice in Environmental Matters (Aarhus Convention)[31] and the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention),[32] which is a matter of great concern for European countries. In addition, as in the case of safety, the EU Environmental Impact Assessment (EIA) Directive[33] and the other Aarhus Convention-related Directives,[34] and regulations place extra requirements on EU member states.

There are a few international treaties that regulate nuclear third-party liability, including "the Paris Convention on Third Party Liability in the Field of Nuclear Energy,"[35] "the Vienna Convention on Civil Liability for Nuclear Damage,"[36] "the Vienna Convention as amended by the 1997 Protocol,"[37] and "the Convention on Supplementary Compensation for Nuclear Damage."[38] SMRs are included in the definition of "nuclear installation"[39] in these protocols, which also includes "reactors other than those included in any means of transport." WithExcept

[31] 'Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters' *(Aarhus Convention*, 1998*)* <https://unece.org/DAM/env/pp/documents/cep43e.pdf> accessed 31 January 2023

[32] 'Convention on Environmental Impact Assessment in a Transboundary Context' *(Espoo Convention*, 1991*)* <https://unece.org/environment-policy/publications/convention-environmental-impact-assessment-transboundary-context> accessed 31 January 2023

[33] Directive 2014/52/EU Of The European Parliament And Of The Council [2014] OJ L 124/1

[34] Directive 2003/4/EC Of The European Parliament And Of The Council [2003] OJ L 41

[35] 'Paris Convention on Third Party Liability in the Field of Nuclear Energy (Paris Convention or PC)' (*Nuclear Energy Agency*, 2023) <https://www.oecd-nea.org/jcms/pl_20196> accessed 31 January 2023

[36] 'Vienna Convention on Civil Liability for Nuclear Damage' (*IAEA*, 27 August 2014) <https://www.iaea.org/topics/nuclear-liability-conventions/vienna-convention-on-civil-liability-for-nuclear-damage> accessed 31 January 2023

[37] 'Protocol to Amend the 1963 Vienna Convention on Civil Liability for Nuclear Damage (1997 Vienna Protocol)' (*NEA*, 2023) <https://www.oecd-nea.org/jcms/pl_29285/protocol-to-amend-the-1963-vienna-convention-on-civil-liability-for-nuclear-damage-1997-vienna-protocol> accessed 31 January 2023

[38] 'Convention on Supplementary Compensation for Nuclear Damage' (*IAEA*, 20 October 2014) <https://www.iaea.org/topics/nuclear-liability-conventions/convention-supplementary-compensation-nuclear-dam> accessed 31 January 2023

[39] 'Paris Convention on Third Party Liability in the Field of Nuclear Energy (Paris Convention or PC)' (*NEA*, 2023) <https://www.oecd-nea.org/jcms/pl_20196/paris-convention-on-third-party-liability-in-the-field-of-nuclear-energy-paris-convention-or-pc> accessed 31 January 2023

Vienna Convention,[40] these conventions let governments set a lower level of liability for that installation, but that level must be lower than the number of low-risk installations as specified by the conventions. With this flexibility, nuclear operators won't have to worry about paying for excessive insurance or financial security,[41] which would be a hardship. So long as the installation's governing conventions and regulations permit it and the low-risk component doesn't change, SMRs can be regarded as low-risk installations. Therefore, if we wish to make considerable progress toward the commercial deployment of the most recent SMR technology, these concerns must be resolved.

E. Small Modular Reactors and prospects

SMRs have the potential to play a significant role in the future of nuclear energy, particularly when it comes to providing energy to remote regions and developing countries. According to the International Atomic Energy Agency (IAEA), nuclear energy might provide 12% of the world's electricity by 2050.[42] And, SMR will play a significant role in achieving this target.[43] According to data from a 2010 study to estimate the economic and employment impacts of SMR deployment, a typical 100 MWe SMR, which cost about $500 million to manufacture and install, created close to 7,000 jobs, generated $1.3 billion in sales revenue, $404 million in earnings, and $35 million in indirect business taxes.[44] Though SMRs will only be successful if the difficulties and issues around their deployment are resolved, particularly from a legal standpoint. To account for the unique qualities of SMRs and ensure their safe and secure deployment, legal laws must be created and modified.

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[40] 'Vienna Convention on Civil Liability for Nuclear Damage' (*IAEA*, 27 August 2014) <https://www.iaea.org/topics/nuclear-liability-conventions/vienna-convention-on-civil-liability-for-nuclear-damage> accessed 31 January 2023

[41] 'Nuclear Operators' third party liability amounts and Financial Security Limits' (*OECD*) <https://www.oecd-nea.org/law/table-liability-coverage-limits.pdf> accessed 31 January 2023

[42] 'IAEA Increases Projections for Nuclear Power Use in 2050' (*IAEA*) <https://www.iaea.org/newscenter/pressreleases/iaea-increases-projections-for-nuclear-power-use-in-2050> accessed 28 January 2023

[43] 'Advanced Small Modular Reactors (SMRs)' (*Energy.gov*) <https://www.energy.gov/ne/advanced-small-modular-reactors-smrs> accessed 28 January 2023

[44] 'Benefits of Small Modular Reactors (SMRs)' (*Energy.gov*) <https://www.energy.gov/ne/benefits-small-modular-reactors-smrs> accessed 28 January 2023

Last but not least, nuclear power plants classified as Small Modular Reactors (SMRs) are designed to be more flexible and smaller than traditional nuclear power plants. From a legal standpoint, they differ from conventional nuclear power plants in several ways, including the potential for more flexible deployment options and fewer environmental and safety concerns. They do, however, have several shortcomings, including a lack of operational competence and a lack of appropriate power output. SMRs may produce electricity at a higher cost per kilowatt hour than other energy sources, including existing commercial reactors because they are less economical than larger reactors.[45] Another concern was raised in a publication about the SMR's inherent safety features.[46] The Institute for Energy and Environmental Research questioned the lower capital investment needed for SMR construction, claiming that the establishment of a modular nuclear plant would necessitate the expensive early construction of shared facilities, like a containment structure, intended for use with all planned reactor modules.[47] Because SMRs are still in the early stages of development, additional research and development are needed to find solutions to issues with the law, safety, and security as well as to construct regulatory and legislative frameworks that support SMRs.

NUCLEAR NON-PROLIFERATION AND LEGAL CONSIDERATIONS

A. Overview of Nuclear Non-Proliferation and legal framework

The fight against the spread of nuclear weapons to nations that do not already have them is known as nuclear non-proliferation. International laws and agreements, such as the Comprehensive Nuclear Test Ban Treaty and the Treaty on the Non-Proliferation of Nuclear Weapons, are principally responsible for establishing the legal foundation for nuclear non-proliferation (CTBT). These accords create enforceable commitments for states to cooperate in the peaceful use of nuclear energy and to refrain from developing or acquiring nuclear weapons.

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[45] *Ibid*

[46] 'Technology neutral: safety and licensing of SMRs' (*IAEA*) <Technology Neutral: Safety and Licensing of SMRs | IAEA> accessed 31 January 2023

[47] Arjun Makhijani & Michele Boyd, 'No solution for the cost, safety, and waste problems of Nuclear power' (*IEER*) <https://ieer.org/wp/wp-content/uploads/2010/09/small-modular-reactors2010.pdf> accessed 28 January 2023

B. Discussion of the advantages and disadvantages of Nuclear Non-Proliferation from a legal perspective

The real benefit of nuclear non-proliferation from a legal standpoint is that it aids in preventing the spread of nuclear weapons, which in turn advances global peace and security. A framework for the peaceful use of nuclear energy and the transfer of nuclear technology for peaceful purposes is also provided by the NPT and other accords, which can have positive economic and social effects.[48]However, from a legal standpoint, there are several drawbacks to nuclear non-proliferation.[49] One of the biggest drawbacks is that despite nuclear disarmament is one of the key objectives of nuclear non-proliferation, the NPT and other accords fall short in this regard. Additionally, some states may not comply since the legal foundation for nuclear non-proliferation is not always adequately implemented. It might be challenging to hold states accountable for non-compliance due to the lack of legal tools for enforcing nuclear non-proliferation obligations.

C. Analysis of the current state of Nuclear Non-Proliferation and prospects about legal prospects

Non-proliferation of nuclear weapons is now in an uneven stage. While the NPT and other accords have been successful in stopping the spread of nuclear weapons to many nations, there are still a few of them, notably North Korea and Iran, that have not accepted or signed them. Concerns concerning non-compliance by some states that have ratified and signed the agreements are another issue. The legal foundation for nuclear non-proliferation needs to be strengthened to improve future possibilities. Included in this is the necessity of continuing efforts to address the issue of nuclear disarmament as well as the need for efficient enforcement mechanisms to hold states accountable for non-compliance. To stop the spread of nuclear weapons, there is also a need for more effective international cooperation, including the

[48] 'Milestones: 1961–1968 - Office of the Historian' (*State.gov*, 2023) <https://history.state.gov/milestones/1961-1968/npt> accessed 30 January 2023

[49] 'The NPT at Fifty: Successes and Failures' (2020) 3(2) Journal for Peace and Nuclear Disarmament <https://www.tandfonline.com/doi/full/10.1080/25751654.2020.1824500> accessed 30 January 2023

application of penalties and other measures against states that participate in actions that violate the NPT and other accords.

INTERNATIONAL COOPERATION IN NUCLEAR ENERGY

A. Overview of international cooperation in nuclear energy

Nuclear energy needs to be used in a safe, secure, and peaceful manner, and this requires international cooperation. To solve the issues and opportunities in this subject, which relate to nuclear energy, nations, and international organizations must work together. The primary international agency in charge of advancing nuclear energy's peaceful applications and offering nations technical support is the International Atomic Energy Agency (IAEA). Numerous nations have also established bilateral and multilateral agreements to boost nuclear energy cooperation.[50]

B. Discussion of international treaties and agreements

International collaboration in nuclear energy is governed by several significant international treaties and agreements. The foundation of the global non-proliferation regime is the Treaty on the Non-Proliferation of Nuclear Weapons (NPT).[51] It strives to stop the proliferation of nuclear weapons and advance nuclear energy's benign use. Another significant agreement that deals with the management of spent fuel and radioactive waste safely is the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management.[52] Additionally, important agreements that support the security and safety of nuclear energy

[50] 'Bilateral, Regional and Multilateral Agreements Relating to Co-Operation in the Field of Nuclear Safety' (*IAEA*, 28 February 2019) <https://www.iaea.org/publications/3721/bilateral-regional-and-multilateral-agreements-relating-to-co-operation-in-the-field-of-nuclear-safety> accessed 30 January 2023

[51] 'Treaty on the Non-Proliferation of Nuclear Weapons (NPT)' (*UN*, 2015) <https://www.un.org/disarmament/wmd/nuclear/npt/> accessed 30 January 2023

[52] 'Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management' (*IAEA*, 25 July 2014) <https://www.iaea.org/topics/nuclear-safety-conventions/joint-convention-safety-spent-fuel-management-and-safety-radioactive-waste> accessed 30 January 2023

include the Convention on Nuclear Safety and the Convention on Early Notification of a Nuclear Accident.[53]

C. Analysis of challenges and opportunities in international cooperation

The lack of trust and transparency among nations, a lack of agreement on the hazards and advantages of nuclear energy, and a lack of a unified strategy for nuclear safety and security are just a few of the difficulties that international cooperation in nuclear energy faces. A major obstacle to international collaboration is the problem of nuclear non-proliferation since the spread of nuclear weapons threatens world security. On the other side, there is a lot of potential for international nuclear cooperation. Sharing technical know-how and knowledge among nations is one of the primary opportunities, as it can help to increase the safety and effectiveness of nuclear energy. International cooperation can also aid in promoting nuclear energy's peaceful applications and tackling issues like climate change and energy security that are related to the world's energy supply.

Finally, cooperation between nations is essential for ensuring nuclear energy is used securely and peacefully. The rules governing international collaboration in this area are mostly governed by international treaties and agreements. But there are also many obstacles to international cooperation, such as a lack of transparency and trust among nations and a lack of a unified strategy for nuclear security and safety. However, there are other opportunities provided by international cooperation, including the promotion of nuclear energy's peaceful applications and the sharing of technical know-how and knowledge. To address the difficulties and possibilities of global collaboration in nuclear energy, it is crucial for nations and international organizations to keep cooperating.

FOCUS ON THE INDIAN SCENARIO

A. Overview of current nuclear law and policies in India

[53] 'Convention on Early Notification of a Nuclear Accident (Early Notification Convention)' (*Nuclear Energy Agency*, 2023) <https://www.oecd-nea.org/jcms/pl_29135/convention-on-early-notification-of-a-nuclear-accident-early-notification-convention> accessed 30 January 2023

In the previous few decades, India's nuclear laws and regulations have experienced major development. Since the late 1950s, India has had a long history of employing nuclear energy for peaceful reasons. Since India's first nuclear power plant was built in 1969, the nation has achieved great strides in the growth of its nuclear energy industry.[54] However, India's past conflicts and political ties with other nations also influenced its nuclear policies, particularly regarding its nuclear weapons development. The Non-Proliferation Treaty (NPT), the Comprehensive Test Ban Treaty (CTBT), and the International Atomic Energy Agency (IAEA) safeguard agreement are the primary international treaties and agreements that have an impact on India's nuclear policies. India has faced challenges with its nuclear weapons program and is not a signatory to the NPT.[55] However, India has made great strides lately toward normalizing its relations with the world community and participating in international nuclear and disarmament conferences.

To regulate its nuclear energy industry, India has also passed several national legislation and regulations. The primary piece of legislation governing the use of nuclear energy in India is the Atomic Energy Act of 1962. The Atomic Energy Commission (AEC), which is in charge of regulating the nuclear energy sector in India, is established under the Act, which also creates the framework for the establishment and regulation of nuclear plants. With multiple major nuclear power plants in the works, the Indian nuclear energy sector is now in a relatively good state. The country of India has set a target of having 63,000 MW of nuclear power by 2032. As part of its efforts to promote the advancement of nuclear technology for peaceful uses, the nation has also established research institutions and improved the climate for private investment in the field.

[54] 'Evolution Of India's Nuclear Policy' (2010) <https://media.nti.org/pdfs/32_ea_india.pdf> accessed 30 January 2023

[55] 'India, China and the Non Proliferation Treaty (NPT)' (*World Nuclear Association*, 2016) <https://www.world-nuclear.org/information-library/safety-and-security/non-proliferation/india,-china-npt.aspx> accessed 30 January 2023

B. Emerging issues in nuclear law and policies in India

India has recently encountered several new problems with nuclear law and regulations that need to be addressed. Key emergent issues include the following:

- Nuclear energy is increasingly being used for peaceful reasons because India has ambitiously established a goal to expand its nuclear energy capacity, which has raised the demand for nuclear energy. To meet this demand, the nation must overcome several obstacles, including a lack of skilled labor, the need for investment in R&D, and the requirement for regulatory reforms.
- Technological developments and their effects on Indian nuclear policies: With multiple cutting-edge reactors currently under construction, India is at the forefront of nuclear technology. These developments in technology bring up questions, nevertheless, about the security of nuclear power and the necessity of suitable regulatory structures.
- Climate change and its effects on nuclear energy in India: As one of the most severely impacted nations, India is under intense pressure to cut its greenhouse gas emissions. Concerns concerning the effects of nuclear waste on the environment are raised by the growing usage of nuclear energy as a source of low-carbon energy.
- Nuclear weapons proliferation: The international community has expressed worry about India's nuclear weapons program, particularly in light of non-proliferation and disarmament. India has made efforts to strengthen its ties with other nations, but the nation's stance on disarmament continues to raise skepticism in international forums.
- Management and disposal of nuclear waste: Given the scarcity of suitable places for waste disposal, managing and eradicating nuclear waste poses a huge challenge for India. Developing adequate legislative frameworks for the management and disposal of nuclear waste, as well as maintaining the safety and security of nuclear waste, provide problems for the nation.

C. India's nuclear policies in the global context

India's place in the international nuclear arena is complicated and influenced by its political and historical ties to other nations. The international world is nonetheless concerned about India's nuclear weapons development and non-signatory status to the NPT, despite the country's growing participation in international forums on nuclear energy and disarmament. In recent years, India has made tremendous strides toward normalizing its relations with other nations and participating in international discussions on nuclear energy and disarmament. The nation has also made tremendous progress in developing its nuclear energy industry and solidifying its position as a world leader in nuclear technology. However, India also has a lot of work to do in the nuclear field, especially when it comes to managing nuclear waste, regulating its nuclear energy industry, and preventing the spread of nuclear weapons. For the Indian nuclear energy sector to grow in a safe, secure, and sustainable way, the Indian government and the international community will need to pay close attention to and make major efforts on these concerns.

CONCLUSION

Summary of key legal aspects of nuclear conduct and activities: The legal system that governs nuclear activities and conducts is intricate and dynamic. The creation, production, and use of nuclear weapons, as well as the non-proliferation of nuclear weapons, are all governed by this system of international treaties, accords, national laws, and regulations.

Assessment of the current state of the legal framework for nuclear activities and conduct: Although there is a comprehensive legal framework in place, there are still several issues that must be resolved. Ensuring adherence to international treaties, accords, and national rules and regulations is the key difficulty. To handle the issue of nuclear disarmament and guarantee the peaceful use of nuclear energy, additional legal frameworks are also required.

Recommendations for future legal considerations in the field of nuclear activities and conducts.

The following actions are advised given the difficulties facing the legal framework for nuclear activities and conduct:

- Enhancing the legal framework for the international accords and treaties governing nuclear activity and behavior. This will make it easier to guarantee that states uphold the requirements outlined in these agreements.
- Developing new legal frameworks and measures to address the problem of nuclear disarmament. This will support international peace and security and lessen the threat posed by nuclear weapons.
- Encouraging international collaboration and the exchange of nuclear technologies to promote the peaceful use of nuclear energy. This will aid in addressing the rising energy demand and promoting sustainable development.
- Giving international agencies and organizations that are involved in the legal regulation of nuclear activities and conducts more funding and assistance. This will support addressing the field's issues and enhancing the efficiency of the judicial system.