Chapter 6
Nuclear Power Plays: Complexities of Armament, Disarmament, and (Non-) Proliferation of Nuclear Weapons



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6.1 Introduction

In world politics, power is a decisive factor, and nuclear weapons guarantee their possessor a unique kind of bargaining power in their international relations. To credibly threaten the use of nuclear weapons, the core of nuclear deterrence, is to threaten to cause devastating, immediate and long-term destruction and human suffering on a scale that no other type of weapon can (cf. Schelling 1966). The devastating impacts of any use of nuclear weapons have driven both deterrence and disarmament discourses for the past decades. They will continue to be the driver of both allure and damnation of this category of weapons of mass destruction and the interlinked dynamics of (dis)armament and (non)proliferation.

Nuclear weapons were first tested by the United States of America (US) in July and then used for the first time in August 1945 in the bombings of the Japanese cities of Hiroshima and Nagasaki, causing immense loss of life and suffering. Since

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then, seven other states have tested nuclear devices[1]—amounting to a total of more than 2,000 nuclear tests.[2,3] Nuclear weapons are credited with the ability to instantly change the nature of any conflict (Schelling 1960). Yet, apart from the US, no other country has dared to use nuclear weapons in combat—leading to the assumption of the "nuclear taboo", which stipulates that nuclear weapons will not be used again due to their stigmatization (cf. Tannenwald 2007). Over the past decades, rules, norms, and legal frameworks have been developed to manage and reduce the risks associated with nuclear weapons. The global nuclear order, centered around the Nonproliferation Treaty (NPT), is shaped by a complex web of interrelated and often conflicting interests and behaviors tied to the presence and persistence of nuclear weapons. The NPT also ascribes who may possess nuclear weapons, i.e., who has the power to threaten their use. Of the nine nuclear-armed states, with a total of more than 12,100 nuclear warheads currently in their collective possession, four fall outside the NPT regime's direct influence.[4] Meanwhile, a large group of states strongly opposes nuclear weapons. A divide persists between those who support nuclear deterrence and those advocating for "Global Zero"—a world without nuclear weapons—and the surrouding nuclear politics shape international relations in many, often unseen ways.

This chapter traces the history of the nuclear age along the lines of four distinctive but interrelated and sequential concepts: armament, proliferation, nonproliferation, and disarmament, to describe how nuclear weapons have the power to shape international relations. Section 6.2 scrutinizes the developments and dynamics initiated by the discovery of nuclear fission, paving the way for the evolution of nuclear armament and proliferation. It highlights how states have navigated the complex interplay of technical capabilities and political motivations in their (non)pursuit of nuclear weapons. Section 6.3 describes the global efforts and frameworks designed to curtail the spread of nuclear weapons, with a primary focus on the NPT and its role in shaping international norms and practices, exploring both its successes and challenges. Section 6.4 describes the complexity of nuclear disarmament, outlining both its theoretical goals and practical processes. Section 6.5 concludes with a summary of current and potential future developments in the nuclear weapons landscape.

[1] While Israel is widely believed to be a nuclear-armed state, it has not conducted a nuclear test in accordance with its policy of nuclear opacity (see Sect. 2.3). Despite the plausible likelihood of an atmospheric low-yield nuclear test, the 1979 'Vela Incident' has never been officially confirmed as a nuclear explosion, nor has there been a consensus on its attribution to Israel, South Africa, or possibly both countries (cf. De Geer and Wright 2018).

[2] https://www.atomicarchive.com/almanac/test-sites/testing-chronology.html, last accessed on 14–02-2025. This date holds for all other online references unless otherwise indicated.

[3] Due to the secretive nature of nuclear weapons programs, it is impossible to provide a comprehensive and verified account of every initiative that was launched but never completed. South Africa is the only other country known to have built nuclear weapons but has dismantled its arsenal. With the demise of the Soviet Union, Belarus, Kazakhstan, and Ukraine temporarily had ownership over nuclear weapons stationed on their soil but transferred them to Russia (see Sect. 4.2).

[4] https://fas.org/initiative/status-world-nuclear-forces/.

6.2 Nuclear Armament and Proliferation

Nuclear armament and proliferation have played pivotal roles in shaping the global strategic environment in recent decades. Nuclear armament refers to "the process of increasing the number and strength of a country's [nuclear] weapons".[5] It is closely linked to both understandings of proliferation: On the one hand, vertical proliferation, which involves the modernization and expansion of existing nuclear weapons stockpiles, and on the other hand, horizontal proliferation, which refers to the spread of nuclear weapons, material, or technology to states and potentially non-state actors that do not yet possess nuclear weapons capabilities (Goldansky 1988).

6.2.1 Technical and Political Considerations of Armament and Proliferation

To acquire nuclear weapons, a state must meet several technical and political conditions. From a technical standpoint, the state must have mastered complex scientific and industrial processes, including the enrichment of uranium (for weapons using highly enriched uranium) or the operation of nuclear reactors and reprocessing of spent fuel (for weapons using plutonium), as well as the development of delivery systems (i.e., missiles, bombers, or submarines). Politically, nuclear acquisition often depends on a state's security perceptions, geopolitical ambitions, and domestic political consensus. The various factors that influence nuclear proliferation are debated and highly case-dependent. Most likely, however, states pursue nuclear weapons when they perceive significant security threats and see them as a valid solution (generating the willingness), have access to the necessary resources and technology (generating the opportunity), or likely both (cf. Jo and Gartzke 2007; Monteiro and Debs 2014).

While only nine states possess nuclear weapons, several other nations had or have the technical capacity to build nuclear weapons (for example, South Africa, Argentina, Brazil, Germany, Italy, Japan, South Korea, and Sweden), referred to as "nuclear latency," but have opted not to pursue nuclear ambitions (cf. Fuhrmann and Tkach 2015) often due to their commitment to international norms, treaties, their role in security alliances, but also cost–benefit and risk analyses.

[5] https://dictionary.cambridge.org/de/worterbuch/englisch/armament.

6.2.1.1 The Physics Behind Nuclear Weapons and Their Destructive Power

The explosive yield of nuclear weapons sets them apart from other weapons. Unlike conventional explosives, which derive their energy from chemical reactions, i.e., changes in the molecular (electromagnetic) structure of molecules, the energy released upon detonation from nuclear weapons stems from nuclear reactions, i.e., changes in the structure of atomic nuclei (fission or fusion reactions). Because more energy is stored more densely in atomic nuclei than in molecular bonds, more energy can be harnessed. For example, fissioning one gram of uranium U-235 releases 10 million times more energy than burning one gram of TNT. This principle is used in both civilian nuclear reactors and weaponry. Typical fission materials in nuclear weapons are highly enriched uranium (HEU, uranium with a large percentage of the isotope U-235) and plutonium (Goodwin 2021).

Explosions require a rapid release of energy. Thus, instead of controlling the energy-releasing fission reactions as in a critical nuclear reactor, a supercritical setting is specifically sought to initiate an explosive fission chain reaction, where neutrons from the fission exponentially initiate new fission reactions, leading to very high energy releases when the weapon is triggered (Goodwin 2021). To achieve such a supercritical setting, two main fission weapon designs have been developed:

- Gun-Type Design: Two subcritical configurations of fissile material are rapidly smashed together with conventional explosives. This design is easier to develop,[6] but it only works with highly enriched uranium (HEU) (Miller 2022).
- Implosion-Type Design: A subcritical configuration of fissile material is rapidly compressed with conventional explosives surrounding it. This requires more development effort due to the precise timing of the conventional explosives, but the design can also use plutonium, which allows for greater explosive yields (Miller 2022).[7]

Modern nuclear weapons, thermonuclear weapons or hydrogen bombs, utilize a two-stage design that combines fission and fusion reactions. The first stage is typically an implosion-type fission design as described above. This ignites the second stage, in which deuterium and tritium are fused into helium. The second stage not only significantly increases the energy for the explosion itself but also provides additional neutrons to achieve higher fission rates in the first stage (Schumann 2022).

The yield of nuclear weapons is usually expressed in terms of the equivalent energy released by the explosion of a thousand tons (kilotons, kT) or a million tons (megatons, MT) of TNT. The first nuclear weapon ever tested, known as Gadget in the Trinity Test of July 16, 1945, had a yield of 21 kT (Selby et al. 2021). The largest

[6] This design was developed early in the Manhattan Project and was never tested by the US before using it on Hiroshima.

[7] A slightly more advanced, but nowadays common nuclear weapon design increases its yield by adding tritium and deuterium to 'boost' the weapon; their fusion process releases more neutrons to increase the amount of fissioned material. The tritium must be constantly replaced due to its short half-life of about twelve years.

weapon ever tested, the Soviet Tsar Bomb, had a yield of about 50 MT,[8] which is over 100,000 times more powerful than the largest conventional explosives, with typical yields below 0.5 kT. The nuclear weapons used on Hiroshima and Nagasaki in August 1945 had yields of approximately 15 and 21 kT, respectively (Malik 1985). Today, the largest nuclear weapon in the US arsenal has a yield of 1.2 MT—over thousands of times the yield of the largest conventional explosives.[9]

This comparison underscores that nuclear weapon explosions release vastly more energy than conventional explosives, which further leads to also qualitatively different effects (cf. Glasstone and Dolan 1977). The correspondingly higher temperatures deriving from a nuclear explosion cause a significant amount of energy to be released as thermal radiation, which can ignite flammable materials and cause severe burns over considerable distances. Additionally, nuclear explosions emit both initial and residual nuclear radiation,[10] which can inflict far-reaching and long-term harm to living beings and the environment in general. This is particularly evident from the experiences of the bombings of Hiroshima and Nagasaki but also from the regions affected by nuclear testing that continue to experience high radiation levels even decades later (Abella et al. 2019).

In addition to the immediate effects of individual nuclear explosions, multiple detonations could have severe global climate consequences. Corresponding large-scale fires could release vast amounts of soot into the atmosphere, leading to decreasing global temperatures and precipitation, referred to as "nuclear winter" (Turco et al. 1983). For instance, an analysis of a hypothetical regional conflict between India and Pakistan involving the use of 100 nuclear weapons, each with a yield of 15 kT, suggests that about 255 million people could face death from famine caused by global climate disruptions, in addition to the about 27 million direct fatalities from the weapons themselves. In a worst-case scenario involving an all-out global nuclear war, over five billion people could be affected by famine due to the extensive changes in the global climate (Xia et al. 2022).

6.2.1.2 Reasons for Armament and Proliferation: Why Do States Want Nuclear Weapons?

For a long time, national security interests were seen as the sole motivation for a state's decision to pursue the possession of nuclear weapons. In situations of significant military threats—whether conventional or nuclear—the acquisition of nuclear weapons is often seen as the ultimate defense mechanism. The key rationale behind this is deterrence: by acquiring nuclear weapons, a state aims to prevent aggression by

[8] https://thebulletin.org/2021/11/the-untold-story-of-the-worlds-biggest-nuclear-bomb/.

[9] https://thebulletin.org/2024/02/why-the-biden-administrations-new-nuclear-gravity-bomb-is-tragic/.

[10] The initial radiation comes from highly energetic and penetrating light ("gamma rays") produced in the fission processes; the residual nuclear radiation ("fallout") comes from the further decaying unstable fission products.

convincing potential adversaries that the costs of conflict will outweigh any potential benefits. In this logic, simply possessing nuclear weapons acts as a deterrent, making their actual use less necessary, but always an implicit threat (cf. Waltz 1981). This could also be leveraged in case the aggressor possesses nuclear weapons, as their use lingers over any conflict involving a nuclear-armed state.

A crucial element of deterrence is credibility: adversaries must believe in both a state's capability and its willingness to follow through with its threats of actual nuclear weapons use (cf. Nye Jr. 2023). When both adversaries possess nuclear weapons, establishing and maintaining mutual vulnerability is credited with ensuring stability and peace in the international system.[11]

Nuclear deterrence also contains an inherent contradiction: states possess and threaten the use of nuclear weapons with the hope that they will never actually need to use them (cf. Aron 1980). While deterrence is often viewed through the lens of rational calculation—balancing goals, costs, and risks—it also involves significant uncertainty, misperceptions, and psychological factors. Strategic considerations, military scenarios, and security dilemmas are largely driven by national interests that are assessed in relation to other states and in the context of the broader international system. These considerations focus heavily on how potential adversaries perceive threats, with deterrence policy traditionally viewed from the perspective of a potential aggressor at the state level (cf. Mazarr 2018).

However, while the threat of mutual destruction through nuclear weapons can create stability at the strategic level by preventing large-scale wars between nuclear weapons possessor states, it can simultaneously foster instability at lower levels of conflict, often referred to as the "stability-instability-paradox" (Snyder 1965). This paradox suggests that while nuclear deterrence may help maintain peace between nuclear-armed states—contributing to a form of "nuclear peace"—it can also embolden these states to engage in limited conventional conflicts or proxy wars, particularly involving non-nuclear weapon states as their adversary. This highlights the complex role that nuclear weapons play in both preventing and encouraging certain forms of conflict.

Furthermore, while the devastating humanitarian consequences of nuclear weapons use are rarely explicitly addressed in strategic calculations, awareness of these consequences reinforces the deterrent effect. Nonetheless, discussions surrounding deterrence and security often downplay these impacts, focusing instead on state-centric concerns and rivalries. Consequently, states facing hostile nuclear-armed neighbors or rivals may feel compelled to pursue their own nuclear capabilities.

Nuclear acquisition, however, is no longer seen as driven solely by national security concerns. Scott Sagan (1996) argues that nuclear weapons are also powerful political symbols, playing a significant role in domestic politics and shaping a state's

[11] https://thethirdnuclearage.com/2022/04/22/andrew-futter-publishes-paper-deterrence-disruptive-technology-and-disarmament-in-the-third-nuclear-age-for-hiroshima-organisation-for-global-peace/.

international identity. The author identifies three interconnected reasons, or "models," for why states pursue nuclear weapons:

- Security Model: The most traditional view, where nuclear weapons are pursued to deter external threats, especially from adversaries with nuclear capabilities or superior conventional forces.
- Domestic Politics Model: In this model, internal political pressures—such as bureaucratic interests, military influence, or political competition—drive nuclear development. Nuclear weapons programs may be advanced to consolidate power or appease influential domestic groups.
- Norms Model: Nuclear weapons can also serve as symbols of modernity, prestige, and identity. For some states, possessing nuclear weapons elevates their status on the global stage and aligns them with the most powerful nations.

This view has been echoed in the literature and the models have been expanded, highlighting the complexity of motivations behind nuclear proliferation decisions. For example, Singh and Way (2004) and Jo and Gartzke (2007) emphasize the interplay between a country's domestic capacity and its likelihood of pursuing nuclear weapons. Jacques E. C. Hymans (2007) argues that national identity, particularly as perceived by a state's leadership, plays a crucial role in these decisions. In this view, the pursuit of nuclear weapons is linked to the leadership's vision of national identity and its ability to navigate complex domestic and international political landscapes.

6.2.1.3 Strategies and Barriers to the Acquisition of Nuclear Weapons

While acquiring nuclear weapons requires both technical capabilities and political willingness, empirical evidence suggests that international support is also a necessary component of the decision-making process. No nuclear-armed state developed its nuclear arsenal in isolation (Kroenig 2011). Sensitive nuclear transfers—including the exchange of materials, technology, or expertise—have played a significant role in the development and proliferation of nuclear weapons (Kroenig 2009). These dynamics of demand and supply are often driven by geopolitical alliances, covert assistance, or shared scientific expertise.

Several technical factors may hinder states' ambitions in building or acquiring nuclear weapons. First and foremost, from a practical perspective, the development of nuclear weapons relies on acquiring enough fissile material, i.e., HEU or plutonium, for which the following production pathways exist:

Weapons-grade uranium requires enrichment of the isotope U-235 (typically to above 90% U-235[12] relative to the most abundant isotope U-238, which makes up 99.3% of natural uranium).[13] The isotopes can only be separated by exploiting

[12] The exact level of enrichment needed for a nuclear weapon is not precise; potentially, lower enrichment levels would suffice (see e.g. Kemp et al. 2024).

[13] Uranium in fuel for typical nuclear power reactors is enriched to between 3 and 5%, see Chapter XXX of this book.

their slight difference in mass, as they behave chemically the same. Today, uranium isotopes are usually separated in large complexes of gas centrifuges after converting them to gaseous form (uranium hexafluoride). Gas centrifuges are technologically advanced and require significant research and development efforts, and existing designs are considered sensitive and not openly available (Kemp 2017).

Plutonium is produced by irradiating uranium U-238, the main component of natural uranium, with neutrons in a nuclear reactor. From this irradiated uranium, reprocessing facilities are needed to chemically separate the plutonium from the residual uranium or produced elements in the reactor.[14] The technologies used in the civilian nuclear fuel cycle (enrichment capabilities for reactor fuel production, reprocessing for nuclear recycling), are considered "dual-use" since they, in principle, can be used for civilian and military nuclear applications. As such, they are monitored by the International Atomic Energy Agency (IAEA) since the early 1960s for non-nuclear weapon states to ensure that they are not misused to produce materials for nuclear weapons (Schneider and Thränert 2014).

The 1970 NPT is crucial in fostering nonproliferation, as Article III requires non-nuclear weapon state party to the treaty to conclude a safeguards agreement with the IAEA, to let the agency verify that the state uses its nuclear programs only as prescribed within the treaty. These safeguards agreements allow the IAEA to apply nuclear safeguards, in which the agency collects and analyses information to verify compliance with the NPT. Some of this information is provided by the states themselves (e.g., with declarations of fissile material inventories and changes, information on the designs of nuclear facilities), some is collected by the IAEA itself (e.g., through inspections at relevant sites), and some is based on information provided by third parties (e.g., through open-source information). The measures applied during IAEA inspections include the comparison of declared information with on-site examinations, such as visual inspections (counting), measurements (destructive or non-destructive assay), or application and checking of seals (cf. IAEA 2016).

Over time, the safeguards agreements and measures have changed. A major turning point was the discovery of Iraq's clandestine nuclear weapons program in 1991, which showed that focusing on the verification of the correctness of declared materials and activities was not enough, and further capabilities for assessing completeness were required (cf. Acton and Newman 2006). For this, the "Additional Protocol" was drafted to provide the agency with extended rights, such as an expanded right to take environmental samples—eventually allowing the agency further to "detect any undeclared nuclear material or activities in the [s]tate as a whole" (IAEA 2022a). To date, 142 states have concluded an Additional Protocol with the IAEA, and the IAEA's goal is universalization of comprehensive safeguards (cf. Davenport 2024). For nuclear weapon states, Voluntary Offer Agreements (VOA) allow the agency to inspect civilian fissile materials and facilities (cf. Davenport 2024).

In addition to these obligations arising from the NPT and agreements with the IAEA, states that forego ambitions for an indigenous nuclear weapons program due

[14] https://www.ucsusa.org/resources/fissile-materials-basics.

to domestic opposition, concerns over diplomatic repercussions, or their international obligation. For many states, the potential political, economic, and social costs of developing or acquiring a nuclear arsenal outweigh the perceived security benefits. States may also assess that they do not face an existential threat necessitating nuclear weapons, or that their security can be sufficiently ensured through other means, such as strong conventional forces or international alliances. In some cases, the decision to forgo the development of nuclear weapons is also shaped by their participation in extended nuclear deterrence arrangements, whereby they rely on the so-called "nuclear umbrella" of an allied nuclear power. This reliance on allies' nuclear weapons capabilities can provide a sense of security without the need for an independent nuclear arsenal (Erästö 2023).

After 1945, the United States pioneered the stationing of nuclear weapons on foreign soil, a move soon followed by the Soviet Union and the United Kingdom. By the mid-1950s, these major nuclear powers had established extensive foreign stationing practices, driven by deterrence strategies, nonproliferation goals, and perceived geographic necessities. Geographic proximity was particularly essential early in the Cold War due to limited long-range missile technology, necessitating closer positioning of nuclear weapons to potential targets. Additionally, stationing weapons in states like Italy and Germany helped prevent these countries from developing their own nuclear arsenals, balancing security commitments with nonproliferation aims (Fuhrmann & Sechser 2014).

At the height of the Cold War, estimates suggest that over 20 states hosted foreign nuclear weapons, sometimes without their explicit knowledge. The United States had over 7,000 nuclear weapons stationed abroad, primarily in Europe and Asia, while the Soviet Union deployed around 800 in satellite states (Ibid.). With the end of the Cold War, many of these arrangements were dismantled due to high costs, strategic shifts, and disarmament efforts. Countries like Canada and Greece withdrew from these agreements, citing political and security concerns (Erästö 2023).

NATO's nuclear sharing is the only existing institutional framework for hosting foreign nuclear weapons. This arrangement allows non-nuclear NATO members to host US nuclear weapons while command and control as well as launch authority remain with the United States. Currently, Belgium, Germany, Italy, the Netherlands, and Turkey host US nuclear weapons, with ongoing modernization efforts (Kristensen et al. 2023). NATO's Art. 5 and nuclear sharing arrangements are interconnected, as the former guarantees the alliance's collective defense commitment, potentially including nuclear retaliation (NATO 2022), while the latter enhances deterrence by involving non-nuclear allies in the planning and possible delivery of US nuclear weapons. This, in turn, bolsters both the credibility and unity of the alliance's response to an armed attack.

Recently, Belarus has agreed to host Russian nuclear weapons, marking the first instance of such deployment outside Russia since the end of the Cold War (Kristensen and Korda 2023). This development has raised concerns about a potential resurgence of an arms race in Europe and reignited debates regarding the legality of foreign nuclear stationing under the NPT Art. I and II (UN Press 2023).

Moreover, states that reject nuclear weapons often support international initiatives against nuclear weapons such as the Treaty on the Prohibition of Nuclear Weapons (TPNW). This treaty, which entered into force on January 22, 2021, outlaws the development, testing, possession, and use of nuclear weapons, reinforcing global norms against nuclear armament. By endorsing or ratifying this treaty, non-nuclear weapon states affirm their commitment to disarmament and contribute to a collective effort to mitigate nuclear risks and enhance global security (Müller and Wunderlich 2020). As of March 2025, four years after its entry into force, 94 states have signed, and 73 states have ratified the TPNW.[15]

Additionally, the norm against the use of nuclear weapons, the "nuclear taboo", plays a critical role in shaping these decisions. States adhering to this taboo view nuclear weapons use as morally unacceptable and strategically destabilizing. Their commitment to this norm thereby helps maintain international peace and stability, reflecting a broad-based ethical stance against the proliferation and use of nuclear weapons (Tannenwald 2007).

Another factor influencing decision-making on nuclear weapons is risk: the risk of escalation and risks of errors, miscalculations, and unintended calculations. Since 1945, the world has been at the brink of accidental nuclear war on several occasions.

While the Cold War saw many crises where nuclear use was threatened (Sechser and Fuhrmann 2017), the most severe nuclear crisis was the Cuban Missile Crisis of 1962. Tensions escalated when the US discovered that the Soviet Union, under Nikita Krushchev, had begun constructing missile sites and deploying medium- and intermediate-range ballistic missiles in Cuba to strengthen its ties with the island nation. To prevent further shipment of missiles, US President John F. Kennedy decided to install a maritime blockade of Cuba on October 22, 1962, leading the two sides to the brink of nuclear war. Khrushchev capitulated six days later, and the Soviet missiles were removed from Cuba (cf. Burr and Kimball 2022).

On November 9, 1979, a malfunction at the North American Aerospace Defense Command (NORAD) led to a false identification of a Soviet missile attack, nearly triggering a US nuclear response (cf. Barrett 2016). Similarly, on September 26, 1983, Soviet officer Stanislav Petrov prevented disaster by recognizing a false alarm in the Soviet system, avoiding a mistaken retaliation of an imminent US nuclear attack. Both incidents underscore the crucial role of human judgment in averting nuclear catastrophe. In November 1983, the NATO exercise "Able Archer 83" was mistakenly perceived by the Soviet Union as a potential nuclear first strike, escalating tensions to perilous levels before simmering down through diplomatic engagement (cf. Fraise and Egeland 2023).

For the years between 1950 and 1988, Gregory and Edwards (1989) catalog a range of significant incidents and accidents involving bombers, submarines, and nuclear missiles that were dropped, collided, or otherwise involved in dangerous and potentially catastrophic situations. These occurrences highlight the substantial risks associated with managing and operating nuclear weapons systems, with many details of these incidents still shrouded in secrecy.

[15] https://www.icanw.org/signature_and_ratification_status.

In 1995, the Norwegian Rocket Incident nearly triggered a nuclear conflict when Russia misidentified a scientific rocket launch conducted by the United States and Norway as a missile attack before the falsely declared nuclear device landed in the Barents Sea, disproving an imminent nuclear attack (cf. Barrett 2016).

Such incidents have become fewer since improved communication, enhanced verification mechanisms, and more robust command and control systems help mitigate the dangers of technical failure or human error. However, risks remain, as last seen in the 2018 Hawaii false missile alert (cf. CNN 2018), the 2019 Pulwama crisis between India and Pakistan (cf. Yusuf 2019), and ongoing nuclear threats and coercion attempts in the context of the Russian war of aggression against Ukraine (cf. Horovitz and Arndt 2024; Arndt and Horovitz 2023).

6.2.1.4 Consequences of the Pursuit of Nuclear Weapons

Any decision to pursue nuclear weapons involves a complex balance of risks and rewards. States that seek to develop nuclear weapons often face significant challenges. They may encounter technology denial and international sanctions, which aim to impede their nuclear ambitions (Abraham 2010). In addition to these measures, states might experience further diplomatic coercion or isolation as the international community exerts pressure to curb their nuclear ambitions (Maller 2010). In more severe cases, the threat of military intervention can be employed to prevent or halt nuclear development (Monteiro and Debs 2014). The pursuit of nuclear weapons can thus lead to a range of negative repercussions that undermine a state's international standing and economic stability.

However, acquiring nuclear weapons or signaling such interest can offer substantial advantages. For many states, nuclear armament can enhance their international status and provide considerable leverage in global negotiations. Nuclear-armed states are often perceived to enjoy increased diplomatic influence and, importantly, greater security through deterrence (see Sect. 2.1.2). Some states engage in nuclear "hedging," i.e., maintaining the technical capability and infrastructure to develop nuclear weapons without formally pursuing them. This strategy allows these states to benefit from the political leverage associated with having latent nuclear capabilities, while avoiding the direct repercussions of full-scale nuclear development (Volpe 2023).

6.2.2 From Splitting the Atom to Bombing Japan (1938–1945)

The historical context and political motivations for developing nuclear weapons in the 1930s and early 1940s were profoundly influenced by both geopolitical tensions and scientific discoveries, with vastly differing national approaches and conditions.

In the 1930s, European scientists made significant advances in nuclear physics. The research conducted by Austrian physicist Lise Meitner, along with German chemists Otto Hahn and Fritz Strassmann, led to the discovery of nuclear fission in 1938 which paved the way for the development of nuclear weapons (Sime 1996). Considering the impending World War II (WW II) and the ambitions of the National Socialist regime in Germany, the potential of nuclear weapons was deemed of great interest by several states at the time. The German Uranium Project, also known as the Uranverein (uranium society), was initiated in 1939 to investigate the feasibility of using nuclear fission for military purposes. Under the leadership of physicists such as Werner Heisenberg and Kurt Diebner, the development of a functional nuclear reactor and research into nuclear weapons began. Despite these efforts, the Hitler regime failed to develop an operational nuclear weapon. Contributing factors included resource shortages, strategic missteps, and Allied bombing of infrastructure (Grunden et al. 2005).

The fear of the rise of fascism in Europe and the threat posed by National Socialist Germany prompted the US to initiate its own nuclear weapons program.[16] In August 1939, President Franklin D. Roosevelt and his advisors received a letter from Albert Einstein, with the support of Leo Szilard, warning of the potential dangers of a German nuclear weapons program (cf. Einstein 1939). The letter recommended a rapid increase in research funding and the beginning of uranium mining in the Belgian-colonized Congo[17] to circumvent a potential German nuclear weapon monopoly. Consequently, the Manhattan Project was established in 1942 under the direction of General Leslie Groves and scientific director Robert J. Oppenheimer, with the collaboration of scientists who had fled Europe. This top-secret initiative was aimed at developing a functional nuclear weapon first. The prospect of a weapon of such destructive power promised not only military superiority but also was envisioned to swiftly end WW II as well as secure a dominant role in the post-war order. The project utilized immense financial, material, and human resources, culminating in the first successful nuclear test in July 1945 in the desert of New Mexico and the bombings of Hiroshima and Nagasaki in August 1945 (Pyle 2013). Shaped by the experiences of both World Wars, the great powers envisioned to possess the "ultimate weapon" to prevent a recurrence of the devastating war experiences and to secure their preeminent position in the global order. With the beginning of the first nuclear age, the nuclear arms race was on (Karlsch and Zeman 2008).

[16] Refer to Chapter 11 of this book for more details on the US development efforts.

[17] Due to the intensified exploration for natural resources in occupied, colonized, and indigenous territories, Einstein surmised that, alongside regions in Canada and the former Czechoslovakia, there were substantial uranium deposits, particularly in Congo.

6.2.3 *The Race is on: Proliferation and Arms Racing During the Cold War*

The Soviet Union stepped up the efforts to develop its own nuclear weapons after 1945 and tested its first nuclear device on August 29, 1949, at the Semipalatinsk testing site (situated in present-day Kazakhstan). The test, codenamed "First Lightning" by the Soviets and "Joe-1" by the US, involved a 22 kT plutonium device. While the development and test were veiled in secrecy per se, President Truman publicly announced the end of the US nuclear hegemony on September 23, 1949 (Herken 1980).

The Soviet Union developed its nuclear weapons program primarily because it recognized the necessity of nuclear armament to restore and maintain a strategic balance with the nuclear-armed USA. For Soviet leader Joseph Stalin, who had initially shown little interest in developing nuclear weapons, the bombings of Hiroshima and Nagasaki underscored the urgency of countering the US nuclear monopoly. This shift in perspective was driven by the perception of an existential threat, emphasizing the need to secure national defense and ensure the survival of the state (Karlsch and Zeman 2008). In contrast to the Manhattan Project, the Soviet Union had to develop its program largely independently and under immense pressure. Soviet spies at the Manhattan Project played a crucial role in the 1940s, enabling the timely development of their nuclear weapons (Futter 2021).

Throughout the Cold War, the arms race between the United States and the Soviet Union became a defining feature. Both superpowers relentlessly competed to expand their nuclear arsenals, striving for nuclear superiority or at least parity. This intense rivalry led to the development and deployment of a vast array of nuclear weapons, including intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs), and strategic bombers (Burr and Rosenberg 2010). This horizontal proliferation and diversification of arsenals peaked in the 1980s, when the combined nuclear arsenals of the two superpowers exceeded 60,000 warheads (Fig. 6.2). The doctrine of Mutually Assured Destruction (MAD) underpinned this arms race, asserting that the sheer scale of destructive power held by both sides would deter either from launching a first strike, as it would result in their own annihilation (Wohlstetter 1958).

6.2.3.1 Uranium Mining as a Prerequisite of Nuclear Weapons Development

For both the US and the Soviet Union, and any other nuclear-armed state, the production of nuclear weapons inevitably requires uranium, making uranium mining an integral part of any nuclear armament process. Although uranium is existent in various regions across the world, exploration and subsequent extraction have primarily been concentrated in territories that were (formerly) occupied, colonized, or inhabited by Indigenous communities (cf. Biswas 2021). During the entire Cold War period,

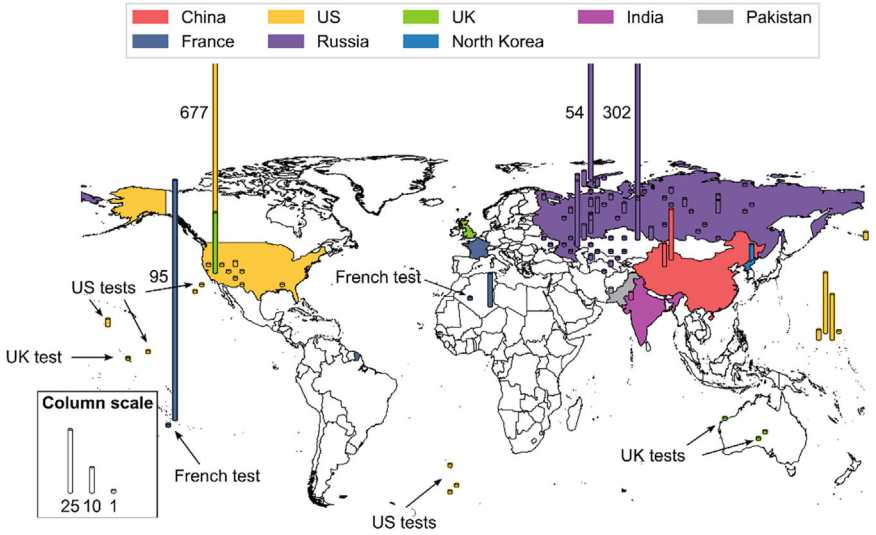


Fig. 6.1 Locations and number of global nuclear weapons tests. *Note* The color indicates the state that conducted the nuclear weapons tests, and the location is shown at the bottom of the bar (nearby locations have been clustered into one column). The height of the bar indicates the number of weapons tests. For large numbers of nuclear weapon test occurrences, the number to the left of the bar indicates the precise number. *Source* Own depiction with data taken from Yang et al. (2003), Johnston (2008), and Delbridge et al. (2023)

African states supplied 20–50% of the annual uranium supply to nuclear-armed states. One of the most important uranium suppliers for the US, besides Canada and indigenous uranium deposits, was the Shinkolobwe mine in the Haut-Katanga region of the Democratic Republic of Congo, a then Belgian colony.[18]

To gain and maintain parity with the US, the Soviet Union was urgently in need of large amounts of uranium for its nuclear weapons production, and significant effort was spent to close the uranium gap (Schütterle 2010). Domestic uranium deposits[19] and those in its Eastern European satellite states, especially in Czechoslovakia and the German Democratic Republic (GDR), were exploited. As early as the summer of 1945, military-led exploration expeditions for uranium ore were ordered and carried out. Uranium was first discovered on the Czechoslovak side of the Ore Mountains, and mining began immediately, using mainly political prisoners in the process (Ibid.). When the Soviet Union also detected uranium deposits in the GDR, extensive measures were implemented to extract it as quickly as possible. Between 1946 and 1990, uranium was mined by the company Wismut in Thuringia and Saxony,

[18] There has been no acknowledgement, let alone compensation or sustainable remediation measures, for the health consequences of radiation exposure, water pollution, and environmental damage caused by uranium mining (cf. Hecht 2012; Winde et al. 2017).

[19] The uranium deposits within the Soviet Union predominantly originated from regions in present-day Kazakhstan, Uzbekistan, Ukraine, and Tajikistan.

making the GDR and Wismut the fourth largest uranium producer in the world after the Soviet Union, the US, and Canada.[20]

6.2.3.2 The Role of Nuclear Testing in the Cold War Arms Race

Apart from mining, testing is another important component of the cold war arms race. States conduct nuclear tests for two purposes: First, to determine the performance and effects of nuclear devices under different conditions, and second, for nuclear signaling to either prove to the world that a state has managed to develop nuclear weapons or continued capability for potential use by an already nuclear-armed state. Nuclear testing is the defining criterion for nuclear weapon states under NPT Art. IX, Para. 3. The US and the Soviet Union continuously embarked on a qualitative and quantitative arms race, including the development of the hydrogen bomb, which the Soviet Union first tested in August 1953 (Wellerstein and Geist 2017). Both also began their extensive series of nuclear tests, with as many as 178 yearly tests in 1962.

Since 1945, more than 2000 nuclear weapons tests have been conducted, most of them by the US (1030), followed by the Soviet Union/Russia (715), France (210), the UK (45), China (45), North Korea (6), India (3), and Pakistan (2). The last nuclear weapon test (as of September 2025) was conducted by North Korea in 2017, but work on computer simulations of nuclear weapons tests (US Department of State 2017) and subcritical tests (NNSA 2024) continues. Noteworthy is also recent research on inertial confinement fusion, a process to initiate nuclear fusion reactions, which is not mainly conducted to gain insights into nuclear fusion for power generation but rather to study material properties relevant for nuclear weapons (cf. Mecklin 2022).

Similar to uranium mining, the history behind nuclear testing is shaped by colonial, patriarchal, and racist power mechanisms within the nuclear order and the associated systemic injustice (Teaiwa 2010; Biswas 2014). The nuclear weapons tests were conducted mainly in (formerly) colonized, peripheral, or indigenous territories (Baldus et al. 2021), including, e.g., in Kazakhstan, Australia, Algeria, the Pacific Island states and indigenous land in the US and China (Fig. 6.1). They have caused intergenerational health damage, displacements, environmental destruction on land and sea, contamination of food and water sources, and the loss of cultural heritage (Hood 2023). The consequences have largely not been addressed, redressed, or reconciled.

6.2.3.3 The Globalization of the Nuclear Arms Race

The UK began its nuclear weapons research during the 1940s, with British scientists directly involved in the Manhattan Project. As close allies, the two countries signed an agreement in 1943 to share all nuclear fission and weapons development research. However, the 1946 US Atomic Energy Act (or McMahon Act) disrupted

[20] https://www.wismut.de/de/wismut_chronik.php.

this collaboration due to fears of Soviet espionage, placing all nuclear research under civilian rather than military supervision and severing the ties between the US and the UK in this regard (Government of the United Kingdom 2006). Consequently, British scientists worked independently on their nuclear weapons program. The UK conducted its inaugural nuclear tests on October 3, 1952, aboard the HMS Plym in a lagoon of the Montebello Islands off the coast of Australia (Tynan 2016).

Shortly after, in November 1952, the US conducted its first thermonuclear test and throughout the 1950s, atmospheric testing continued, contributing to global concerns about radioactive fallout. While France conducted its first nuclear test in 1960, followed by China in 1964, the Partial Test Ban Treaty (PTBT) of 1963 banned nuclear tests in the atmosphere, outer space, and underwater. Verification measures at that time did not allow checks against underground explosions, limiting the treaty's scope. Some argue that this limitation was used to justify continued testing by the nuclear-armed states. Civil society actors and scientists worldwide were engaged in advocating for the PTBT, driven by public concerns about the global consequences of nuclear testing. For instance, traces of radioactive fallout were found in the teeth of infants, highlighting the widespread impact of atmospheric tests (Reiss 1961). By the mid-1960s, the five permanent members of the UN Security Council, the US, the Soviet Union, UK, France, and China (collectively known as the P5) had all become nuclear-armed states. This period marked the peak of nuclear tension, specifically with the Cuban Missile Crisis of 1962 standing as the closest the world came to nuclear war, while close calls and near catastrophes are a constant throughout the nuclear age (See Sect. 6.2.1.3).

During the same period, Israel's nuclear ambitions rose, and it presumably assembled its first nuclear weapon in 1967, although it has never conducted a nuclear weapon test to confirm its capabilities (see Footnote 1). Israel's nuclear program was inaugurated in the 1950s under Prime Minister David Ben-Gurion, with significant assistance from France, which provided a research reactor and plutonium production technology in 1957 (Cohen 1998). By 1958, construction of the Negev Nuclear Research Center near Dimona was underway, officially for civilian purposes (Kristensen and Korda 2022), and Israel acquired 20 tons of heavy water from Norway in 1959, enabling plutonium production by 1966.[21] Israel's policy of "nuclear opacity" or "Animut"—maximal ambiguity regarding its nuclear arsenal—allows it to maintain deterrence without openly declaring itself a nuclear—armed state (Cohen 2010), reflected in statements such as "We won't be the first to introduce nuclear weapons into the Middle East."[22] This was tested during crises such as the Six-Day War in 1967, the Yom Kippur War in 1973, and the Vela Incident in 1979 (Kristensen and Korda 2022), but remains a cornerstone of Israel's nuclear strategy today.[23]

[21] https://nsarchive2.gwu.edu/nukevault/ebb510/

[22] https://www.cfr.org/blog/israels-nuclear-weapons-program-and-lessons-iran.

[23] In 2023, Israel's Heritage Minister Amihai Eliyahu was suspended by Prime Minister Benjamin Netanyahu for suggesting that attacking Gaza with nuclear weapons would be an option in the ongoing conflict following the October 7 attacks by Hamas (Mecklin 2023).

6.2.3.4 Negotiating Stability: The Impact of Nuclear Arms Control and Verification

In parallel with the arms race, significant efforts were made with key treaties negotiated in the realm of arms control to enhance strategic stability and reduce the risk of nuclear conflict between the two superpowers. The Strategic Arms Limitation Talks (SALT) led to the SALT I treaty in 1972 and SALT II in 1979, which placed limits on the number of strategic ballistic missile launchers and provided verification measures to build trust for further deliberations. The Anti-Ballistic Missile (ABM) Treaty of 1972 limited the deployment of missile defense systems, reinforcing the MAD doctrine by ensuring that neither side could fully protect itself from a retaliatory strike. The Intermediate-Range Nuclear Forces (INF) Treaty of 1987 was another landmark agreement which eliminated an entire class of nuclear missiles and helped to reduce tensions in Europe. Despite facing numerous challenges and periods of tension, these arms control efforts played a crucial role in mitigating the dangers of the nuclear arms race and contributed to easing Cold War hostilities by offering avenues for building confidence and trust (Woolf 2023).

Verification efforts are key to any confidence-building measure and in the context of arms control refer to "the process of determining whether parties to an agreement are in compliance with their obligations" (cf. Hinderstein 2010). Typically, verification measures are defined in the treaty text, and the measures combine obligations to provide information (e.g., how many weapons are deployed on delivery systems) and ways for the other party to collect data (e.g., conducting inspections). The goal of verification is to build confidence in the other party's compliance, to be able to detect relevant violations early enough to respond, and thus to deter violations. Verification can also be seen as an opportunity for cooperation and collaboration, as well as being able to demonstrate one's own "good will" and assessing the other's intention for compliance (cf. UNIDIR 2010).

Agreeing on verification measures is challenged by the need to find a balance between requirements for secrecy on the one hand and the needs for transparency on the other. The history of US–Soviet/Russian nuclear arms control provides a good example of how such balance can shift (cf. Müller 1993): Verification of the SALT I treaty simply meant acknowledging that the other party would use "national technical means" (NTM), e.g., satellite imagery, to monitor the other's activities; any access to the other's territory was deemed too intrusive. Notably, the 1964 PTBT did not include a ban on underground testing, in part because the USA and Russia could not agree on verification measures that would be able to detect these tests (cf. Schmalberger 1991).

This changed with time and the accumulation of experience in bilateral arms control. The 1987 INF Treaty, banning, among others, nuclear-capable intermediate-range weapons—included more intrusive and cooperative measures, including permanent monitoring of one INF missile assembly factory for each party, and on-site inspections on Soviet and US territory. This path was continued with the 1991 START Treaty, which provided even more data sharing (including weapons and their

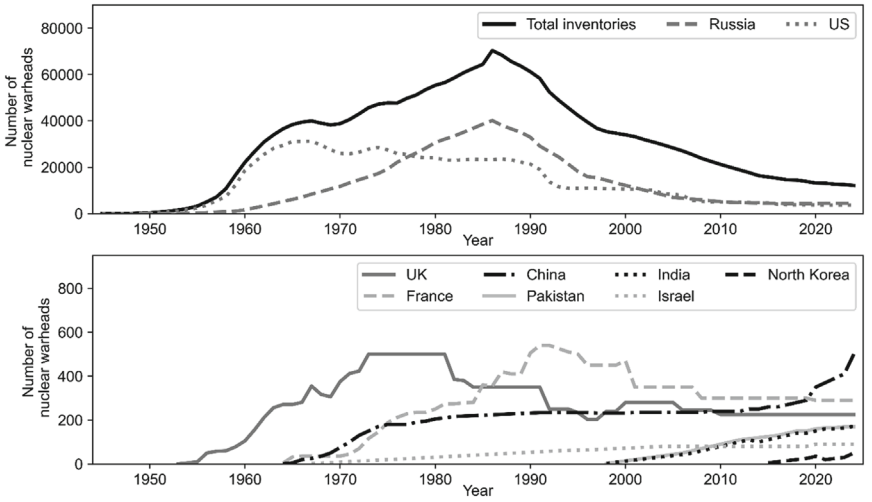


Fig. 6.2 Development of nuclear warheads. *Source* Own depiction with data taken from the Federation of American Scientists[24]

locations) and extensive on-site inspections including random short-notice challenge inspections (cf. Russell 2001).

Finally, the 2010 New START Treaty again reduced the number and complexity of the inspection system; this time, not because of mistrust but in recognition of the change in US-Russian relations (cf. Woolf 2011). The large amount of comprehensive information collected in the past, and along with it diminished concern about the other party's incentive, reduced concerns about breaches of the treaty obligation. Unfortunately, this trend has not continued to the present day: Since the Covid pandemic, Russia has suspended New START inspections, and since 2023, has even suspended its participation in New START (cf. Bugos 2023), which formally expires without the possibility of an extension on February 4, 2026. This will likely leave the US and Russia, but also the world, without an active nuclear arms control treaty for the first time in 50 years, if no successor agreement is negotiated.

6.2.4 The Nuclear Club and Its Current Members

Over time, the landscape of nuclear weapons proliferation has evolved significantly, with several new nations joining the ranks of nuclear-armed states. The so-called "Nuclear Club" now encompasses a broader range of countries (Fig. 6.2 shows the development of current estimates of nuclear weapons arsenals), each with distinct motivations, strategies, capabilities, and arsenal configuration.

[24] https://fas.org/initiative/status-world-nuclear-forces/

India, never having signed the NPT, embarked on its nuclear journey in the 1960s under Prime Minister Jawaharlal Nehru with a stated focus on civilian technology. In this effort, India received significant assistance from the US through the Atoms for Peace program, as well as support from Canada to develop its civilian nuclear infrastructure, enabling the production of plutonium (Mishra 2018). Despite early collaboration with Western nations, India maintained a degree of opacity regarding its nuclear capabilities, conducting its first test in 1974, known as "Smiling Buddha", framing it as a peaceful nuclear explosion (PNE), which cast doubt on the nonproliferation regime and its prospects of curbing further proliferation (O'Mahoney 2020). Officially, India claims to have conducted its first nuclear weapons test in 1998.[25]

While official numbers remain undisclosed, India has since expanded its arsenal, initially focusing on regional deterrence, particularly against Pakistan, and later also shifting its attention also toward long-range missile development with China in mind (Kristensen et al. 2024a). India has maintained a No First Use (NFU) policy since 1994 (Sundaram and Ramana 2018), though it softened this stance in 2003 and again in 2018, allowing for contingencies for nuclear response to attacks involving chemical and biological weapons. India's nuclear arsenal continues to grow and is being modernized, with increasing emphasis on missile systems, though its warheads are reportedly stored separately, with uncertain readiness levels (cf. Kristensen et al. 2024a).

Pakistan's nuclear program, which was begun in the 1950s, was first focused on civilian technology with the acquisition of a heavy-water reactor from Canada (Schalz et al. 2024). However, after India's first nuclear test in 1974, Pakistan intensified its efforts, receiving substantial support from China in the 1980s, including critical technology, expertise, and materials (Munir 2018). Technological collaboration with North Korea, along with possible financial backing from Islamic states like Saudi Arabia and Libya, further accelerated its nuclear development (Ahmed 1999). Abdul Quadeer (A. Q.) Khan, often called the "father of Pakistan's nuclear bomb," played a pivotal role through his work on uranium enrichment at URENCO, a nuclear fuel company in the Netherlands, leveraging his expertise to help Pakistan fulfil its nuclear ambitions (Squassoni 2006).

Pakistan conducted its first nuclear test in 1998, shortly after India's series of tests. Official numbers regarding its arsenal remain undisclosed. It follows a policy of "credible minimum deterrence," limiting the numbers and scenarios of use to defense and deterrence purposes while keeping weapons and delivery systems stored separately. Pakistan has continuously expanded its nuclear capabilities, particularly its delivery systems, and its Strategic Plans Division within the National Command Authority plays a key role in decision-making. Ongoing tensions with India, alongside implicit nuclear threats, remain central to Pakistan's strategic posture, as well as a steady increase in its stockpile of fissile materials.[26]

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[25] https://www.fes.de/ipg/ipg4_98/artmohan.html.

[26] https://www.armscontrol.org/act/2023-10/features/pakistans-evolving-nuclear-doctrine#endnote05.

The last country to join the "Nuclear Club" was North Korea, which also began to pursue its nuclear program in the 1950s, supported initially by the Soviet Union, which provided training and technology for civilian nuclear development (Barannikova 2022). By the 1980s, North Korea had shifted focus toward developing weapons, secretly constructing facilities for plutonium production. In the 1990s, cooperation with Pakistan, particularly through the A.Q. Khan network, enabled North Korea to advance its uranium enrichment capabilities.

North Korea conducted its first nuclear test in 2006, marking its emergence as a nuclear-armed state, though the exact number of warheads remains unknown due to the secretive nature of its program. The regime's nuclear doctrine emphasizes deterrence, aiming to counter perceived threats from the US and South Korea, with a declared willingness to use nuclear weapons if attacked. North Korea has continuously developed its missile systems, now capable of reaching long-range targets, including the US mainland. Despite international sanctions and diplomatic pressure, the country steadily expands its stockpile of fissile materials, leveraging its nuclear capabilities as a central tool for both domestic legitimacy and international bargaining power (Kristensen et al. 2024b).

In summary, today's "Nuclear Club" encompasses nine members with more than 12,100 warheads in their possession,[27] as well as large stockpiles of HEU and separated plutonium that could be used to build even more nuclear weapons. For the US and the UK, relatively recent government declarations are available; for the others, expert assessments provide estimates with uncertainties between 10 and 30% (Fig. 6.3). In 2021, the global military stockpiles of separated plutonium amounted to 140 ± 10 tons, and of HEU to about 1290 ± 125 tons, most of which are held by the US and Russia (International Panel on Fissile Materials 2022).

In addition to these military stockpiles, significant amounts of fissile material potentially available for nuclear weapons production are also present in the civilian programs in form of HEU, as fuel for civilian research reactors or medical isotope production, and separated plutonium, envisaged to be used as nuclear fuel.[28] Today, global civilian stockpiles yield some 317 tons of separated plutonium and 42 tons of HEU overall, most of which are held again by the US and Russia (International Panel on Fissile Materials 2022). Significant civilian stocks of separated plutonium are also held by France and Japan, whose nuclear industries include reprocessing capabilities. For non-nuclear weapon states, such as Japan, civilian stocks are subject to mandatory monitoring under IAEA Safeguards. However, the five nuclear-armed states party to the NPT also provide these civilian stocks to IAEA Safeguards as part of a voluntary agreement with the IAEA.

[27] The total stockpiles of the US and Russia also include warheads that have been selected for dismantlement but are still intact ($\approx$ 1000 for each). Information taken from https://fas.org/initiative/status-world-nuclear-forces/.

[28] For more details on plutonium separation from spent fuel for fuel recycling, see von Hippel and Takubo (2022).

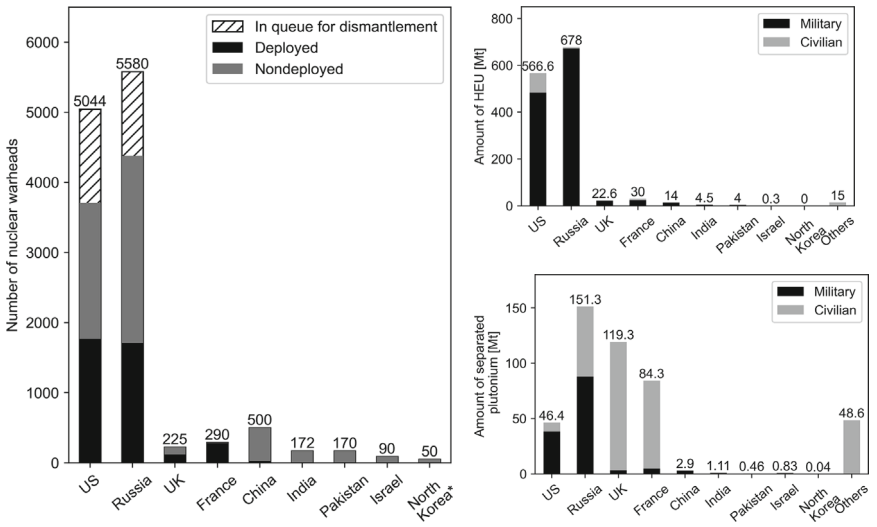


Fig. 6.3 Nuclear warhead and fissile material inventories 2025. *Sources* Bar chart showing (left) nuclear weapon inventories of the nuclear armed states (as of July 2024 taken from the Federation of American Scientists[29]) and (right) fissile material inventories in metric tons (Mt) (as of end of 2020), (International Panel on Fissile Materials 2022) for (top) HEU for civilian (grey) and military (black) purposes and (bottom) separated plutonium

6.3 Nuclear Nonproliferation

Throughout the nuclear age, both nuclear armed and non-nuclear armed states have continuously strived to constrain and hinder proliferation efforts of others. Nuclear nonproliferation, or "the effort to stop the increase in nuclear weapons,"[30] was one of the driving factors of the negotiations of the NPT in the 1960s and has stayed a core principle in the global nuclear order. Yet, motives for nonproliferation differ, ranging from a normative aspiration against the further spread of nuclear weapons to the retention of the power heralded within the possession and not wanting other states to acquire such power.

6.3.1 Nonproliferation Efforts and Treaties

The NPT is the single most important instrument and framework in this regard, prohibiting non-nuclear weapon states from acquiring or developing nuclear weapons, and obliging nuclear weapon states to not disseminate nuclear weapons to others—often referred to as the "grand bargain"—committing all signatories to

[29] https://fas.org/initiative/status-world-nuclear-forces/.

[30] https://dictionary.cambridge.org/de/worterbuch/englisch/nonproliferation.

pursue disarmament negotiations and guaranteeing the right to use nuclear technology for any peaceful purposes.[31] The NPT was, on the one hand, negotiated to slow down, if not hinder, further proliferation, particularly of those states that were known to have nuclear weapons development programs. On the other hand, it was negotiated to foster and institutionalize the norm against proliferation and set an international legal framework to harness efforts towards disarmament.

Another significant aspect of the nonproliferation agenda is the establishment of Nuclear-Weapon-Free Zones (NWFZs). The Treaty of Tlatelolco, signed in 1967, was a pioneering agreement that established the first NWFZ in Latin America and the Caribbean. This treaty was groundbreaking as it prohibited the testing, use, manufacture, production, and acquisition of nuclear weapons within the designated zone. The Treaty of Tlatelolco set a significant precedent for regional nonproliferation efforts and inspired subsequent NWFZ treaties in other parts of the world. By promoting the idea of nuclear weapon-free regions, the treaty contributes to global nonproliferation objectives and enhances regional security and stability. Since then, four more NWFZs have been established, covering vast regions including the South Pacific, Southeast Asia, Africa, and Central Asia. Additionally, Mongolia has declared itself a single-state NWFZ (Kutchesfahani 2019).

The Comprehensive Nuclear-Test-Ban Treaty (CTBT) and the Nuclear Suppliers Group (NSG) are additional frameworks that bolster the nonproliferation regime. The NSG, a group of nuclear supplier countries,[32] seeks to control the export of materials, equipment, and technology that could be used to produce nuclear weapons, thereby ensuring that nuclear trade does not contribute to proliferation (Kimball 2016). The CTBT, although not yet in force, introduces a ban of all nuclear test explosions and thereby surpasses the CTBT and establishes a verification system that is already in place and functioning. To this end, the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO) has established and maintains the International Monitoring System (IMS), which is capable of detecting nuclear explosions with yields larger than 1 kT worldwide, and down to 0.1 kT in many environments (National Academy of Sciences 2002) with globally distributed monitoring stations that record seismic, infrasound, hydroacoustic, and radionuclide data. By combining information from these stations, nuclear explosions could be detected and located. The nuclide stations are of particular value because only they can prove that an explosion was indeed a nuclear explosion; together with atmospheric transport models and weather data, the origin of such nuclides can be deduced, and the type of nuclides allows to distinguish traces from civilian facilities, such as medical isotope production, from nuclear explosions. The IMS enabled the detection and localization of North Korea's six nuclear tests between 2006 and 2017 (CTBTO 2024).

However, the effectiveness of any such nonproliferation efforts can be undermined by discrepancies between declaratory policies and actual practices. While

[31] https://www.armscontrol.org/act/2003-12/features/nuclear-weapon-states-and-grand-bargain.

[32] The NSG was founded in 1974 by the US, the Soviet Union, the UK, France, Germany and Canada and comprises a total of 48 members today.

many states publicly support nonproliferation, their (in-)actions sometimes contradict their stated commitments. For example, all nuclear-armed states continue to modernize and expand their nuclear arsenals and certain non-nuclear-weapon states (e.g., Iran, Libya, and South Africa) have been or are suspected of pursuing nuclear capabilities under the guise of peaceful programs, others strive for nuclear latency. These contradictions highlight the ongoing challenges in achieving comprehensive and consistent nonproliferation. The recent emergence of "loose talk" about nuclear weapons (Meier and Vieluf 2021), further escalatory nuclear rhetoric, and threats are both symptoms and drivers of such damaging dynamics. Nuclear nonproliferation, therefore, remains a complex and multifaceted challenge, and its pursuit continues to require vigilance, cooperation, and the alignment of policies and practices to address the evolving landscape of nuclear risks and threats.

6.3.2 Recent Challenges to the Nonproliferation Regime

The global nonproliferation regime faces multiple challenges. On the one hand, today's world order is characterized by rising global tensions and increasingly nationalist-oriented leaders affecting a plethora of multilateral fora and negotiations. On the other hand, technological progress can lead to new challenges. The following section highlights three examples of recent developments that are discussed as potentially endangering the nonproliferation regime, namely Iran's nuclear ambitions, the AUKUS deal, and the "renaissance" of nuclear energy.

6.3.2.1 Iran's Nuclear Program and the JCPOA

Iran ratified the NPT in 1970, committing to remain a non-nuclear weapon state and accept IAEA safeguards under Article III. In line with this commitment, it signed a Comprehensive Safeguards Agreement (CSA) with the IAEA in 1974 and later signed the Additional Protocol in 2003.[33] Since 2002, Iran's nuclear activities have come under international scrutiny for its potential pursuit of nuclear weapons capabilities. Areas of concern include gas centrifuge uranium enrichment and uranium conversion facilities, both of which could facilitate the production of HEU, and the construction of a heavy-water reactor that could be used to produce plutonium (cf. Kerr 2024).

In 2005, the IAEA's Board of Governors found Iran to be in noncompliance with its CSA, and the case was reported to the UN Security Council in 2006. Despite diplomatic efforts, including engagement from France, Germany, and the UK, the collaboration between Iran and the IAEA remained challenging, with Iran resisting full transparency and cooperation. The UN Security Council issued six resolutions imposing sanctions on Iran to pressure compliance. In 2015, the Joint Comprehensive Plan of Action (JCPoA) was negotiated between Iran, China, France,

[33] https://www.iaea.org/newscenter/news/iran-signs-additional-protocol-nuclear-safeguards.

Germany, Russia, the UK, the US, and the EU as coordinator. This landmark agreement restricted Iran's nuclear program in exchange for sanctions relief, with Iran agreeing to limit its enriched uranium stockpile, dismantle most of its centrifuges, and halt plutonium production activities. The deal was endorsed by UN Security Council Resolution 2231, which set the framework for the implementation of the JCPOA (cf. Kerr 2024).

However, in 2018, the US, under President Donald J. Trump, unilaterally withdrew from the JCPoA, stating that the deal "failed to protect America's national security interests" and alleging that Iran "negotiated in bad faith," used its benefits to fund "terrorist proxies such as Hizballah and Hamas," and preserved its ability to develop nuclear weapons whatsoever.[34] In response, Iran began scaling back its compliance with the agreement, and tensions heightened. By 2019, the IAEA reported that Iran had exceeded JCPoA limits on the number of installed centrifuges, enriched uranium stockpile, and the level of uranium enrichment. Tehran also resumed research and development activities prohibited by the JCPoA. Furthermore, unresolved issues regarding undeclared nuclear material and related activities continue to strain relations between the IAEA and Iran, as the government in Tehran remains unwilling to fully cooperate and ensure transparency (IAEA DG 2024).

The NPT's framework lacks formal procedures to undeniably determine whether a state has violated its obligations, particularly concerning compliance with IAEA safeguards under Article III and the prohibition on acquiring nuclear weapons under Article II. This gap complicates the international community's ability to address Iran's noncompliance effectively (Kerr 2019). After a decline in cooperation and several suspicious findings regarding undeclared and highly-enriched nuclear material and sites linked to potential weaponization activities, the IAEA Board of Governors on June 12, 2025 found Iran in non-compliance with its Safeguards Agreement (IAEA 2025a). The following day, Israel attacked Iranian nuclear infrastructure, later joined by the United States in the declared effort to disrupt if not destroy the potential nuclear weapons program. Iran subsequently seized cooperation with the IAEA, severely restricting inspector access and failing to provide credible explanations for outstanding concerns (Davenport 2025). As a response to Iran's continued non-compliance with its commitments under the JCPoA, the E3 countries (France, Germany, and the UK) initiated the snapback mechanism set forth in paragraph 11 of the UN Security Council Resolution 2231 to reinstate the sanctions due to "significant non-performance" by Iran after a 30-day deadline (UK Government 2025). After threatening to leave the NPT altogether and challenges to the legality of the initiation of the snapback, Iran and the IAEA advanced on the resumption of cooperation in September 2025 (IAEA 2025b). At the time of writing (mid-September 2025), it remains unclear whether negotiations will lead to the reinstatement of sanctions after the deadline on September 27, 2025, or whether Iran will be granted an extension to return to compliance with the JCPoA.

[34] https://trumpwhitehouse.archives.gov/briefings-statements/president-donald-j-trump-ending-united-states-participation-unacceptable-iran-deal/.

6.3.2.2 Non-Nuclear Weapon States Acquiring Nuclear Submarines

As of March 2025, six nuclear-armed states (the P5 and India) are in possession of nuclear submarines. On September 15, 2021, the UK and the US announced that they would provide Australia with at least eight conventionally-armed but nuclear-powered submarines as part of the "enhanced trilateral security partnership" (Carlson 2021). The submarines provided under the agreement, referred to as AUKUS, will contain small nuclear reactors that are likely to be fueled with HEU, similar to the submarines possessed by the UK and the US. These reactors will be built into the hull of the submarine, and they are fueled by the manufacturer for their entire lifetime of about approximately 30 years, after which they will be returned to the manufacturer, i.e., the reactors will not be refueled in Australia.[35]

This type of agreement is unprecedented[36]: for the first time, a non-nuclear weapon state will acquire HEU enriched to weapon-grade levels (~93% enrichment) for military purposes; not for nuclear explosions, but for military submarines. In this case, Article 14 of the CSA signed with the IAEA allows this fissile material to be kept outside the safeguards regime; all that is required is an agreement with the IAEA to assure that the material will not be used to build nuclear weapons and to inform the Agency of the total quantity and composition of the withheld material (Hoppenbrouwers 2024).

This precedent raises proliferation concerns, since it provides weapons-usable material outside the safeguards regime to the non-nuclear weapon state, namely Australia. While it may be plausible that the HEU is virtually inaccessible without cutting the hull of the submarine (the submarines will be delivered with a fully fueled naval reactor without the possibility for refueling in Australia); further concerns go beyond the AUKUS arrangement including fears of other non-nuclear-weapons following suit and even seeking to produce their own HEU for nuclear submarines outside of nuclear safeguard regimes under Article 14. In any case, the agreements concluded with the IAEA in the AUKUS case, for which an 18-month consultation period was set to find a solution with the IAEA, will set a precedent for the future (IAEA 2022b).

6.3.2.3 A Potential Renaissance of Nuclear Energy

At the NPT Review Conference 2022, the state parties could not agree on a final document, fueling the perception of a lack of engagement of nuclear-armed states

[35] https://thebulletin.org/2022/11/aukus-and-nuclear-powered-submarines-lets-all-just-take-a-breath/.

[36] The only other non-nuclear weapon state with a domestic nuclear-powered submarine program is Brazil. This ambition originally dates back to the 1970s, but was only revisited after 2008 and concretized through technical cooperation with France. In comparison with AUKUS, Brazil intends to use indigenous LEU for its submarines and therefore not triggering the same nonproliferation concerns (Stewart 2022).

towards disarmament. The additional lack of support for civilian nuclear technologies for non-nuclear weapon states frustrates some non-nuclear weapon states, who increasingly feel the "grand bargain" of the NPT not being fulfilled (Notte 2024).

Those challenges to the nonproliferation regime coincide with discussions to ramp up the development and use of civilian nuclear technologies. Potential new systems, such as small modular reactors (SMRs) could present new technological and organizational challenges to the nonproliferation regime: new reactor designs would potentially require new approaches within IAEA safeguards, and new reactors or technologies could become simply more abundant and located at more complicated to reach areas—a challenge to the IAEA who already faces the need to monitor an increasing amount of fissile material while being staffed with inadequate resourcing (Rotte 2024). While there is no automatic link between civilian nuclear technologies and nuclear weapons programs, the nuclear renaissance could lead to more states being nuclear latent in the future.[37]

6.4 Nuclear Disarmament

The call for nuclear disarmament is as old as the development of the weapons themselves. With that, however, nuclear disarmament advocates sometimes mean different things: Nuclear disarmament is either referred to as the process of reducing or giving up such weapons, or it is envisioned as the goal of complete disarmament or the absolute absence of nuclear weapons, often referred to as "Global Zero".

6.4.1 Disarmament as a Goal

The debate about whether nuclear weapons make the world safer or less safe has persisted throughout the nuclear age. Central to this discourse are differing perspectives on how security is achieved and for whom it is guaranteed. One common thread in these debates is the consideration of risk, understood as a combination of the probability of an event and the consequences of that event. Proponents of the view that nuclear weapons enhance global security argue that their existence lowers the likelihood of global wars through deterrence, thus reducing the associated risk of nuclear extinction or large-scale conflicts. This perspective emphasizes state security, defined by military power, sovereignty, and territorial integrity (Tickner and Sjoberg 2011).

Conversely, disarmament proponents emphasize that, no matter how small, the probability of nuclear war is never zero. They argue that the catastrophic consequences of any nuclear weapons use make the mere existence of these weapons an

[37] Refer to the reports by Pistner et al. (2021, 2024) for safety and proliferation-related assessments of non-light water and so-called small modular reactors.

unacceptable risk. This view shifts the focus from state to human security, which encompasses individual well-being and considers multiple dimensions of security, including health, environmental sustainability, and economic stability. It critiques structural violence and the injustices that nuclear weapons perpetuate (Tickner and Sjoberg 2011).

While inequality and injustice are deeply intertwined with the issue of nuclear weapons, these factors have not historically held a central place in international relations or scholarly nuclear discourse (Acheson 2016). The prioritization reflects a broader historical emphasis on stability, predictability, and order, overshadowing concerns for justice, thereby sustaining an ahistorical realism that disregards the negative effects of the existence of nuclear weapons (Ray 1999). The concept of nuclear justice, primarily shaped by the testimonies of communities affected by nuclear testing, focuses on lived experiences and the humanitarian consequences of nuclear weapons. From this perspective, any compensation or reparation for the suffering caused cannot focus only on the victims and affected populations must also hold the responsible states accountable and ensure that they take responsibility for their actions (cf. Baldus et al. 2021).

Within an institutional framework, nuclear justice is discussed in regard to the asymmetry between nuclear and non-nuclear weapon states, particularly in the context of the NPT**.** Nuclear technology and responsibility are unequally distributed among the states, especially since only nuclear-armed states can fulfill the disarmament obligations as the sole possessors of these weapons (Biswas 2014; Egeland 2021). Even though most, if not all, states continuously state their commitment towards nuclear disarmament in national and international fora, the nuclear-armed states have a special obligation to suit their actions to these words. The goal to fully reduce the risks associated with nuclear weapons and their use can only be reached by their total elimination through concrete steps and regulations. Work towards a world without nuclear weapons hinges on the engagement, willingness, and commitments of nuclear-armed states to disarm and non-nuclear weapon states to demand for it—with the former lacking both concrete and holistic initiative, particularly beyond the P5 and including all nuclear-armed states.

6.4.2 Disarmament as a Process

The technical process of dismantling nuclear weapons itself is simple: since all nuclear weapon states have extensive knowledge and experience in maintaining their nuclear warheads, dismantling them would be straightforward. Russia and the US have demonstrated their dismantlement capabilities by reducing the large numbers of warheads from the heights of the Cold War. The open question, however, is how the role of nuclear weapons for security can be reduced, or what the conditions for nuclear disarmament would be, so that the desire for security can be met for all states without nuclear weapons, or where nuclear weapons become too much a burden, regarding it risk or costs, compared to their benefit.

A world without nuclear weapons, however, is likely to be different from today's world in which the nuclear order is so deeply embedded in the international system. Extrapolating from today's world to the world in which nuclear disarmament takes place is likely to be uncertain. Within these limits, however, it seems plausible that disarmament would take place within a bi- or multilateral agreement, and that in this context states would be required to take steps to: (1) prove that they are disarming or have already disarmed, and (2) take steps that deny them the possibility to quickly rearm. These two aspects can only be achieved if the disarmament efforts are conducted in a transparent, verifiable, and irreversible manner.

A case of nuclear disarmament can be considered verifiable if the relevant steps towards the disarmed end-state or the end-state itself can be verified properly; how much verification would be sufficient depends strongly on the specific conditions. Particularly in the case of nuclear disarmament, verification is challenged by the fact that the disarming state may still want to keep its nuclear secrets, e.g., the design of warheads. Whether for military-strategic reasons or simply to hide past issues like environmental disasters during weapons production, this interest must be balanced with the need to collect data to assess whether the state is disarming and not cheating. An additional concern is that under the NPT, non-nuclear weapons states are not allowed to see details on the nuclear weapons designs, as this would violate their nonproliferation obligations. To address these challenges, research has been conducted and is ongoing, particularly in the field of measurement techniques to authenticate nuclear warheads without revealing sensitive data (Glaser et al. 2014), or even the development and testing of complete protocols for a warhead dismantlement procedure, from the detachment of the delivery vehicle to the disposal of the separate parts (IPNDV 2020).

In addition to the dismantlement of declared warheads and materials, there is the question of how to ensure that no undeclared warheads or materials remain. Methods for reconstructing the nuclear material production and removal history in a state ("nuclear archaeology") could be useful in this regard, as they would make it possible to assess whether they are consistent with today's declared amount of material. This approach was used by inspectors to verify the disarmament in South Africa.

While there is a rich body of literature on nuclear disarmament verification, the issue of irreversibility has only recently entered the scholarly debate. Irreversible nuclear disarmament can be defined as "a feature/quality of a disarmament or an arms control process that involves limiting the capacity for re-armament, including the possible re-constitution of aspects of weapons program[s]" (Muti et al. 2023, 292). It is generally accepted that *irreversibility* is a spectrum rather than a binary. Nuclear disarmament that would only involve the dismantlement of nuclear warheads, but also include the retention of all nuclear materials and weapons facilities within the state, would possibly be associated with a lower degree of irreversibility, as the state could relatively quickly use this material to rebuild nuclear weapons. At the other end of the spectrum would be a world without any nuclear technology, similar to the world before the invention of the nuclear weapon in 1945. The level of irreversibility required and accepted would depend on the specific case and context.

Recent commentaries have also suggested that a strong degree of irreversibility could be counterproductive, as states could be less willing to join an agreement on nuclear disarmament without a certain degree of flexibility (Rodgers and Williams 2023).

Beyond these technical dimensions, the scholarly debate further emphasizes that there are also political, social, and legal factors to irreversibility, for example, nuclear disarmament embedded in a formal agreement may be considered more irreversible than one based on a unilateral decision. Nuclear disarmament cases that are strongly supported by civil society and embedded in a national identity may also be more irreversible than those where a leadership/elite has taken the decision (which could then be changed simply by another leadership).

The case of South Africa, the only country known to have dismantled a nuclear weapons program, is illustrative. Between 1979 and 1989, South Africa secretly developed a nuclear weapons program, culminating in the creation of six completed and one incomplete nuclear warhead using HEU from its domestic uranium mines and enrichment facilities. In the context of its international isolation and Cuban forces in Angola, these nuclear weapons were part of South Africa's *three-phase* doctrine, in which South Africa would first maintain strategic ambiguity, i.e., neither confirming nor denying the weapons, and possibly later, if South Africa's territory was attacked, revealing their existence to pressure international intervention (cf. Stumpf 1995). However, once the war was over and the apartheid regime dissolved, South Africa sought to participate in the international community and abandon its isolated, sanctioned position, for which joining the NPT was the first step.

In 1991, South Africa secretly dismantled its nuclear weapons and acceded to the NPT, just as IAEA inspectors were verifying South Africa's initial declarations (which included a suspiciously large amount of HEU, for which South Africa was not required to declare its origin or purpose), then-President Frederik Willem de Klerk revealed the past nuclear weapons program (cf. de Klerk 1993). The IAEA's mandate, through a UN resolution, was expanded to include: (1) inspections of the weapons complexes conducted by US nuclear weapons experts, and (2) reconciliation of many historical documents and materials to reconstruct and verify the past production of the HEU to confirm that all material had now been put under IAEA monitoring. This task was extensive, involving more than 12,000 technical documents (cf. Albright and Stricker 2016), and relied on the strong cooperation shown by the South Africans; the latter is likely to be even more important for future disarmament cases, as today's nuclear weapons programs contain much more complex and large fissile material production histories that need to be understood.

While often referred to, particularly since the Russian invasion of Ukraine since February 2022, Ukraine is not a case of disarmament but an example of the influence and importance of international norms and agreements. After the Soviet Union dissolved in December 1991, Ukraine inherited the third-largest nuclear arsenal in the world, with approximately 1,700 nuclear warheads stationed on its territory. However, lacking both the infrastructure to maintain the warheads and the political will to become a nuclear-armed state (see Sect. 2), Ukraine chose a non-nuclear path. With memories of the 1986 Chernobyl nuclear power plant disaster still fresh, Ukraine negotiated away the nuclear arsenal it inherited in exchange for security

assurances in the 1994 Budapest Memorandum. These guarantees, offered by the United States, Russia, and the United Kingdom, affirmed Ukraine's sovereignty and territorial integrity in return for its commitment to nuclear disarmament.[38]

Ukraine never assumed operational control over the warheads and its decision to pursue a non-nuclear status was pivotal in shaping the global nonproliferation regime. However, the effectiveness of the security assurances has been questioned, particularly considering Russia's annexation of Crimea in 2014 and its ongoing war of aggression against Ukraine since February 2022.

Similar to Ukraine, Kazakhstan and Belarus also inherited Soviet nuclear weapons in 1991. Both nations chose to relinquish these arsenals and signed agreements that ensured the removal of nuclear warheads from their territories (cf. Potter and Matthewss 1998). Today, both Kazakhstan and Belarus are non-nuclear weapon states under the NPT. Kazakhstan, in particular, has since become a strong advocate for nuclear disarmament, by hosting negotiations on the CTBT, actively promoting the establishment of a Central Asian Nuclear-Weapon-Free Zone and TPNW[39](cf. NTI 2020; Nuclear Weapons Ban Monitor 2023).

6.5 Conclusions and Outlook

This chapter gives an introduction to the multifaceted dynamics of nuclear weapons, from their development and proliferation to efforts aimed at nonproliferation and disarmament. It traces the historical and political conditions that have shaped the global nuclear landscape, beginning with the scientific discovery of nuclear fission and the subsequent development of nuclear weapons during WW II, through the Cold War arms race, to the current complexities of the nuclear order.

Nuclear weapons have remained central to international relations, as demonstrated by the enduring dominance of nuclear deterrence strategies and failure to address and redress past harm. The possession of nuclear weapons has granted states unique forms of power, not only in terms of deterrence and defense, but also in geopolitical bargaining. At the same time, nuclear proliferation has been a major concern, as an increasing number of states have either acquired nuclear weapons or developed the technical capacity to do so. A complex interplay between motivations—including security concerns and symbolic power—drives states' decisions to acquire or forgo nuclear weapons.

The future of disarmament is uncertain, but disarmament remains a critical goal for many actors in international politics. Despite the complexity of the current geopolitical landscape, opportunities for new agreements and initiatives may arise, especially with the involvement of emerging powers and non-state actors. Moreover,

[38] https://www.armscontrol.org/act/2014-12/features/looking-back-ukraines-nuclear-predicament-and-nonproliferation-regime#note2.

[39] http://www.nti.org/education-center/treaties-and-regimes/central-asia-nuclear-weapon-free-zone-canwz/; https://banmonitor.org/profiles/kazakhstan.

public opinion and advocacy by non-governmental organizations, civil society, and grassroots movements will continue to play a significant role in driving disarmament efforts, as could be seen with the TPNW. The influence of these actors has historically shaped the discourse on nuclear weapons and will likely push for greater accountability and transparency in nuclear policy.

Technological advancements, on the one hand, offer new tools for verification and monitoring. On the other hand, they bring their own set of challenges: Cyber threats, the modernization of missile systems, and other emerging technologies complicate efforts to control nuclear arsenals and will require the development of sophisticated verification mechanisms to ensure compliance with nonproliferation and disarmament treaties. Simultaneously, such technologies could undermine stability by increasing the risk of miscalculations or accidental launches.

The economic implications of disarmament are another important consideration. For nuclear-armed states, the cost of maintaining an arsenal is substantial, and the financial burden of modernization projects can be overwhelming. At the same time, dismantling nuclear weapons systems involves significant costs, raising questions about the feasibility and economic sustainability of large-scale disarmament efforts.

The fear and fascination associated with nuclear weapons have shaped international politics for decades and will continue to do so for the foreseeable future. With the potential resurgence of the nuclear arms race, paired with climate change developments, overall heightened geopolitical tensions, and a potential future expansion of civilian nuclear infrastructure, more countries will consider their role in the global nuclear order and foster their nuclear latency, their participation in extended nuclear deterrence arrangements, or even consider acquiring or building their own nuclear weapons. While the vision of a world free of nuclear weapons ("Global Zero") is fraught with obstacles, it is not impossible. The future of nuclear disarmament will depend not only on the geopolitical context, but also on the ability to establish new multilateral agreements that account for the roles of emerging powers and non-state actors. Advances in technology, combined with shifting political dynamics and public advocacy, may create new opportunities for disarmament in the coming years. This is already reflected in national and international fora, for which the resolutions voted for in the 79th Session of the UN General Assembly First Committee in November 2024[40] are an example: Alongside reaffirmations, e.g., that achieving a world without nuclear weapons is a common goal shared by the international community, it was decided to support one resolution on "Nuclear War Effects and Scientific Research," effectively launching a two-year study on the effects of nuclear war.[41] Achieving a future where the salience of nuclear weapons is reduced will require sustained international cooperation, innovative verification methods, remediation of human harm, and a re-evaluation of the role that nuclear weapons play in global security. Only then, a world without nuclear weapons will become a reality rather than a distant goal.

[40] https://press.un.org/en/2024/gadis3754.doc.htm.

[41] https://thebulletin.org/2024/11/un-to-conduct-new-study-of-the-broad-impacts-of-nuclear-war-not-all-countries-want-to-know/.

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