Chapter 3: Fusion in the Existing Legal Framework

Chapter 1 has demonstrated that the development of nuclear fusion as a clean and sustainable energy source has applications in nuclear weapons programmes. Chapter 2 has presented the dynamics, content and limitations of the legal framework which tries to prevent the use of civilian nuclear programmes for military purposes. This chapter now analyses how this legal framework applies to fusion and the technology's role in the existing legal framework of non-proliferation and disarmament.

Firstly, the chapter explores the role of fusion within the most important sub-regime in nuclear weapons law, namely the IAEA's verification regime. In that regard, it focuses on the IAEA's Statute, the NPT and safeguards agreements (1). The chapter proceeds to analyse how export control regimes apply to fusion (2). It continues to explore the applicability of further regimes to fusion, including the ITER Agreement, the Euratom Treaty, the TPNW and NWFZ Treaties (3). The chapter concludes with an evaluation of the role of fusion in the broader regime of nuclear weapons law (4). As this chapter will show, there is a gap between the regime's purpose and intent – which is to limit, deter or prevent the use of nuclear technology for nuclear weapons purposes – and its applicability to fusion, despite the technology's applications in nuclear weapons programmes.

1 Fusion in the IAEA's Safeguards Regime

This section explores the applicability of different instruments of the IAEA's safeguards regime to fusion. As will be shown, ambiguity in the application to fusion characterises this framework. This section starts with analysing the role and mandate of the IAEA with regard to fusion (1.1). It proceeds to examine the applicability of the Nuclear Non-Proliferation Treaty (1.2) and of safeguards agreements (1.3) to fusion.

1.1 IAEA and Fusion

As the IAEA is widely regarded as the nuclear watchdog[590], this section explores the role of the IAEA in the development of fusion energy (1.1.1), with a particular focus on its efforts to ensure the peaceful use of fusion (1.1.2).

1.1.1 Fusion and Atoms for Peace and Development

The IAEA represents the most significant international organisation within the nuclear field, with the stated objective of this organisation to "accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world."[591] The IAEA itself promotes itself with the motto "atoms for peace and development."[592]

This broad mandate is wide enough to include fusion into the IAEA's undertakings. While the ordinary meaning of 'atomic energy' may suggest a narrow focus on fission – which is currently the only nuclear process used for energy production – this interpretation is not inherently required by the term itself. Nuclear fusion liberates the same force that is liberated in fission reactors, the strong nuclear force. The release of the strong nuclear force translates into a release of energy – the energy of the atomic nucleus or short atomic energy. In addition, subsequent practise warrants an interpretation to include fusion under the wide scope of Article II of the IAEA Statute. Subsequent practise is part of the interpretational canon of Article 31 of the Vienna Convention on the Law of Treaties (VCLT) in the application of the general rule of treaty interpretation.[593] First and foremost, it is the subsequent practise by States which is relevant for interpreting a treaty provision as it is them that have concluded the treaty and have the power over it. In recent times, States have addressed the topic of fusion during the

590 See Chapter 2, Section 2.2.1.
591 Article II of the IAEA Statute.
592 See for example *Yukiya Amano*, Atoms for Peace and Development: Working Towards the Sustainable Development Goals, IAEA Bulletin 59–1 (2018), 1–1; *Arjan Koning/Ian Swainson/Kalliopi Kanaki et al.*, Physics and IAEA: Atoms for Peace and Development, Nuclear Physics News 33 (2023), 10–14.
593 Article 31 para. 3(b); *International Law Commission*, Draft Conclusion on Subsequent Agreements and Subsequent Practice in Relation to the Interpretation of Treaties, in: United Nations (ed.), Yearbook of the International Law Commission, Volume II, Part Two, New York: United Nations 2018, 23–88, Conclusion 3.

IAEA's General Conference,[594] underlying that they consider the IAEA as the competent international organisation for questions relating to fusion. Similarly, there is no other international organisation where States have raised questions of fusion to a similar extent. Thus, the subsequent practise of the States warrants and extensive interpretation of *atomic energy*.

In addition to States' subsequent practise, subsequent practise by the international organisation itself can be of relevance in interpreting its constituent treaty.[595] An international organisation's subsequent practise can either be seen as subsequent practise by its Member States or as autonomous subsequent practise, depending on the degree of involvement of Member States.[596] While the former is directly covered by Article 31 para. 3(b) VCLT, the latter requires further justification under international law.[597] These justifications include explicit or implied powers granted by the States in the Statute of the international organisation. As the IAEA is charged with the promotion of atomic energy and is equipped with several powers to fulfill this mandate,[598] the Statute explicitly mandates the IAEA to act. As the Statute expects practise from the IAEA, it is justified to take into account the subsequent practise of the Agency in order to interpret the term *atomic energy* in Article II of the Statute.

The IAEA has demonstrated subsequent practise regarding fusion, further supporting the interpretation that the Agency's mandate covers fusion. Since 1960, only three years after its creation, the IAEA is the publisher of the academic journal *Nuclear Fusion*, which is one of the leading scientific publications in the field of plasma physics and fusion research. In addition, the IAEA hosts several conferences, workshops and other events with relation to fusion, including the biannual Fusion Energy Conference, which it has hosted since 1961. Moreover, since 2023, the IAEA has been publishing its World Fusion Outlook annually,[599] in which the international organisa-

594 See for example the Statements during the 68th General Meeting by Japan in GC(68)/OR.1 para. 31; Italy in GC(68)/OR.2 para. 114; Spain in GC(68)/OR.3 para. 50 and Australia in GC(68)/OR.11 para. 21.

595 *International Law Commission* (n 593), Conclusion 12.

596 *Christopher Peters*, Praxis Internationaler Organisationen – Vertragswandel und völkerrechtlicher Ordnungsrahmen, Berlin, Heidelberg: Springer 2016, at 182 ff.

597 An overview of argumentative approaches is given by ibid, at 216 ff.

598 Articles VIII to XII.

599 *International Atomic Energy Agency*, IAEA World Fusion Outlook 2023 – Fusion Energy: Present and Future, Vienna: IAEA 2023; *International Atomic Energy Agency*, IAEA World Fusion Outlook 2024, Vienna: IAEA 2024.

tion displays itself as a "hub for fusion research & development."[600] The documents seek to find fusion's role within several international treaties adopted under the IAEA's auspices and where it acts as depositary.[601] Furthermore, the General Conference, i.e. the body of the IAEA where every Member State is represented, has mandated the Secretariat to analyse the legal, institutional, safety and regulatory dimensions of fusion.[602] In addition, the IAEA has started a process in which it analyses safety aspects of fusion.[603] As States participate in these activities or at least do not object them,[604] the IAEA's subsequent practise also reflects the practise of Member States, further allowing for its consideration under Article 31 (3)(b) VCLT. Consequently, fusion energy is part of the IAEA's broader mandate of promoting the atom for peace and development.

1.1.2 Fusion and the Peaceful Use of the Atom

As it is in nuclear weapons law, where the IAEA's characterisation as *nuclear watchdog* comes from, this section examines how far the IAEA's authority extends with its mandate to ensure the peaceful use of the atom. This mandate is delineated in two articles of the Statute. While Article III.A.5 provides the overarching principles of the IAEA's authority with regard to safeguards, Article XII provides the details of the IAEA's competences and powers.

1.1.2.1 Article III.A.5 of the IAEA Statute

The IAEA's motto of promoting atoms for peace and development are materialised in what the Statute calls "functions" of the Agency and are further described in Article III of the Statute. This article provides for a range of aspects under the broader mandate of atoms for peace and development and specifies the extent of the IAEA's authority.

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600 *International Atomic Energy Agency*, IAEA World Fusion Outlook 2023 (n 599), at 4.

601 Ibid, at 23 ff.

602 Ibid, at 87.

603 IAEA TECDOC Series 2076, Experiences for Consideration in Fusion Power Plant Design Safety and Safety Assessment.

604 On the role of *acquiescence* of States in interpreting an international organisation's constitutive treaty *Anne Peters*, Das Gründungsdokument internationaler Organisationen als Verfassungsvertrag, Zeitschrift für öffentliches Recht 68 (2013), 1–57, at 48.

With regard to safeguards, according to Article III.A.5 of its Statute, the IAEA has the authority

> *to establish and administer safeguards designed to ensure that special fissionable and other materials, services, equipment, facilities, and information made available by the Agency or at its request […] are not used in such a ways as to further any military purposes; and to apply safeguards, at the request of the parties, to any bilateral or multilateral arrangement, or at the request of a State, to any of that State's activities in the field of atomic energy.*

Or in short terms, the IAEA has the authority to apply safeguards in two circumstances: Firstly, if the IAEA functions as a supplier of nuclear material, equipment or technology similar to Euratom; and secondly, if States request the IAEA to administer safeguards.

Despite the fact that the IAEA has been envisaged to also function as a global uranium bank and thus as a supplier,[605] the IAEA has never assumed such a role. The IAEA's involvement in this aspect is limited to training and support through its Technical Cooperation Programme,[606] where the IAEA does not provide any material, including material used in fusion. Similarly, the IAEA does not provide States with any detailed information on fusion power plants. Thus, this provision of the IAEA Statute is currently not in use, thus also not applicable to fusion, but this might change in the future. As fusion is covered by the broad mandate of atoms for peace and development, the IAEA would have the powers to act actively in the promotion of fusion, including fusion in its Technical Cooperation Programme or other future support programmes. One such option might be the administration of rare tritium resources as "other materials" in the sense of Article III.A.5 of the Statute, since an external tritium supply is necessary for the first power up of a fusion facility. This provision in the Statute provides the IAEA with the authority to act as a tritium bank in case its Member States request the Agency to take up such a role. Such a scenario then would require the application of safeguards under Article III.A.5.

605 *Elisabeth Röhrlich*, Inspectors for Peace, Baltimore: John Hopkins University Press 2022, at 41.

606 Article III.A.1 of the IAEA Statute. An overview of the IAEA's role in the development of nuclear energy programmes is found at *International Atomic Energy Agency*, Technical Cooperation Report for 2022, GC(67)/INF/5, Vienna: IAEA 2023, at 82 f.

This leaves the second subclause as the only case where the IAEA currently exercises its mandate under Article III.A.5: The request by Parties to apply safeguards following an agreement or a unilateral request. As the Article only requires a request to administer safeguards, this subclause is sufficiently broad to include fusion. In the event that IAEA Member States or an agreement requests the IAEA to administer safeguards on fusionable material and/or fusion facilities, the IAEA has the mandate to do so under Article III.A.5. The most prominent example of an agreement requesting the IAEA to administer safeguards is the NPT, but this also includes the TPNW and NWFZ Treaties. Their application to fusion will be analysed below.

1.1.2.2 Article XII of the IAEA Statute

Once the IAEA applies safeguards following such an agreement or request, Article XII of the Statute defines "rights and responsibilities" of the IAEA. While the application of safeguards on fusion depends on the exact agreement (see below), the Statute already gives some cornerstones to the application of safeguards, with some of these cornerstones applicable to fusion and others not.

Firstly, where the mandate applies to fusion: According to Article XII.A.1, the IAEA has the competence to examine designs of specialised equipment and facilities, including nuclear reactors. The purpose of the paragraph is to ensure that such equipment and facilities "will not further any military purpose" and that it "will permit effective application of safeguards." As the phrasing is not limited to fission, such a design review includes the role of fusion in ensuring that the facility is not supporting military purposes. In addition, according to Article XII.A.4, the IAEA has the right to call for and receive progress reports. As this paragraph does not focus on fission, the IAEA can demand reports on fusionable material and from fusion facilities.

However, the mandate of the IAEA has its limitations. This is due to the fact that many provisions limit themselves to *source or special fissionable material*. The IAEA has the right to require the maintenance and production of records and accounting for *source and special fissionable materials*. In addition, the most important part of IAEA safeguards, sending inspectors into the State territory to access at all times all places and data as well as persons involved in the operations, is limited to account for *source and special fissionable material*. The notion of *source and special fissionable* *material* is defined in Article XX of the IAEA Statute. The next section analyses whether Article XX of the IAEA Statute covers the application of IAEA safeguards to fusion.

1.1.2.3 Article XX of the IAEA Statute

Article XX of the IAEA Statute defines the key term *source and special fissionable material*.

Source material is defined in Article XX.3 of the IAEA Statute as "uranium containing the mixture of isotopes occurring in nature; uranium depleted in the isotope 235; thorium any of the foregoing in the form of metal, alloy chemical compound, or concentrate; any other material containing one or more of the foregoing in such as the Board of Governors shall from time to time determine; and such other materials as the Board of Governors shall from time to time determine."

Special fissionable material is defined in Article XX.1 of the IAEA Statute as "plutonium-239, uranium-233, uranium enriched in the isotopes 235 or 233, any material containing one or more of the foregoing, and such other fissionable material as the Board of Governors shall from time to time determine." Uranium, thorium and plutonium are atoms that can only undergo fission, not fusion.

Even if one disregards the explicit list of elements, there are other indications why there is no interpretation of *source and special fissionable material* which could include fusionable material. As has been highlighted by both international courts[607] and academia[608], science plays an important role in the interpretation of treaty provisions. In order to determine the ordinary meaning in the sense of the general rule of interpretation, as

607 *International Tribunal for the Law of the Sea*, Advisory Opinion, Request for an Advisory Opinion Submitted by the Commission of Small Island States on Climate Change and International Law, 21 May 2024, Case No. 31; *International Court of Justice*, Whaling in the Antarctic (Australia v. Japan: New Zealand intervening), Judgment, ICJ Reports 2014, p. 226.

608 David Duarte/Pedro Moniz Lopes/Jorge Silva Sampio (eds.), Legal Interpretation and Scientific Knowledge, Heidelberg: Springer 2019. On the increased role of science in international courts, see *Katalin Sulyok*, Science and Judicial Reasoning: The Legitimacy of International Environmental Adjudication, Cambridge: Cambridge University Press 2020.

reflected under customary law[609] and Article 31 para. 1 VCLT, reference to physics is necessary.

The fuels most likely to be used in commercial fusion power plants are tritium and deuterium, with ^6Li also playing a role as it is used to produce tritium within the fusion machine. These materials are neither uranium nor thorium nor plutonium; thus, they are not covered by the definition provided by the IAEA Statute. These materials are lighter than iron. As illustrated in Figure (1) in Chapter 1, there is a clear physical distinction between fusionable and fissionable material. Atoms that are heavier than iron undergo fission, while only those atoms lighter than iron undergo fusion. Each atom can be divided into distinct blocks of either being fissionable or fusionable. Given this clear difference, fusionable material, such as deuterium or tritium, cannot be considered fissionable material. Deuterium and tritium can only undergo nuclear fusion, not fission. Consequently, these materials are not fissionable material. The ordinary meaning in the sense of the general rule of interpretation (Article 31 para. 1 VCLT) is limited to the enumerated material of specific uranium and thorium isotopes.

Other interpretative methods do not allow for an inclusion of fusionable material under the term of fissionable material as well. The purpose of the provision is to prevent the specific dual use nature inherent in fissionable material. As highlighted in Chapter 1, the connection between a fission power plant and a nuclear weapon is close given the physics involved. This is in contrast to fusion, where the material only plays more of a secondary role within a broader nuclear weapons programme. Similarly, the historical application of the treaty provisions is limited to the materials explicitly listed in Article XX, or at least other fissionable materials.

Given the focus on source and special fissionable material and its narrow definition in Article XX, fusionable material is outside the scope of the provisions of the Statute that refer to source or special fissionable material.

609 *International Court of Justice*, Case Concerning the Arbitral Award of 31 July 1989 (Guinea-Bissau v. Senegal), Judgment, ICJ Reports 1991, p. 53, para. 48; *Anthony Aust/Oliver Dörr*, Vienna Convention on the Law of Treaties (1969), in: Anne Peters/Rüdiger Wolfrum (eds.), Max Planck Encyclopedia of Public International Law, Heidelberg, Oxford: Oxford University Press 2023, at paras 14 ff.; *Oliver Dörr*, Article 31, in: Oliver Dörr/Kirsten Schmalenbach (eds.), Vienna Convention on the Law of Treaties – A Commentary, Heidelberg: Springer 2018, 559–616, at paras 6 ff.; *Matthias Herdegen*, Interpretation in International Law, in: Anne Peters/Rüdiger Wolfrum (eds.), Max Planck Encyclopedia of Public International Law, Heidelberg, Oxford: Oxford University Press 2020, at para. 7 with further references. Wherever the VCLT is used for interpretation, the findings presented in this chapter are equally valid under the customary rule.

Despite the use or occurrence of deuterium and tritium in the fission cycle, these materials are not covered by the scope of IAEA safeguards.

This limitation does not mean that inspecting fusion facilities would be outside the IAEA's mandate. Yet, the default safeguarding authority by the IAEA created by the request by States or agreements to apply safeguards would not suffice to apply the same safeguards to fusion as the IAEA currently applies to fission, as this authority is limited to fissionable material. Only if a State or treaty specifically demands the IAEA to apply safeguards to fusion, the IAEA has the authority to extend its safeguarding activities to fusionable material and the fusion fuel cycle.

1.1.3 Summary

The IAEA's mandate to promote atoms for peace and development includes promoting fusion. The IAEA's authority to administer safeguards, however, is constrained by the system's focus on *source and special fissionable material*, not including fusion technology in IAEA safeguards unless another treaty explicitly mandates the IAEA to apply safeguards on fusion technology. Without such an explicit referral by Parties or Treaties, the extent to which safeguards are described in the Statute limits the scope of application of safeguards to fusion to a general level, exempting large parts of the IAEA's verification activities.

1.2 Fusion and the NPT

While the NPT is not a treaty under the auspices of the IAEA, rather a treaty created under the UN regime, the treaty mandates the IAEA to implement measures to verify the compliance of NNWS with the obligation not to acquire nuclear weapons, a possibility opened by Article III.A.5 of the IAEA Statute. This section analyses the extent and limitations to which the NPT applies to fusion.

1.2.1 Article I NPT

Article I NPT allows NWS to possess nuclear weapons. The term *nuclear weapon* is commonly defined, both by academia[610] and jurisprudence[611], as "explosives that derive their destructive force from either fission or fusion of atomic nuclides." The inclusion of fusion weapons within this definition is supported by a historic argument: Research on thermonuclear weapons began as early as in 1949, with numerous tests in the following decade. Thus, following an interpretation according to Articles 31 para. 1 and 32 of the VCLT, a weapon using fusion processes is a nuclear weapon in the sense of the NPT. As nuclear weapons include both fission and fusion driven nuclear weapons, the NPT allows NWS to use nuclear fusion research and reactors for military purposes. Fusion is relevant for both the miniaturisation of nuclear warheads and the increase of the yield for strategic nuclear weapons, thus there is a specific relevance for vertical proliferation. The NPT only prohibits horizontal proliferation, not vertical.[612] Consequently, NWS are permitted by the NPT to utilise fusion processes and fusion research in their nuclear weapons programmes.

1.2.2 Article II NPT

Article II NPT is what makes the NPT the non-proliferation treaty: Non-nuclear weapon States are obliged to maintain their non-nuclear status and are prohibited from receiving the transfer of, manufacturing or any other acquisition of nuclear weapons under any circumstances. The application of this norm to fusion is unambiguous. If a NNWS uses fusion research to

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610 *Stefan Kadelbach*, Nuclear Weapons and Warfare, in: Anne Peters/Rüdiger Wolfrum (eds.), Max Planck Encyclopedia of Public International Law, Heidelberg, Oxford: Oxford University Press 2019; *Stuart Casey-Maslen*, The Impact of the TPNW on the Nuclear Non-Proliferation Regime, in: Jonathan L. Black-Branch/Dieter Fleck (eds.), Nuclear Non-Proliferation in International Law – Volume VI: Nuclear Disarmament and Security at Risk – Legal Challenges in a Shifting Nuclear World, The Hague: T.M.C. Asser Press 2021, 385–409, at 388.

611 *International Court of Justice*, Legality of the Threat and Use of Nuclear Weapons, Advisory Opinion, Reports 1996, p. 226, at para. 35.

612 On the critique of vertical proliferation being outside the NPT, see *Tarja Cronberg*, For Survival, the NPT Has to Be Renegotiated in: European Leadership Network, https://www.europeanleadershipnetwork.org/commentary/for-survival-the-npt-has-to-be-renegotiated/, last accessed 17 July 2025.

develop a nuclear weapon, that State is in violation of its obligations under the NPT.

These considerations are especially true for two of the three above-mentioned proliferation risks. In the event of a fusion facility in a NNWS producing plutonium for use in a weapon, the State is in violation of Article II of the NPT. Similarly, if a NNWS uses inertial confinement research to build a hydrogen bomb, the manufacturing and later possession of that weapon is a violation of Article II of the NPT. Regarding the use of tritium, the role of Article II is not clear. If a NNWS uses tritium produced in a fusion facility to boost a nuclear weapon, the possession of the nuclear weapon itself is the violation of Article II of the NPT. It is debatable if the mere act of boosting an existent weapon constitutes a separate violation of Article II of the NPT, as the original act of acquiring a nuclear weapon already constitutes a violation.

1.2.3 Safeguards: Article III.1 NPT

Article III.1 of the NPT is of fundamental importance to the safeguards system, as it introduces mandatory safeguards for NNWS. Following this article, all NNWS are required to enter into a safeguards agreement with the IAEA. Article III.A.5 of the IAEA's Statute expressly extends the safeguarding authority to any bi- or multilateral arrangement upon request by the relevant Parties. This system aims to prevent the diversion of nuclear energy to nuclear weapons or other nuclear explosive devices.[613] Fusion is of relevance for the non-proliferation framework as it plays a role under both Articles I and II of the NPT. While compliance of NNWS with Article II is ensured by the safeguards system, this section shows that the scope of the NPT's safeguards provision does not extend to fusion.

1.2.3.1 Objective of Article III.1 NPT

Article III.1 of the NPT introduces the connection between the NNWS' obligation not to possess nuclear weapons and the implementation of this obligation by mandating nuclear safeguards. NNWS are required to accept

613 Art. III. 1 of the NPT. The distinction between nuclear weapons and other nuclear explosive devices stems from plans by some States to use nuclear explosions for civilian purposes such as excavation.

the discriminatory nature of the NPT and they have to accept the exercise of authority by the IAEA in verifying the State's compliance with its obligations assumed under the NPT. Given the significance of fusion within Article II NPT, verifying a State's compliance is necessary with regard to fusion.

The objective of NPT safeguards would include fusion. According to Article III.1 cl. 1, the goal of the inspection is the "verification of the fulfilment of [the NNWS's] obligations assumed under this Treaty, with a view of prevention diversion of nuclear energy from peaceful uses to nuclear weapons." It is evident that the NPT does not limit the purpose of its inspections to nuclear fission, rather it looks at *nuclear energy* at its entirety.[614] As argued above, fusion energy is a specific form of nuclear energy, also in the sense of the NPT.

While the objective of Article III.1 would include verifying fusion, the scope of the safeguards required by Article III.1 of the NPT is constrained by two core requirements that must be met in order for safeguards to apply: The presence of *source or special fissionable material* being produced, processed or used in or outside a *principal nuclear facility*. In this section, interpretative methods are applied to show that this article does not cover the application of NPT safeguards to fusion.

1.2.3.2 Source or Special Fissionable Material

Safeguards under the NPT are mainly material-based, meaning that Article III.1 of the NPT mandates safeguards to control the use, amounts and location of this specific kind of material. Notably, unlike other international agreements on nuclear non-proliferation and disarmament, the NPT does not contain a definition of the term *source or special fissionable material*. However, the Statute of the IAEA, as mentioned above, contains such definition of source or special fissionable material.

The question arises whether the interpretation of *fissionable material* of Article XX of the IAEA Statute is identical to *fissionable material* in the sense of the NPT. The first indication of this is the exact same wording. The second indication is the context of the provision. The treaty makes reference to source and special fissionable material in Article III, wherein the two verification mechanisms are introduced: safeguards and export

614 *George Bunn*, Nuclear Safeguards – How Far Can Inspectors Go?, IAEA Bulletin 48–2 (2007), 49–55.

controls. Article III.1 mandates the IAEA to apply its safeguards system in accordance with its Statute, thereby strongly indicating an understanding of fissionable material in the sense of the IAEA Statute. Otherwise, there could be a collision between the required safeguards by the NPT and the IAEA Statute and thus, the treaty would not bring its intended effects. In accordance with Article 31 para. 2 VCLT, the preamble is also relevant in exploring the context of a treaty provision and thus in the application of the general rule of interpretation. According to the preamble of the NPT, the Parties to the Treaty undertake to cooperate in facilitating the application of IAEA safeguards on peaceful nuclear activities. In addition, they express their support to further the application of effectively safeguarding the flow of source and special fissionable material within the framework of the IAEA safeguards system given pre-existing safeguards. Accordingly, the meaning of *fissionable material* in the sense of the NPT is to be interpreted in the sense of Article XX of the IAEA Statute.

The only application of this notion to fusion is in the context of the first proliferation potential mentioned above, i.e. using a fusion reactor to produce nuclear weapons material. If a proliferator uses fusion processes as an intense neutron source to produce plutonium from uranium, the material in question is specifically listed in Article XX.1 of the IAEA Statute. However, as a civilian fusion facility does not customarily handle fissionable material, the IAEA would not apply safeguards to such a facility.

Article III.1 is not applicable to the proliferation potential of the use of tritium. As analysed above, fusionable material cannot be understood as fissionable material under Article XX of the IAEA Statute. Consequently, Article III.1 of the NPT seems to not apply to tritium.

This finding that fusionable material is not covered by the scope of Article III.1 is further supported by statements issued by NPT Member States in the context of the negotiations and ratification. The United States articulated during the NPT negotiations its view that the NPT would not affect thermonuclear fusion technology.[615] Germany made reference to the US statement in its depositary note and emphasised that the treaty "may never be interpreted or applied in such way to hamper or inhibit

615 Statement by United States *Ambassador Goldberg*, Security Assurances and the Nonproliferation of Nuclear Weapons, May 15, 1968, Documents on Disarmament 1968, United States Arms Control And Disarmament Agency (1969), 336–345, p. 344.

research and development in this sphere."[616] Although such interpretative declarations are outside the scope of the VCLT,[617] they can nevertheless be taken into account in interpreting a treaty.[618]

Consequently, Article III.1 of the NPT does not apply to fusionable material and is limited to fissionable material.

1.2.3.3 Principal Nuclear Facility

Secondly, safeguards following Article III.1 apply to source or special fissionable material *in- or outside a principal nuclear facility*, thereby establishing a second requirement for the application of the NPT's safeguards provision. In contrast to *source or special fissionable material*, the term *facility* is not defined by the IAEA Statute.

The context (Article 31 para. 1 VLCT) speaks against the inclusion of fusion facilities under the term *nuclear facility* under the NPT. First, the term is used in the context of source and special fissionable material. As safeguards apply to source and special fissionable material inside and outside a nuclear facility, the NPT assumes a facility, which is part of the fission fuel cycle, as the primary location to find source and special fissionable material. This material, as will be shown below, is referred to as *nuclear material* in subsequent agreements and practice (Article 31 para. 2(b) VCLT). Thus, the term nuclear facility is used in the context of nuclear material, while nuclear material is fissionable material. The context, hence, indicates a limitation to fission facilities.

However, the ordinary meaning does not preclude the application to fusion facilities. Fusion processes are nuclear processes, thus a facility where nuclear fusion takes place can – linguistically and scientifically – be considered a nuclear facility. The purpose of the term supports this finding. The decision to include nuclear facility was to give the IAEA the freedom to develop a safeguards system that does not solely focus on

616 Germany's Depositary Note is available in UN Treaty Series, volume 729, at 267 ff., with a reference to fusion on p. 268.

617 *Malgosia Fitzmaurice*, Treaties, in: Anne Peters/Rüdiger Wolfrum (eds.), Max Planck Encyclopedia of Public International Law, Heidelberg, Oxford: Oxford University Press 2021, at para. 73.

618 Article 4.7.1 of the ILC Guide to Practice on Reservations to Treaties (2011); *D. M. McRae*, The Legal Effect of Interpretative Declarations, British Yearbook of International Law 49 (1979), 155–173, at 169.

nuclear material.[619] While the focus of this article is on material, such material is referenced in relation to a nuclear facility. The combination of material and facility under the NPT has historic reasons. Pre-NPT safeguards under INFCIRC/66 included safeguards for nuclear materials *and* principal nuclear facilities.[620] The language of safeguarding material inside and outside any principal nuclear facility was a compromise to leave it open to the IAEA on how material-focused (meaning safeguards to primarily apply on nuclear material) or facility-focused (meaning safeguards to apply primarily on nuclear facilities) the safeguards system should be.[621] Thus, the purpose of the term "principal nuclear facility" is to extend the IAEA's flexibility in implementing safeguards agreements. Such a flexibility speaks against a narrow interpretation which only focuses on fission facilities. Furthermore, a teleological interpretation,[622] i.e., giving the definition the greatest possible effect in order to ensure the objective of non-proliferation, leads to the conclusion that any facility where nuclear processes occur and which has the capacity to support nuclear weapons programmes should be considered a principal nuclear facility. This includes a fusion facility.

As the application of the general rule of interpretation leaves some ambiguity, recourse to historic arguments may be made (Article 32(a) VCLT). Historic arguments both speak for and against the inclusion of fusion facilities in the definition of a nuclear facility. The IAEA interprets the term to exclude fusion facilities and does not apply safeguards to fusion facilities.[623] As the IAEA is an international organisation that applies a treaty within

619 *Ben Sanders*, IAEA Safeguards: A Short Historical Background, in: David Fischer/Ben Sanders/Lawrence Scheinman/George Bunn (eds.), A New Nuclear Triad: The Non-Proliferation of Nuclear Weapons, International Verification and the International Atomic Energy Agency, Southampton: Mountbatten Centre for International Studies, University of Southampton 1992, 1–13, at 3 ff.

620 INFCIRC/66/Rev.2, at para. 45.

621 *George Bunn*, Does the NPT Require its Non-Nuclear-Weapon Parties to Permit Inspections by the IAEA of Nuclear Activities that have not been Reported to the IAEA?, in: David Fischer/Ben Sanders/Lawrence Scheinman/George Bunn (eds.), A New Nuclear Triad: The Non-Proliferation of Nuclear Weapons, International Verification and the International Atomic Energy Agency, Southampton: Mountbatten Centre for International Studies, University of Southampton 1992, 44–58, at 52.

622 Teleological interpretation is based on the object and purpose as part of Article 31 para. 1 VCLT's canon, *Herdegen* (n 609), at para. 14.

623 *International Atomic Energy Agency*, IAEA World Fusion Outlook 2023 (n 599), at 25.

its mandate, it has the right to interpret a treaty.[624] Such an interpretation stands next to the interpretation of all other actors, including States and international courts.[625]

What speaks historically for an inclusion of fusion facilities under the term of nuclear facility is the fact that fusion and its role in weapons have been known in 1968 when the NPT was concluded. Nuclear fusion is known since the 1930s, even predating the discovery of nuclear fission.[626] Thermonuclear weapons based on fusion research for military purposes have been proposed during the Manhattan Project in the early 1940s.[627] The first thermonuclear explosion took place in 1951.[628] Major research facilities were established in the 1950s and 1960s, such as the Princeton Plasma Physics Laboratory in 1951, the Max-Planck-Institute for Plasma Physics in 1960 or the Culham Centre for Fusion Energy in 1965. In addition, the aforementioned comments by the United States and Germany during the negotiations and ratification process support the finding that the inclusion of fusion facilities has been considered in the negotiations. The lack of a clarification of the meaning of “principal nuclear facility” indicates – also from a historic argument – that fusion facilities are within the scope of this term.

Apart from Germany and the United States, there are no records of States mentioning fusion in the non-proliferation context. Furthermore, there are no records of States requiring the IAEA to apply safeguards to fusion research facilities. In addition, the IAEA does not regularly inspect

624 *Richard K. Gardiner*, Treaty Interpretation, Oxford: Oxford University Press 2015, at 125; *Paul Reuter*, Introduction to the Law of Treaties, London, New York: Kegan Paul International 1995, at 95; *Dörr* (n 609), at 568 f. The ICJ accepted the UN Security Council’s authority to interpret its own resolutions in *International Court of Justice*, Kosovo Unilateral Declaration of Independence, Advisory Opinion, ICJ Reports 404, at 442, para. 94.

625 *Gardiner* (n 624), at 125; *Reuter* (n 624), at 95; *Dörr* (n 609), at 568 f.

626 Fusion has first been described by *Marcus Laurence Elwin Oliphant/Ernest Rutherford*, Experiments on the Transmutation of Elements by Protons, Proceedings of the Royal Society of London. Series A, Containing Papers of a Mathematical and Physical Character 141 (1933), 259–281, while fission was first described by *Otto Hahn/Fritz Strassmann*, Über den Nachweis und das Verhalten der bei der Bestrahlung des Urans mittels Neutronen entstehenden Erdalkalimetalle, Naturwissenschaften 27 (1939), 11–15 and *Lise Meitner/Otto R. Frisch*, Disintegration of Uranium by Neutrons: a New Type of Nuclear Reaction, Nature 143 (1939), 239–240.

627 *Herbert F. York*, The Advisors: Oppenheimer, Teller, and the Superbomb, Stanford: Stanford University Press 1989, at 62.

628 The so-called Ivy Mike weapon exploded on 1 November 1952 during a test conducted by the United States.

fusion research facilities. Fusion has only been relevant in advanced NWS, but in NNWS has been limited to academic research and experiments, not necessitating the attention of the IAEA or other States under the non-proliferation regime. Whether or not the safeguards system will be applied in the future once fusion power plants exist is a discussion that has just recently started. The historical practise indicates that a fusion facility does not fall within the scope of "principal nuclear facility."

Consequently, it remains an open question whether a fusion facility qualifies as a principal nuclear facility within the meaning of Article III.1 of the NPT, as compelling arguments exist on both sides without a predominating position.

1.2.3.4 Summary

While the purpose of safeguards is to verify compliance of NNWS with their obligations not to possess nuclear weapons assumed under Article II NPT, the mandated safeguards regime of Article III.1 of the NPT largely do not include fusion, or is at least ambiguous in its applicability. As the article focuses on *source and special fissionable material*, safeguards under the NPT do not apply on *fusionable material*. While safeguards have nuclear facilities as starting point for its application, it is ambiguous whether a fusion facility would fall under the scope of the provision. Ambiguity remains whether a fusion facility can be considered a *principal nuclear facility*.

1.2.4 Export Controls: Article III.2 NPT

Next to safeguards, export controls are the second verification mechanism of the NPT as mandated by Article III.2 NPT. However, the application of export controls on fusion faces the same obstacle as the safeguards provision: The restriction to *source and special fissionable material*, as set out in the IAEA Statute and Article III.1 NPT. Article III.2 NPT contains the same limitation for the application of export controls. State Parties are under the obligation not to provide source or special fissionable material or equipment or material especially designed or prepared for the processing, use or production of such material, unless that material is subject to safeguards. Export controls are based on *source or special fissionable material* or technology with a direct link to such material. As a consequence, the NPT does not mandate export controls for a fusion fuel cycle.

1.2.5 Summary

The application of the NPT to fusion shows gaps and is in parts ambiguous. NWS are allowed to use fusion technology for their nuclear weapons, while the prohibition for NNWS to use nuclear technology for the development of nuclear weapons extends to both fission and fusion. However, Article III, which introduces the verification mechanisms of safeguards and export controls to ensure the compliance of NNWS, does not apply to a large extent to fusion. Both safeguards and export controls mandated under the NPT limit themselves to *source and special fissionable material* or technology related to such material, thereby excluding its application to fusion.

1.3 Fusion and Safeguards Agreements

This section analyses the applicability of various types of safeguards agreements to fusion. There are two fundamental questions regarding their application to fusion: Firstly, do safeguards apply to fusionable material – especially deuterium, tritium and ^{6}Li? Secondly, do safeguards apply to a fusion facility, regardless of whether the material present is fissionable or fusionable?

To recall, there are different types of safeguards agreements. NNWS under the NPT have Comprehensive Safeguards Agreements (CSAs) in place. The majority of them also have concluded an Additional Protocol (AP). NWS outside the NPT have concluded so-called item-specific safeguards agreements, based on INFCIRC/26 and INFCIRC/66. NWS recognised by the NPT have concluded Voluntary Offer Agreements. In all these cases, safeguards agreements are concluded bilaterally with the IAEA.

1.3.1 Comprehensive Safeguards Agreements

Comprehensive Safeguards Agreements put in place the safeguards that are mandated by Article III.1 of the NPT. Within these agreements, the States specify the rights and privileges of the IAEA with regard to the verification of the non-diversion of nuclear material from civilian to military purposes.

There is a notable difference between the CSAs and the NPT: CSAs use a different wording compared to the NPT's safeguards mandate of Article III.1. These agreements use the term *nuclear material* instead of *source and special fissionable material* and refer to *facilities* instead of *principal nuclear* *facilities*. This section explores whether the use of different wordings allows for the application of CSAs to fusion.

1.3.1.1 Nuclear Material

Wherever obligations of States and procedures are described, the agreement uses the term "nuclear material"[629] or "*nuclear material* subject to safeguards."[630] The ordinary meaning of the term would allow fusionable material to be covered, as fusionable material can undergo nuclear fusion which is a nuclear process. However, paragraph 112 of the CSA refers to the definition of nuclear material in Article XX of the IAEA Statute. As analysed above, it is not possible to include fusionable material within the definition of Article XX of the IAEA Statute. Therefore, the safeguards regime circumscribed by the CSA is limited to fissionable material and does not include fusionable material.

1.3.1.2 Facility

While the CSA does not allow the IAEA to inspect fusionable material, there would still be a benefit if a fusion facility falls under the CSA. One proliferation potential of fusion comes from the technology's capability to transform uranium into plutonium. As both these materials are *source or special fissionable material*, and thus fall under the scope of nuclear material, inspecting fusion facilities for the absence of nuclear material would still be a key measure in addressing at least one of fusion's proliferation potential.

The CSA uses the term *facility* in a general sense, in contrast to the NPT, which refers to *principal nuclear facility*. According to para. 106 of the CSA, a facility is defined as "a reactor, a critical facility, a conversion plant, a fabrication plant, a reprocessing plant, an isotope separation plant or a separate storage installation" or "any location where nuclear material in amounts greater than one effective kilogram is customarily used." This section analyses whether a fusion fuel cycle will include facilities that might be put under one of these elements of the definition, allowing the IAEA to inspect them.

629 See for example paras 4–8, 11–14.
630 Ibid.

Critical Facility

A critical facility is a facility where criticality can be reached, meaning to sustain a chain reaction of fission events.[631] A fusion facility is not a critical facility as criticality is exclusively associated with sustaining a chain reaction of fission events.[632] Fusion does not include chain reactions as, unlike in fission, it is not the previous reaction that induces the following reaction. Conversely, the energy production in fusion is maintained by constant external influence, such as magnetic fields or lasers (depending on the confinement method of the fusion reactor), heat and fuel supply.

Conversion Plant

A conversion plant is a facility where the chemical composition of nuclear material is converted with the purpose for facilitating its use or processing.[633] The IAEA Safeguards Glossary lists the conversion of uranium ore into uranium hexafluoride (UF_6) as an example. Such a conversion is necessary for the enrichment process of fission fuel. Another example is the conversion from UF_6 into uranium dioxide (UO_2), a process used in the fuel production for fission reactors. These processes are specific for fission. In fusion, no enrichment is necessary, thus, there is no chemical conversion similar to fission prior the use of the fuel. Furthermore, since the fuel is simply hydrogen gas (both in magnetic confinement and inertial confinement[634]), there is no conversion necessary for the fuel production. Consequently, the fusion fuel cycle does not include a conversion plant.

Fabrication Plant

A fuel fabrication plant is limited to plants that manufacture fuel elements or other reactor components containing nuclear material.[635] Examples of fuel elements include the fuel rod or fuel pellet elements. In fusion, it depends on the confinement method if one could speak of fuel elements.

631 *International Atomic Energy Agency*, IAEA Safeguards Glossary, Vienna: IAEA 2022, at para. 4.55.

632 See for example ibid, at para. 4.55; *David Hafemeister*, Physics of Societal Issues: Calculations on National Security, Environment, and Energy, Springer 2016, at 8 ff.

633 *International Atomic Energy Agency* (n 631), at para. 4.56.

634 The only difference between magnetic and inertial confinement is that in ICF the gas is inside a spherical shell, see *Garry McCracken/Peter Stott*, Chapter 7 – Inertial-Confinement Fusion, in: Garry McCracken/Peter Stott (eds.), Fusion (Second Edition), Boston: Academic Press 2013, 67–81, at 67.

635 *International Atomic Energy Agency* (n 631), at para. 4.57.

Inertial confinement fusion uses fuel pellets, which contain the fusionable material, and these are manufactured in a dedicated facility. However, as these fusion pellets fabrication plants do not involve the handling of nuclear material in the sense of the CSA, they do not fall under the classification of a fuel fabrication plant. In the case of magnetic confinement fusion, it is even clearer as the fuel is simply gas that is introduced into the fusion device. One could then focus on the plant that produces the fusionable material, e.g. deuterium and tritium. Deuterium is produced in heavy water production plants and is then separated from oxygen through electrolysis. Heavy water plants are only of limited interest under current IAEA safeguards.[636] Tritium will be produced on site of the fusion facility, not requiring a facility on a separate site. As a consequence, the fusion fuel cycle does not include a fabrication plant in the sense of the CSA. Plants to fabricate the blanket for fusion facilities come close to a fabrication plant in fission, however they also do not use nuclear material.

Reprocessing Plan

A reprocessing plant is a facility that undertakes the reprocessing of nuclear material.[637] Reprocessing is the separation of nuclear material from fission products in irradiated nuclear material.[638] While waste from fusion facilities will contain irradiated material, fusion waste will not be treated in conventionally defined reprocessing plants as they do not intend to separate nuclear material from the waste.

Isotope Separation Plant

An isotope separation facility is an enrichment plant.[639] The typical example is a plant in which uranium gets enriched in its isotope U-235. This process is specific to fission and has no relevance for the fusion fuel cycle. However, the definition is not limited to specific isotopes. Fusion requires isotope separation, mainly for ^{6}Li, opening the door for some parts of the fusion fuel cycle to being covered by existing definitions.

636 They are limited to the provision of a description of the scale of operations and only for those States that have ratified the Additional Protocol, Article 2.a.iv and Annex I para. xi Additional Protocol. The Additional Protocol refers to deuterium as "non-nuclear material for reactors." The application of safeguards to heavy water is extremely limited, *Martin Kalinowski*, International Control of Tritium for Nuclear Nonproliferation and Disarmament, Boca Raton: CRC Press 2004, at 195.

637 *International Atomic Energy Agency* (n 631), at para. 4.58.

638 Ibid, at para. 4.22.

639 Ibid, at para. 4.59.

Separate Storage Installation

A separate storage facility is defined as any installation which stores or is specifically designed to store nuclear material generated or to be used by another installation.[640] In the context of fusion, deuterium as material is produced in separate facilities. Tritium is both produced and consumed by the fusion reactor itself. The separation and storage of the tritium takes places on the site of the fusion power plant. An exception might occur for the start-up of a fusion plant. The start-up of a fusion facility requires a certain amount of tritium which might be stored in a separate storage facility. Moreover, given ICF uses specifically produced targets, it is conceivable that the target production will be outsourced from the actual plant installation, thereby necessitating separate storage facilities. However, as the CSA links separate storage facilities to *nuclear material* in the sense of fissionable material, there is no storage facility including nuclear material in the fusion fuel cycle.

Facility where nuclear material of at least one effective kilogram is customarily used

Furthermore, a fusion facility is not a facility where nuclear material of at least one effective kilogram is handled. An effective kilogram is either the weight of the material itself or the weight multiplied by an enrichment factor.[641] An effective kilogram is defined with reference to plutonium and uranium, thus not a material that is used in a fusion facility. Even if one would consider one effective kilogram of tritium or deuterium to equal one kilogram of its material, many fusion facilities would not exceed the threshold of handling one kilogram customarily. Fusion power plants will customarily handle only grams of materials at any given time; kilograms of tritium and deuterium are enough to power a power plant for an entire year or even longer. Due to the constant need of refuelling and the constant production of tritium with the fusion device itself, an effective kilogram is not a suitable order of magnitude for fusion.[642] Consequently, no such facility is part of a fusion fuel cycle.

640 Ibid, at para. 4.60.
641 Para. 104 of INFCIRC/153.
642 *Kalinowski* (n 636), at 130 ff. proposes a significant quantity of one gram for tritium, showing the vast difference of orders of magnitude.

Reactor

The term *reactor* requires interpretation. Scientifically speaking, a reactor is any device where reactions take place. The term *reactor* is also used in the context of fusion to describe a machine that produces a net-energy output.[643] In fission, the production of energy requires a self-sustaining fission reaction, while in fusion this requires that the fusion processes produce more energy than the initiation of the process – mainly heating to hundreds of millions of degrees – and maintaining the fusion reactions require. The ordinary meaning of the term would allow for an inclusion of fusion under the term *reactor*. However, the context indicates that fusion reactors would not be included. A reactor is listed as one of eight subtypes of facilities while all seven others clearly do not include fusion and are focused on a fission fuel cycle. In addition, in light of the objective and purpose defined in para. 1 of INFCIRC/153, which is "in accordance with Article III.1 of the Treaty on the Non-Proliferation of Nuclear Weapons [...] to accept safeguards [...] on all source or special fissionable material in all peaceful nuclear activities", there are strong indications to not include fusion. The CSA sees peaceful nuclear activities as involving fissionable material, indicating that a *reactor* is also a fission reactor. A further indication is the IAEA Safeguards Glossary, which defines a nuclear reactor as any device in which a controlled, self-sustaining fission reaction can be maintained,[644] thus excluding fusion reactors. However, as the wording is wide enough and as will be shown below, the Board of Governors could extend the authority of the IAEA to fusion reactors by broadening the term's interpretation.

1.3.2 Additional Protocol to the CSA

While fusion largely falls outside the scope of the CSA, the Additional Protocol offers some aspects where the existing regime grants the IAEA the authority to apply safeguards to fusion. The Additional Protocol allows for the implementation of some procedures and verification mechanisms in order to verify the absence of nuclear material within fusion facilities, addressing the proliferation concern of breeding nuclear weapons material.

643 See for example *Paul-Henri Rebut*, ITER: The First Experimental Fusion Reactor, Fusion Engineering and Design 30 (1995), 85–118; *Tetsuo Tanabe*, Introduction of a Nuclear Fusion Reactor, in: Tetsuo Tanabe (ed.), Tritium: Fuel of Fusion Reactors, Tokyo: Springer Japan 2017, 3–25.

644 *International Atomic Energy Agency* (n 631), at para. 4.53.

This section analyses the extent to which the AP and its mechanisms, including *complementary access* and *environmental sampling*, applies to fusion.

The Additional Protocol uses mostly the same definitions as the CSA. Article 18(h) of the Model Additional Protocol refers to Article XX of the IAEA Statute in its definition of nuclear material, thus also excluding fusionable material. Similarly, the CSA uses the term "facility" and defines it identically to the CSA in Article 18(i). There is, however, a key difference: In contrast to the CSA, the AP refers explicitly to fission reactors in its Annex.[645] In Annex II, the AP lists equipment which requires reporting of exports and imports according to Article 2.a.(ix) of the AP. There, it lists *complete nuclear reactors* and defines them as "[n]uclear reactors capable of operation so as to maintain a controlled self-sustaining fission chain reaction." In addition, other reactor components and fuels are defined with reference to fission reactors, indicating that a *reactor* is limited to fission reactors. This difference in wording between the Additional Protocol and the CSA further raises doubts regarding the applicability of safeguards to fusion facilities.

In contrast to the focus on facilities, the Additional Protocol extends the IAEA's authority to other locations. The IAEA can access *locations not involving nuclear material*, can demand *complementary access* and conduct *environmental sampling*.

Regarding *locations not involving nuclear material*: According to its Article 2.a.(i), the State has to provide a "general description of and information specifying the location of *nuclear fuel cycle-related research and development* activities not involving *nuclear material* carried out anywhere that are funded, specifically authorized or controlled by, or carried out on behalf of" the State. The explicit exclusion of nuclear material, on the first glance, indicates that activities in fusion need to be reported to the IAEA, especially as fusion would be considered as nuclear research and development. However, the scope of *nuclear fuel cycle-related research and development* is defined in Article 18.a, which also limits research and development on processes related to *nuclear material*, i.e. *source and special fissionable material*, not including fusion.

Nevertheless, the AP includes a provision that allows the IAEA to apply safeguards to fusion to some extent: complementary access. The AP

645 Annex II (List of Specified Equipment and Non-Nuclear Material for the Reporting of Exports and Imports According to Article 2.a.(ix)), at para. 1 of INFCIRC/540(Corrected).

provides the IAEA with the authority to complementary access without focussing on *nuclear material*, a tool allowing the IAEA to access locations outside the regular scope of inspections under the CSA. This provision encompasses the right to access any place on a site, any location identified under Article 2.a.(v)-(viii) or any decommissioned facility or decommissioned location where nuclear material was customarily used (Article 5.a). The locations identified under Article 2.a.(v)-(viii) are uranium mines, concentration plants, locations where source material or small quantities are handled and locations of high-level waste containing plutonium, high enriched uranium or ^{233}U. A site is defined as a delimited area for a facility (Article 18.b), while a fusion facility is currently not considered by the IAEA as a facility in the sense of the CSA or the AP (see above). A fusion facility is also not a location identified under Article 2.a.(v)-(viii), nor is it a location where nuclear material in the sense of the Additional Protocol is customarily used. IAEA inspectors can, however, require complementary access by demanding to verify uranium beds in which tritium is stored. Complementary access can not only help to assure the absence of nuclear material such as uranium, but also the absence of nuclear activities, such as tritium breeding or enrichment of lithium.

In addition, the IAEA can also demand complementary access for environmental sampling, Articles 5.c and 9.Environmental sampling allows the IAEA to detect clandestine nuclear activities. While there was some limited authority already under the CSA,[646] it is only with the adoption of the Additional Protocol that environmental sampling is conducted on a regular basis.[647] Fissile materials leave a characteristic environmental signature, indicating nuclear activities.[648] Consequently, if environmental samples show such a signature in the vicinity of fusion facilities, there would be an indication for a breakout scenario and hint at the production of fissile material in a fusion reactor.

646 *Laura Rockwood*, IAEA Safeguards: Correctness and Completeness of States' Safeguards Declarations, in: International Atomic Energy Agency (ed.), Nuclear Law: The Global Debate, The Hague: T.M.C. Asser Press 2022, 205–222, at 209 f.

647 *David L. Donohue*, Strengthening IAEA Safeguards Through Environmental Sampling and Analysis, Journal of Alloys and Compounds 271–273 (1998), 11–18.

648 *Paula Cable-Dunlap/Lee Trowbridge/Debra Bostick et al.*, Comparison of Active and Passive Environmental Sampling for Safeguards Applications, Journal of Radioanalytical and Nuclear Chemistry 296 (2013), 943–949; *A. Axelsson/D. M. Fischer/M. V. Peńkin*, Use of Data From Environmental Sampling for IAEA Safeguards. Case Study: Uranium With Near-Natural 235U Abundance, Journal of Radioanalytical and Nuclear Chemistry 282 (2009), 725–729.

The Additional Protocol differentiates between *location-specific* environmental sampling, Article 5.c, and *wide-area* environmental sampling, Article 9. Location-specific environmental sampling is permitted in any location specified by the IAEA. Thus, the IAEA has the possibility to select specific locations to carry out inspections in order to ensure that no undeclared nuclear material is present.[649] Such a location would also be a fusion facility, providing the IAEA with possibilities for deploying safeguards inspectors to access fusion facilities or close-by areas to carry out environmental sampling. However, since the IAEA does not have the authority to demand design information, it is difficult for inspectors to decide where exactly in the facility they should take the samples. Furthermore, in cases where the samples cause questions or are inconsistent with the reporting of the State, the IAEA has the right to visually observe the location, carry out radiation detection and measurements as well as "other objective measures", Article 6.d. Thus, location-specific environmental sampling allows the IAEA to address the proliferation concern of producing nuclear weapons material with a fusion facility.

A second tool which allows the IAEA to address this proliferation concern is wide-area environmental sampling. In the event that a State uses a fusion facility to irradiate ^{238}U to produce plutonium for nuclear weapons, the result is a mixture of several isotopes. In order to use that plutonium for nuclear weapons, the material has to be reprocessed at a separate facility, which in turn produces traces in the environment. In such a scenario, the implementation of wide-area environmental sampling increases the level of assurance that no clandestine nuclear weapons programmes supported by fusion exist. The extraction of plutonium from the resulting alloy is a complicated chemical process which requires a plutonium extraction facility. Environmental sampling and atmospheric measurements assist in detecting clandestine plutonium extraction facilities.[650] In these activities, the IAEA can collect environmental samples at a set of locations in order

649 Article 18 (f) AP. On environmental sampling, see *Martin B. Kalinowski/Johann Feichter/Mika Nikkinen et al.*, Environmental Sample Analysis, in: Rudolf Avenhaus/Nicholas Kyriakopoulos/Michel Richard/Gotthard Stein (eds.), Berlin, Heidelberg: Springer 2006, 367–387; *Laura Rockwood*, The IAEA's Strengthened Safeguards System, Journal of Conflict and Security Law 7 (2002), 123–136, at 132 f.

650 *Michael Schoeppner/Alexander Glaser/Mark. E Walker*, Detecting Clandestine Plutonium Separation Activities With Krypton-85 (2015), INMM 56th Annual Meeting Proceedings.

to get a more comprehensive overview over a wide area.[651] What limits the IAEA's authority to conduct wide-area environmental sampling are procedural requirements set out in Article 9 AP, which requires pre-approval by the Board of Governors after consultations with the concerned State. The Board of Governors has never authorized wide-area environmental sampling.

To summarise, the Additional Protocol provides the IAEA with the authority of location-specific environmental sampling accompanied with complementary access to these location under the Additional Protocol and further supported by wide-area environmental sampling to address one proliferation potential associated with fusion: the clandestine production of nuclear weapons material. Other proliferation potentials such as the abundance of tritium or the military dimension of ICF research is not addressed by the Additional Protocol.

1.3.3 Item-Specific Safeguards Agreements

INFCIRC/66, which is an evolution from the original safeguards system contained in INFCIRC/26, forms the basis for item-specific safeguards agreements for State Parties outside the NPT. Item-specific safeguards apply to *nuclear material* in *principal nuclear facilities* in India, Pakistan and Israel. This section analyses the application of these agreements to a fusion fuel cycle.

1.3.3.1 Nuclear Material

Fusion material cannot be considered *nuclear material* under INFCIRC/66 safeguards, albeit a first observation would suggest otherwise.

Safeguards based on INFCIRC/66 predate NPT safeguards and their implementation with CSAs. While the NPT and the IAEA Statute explicitly refer to *source and special fissionable material*, INFCIRC/66 instead uses

651 Article 18 (g) AP. On wide-area environmental sampling, see *Ephraim Asculai*, Verification Revisited: The Nuclear Case, Washington DC: Institute for Science and International Security Press 2002, at 101–111; *Ned A. Wogman*, Prospects for the Introduction of Wide Area Monitoring Using Environmental Sampling for Proliferation Detection, Journal of Radioanalytical and Nuclear Chemistry 296 (2013), 1071–1077.

the broader term *nuclear material* without a definition. The term *nuclear material* is also found in CSAs, however there the agreements define the term. Interpreted in light of Article 31(1) of the VCLT – which considers the ordinary meaning as well as the object and purpose of a treaty – this broader terminology could support an interpretation that includes fusionable material. Further, INFCIRC/66 distinguishes between nuclear material and the two categories of fissionable material – source and special.[652] This differentiation suggests that "nuclear material" may be intended as a broader category, within which fissionable material is only one subset. Such an interpretation could allow for the inclusion of other substances involved in nuclear processes, such as fusionable material.

However, several factors weigh against this broader reading. First, INFCIRC/66 includes exemptions for small quantities of specific materials[653] – plutonium, uranium, and thorium – which all fall under the category of source or special fissionable material.[654] The explicit mention of these substances, and the absence of others, indicates an intention to exhaustively define nuclear material in line with the categories established in the IAEA Statute.

Second, the historical lineage of INFCIRC/66 reinforces this narrow scope. It directly builds on INFCIRC/26, which is cited in its preamble. INFCIRC/26 explicitly defines nuclear material by reference to Article XX of the IAEA Statute, which limits the term to source and special fissionable material. No provision is made for fusionable materials, which remain outside the definitional scope of these foundational instruments.

Taken together, the context, historical evolution, and specific material references in INFCIRC/66 support a restrictive interpretation. Despite the initial appearance of a broader term, the item-specific safeguards under INFCIRC/66 do not extend to fusionable material.

1.3.3.2 Principal Nuclear Facility

Furthermore, item-specific safeguards do not apply to fusion facilities. Firstly, safeguards are limited to declared facilities by the country with such

652 See paras 21–24.
653 See para. 21 of INFCIRC/66.
654 On the application of the CSA to States with a Small Quantities Protocol see: *International Atomic Energy Agency*, Safeguards Implementation Guide for States with Small Quantities Protocols, Vienna: IAEA 2013.

an agreement in place. Neither India, nor Pakistan, nor Israel have any relevant fusion facilities that they could declare under their safeguards agreements concluded in the type of INFCIRC/66. Additionally, INFCIRC/66 itself refers to *principal nuclear facilities*, which is defined in INFCIRC/26 as "reactor facilities, plants for processing special fissionable or irradiated source material, plants for separating the isotopes of uranium or isotopes of plutonium an such other facilities or plants which may be designated by the Board."[655] A reactor facility in turn is also limited to fission reactions.[656] Without the designation of the Board of Governors, a fusion facility would be outside the scope of INFCIRC/26 and INFCIRC/66.

Consequently, item-specific safeguards do not apply to fusion facilities, excluding its application on fusion technology.

1.3.4 Voluntary Offer Agreements

The current Voluntary Offer Agreements (VOAs) – safeguards agreements with NWS recognised by the NPT – do not apply to fusion for three reasons. Firstly, they are limited to source and special fissionable material. Secondly, their application is limited to declared facilities, which do not include a fusion facility. Thirdly, some fusion research institutions in these countries are part of dedicated military programmes, such as the National Ignition Facility in the United States or Laser Mégajoule in France, and are thus excluded, as VOAs are limited to civilian facilities.

1.3.5 Summary

Fusion falls mostly outside the various safeguards agreements. They are either focused on material and technology related to *source and special fissionable material* in fission facilities, or they are explicitly not listed where the agreements only apply to pre-defined facilities. It is only in States that have adopted an Additional Protocol where the IAEA has some authority by demanding complementary access and conducting environmental sampling, partly addressing the proliferation concern of using fusion facilities to produce nuclear weapons material. The proliferation potential of the use

655 Para. 15 of INFCIRC/26.
656 Paras 13 and 14 of INFCIRC/26.

of tritium as well as the risks associated with inertial confinement fusion are outside the scope of any safeguards agreement.

1.4 Summary

Fusion falls under the broader mandate of the IAEA to promote the atom for peace and development. However, when addressing the proliferation potential of fusion, there are significant lacks in the legal framework. The IAEA's safeguards system is focused on *source and special fissionable material*, excluding its application on fusion. While the NPT prohibits NNWS from using fusion in developing nuclear weapons, the mandated verification mechanisms do not apply to fusion technology. As the verification is further specified in safeguards agreements, they also widely do not include fusion given their equal focus on *source and special fissionable material* as well as on fission facilities. The IAEA's authority to address the proliferation potential of fusion is thus limited, with only the Additional Protocol providing a partial solution to this issue by allowing for environmental sampling and complementary access.

2 Export Control Regimes

As analysed in the previous chapter, export controls are the second important verification mechanism next to safeguards. While the NPT does not mandate export controls for fusion technology, this section analyses the application of the existing export control regimes to fusion in order to analyse if export controls limit the non-proliferation potential of fusion. To recall from the last chapter, States have established two nuclear export control fora: the Zangger Committee and the Nuclear Suppliers Group. This section will show that both export control regimes apply to a certain extent to fusion, with the export control lists including material and equipment used within a fusion facility. However, as this section will show, the required procedures limit their application to fusion.

This section firstly explores the scope of the two regimes with regard to fusion (2.1). It then proceeds to apply the regimes both with regard to content (2.2) and procedure (2.3) to fusion.

2.1 Scope of Export Control Groups

The two fora for nuclear export controls are not international organisations, as they do not have a constituent treaty, rather they are intergovernmental groups without their own legal personality.[657]

As analysed in the previous chapter, the two groups have much in common: The content of their Trigger lists and their procedures are quite similar, and there is an overlap in membership. However, the scope of the two groups are different.

Governments established the Zangger Committee with the mission to find a common understanding on the interpretation of the term "equipment and material especially designed or prepared for the processing, use or production of special fissile material" in Article III.2 NPT. As the Zangger Committee is not an international organisation and does not possess a separate legal personality, the Committee refers to a "mission" rather than a "mandate."[658] The export of such equipment and material is only allowed under the NPT, if the source or special fissionable material is subject to safeguards under Article III.1 NPT. This is where the direct link between the proliferation potential of fission and the dual-use characteristics becomes apparent. Export controls seek to limit proliferation by ensuring that auxiliary equipment and other materials that could be used to support a nuclear weapons programme are used only for peaceful purposes. As shown above, fusion is outside the scope of Article III.2 NPT and the NPT's mandate on export controls. The mission and *raison d'être* of the Zangger Committee therefore indicate that the Zangger regime is not applicable to fusion. However, as the regime applies once an item is on its list, the regime is applicable even in cases where material or equipment relevant for fusion is listed.

Unlike the Zangger Committee, the aim pursued by governments participating in the NSG is not limited to the common goal of finding an interpretation of a provision of the NPT. As the NSG is not an international organisation or a body thereof and does not possess any legal personality, but rather acts as a discussion forum, the NSG uses the term "aim" rather

657 On the definition of an international organisation, see Article 2(a) of the ILC's Draft Articles on the Responsibility of International Organizations. On the ILC's definition, see *Stephen Bouwhuis*, The International Law Commission's Definition of International Organizations, International Organizations Law Review 9 (2012), 451–465.

658 https://zanggercommittee.org/our-mission.html, last accessed 6 June 2025.

than "mandate." According to its self-understanding, the NSG "is a group of nuclear supplier countries of nuclear material, equipment and technology and nuclear-related dual-use equipment, material, software and related technology, which seek to contribute to the non-proliferation of nuclear weapons."[659] The group further describes the aim of its guidelines as "to ensure that nuclear trade for peaceful purposes does not contribute to the proliferation of nuclear weapons and other nuclear explosive devices."[660] The NSG's purpose is thus much broader than that of the Zangger Committee. As the focus of the NSG is on preventing the proliferation of nuclear weapons by establishing rules for nuclear trade, there is not an exclusive focus on fission as there is in the Zangger Committee. As fusion technology might play an auxiliary role in nuclear weapons, the aim of the NSG includes fusion.

2.2 Material Application of the Guidelines

The Trigger Lists of the NSG and the Zangger Committee are specifically designed to address the proliferation potential of the fuel of fission power plants and places them under export controls: source and special fissionable material as defined in Article XX of the IAEA Statute and related material and equipment.[661] Fissionable material is not intended to be used in a fusion facility. Thus, fusion is not covered by the main provision of the NSG and Zangger Trigger Lists. However, the Trigger Lists also include both deuterium (exceeding 200 kg per year)[662] and plants for the production of deuterium;[663] a material which play an important role in fusion technology. However, as 200 kg of deuterium will be sufficient to operate a single fusion power plant for several years, export controls would only be triggered in the rare case of acquiring deuterium for a large fleet of fusion power plants.

659 The Nuclear Suppliers Group: Its Guidelines, Origins, Structure, and Role, INFCIRC/539/Revision 8, at 1.

660 Ibid.

661 INFCIRC/254/Rev.14/Part 1, at p. 12 (NSG); INFCIRC/209/Rev.5 at p. 1 (Zangger).

662 A single 1 GW_e sized fusion power plant is expected to consume around 125 kg of deuterium per year, *Beom Seok Kim/Suk-Ho Hong/Keeman Kim*, Preliminary assessment of the safety factors in K-DEMO for fusion compatible regulatory framework, Scientific Reports 12 (2022), 8276.

663 INFCIRC/254/Rev.14/Part 1, at p. 13, 19, 51 ff. (NSG); INFCIRC/209/Rev.5 at p. 5, 35 ff. (Zangger).

In addition, some of the equipment used in nuclear (fission) power plants will also be used in fusion power plants as well. This is particularly true for the production of electricity. A fission power plant is – oversimplified – a giant water kettle. The nuclear reactions release heat, this heat is converted into steam by a heat exchanger (listed in para. 1.9 of both Trigger Lists), then the steam drives a turbine and a generator which produces electrical energy. A fusion power plant only changes the type of nuclear reaction at the very beginning of the process, while the remaining technology remains mostly the same. Electricity generation is indifferent to the nuclear processes involved in the heat production. Similarly, the measurement of neutron fluxes is relevant to the operation of any nuclear power plant (para. 1.10 on both Trigger Lists).

As mentioned above, fusion is outside the mission of the Zangger Committee. This exclusion is also reflected in a clarification of the definition of "nuclear reactors and especially designed or prepared equipment and components thereof."[664] This clarification specifically excludes fusion: "This entry does not control fusion reactors." As a result, the export of entire fusion reactors as well as heat exchangers and neutron detectors for fusion reactors falls outside the scope of the Zangger Trigger List. As the Zangger List is relevant for the interpretation of Article III.2 of the NPT, this clarification further supports the result of interpretation in Section 1.2.4 above.

As the NSG's aim is broader than harmonising the interpretation of Article III.2 of the NPT, the NSG's Dual Use List contains more fusion-related material: Firstly, similar to the heat exchangers on the Trigger Lists, some materials and equipment already proven in the nuclear industry will be used in fusion plants. This is particularly true for industrial equipment (para. 1 on the Dual Use List), such as high-density radiation shielding windows (para. 1.A.1), cameras (para. 1.A.2), robots for maintenance (para. 1.A.3), machines and tools with high precision (paras 1.B.2 and 1.B.3) as well as software to operate these machines (para. 1.D).

Secondly, materials and equipment with an auxiliary character in fission are of essential use in fusion. This is particularly the case for the material which is central to fusion's proliferation potential: tritium. The list contains tritium as a material (para. 2.C.17), tritium facilities (2.B.1) and methods to separate tritium from coolants (2.A.2). While tritium in fission power

664 Para. 1 of the Annex to Memorandum B of the Zangger List.

plants is produced only as a by-product,[665] an essential part of a fusion power plant will be its tritium production and recovery. Similarly, beryllium as a material (para. 2.C.2) and lithium isotope separation equipment (para. 2.B.2) play a role in the tritium production. Irradiation of ^{6}Li results in the production of tritium, while the rare isotope of ^{6}Li first has to be separated from the significantly more abundant ^{7}Li. In addition, beryllium can be used as a neutron multiplier to increase production.[666] Furthermore, ^{3}He is listed on the Dual Use List (para. 2.C.18); a material which some start-ups consider as a fuel for their fusion power plants.

2.3 Procedural Application of the Guidelines

Although a significant amount of material and equipment used for fusion is either listed on a Trigger List or the Dual Use List, procedural limitations significantly reduce the effect of limiting the proliferation potential. There are four reasons for this limited effect. They stem from the safeguards requirement for exports, the limited use of exports, the requirement to assess whether an export presents an unacceptable risk of diversion, and the legal character of the regime.

First, all exports of items listed on either a Trigger or the Dual Use list require the application of IAEA safeguards.[667] Countries export such material and equipment despite the potential risk of diversion with the assurance in mind that the application of safeguards significantly reduces that risk of diversion. Exporting countries trust that the IAEA would detect the use of such material and equipment in a nuclear weapons programme. However, the export control regime is based on Article III.2 of the NPT – which does not apply to fusion – and require IAEA safeguards – which do not apply to fusion, in particular to fusion facilities. This procedure with regard to fusion defeats the whole purpose of allowing the export of

665 In CANDU reactors, neutrons from the fission process sometimes interact with the deuterium as part of its heavy water coolant, forming a tritium atom: *Richard J. Pearson/Armando B. Antoniazzi/William J. Nuttall*, Tritium Supply and Use: a Key Issue for the Development of Nuclear Fusion Energy, Fusion Engineering and Design 136 (2018), 1140–1148.

666 *Satoshi Shimakawa/Hisashi Sagawa/Toshimasa Kuroda et al.*, Estimation of the Tritium Production and Inventory in Beryllium, Fusion Engineering and Design 28 (1995), 215–219.

667 Para. 3 Memorandum B of Zangger List; para. 4 of the NSG-Trigger List Guidelines, para. 2 of the NSG Dual-Use Guidelines.

nuclear material and equipment while not securing their end-use through the application of safeguards.

Second, even if export controls applied, they would only apply to exports. Any material or equipment produced within a country's borders is outside the scope of export controls. Export controls can by principle not effectively control the risk of nuclear proliferation in isolation, they can only complement other international verification mechanisms that apply to domestic fuel cycles such as safeguards. This limitation applies in particular to tritium, a material with proliferation potential in fusion. It is unlikely that tritium will be transferred between countries during the operation of a fusion power plant.[668] Because of its high price and the huge quantities required, it is intended to be bred within the fusion vessel itself from ^{6}Li. The only point to apply export controls is the export of lithium, especially enriched in this isotope, or of separation equipment for lithium. However, lithium has a wide range of applications. An export could be denied if there is an unacceptable risk of diversion. The wide range of application makes it is difficult to assess whether the supply of lithium or lithium isotope separation equipment poses an unacceptable risk of diversion in any particular situation.

Third, with regard to the NSG Dual-Use list, the guidelines do not provide a definition of an unacceptable risk of diversion. In the absence of such a definition, it is left to the discretion of each individual nuclear supplier State whether it considers the above-mentioned risks to be acceptable or unacceptable.[669] In the absence of definitions and binding rules, States have historically tended to favour political and economic benefits over proliferation concerns.[670]

Fourth and finally, the export control regimes are *soft law* instruments. The NSG system, in particular, has come under criticism, as there are a number of Member States suspected to ignoring these provisions. The United States supplies India with material on the Trigger List even though India has not accepted comprehensive safeguards and is not a member State of

668 An exception must be made for the start-up of a fusion power plant. The neutrons from fusion reactions allow for the in-situ production of tritium. However, to start the fusion reactions, a start-up quantity of tritium is required.

669 *Abram Chayes/Antonia H. Chayes*, Regime Architecture: Elements and Principles, in: Janne E. Nolan (ed.), Global Engagement: Cooperation and Security in the 21st Century, Washington DC: Brookings Institution 1994, 65–130.

670 Ibid.

the NPT.[671] Similar allegations of violating the NSG procedures have been made against Russia and China.[672] As there is no legal obligation to follow the rules and in the absence of any enforcement mechanism, the readiness of the regime to address fusion's proliferation potential is questionable.

To summarise, given the constraints in the procedure, export control regimes currently do not adequately address the proliferation potential of fusion.

2.4 Summary

The Trigger List drafted by the Zangger Committee is of no relevance for fusion as its mission is limited to interpret Article III.2 of the NPT, which in turn is not applicable to fusion. However, the NSG Guidelines include materials and equipment relevant to fusion, yet their effectiveness is limited. The NSG's broader aim covers fusion-related materials, such as deuterium, tritium, and lithium isotope separation equipment, but its guidelines do not explicitly address fusion reactors or components. In addition, the NSG Guidelines allow for export controls when a procedure is followed, while the procedure has limited effects in addressing fusion's proliferation potential: IAEA safeguards do not apply to fusion, export controls are limited to international trade (not domestic production), and decisions are often based on political considerations. Additionally, the non-binding nature of these guidelines limit their effectiveness. Overall, current export control regimes do not adequately address fusion's proliferation risks.

3 Further Regimes

Preventing the use of nuclear technology for nuclear weapons programmes is also the objective of treaty regimes outside the IAEA regime and export

671 *Oliver Meier*, The US–India Nuclear Deal: The End of Universal Non-Proliferation Efforts?, Internationale Politik und Gesellschaft (2006), 28–43; *Leonard Weiss*, U.S.-India Nuclear Cooperation, The Nonproliferation Review 14 (2007), 429–457.

672 *Fred McGoldrick*, The Road Ahead for Export Controls: Challenges for the Nuclear Suppliers Group, Arms Control Today 41 (2011), 30–36; *Sibylle Bauer*, Developments in the Nuclear Suppliers Group, in: Bates Gill/Ian Anthony/D.A. Cruickshank (eds.), SIPRI Yearbook 2011, Stockholm: SIPRI 2011, 376–386, at 384 f.; *Mark Hibbs*, The Nuclear Suppliers Group and Geostrategic Politics, Strategic Trade Review 3 (2017), 5–24.

controls regimes This section analyses the extent to which these regimes apply to fusion technology. It begins with an analysis of the ITER Agreement, which is the basis for the ITER project, the world's largest fusion research project (3.1). It proceeds to analyse the applicability of Euratom safeguards to fusion (3.2). This is followed by an examination of the verification regimes of the Treaty on the Prohibition of Nuclear Weapons (3.3) and Nuclear Weapon Free Zone treaties (3.4) with a view to their applicability to fusion.

3.1 ITER Agreement

The ITER Agreement is the only international treaty that directly addresses the link between fusion and non-proliferation. The Agreement was signed in 2006 by the seven ITER Members: Euratom, the United States, China, Russia, India, Japan and South Korea. It establishes the ITER Organization as the institution responsible for the ITER project, the largest fusion research facility ever built. ITER in unique in that both NWS and NNWS are working together to build and operate a fusion research facility. In addition, ITER is located in St Paul-lez-Durance, France, thus in an NWS. Nuclear infrastructure in France is in principle not subject to safeguards. Only those facilities where France agrees to are safeguarded by the IAEA under a voluntary offer agreement.[673] However, the ITER project is not a French nuclear installation.[674] According to Article 5 of the ITER Agreement, the ITER Organization has its own international legal personality, separate from its Member States. The ITER Organization itself is responsible for the ITER project. As an international organisation, it is not bound by the NPT or any other safeguards instruments. However, the ITER Agreement itself addresses non-proliferation. According to its Article 20, any material, equipment or technology shall be used solely for peaceful purposes (para. 1) and shall not be transferred to any third party to manufacture or otherwise acquire nuclear weapons (para. 2). Unlike the NPT, the ITER Agreement

673 Accord conclu le 27 juillet 1978 entre la France, la Communauté Européenne de l'Energie Atomique et l'Agence Internationale de l'Energie Atomique relatif à l'application de garanties en France, available as INFCIRC/290.

674 For regulatory purposes, ITER is regulated under the French nuclear code as a nuclear installation, see *Lina Rodriguez-Rodrigo/Joëlle Elbez-Uzan/Carlos Alejaldre*, ITER Licensing Process from Design and Construction to Dismantling, Fusion Science and Technology 56 (2009), 809–813.

does not require a safeguards system. The compliance mechanisms with the agreement are very limited. The only provisions in the agreement stipulate "appropriate measures" to be taken by both the organisation and the members, combined with mandating the ITER Council to "interface with appropriate international fora and establish a policy supporting peaceful uses and non-proliferation." There are no plans to apply IAEA safeguards to ITER.[675] This provision shows that the State Parties to the ITER Agreement have recognised a non-proliferation dimension, while not including any safeguards provisions. This implies that these States regard the proliferation potential as limited, at least in the context of a fusion experiment carried out by an international organisation.

3.2 Fusion in the Euratom Treaty

The role of fusion in the Euratom Treaty is comparable to the situation under the IAEA Statute. While both organisations' broader mandates to promote nuclear technology and research are wide enough to cover fusion, the treaties' safeguards provisions of the Treaties are not applicable to fusion.

Euratom is a major player in the field of fusion research. It funds EUROfusion, a consortium of 28 fusion research institutions in 26 EU Member States, with around 580 million Euros over a five-year period, representing 55 % of the consortium's budget.[676] Euratom is also one of the signatories of the ITER Agreement and provides 45 % of the funding of the ITER project through its joint undertaking Fusion For Energy.[677] According to Article 4 Euratom Treaty, Euratom shall promote and facilitate research in the field of nuclear energy. Annex I of the Treaty specifically lists fusion research

675 Anna Taylor and Laetitia Grammatico, Legal Advisors for ITER, during the 2023 Fusion For Energy Round Table.

676 European Commission – Directorate-General for Research and Innovation, *Euratom Research and Training Programme 2021–2025*, Publications Office, 2021, https://data.europa.eu/doi/10.2777/200656, last accessed 25 February 2025. The remaining 45 % come from the Member States in which the research institution is located.

677 European Commission: Directorate-General for Budget, *The EU's 2021–2027 Long-Term Budget and NextGenerationEU – Facts and Figures*, Publications Office of the European Union, 2021, https://data.europa.eu/doi/10.2761/808559, last accessed 25 February 2025. Fusion For Energy was established following Article 45 Euratom Treaty by Council Decision of 27 March 2007, 2007/198/Euratom.

as an area covered by the mandate of Article 4.[678] Thus, the Euratom Treaty allows the Community to take a role in fusion and to develop legal approaches.

Euratom's important role in fusion research does not come with safeguards. To recall, the central safeguards provision of the Euratom Treaty is that the Commission shall satisfy itself that ores, source materials and special fissile materials are not diverted from their intended uses as declared (Article 77 (a)) and that safeguarding obligations assumed under an agreement with an international organisation (Article 77 (b)) are complied with.

As far as Article 77 (b) is concerned, the same considerations as presented for the IAEA safeguards regime, apply to Euratom. Under this article, the compliance with IAEA safeguards obligations does not require safeguarding fusion facilities.

Concerning Article 77 (a), the other pillar of Euratom safeguards does also not apply to fusion either. The mandate of the Commission is limited to "ores, source material and special fissionable material." Article 197 defines these terms in a similar way to Article XX of the IAEA Statute. Special fissionable materials are defined as certain uranium isotopes or enriched material, while source material is (mainly) natural or depleted uranium. Thus, fusion falls outside the scope of the safeguards system established by Euratom.

Moreover, Euratom's focus on source and special fissionable material is not just a feature of the safeguards regime, but is inherent in the way Euratom operates. One *raison d'être* of Euratom is to have a common European stock of nuclear materials and reactor fuel.[679] Within Europe, it is not the operator or a country that purchases nuclear material on the market, but Euratom with its own Supply Agency. Also, ownership of the material remains with Euratom.[680] The safeguards system is designed in the context that Euratom supplies the material to the individual States and

678 Annex I, para. II.1(e).

679 Articles 2(d) and 52 ff. Euratom Treaty. See also *Pierre Mathijsen*, Some Legal Aspects of Euratom, Common Market Law Review 3 (1966), 326–343.

680 This is set out in Chapter 8 of the Euratom Treaty. On the role of ownership in the broader context of Euratom, see *Peter Böhm*, Ownership of Nuclear Materials in Euratom, The American Journal of Comparative Law 11 (1962), 167–183; *Andre Bouquet*, How Current Are Euratom Provisions on Nuclear Supply and Ownership in View of the European Union's Enlargement?, Nuclear Law Bulletin 68 (2001), 7–38; *Jürgen Grunwald*, Peaceful Uses of Nuclear Energy Under EURATOM Law, in: Jonathan L. Black-Branch/Dieter Fleck (eds.), Nuclear Non-Proliferation in International Law – Volume III: Legal Aspects of the Use of Nuclear Energy for Peaceful Purposes, The Hague: T.M.C. Asser Press 2016, 171–213.

users. However, Euratom only supplies countries with material for their nuclear fission fuel cycle. The exclusion of fusion is therefore a consequence of Euratom's overall focus on a European fission fuel cycle.

As a consequence, the Euratom Treaty does not provide the Commission with adequate tools to address the proliferation potential of fusion. The possibility of including fusion in a broader context of Euratom's procurement and control system is discussed in the next chapter.

3.3 Fusion and the TPNW

Within the TPNW, there are various rules for verifying compliance with the provisions of the treaty: on the one hand, verifying that a former NWS has irreversibly eliminated its nuclear weapons programme (Article 4) and on the other hand, that all Member States remain nuclear-weapons-free (Article 3).

The above findings of limited applicability of the IAEA's safeguards regime have direct implications for the TPNW. For NNWS, the TPNW sets out a safeguards regime in its Article 3. These safeguards are based on a fission-based approach. According to Article 3.2 of the TPNW, the minimum level of safeguards required is that of the CSA. As shown above, the safeguards provisions of the CSA as part of the NPT safeguards system largely do not include fusion from its scope of application. Furthermore, while the Additional Protocol closes some gaps in the regime, its adoption is not required under the TPNW. For NNWS, the TPNW does not fill the gaps in the application of safeguards to fusion.

For NWS, Article 4 of the TPNW provides a procedure towards the complete elimination of nuclear weapons. This article requires the conclusion of a safeguards agreement with the IAEA. Such an agreement must be "sufficient to provide credible assurance of the non-diversion of declared nuclear material from peaceful nuclear activities and the absence of undeclared nuclear material or activities in the State as a whole." While Article III.1 of the NPT mandates safeguards to verify nuclear non-proliferation, Article 4 of the TPNW mandates safeguards to verify nuclear disarmament.

A closer look at this provision leads to several observations. First, such a safeguards agreement is *prima facie* independent of existing safeguards instruments such as INFCIRC/66, a CSA or a VOA. While these instruments could serve as basis,[681] the language is explicitly open to safeguards that go beyond the existing instruments.

Second, similar to other safeguards agreements, an Article 4 TPNW agreement focuses on *nuclear material*. The language of the treaty itself does not define *nuclear material* and goes beyond both the NPT and the IAEA Statute which focus on *special fissionable* or *source material*.[682] Moreover, while both the CSA and its Additional Protocol also use the term *nuclear material*, the TPNW stops short of defining this term, unlike the IAEA instruments, which define nuclear material in accordance with Article XX of the IAEA Statute. By applying a teleological interpretation supported by the preamble of the Treaty (Article 31 para. 1 VCLT) – both with the aim of achieving final and irreversible nuclear disarmament[683] – this definition must be understood more broadly, to include special *fusionable material*. This is supported by historical observations (Article 32 VCLT): The TPNW is influenced by the work on the (Model) Nuclear Weapons Convention.[684] This convention defined nuclear material as "any source or special fissionable or fusionable material as defined in this Convention."[685] There has been an explicit inclusion of fusionable material. Fusionable material was defined as "any isotope capable of undergoing fusion with the same kind of nuclide or with any other nuclide by applying sufficient conditions (pressure, temperature and inclusion time) with technical means."[686] This includes deuterium and tritium as well as any other fusion fuel, as the context indicates a broader understanding of the term.

681 *Stuart Casey-Maslen*, The Treaty on the Prohibition of Nuclear Weapons: a Commentary, Oxford: Oxford University Press 2019, at 193.

682 It should be noted that the NPT refers to nuclear material in its Article III.3 on international exchange.

683 Para. 14 of the Preamble of the TPNW. On the role of fusion in irreversibility of nuclear disarmament, see *Philipp Sauter*, The Emergence of Nuclear Fusion Energy: A New Nuclear Technology, a New Chance for Nuclear Disarmament?, in: Wilfred Wan/Vladislav Chernavskikh (eds.), Expanding Perspectives on Nuclear Disarmament, Uppsala: SIPRI/Alva Myrdal Centre for Nuclear Disarmament 2023, 160–171.

684 *Jonathan L. Black-Branch*, The Treaty on the Prohibition of Nuclear Weapons. Legal Challenges for Military Doctrines and Deterrence Policies, 2021, at 13 f.; *Christopher P. Evans*, Questioning the Status of the Treaty on the Prohibition of Nuclear Weapons as a 'Humanitarian Disarmament' Agreement, Utrecht Journal of International and European Law (2021), 52–74.

685 NPT/CONF.2010/PC.I/WP.17, at para. II. 14; UN document A/C.1/52/7, at para. II.14.

686 UN document A/C.1/52/7, at para. II.17.

Thus, the issue of safeguarding fusionable material would become relevant once the NWS acceded to the TPNW. The development of specific verification mechanisms for former NWS would need to include provisions focusing on fusion. This is particularly relevant to the proliferation concerns associated with inertial confinement fusion: These facilities currently exist only as part of military programmes. Such a mechanism would also need to focus on tritium and its role in nuclear weapons. However, in view of the unanimous rejection of the treaty,[687] which is also supported by the partner States,[688] this does not appear to be likely in the foreseeable future.

3.4 Fusion in Nuclear Weapon Free Zone Treaties

As analysed above, NWFZ Treaties play an important role in ensuring non-proliferation and nuclear disarmament at the regional level.[689] Similar to the IAEA's safeguards system, there are shortcomings in the regional verification systems with regard to fusion. The gap between the objective of a regime and the implementation of its verification regime extends to NWFZ Treaties as well.

3.4.1 Treaty of Tlatelolco

The South and Latin American NWFZ, which is the oldest NWFZ and predates the NPT, establishes an international organisation with structures and authority reminiscent of the IAEA. Article 7 of the Treaty of Tlatelolco establishes the Agency for the Prohibition of Nuclear Weapons in Latin America and mandates its General Conference to "establish procedures for the control system", Article 9 para. 2b. The objective of the verification is to ensure the exclusive use of nuclear material and facilities for peaceful

687 See for example the P5 Joint Statement on the Treaty of Non-Proliferation of Nuclear Weapons of 24 October 2018, available at https://www.gov.uk/government/news/p5-joint-statement-on-the-treaty-on-the-non-proliferation-of-nuclear-weapons, last accessed 25 February 2025.

688 In the case of Germany as a NATO country, see the statement of the German government in the publication of the German parliament Bundestag Drucksache 20/2268 of 10 June 2022. On the consequences for NATO, see *Mika Hayashi*, NATO's Nuclear Sharing Arrangements Revisited in Light of the NPT and the TPNW, Journal of Conflict and Security Law 26 (2021), 471–491.

689 See above, Chapter 2, Section 3.4.

purposes.[690] A particular focus of the control system is to verify that "devices, services and facilities intended for peaceful uses of nuclear energy are not used in the testing or manufacture of nuclear weapons."[691] The term "nuclear material" itself is applicable to both fission and fusion as long as there is no definition limiting the scope to source and special fissionable material as in the CSA. Furthermore, fusion facilities are not excluded from the scope of verification in view of the potential of fusion to develop or support nuclear weapons programmes. However, there is a lack in the design of the control system. The control system comprises of IAEA safeguards (Article 13), semi-annual reports of the Parties (Article 14) and the possibility of special reports and special inspections (Articles 15 and 16). The IAEA carries out regular inspections. As analysed above, mandating the IAEA to apply safeguards does not include the application to fusion as long as there is no clear reference to fusion.

Furthermore, Article 13 requires the States to apply safeguards to their *nuclear activities* without further definition. Given the purpose of the treaty, which is the military denuclearisation of Latin America and constituting a significant contribution towards preventing the proliferation of nuclear weapons[692] as well as its broad obligation to "undertake to use exclusively for peaceful purposes the nuclear material and facilities",[693] *fusion activities* would fall within the scope of *nuclear activities* under Article 13. As a consequence, once Latin American States engage in fusion activities, they would have to negotiate an agreement with the IAEA to apply safeguards to these activities.

As will be shown next, the other NWFZ Treaties were concluded after the adoption of the NPT. Hence, they follow a more fissile material-based approach by the NPT and specifically mention source and special fissionable material. These treaties also refer to specific IAEA safeguards instruments that do not include fusion.

3.4.2 Treaty of Rarotonga

While the South Pacific NWFZ Treaty also renounces the manufacturing or otherwise acquisition of nuclear weapons (Article 3), the undertaking

690 Articles 12 and 1 of the Treaty of Tlatelolco.
691 Article 12 para. 2a.
692 Para. 17 of the Preamble.
693 Article 1.

vis-à-vis peaceful nuclear activities focuses on rules for providing source or special fissionable material or material for its processing, use or production (Article 4). Such material can only be provided to a NNWS if safeguards following Article III.1 NPT apply or to a NWS under a VOA. The control system then focuses on compliance with all obligations from the treaty, including the renunciation of nuclear weapons and peaceful nuclear activities. The objective of Article 3 is broad enough to include fusion. However, the control system does not reflect fusion's proliferation risk. This system is limited to reports to the Director of the South Pacific Bureau for Economic Co-operation, consultations, a complaints procedure and the application of IAEA safeguards to peaceful nuclear activities (Article 8). The IAEA safeguards are further detailed in Annex 2. They are applied on all source or special fissionable material in all peaceful nuclear activities, based on the CSA. While the purpose of these safeguards is to verify the non-diversion of *nuclear material* – which would allow for an inclusion of fusion – CSA-based safeguards apply only to source and special fissionable material. This does not include the application of safeguards to fusion.

3.4.3 Treaty of Bangkok

Similar to all NWFZ Treaties, the South-East Asian NWFZ Treaty prohibits any form of acquisition, development or control of nuclear weapons (Article 3). With regard to the civilian use of nuclear weapons, States shall use nuclear material and facilities exclusively for peaceful purposes (Article 4 para. 2a). Similar to the Treaty of Rarotonga, providing source and special fissionable material to other countries is prohibited without safeguards agreements in place for the recipient State. While the provisions on the use of nuclear energy for civilian purposes focus only on nuclear material – thus allowing for the inclusion of fusionable material –, the verification process is also not adapted to fusion. While the objective of the system includes fusion, its application does not. The verification system consists of reports and the application of IAEA safeguards (Article 10). The safeguards are further described in Article 5 as full-scope safeguards, which is synonymous with the standard introduced in the CSA.[694] As analysed above, fusion is outside the scope of this safeguards regime and thus outside from the Treaty of Bangkok as well.

694 *International Atomic Energy Agency* (n 631), at 4, 11.

3.4.4 Treaty of Pelindaba

The African NWFZ Treaty prohibits any kind of possession or control of nuclear weapons as well (Article 3). Peaceful uses of nuclear energy are to be carried out under strict non-proliferation measures to provide assurance of exclusively peaceful uses (Article 9a). In this respect, the conclusion of a CSA with the IAEA is required (Article 9b). Similar to the other NWFZ Treaties, the provision of a country with source or special fissionable material requires safeguards agreements as well (Article 9c). The verification mechanism includes reports to the African Commission on Nuclear Energy and the implementation of IAEA safeguards (Article 12 and Annex II). While the purpose of safeguards is to verify the non-diversion of nuclear material from peaceful nuclear activities to nuclear explosive devices (Annex II para. 3), the safeguards are limited to source or special fissionable material, thus excluding fusion. Unlike the other NWFZ Treaties, the Treaty of Pelindaba contains its own definitions. It defines nuclear material (Article 1.f) in the sense of Article XX of the IAEA Statute, thus only source and special fissionable material are to be considered nuclear material, thereby excluding fusionable material. It contains a definition of nuclear installation, which includes nuclear-power reactors and nuclear research reactors (Article 1.e). In the absence of any further specification, these terms are broad enough to include fusion powered reactors or fusion research reactors alongside fission reactors.

3.4.5 Treaty of Semipalatinsk

Similar to the other NWFZ Treaties, any form of control or possession of nuclear weapons is prohibited in the Central Asian NWFZ (Article 3). In addition, only the exclusively peaceful use of nuclear material and facilities is permitted. Providing NNWS with nuclear material or related equipment is limited to those NNWS that have both a CSA and an Additional Protocol in place, while there are no requirements for NWS. As in some NWFZ treaties, the treaty's definition of *nuclear material* (Article 1.d) refers to Article XX of the IAEA Statute and the definition of *facility* (Article 1.f) is similar to that of the CSA, limiting the applicability of the treaty to fission. However, there is a difference to the other NWFZ Treaties in terms of verification: The Central Asian NWFZ is the only zone without the establishment of a separate international organisation. Verification is ensured through consultative meetings (Article 10) and the application of IAEA safeguards (Article 8). In contrast to the other treaties, the level of safeguards is not only at the level of the CSA, but also includes the Additional Protocol. As the AP applies to some extent to fusion as well, the Treaty of Semipalatinsk includes the limited possibility of applying safeguards to fusion.

3.4.6 Summary

While the rules regarding the peaceful use of nuclear weapons are open enough to include fusion, there is a gap in verification. Since all NWFZ rely primarily on IAEA safeguards to verify compliance with the respective treaty provisions, these mechanisms do not apply to fusion. NWFZ Treaties do not effectively reduce the gap in the regime between the treaties' objectives of preventing a nuclearisation of their respective regions and their verification mechanisms regarding fusion technology.

3.5 Summary

As with the IAEA's verification regime and the nuclear export control regime, further regimes show gaps in their application to fusion. All the regimes examined- the ITER Agreement, the Euratom Treaty, the TPNW and NWFZ Treaties – aim to prevent the use of fusion technology for nuclear weapons. However, these regimes lack verification mechanisms to ensure that fusion remains exclusively in the peaceful domain.

4 Evaluation of the Applicability of the Framework on Fusion

To conclude this chapter, it is analysed that, despite the gap between the objective of preventing the use of fusion technology to develop nuclear weapons in NNWS and the applicability of the various verification regimes on fusion technology, the regime does not contain an obligation for States to support the development of an effective non-proliferation regime (4.1). The chapter then summarises the findings in order to set the stage for the next chapter, which discusses approaches to adapting the legal framework (4.2).

4.1 A Sprit but not an Obligation to Strengthen the Safeguards Regime

Various international legal instruments contain the spirit of strengthening the safeguards regime. However, in most cases they fall short of a legal obligation.

The NPT as the cornerstone of the non-proliferation regime is a pertinent example. Despite the objective to verify compliance of NNWS with the prohibition to seek nuclear weapons under Article II, the limited scope of application of the verification mechanisms of Article III does not include an obligation to conclude safeguards agreements covering fusion. With the conclusion of a CSA and the implementation of export controls on fission technology, NNWS fulfil their obligations under the NPT to verify that they maintain their nuclear-weapon-free status. The desire to strengthen the safeguards system is only contained in the Preamble, which does not contain legally binding obligations. The Preamble includes the "[u]ndertaking to co-operate in facilitating the application of International Atomic Energy safeguards on peaceful activities" as well as the State Parties "[e]xpressing their support for research development and other efforts to further the application" of IAEA safeguards. While the spirit to strengthening safeguards is clear, the NPT stops short of obliging States to actually taking action to strengthen the regime.

In addition, United Nations Security Council Resolution (UNSCR) 1540 expresses the desire to strengthen the safeguards regime, while at the same time also stopping short of imposing an obligation. Despite the resolution being adopted under Chapter VII of the UN Charter and, thus being legally binding for all Member States, the Security Council does not use an operator that indicates a legally binding obligation. Para. 8 of the resolution *calls upon* all States to "promote […] where necessary, strengthening of multilateral treaties to which they are parties, whose aim is to prevent the proliferation of nuclear […] weapons." While there is some room for interpretation as to whether a strengthening is necessary, such an argument can be made. The implementation of Article II of the NPT is affected by fusion technology, while the verification mechanisms do not address this issue. In addition, it *calls upon* all States to "fulfil their commitment to multilateral cooperation, in particular within the framework of the International Atomic Energy Agency […] as important means of pursuing and achieving their common objectives in the area of non-proliferation." However, the legal operator *calls upon* is the weakest operator used by the UN Security

Council and usually indicates recommendations rather than obligations.[695] When the Security Council intends to impose a legal obligation, it uses operators such as *decides* or *requests*.[696] UNSCR 1540 also distinguishes between clear obligations, such as its *decisions* to take effective measures against non-state actors and weapons of mass destruction, and the *calls* to strengthen the safeguards system.[697]

Where UNSCR 1540 imposes obligations, these are limited to national regimes and do not extend to international frameworks. In the context of export controls, para. 3 of the resolution *requires* States to strengthen their domestic controls to prevent the proliferation of nuclear weapons, including through effective regulation of related materials. This includes reviewing national export control legislation. Since international export regimes do not cover fusion-related materials, they may not align with UNSCR 1540. However, the resolution places obligations solely on States to act within their national systems, not to coordinate through international bodies like the Zangger Committee or the Nuclear Suppliers Group.

Another legal instrument that recommends, rather than obliges, States to adapt the system is the NSG Guidelines. Para. 14 of the Trigger Lists states:

> "Similarly, they should make every effort to support the IAEA in increasing further the adequacy of safeguards in the light of technical developments and the rapidly growing number of nuclear facilities, and to support appropriate initiatives aimed at improving the effectiveness of IAEA safeguards."

Fusion is perhaps the best example of technical developments that challenge the adequacy of safeguards, where the NSG Member States should support the inclusion of fusion in the IAEA's safeguards regime. However, as these guidelines are non-binding soft law, there is no legal obligation.[698]

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695 *Michael Wood/Eran Sthoeger*, The UN Security Council and International Law, Cambridge: Cambridge University Press 2022, at 39 f.; *Justin S. Gruenberg*, An Analysis of United Nations Security Council Resolutions: Are All Countries Treated Equally?, Case Western Reserve Journal of International Law 41 (2009), 469–511, at 487.

696 Ibid.

697 See paras 1–3.

698 On soft law, see *Alan Boyle*, Soft Law in International Law-Making, in: Malcolm Evans (ed.), International Law, Oxford: Oxford University Press 2018, 118–136. Critical towards soft law is *Jan Klabbers*, The Redundancy of Soft Law, Nordic Journal of International Law 65 (1996), 167–182.

There are few exceptions, however, where treaties contain clear obligations for States to work towards the strengthening of the legal regime of nuclear weapons, namely two NWFZ Treaties. The Treaties of Bangkok and Rarotonga contain a specific obligation of their Member States "to support the continued effectiveness of the international non-proliferation system based on the NPT and the IAEA safeguards system."[699] Since effectiveness of the system is limited with regard to fusion, at least the twenty-three Member States of these two NWFZs combined would have to actively support an inclusion of fusion into the safeguards systems, either through the exercise of authority under the existing regime or through treaty changes.

Since there is no legal obligation for most States to actively reform nuclear weapons law to include a verification mechanism for fusion technology, there is a clear gap between the objective of the regime and its application, as well as the spirit to actively work towards the strengthening of the regime. The next chapter will develop approaches to closing the gap between the proliferation potential of fusion and the lack of legal regimes.

4.2 Summary of the Findings

As presented in Chapter 1, fusion has potential applications in nuclear weapons as the technology can be used to support nuclear weapons programmes. The legal framework of nuclear weapons law, which is designed to prevent the use of nuclear technology for nuclear weapons by NNWS, applies to fusion only to a limited extent. There is a gap between the provisions prohibiting the use of nuclear energy, materials and facilities for non-peaceful purposes and the verification regime when it comes to fusion. As the statement of the IAEA's former Director General Blix is true, that "[n]o safeguards system, no matter how extensive the measures, can provide absolute assurance that there has been no diversion of nuclear material or that there are no undeclared nuclear activities in a State,"[700] the existing safeguards regime provides only very limited, and in parts highly ambiguous, assurance with respect to fusion. While the Additional Protocol allows for environmental sampling to address one proliferation potential of fusion, this is not universally applicable as the AP is limited to 141 NNWS and Euratom. Neither instruments or regimes on the international

699 Article 4 para. 2(b) Treaty of Bangkok, Article 4(b) Treaty of Rarotonga.
700 Strengthening the Effectiveness and Improving the Efficiency of Agency Safeguards: Report by the Director General to the General Conference, GC(39)/17, para. 15.

level – the IAEA's safeguards system – nor regional approaches – Euratom and NWFZs – are comprehensively applicable to fusion. Where there are regimes that include the proliferation potential of fusion to a certain extent – the ITER Agreement and export control regimes –, there are no effective procedures to verify that fusion is not being used for nuclear weapons purposes. The next chapter explores interpretative, doctrinal and treaty-making approaches to closing the gap between the existing proliferation potential and the legal regime of nuclear.