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Olli Okko (ed.)

Implementing nuclear non-proliferation in Finland

Regulatory control, international cooperation and the Comprehensive Nuclear-Test-Ban Treaty

Annual report 2023

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Abstract

The regulatory control of nuclear materials, nuclear safeguards, is a prerequisite for the peaceful use of nuclear energy. In order to maintain the Finnish part of the international agreements on nuclear non-proliferation – mainly the Non-Proliferation Treaty (NPT) – this regulatory control is implemented mainly by the Nuclear Materials Safeguards section of the Finnish Radiation and Nuclear Safety Authority (STUK). In addition, the Ministry for Foreign Affairs (MFA) and Ministry of Economic Affairs and Employment (MEAE) play a central role in the state system of accounting for and control of nuclear material (SSAC). STUK cooperates nationally with the ministries, customs, border control and other domestic stakeholders in the areas of non-proliferation, export control and nuclear disarmament.

Core stakeholders in the SSAC are the operators and licence holders that bear the ultimate responsibility for their nuclear materials and related activities. Finland has quite significant nuclear power production, but the related nuclear industry is rather limited. Most of the declared nuclear materials (uranium, plutonium and thorium) in Finland reside at the nuclear power plants at Olkiluoto and Loviisa. In addition, there is an already shutdown and almost decommissioned VTT's research reactor in Espoo with fresh nuclear fuel still at the site. Other Finnish operators include STUK itself, the University of Helsinki and VTT's Centre for Nuclear Safety as mid-sized holders, holders of nuclear materials generated as concentrates or by-products in the mineral processing industry and a dozen minor nuclear material holders.

STUK maintains a national nuclear materials accountancy system and verifies that nuclear activities in Finland are carried out in accordance with the Finnish Nuclear Energy Act and Decree, European Union safeguards regulations and international agreements. These tasks are performed to verify that Finland can assure itself and the international community of the absence of undeclared nuclear activities and materials. In addition to this, the IAEA evaluates the success of the state safeguards system, and the European Commission participates in safeguarding the materials under its jurisdiction.

The results of STUK's nuclear safeguards accounting and verification activities in 2023 continued to demonstrate that Finnish licence holders take good care of their nuclear materials. There were no indications of undeclared nuclear materials or activities, and the inspected materials and activities were in accordance with the operators' declarations. The operators' own nuclear materials accountancy and control systems enabled STUK to fulfil its own obligations under the international agreements relevant to nuclear safeguards.

The working environment of STUK and other stakeholders in the Finnish national safeguards framework gradually stabilised after challenging times during the COVID-19 pandemic. While inspection activities and other in-field work had been carried out almost normally during the pandemic, international events, conferences and in-person meetings made their return in 2023. STUK took advantage of good practices learned from hybrid work and remote inspections. STUK finished the year with 43 inspections and 73 inspection days, which are in line with the long-term averages. The number of international inspections and inspection days were also at a normal level. According to the statements on inspection results and the

conclusion of safeguards implementation provided by the IAEA and the Commission, there were no outstanding questions at the end of 2023.

The experience from STUK's latest strategy period 2018–2022 showed that rapid changes are possible even in the conventional nuclear field. The changes in the nuclear industry and in the working environment were not foreseeable in 2018. Therefore, the current approach is to keep with a rolling strategy to accommodate resources according to changing environment. The Finnish nuclear research organisations have been announcing their plans for small reactors to be located in urban areas for district heating purposes. The facilitation of these projects needs new approach in the legislation. The project to comprehensively renew Finnish nuclear legislation advanced into the stage of developing provisions for the new Nuclear Energy Act.

The development of the safeguards instrumentation for the final disposal of spent nuclear fuel maintained its position as the highlight of the technical development work in the Finnish nuclear safeguards system. This involves the PGET (Passive Gamma Emission Tomography) and PNAR (Passive Neutron Albedo Reactivity) measurement methods. In December 2022, the mining company Terrafame confirmed its aim and investment decision to proceed towards uranium recovery in its metal production in the coming years. This nuclear newcomer introduces new challenges to the Finnish regulators including the Nuclear Materials Safeguards section. The preliminary safety analysis report including nuclear material handbook was under assessment by STUK during 2023.

A major goal of all current Comprehensive Nuclear-Test-Ban Treaty (CTBT)-related activities is the entry into force of the CTBT itself. An important prerequisite for such positive political action is that the verification system of the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) is functioning and able to provide assurance to all parties that it is impossible to carry out a clandestine nuclear test without detection. The FiNDC is committed to its own role in this common endeavour, so that the verification system of the CTBTO can accomplish its detection function.

Tiivistelmä

Ydinaineiden viranomaisvalvonta, eli ydinmateriaalivalvonta, on ydinenergian rauhanomaisen käytön edellytys. Suomessa tätä viranomaisvalvontaa, jonka avulla maa hoitaa omat kansainvälisten ydinsulkua koskevien sopimusten – pääasiassa ydinaseiden leviämisen estämistä koskevan sopimuksen (NPT) – mukaiset velvollisuutensa, toteutetaan pääasiassa Säteilyturvakeskuksen (STUK) ydinmateriaalitoimistossa. Myös ulkoministeriöllä ja työ- ja elinkeinoministeriöllä on tärkeä rooli kansallisessa ydinmateriaalien kirjanpito- ja valvontajärjestelmässä. STUK tekee kansallisella tasolla yhteistyötä ministeriöiden, tullin, rajavalvonnan ja muiden kotimaisten sidosryhmien kanssa ydinsulun, viennin valvonnan ja ydinaseriisunnan alueilla.

Kansallisen ydinmateriaalien kirjanpito- ja valvontajärjestelmän tärkeimpiä sidosryhmiä ovat toiminnanharjoittajat ja luvanhaltijat, joilla on viime kädessä vastuu omista ydinaineistaan sekä ydinaineisiin liittyvistä toiminnoistaan. Suomen ydinvoimatuotanto on melko merkittävä, mutta siihen liittyvä ydinteollisuus on suhteellisen rajallinen. Suurin osa Suomessa sijaitsevista ilmoitetuista ydinaineista (uraani, plutonium ja torium) sijaitsee Olkiluodon ja Loviisan ydinvoimalaitoksissa. Lisäksi Espoossa on sammutettu ja lähes kokonaan käytöstä poistettu VTT:n tutkimusreaktori, jossa vielä on tuoretta ydinpolttoainetta. Muihin suomalaisiin toiminnanharjoittajiin lukeutuvat STUK itse, Helsingin yliopisto ja VTT:n ydinturvallisuustalo, jotka ovat keskikokoisia ydinaineiden hallussapitäjiä, mineraaliteollisuuden rikasteina tai sivutuotteina syntyvien ydinaineiden hallussapitäjiä sekä tusinan verran pieniä ydinaineiden hallussapitäjiä.

STUK ylläpitää kansallista ydinmateriaalien kirjanpitojärjestelmää ja valvoo, että Suomessa tapahtuvassa ydintoiminnassa noudatetaan Suomen ydinenergialakia ja -asetusta, Euroopan unionin ydinmateriaalivalvontaa koskevia asetuksia sekä kansainvälisiä sopimuksia. Nämä tehtävät suoritetaan, jotta Suomi voi varmistaa itselleen sekä kansainväliselle yhteisölle, ettei maassa esiinny ilmoittamatta jätettyjä ydintoimintoja tai ydinaineita. Tämän lisäksi IAEA arvioi kansallisen ydinmateriaalivalvontajärjestelmän toimivuutta ja Euroopan komissio osallistuu ydinmateriaalien valvontaan sen oikeudenkäyttöalueella.

STUKin vuonna 2023 suorittama ydinmateriaalivalvontaan kuuluva kirjanpito- ja todentamistoiminta osoitti tälläkin kertaa, että suomalaiset luvanhaltijat huolehtivat ydinaineistaan hyvin. Valvonnassa ei havaittu viitteitä ilmoittamatta jätetyistä ydinaineista tai ydinainetoiminnoista, ja tarkastetut ydinaineet ja ydinainetoiminnot vastasivat toiminnanharjoittajien ilmoituksia. Toiminnanharjoittajien ydinmateriaalien kirjanpito- ja valvontajärjestelmien avulla STUK saattoi suorittaa omat, ydinmateriaalivalvonnan kannalta olennaisten kansainvälisten sopimusten mukaiset velvollisuutensa.

STUKin ja muiden Suomen kansalliseen ydinmateriaalivalvontaan liittyvien sidosryhmien työympäristö on vähitellen vakaantunut COVID-19-pandemian aiheuttamien haasteiden jälkeen. Tarkastustoiminta ja muut kentällä tehtävät työt suoritettiin pandemian aikana lähes normaaliin tapaan, mutta kansainväliset tapahtumat, konferenssit ja fyysiset tapaamiset käynnistyivät uudelleen vuonna 2023. STUK on hyödyntänyt hybridityöstä ja etätarkastuksista opittuja hyviä käytäntöjä. Vuoden aikana STUK suoritti 43 tarkastusta 73 tarkastuspäivän aikana, mikä vastaa pitkän aikavälin keskiarvoa. Kansainvälisten tarkastusten ja tarkastuspäi-

vien lukumäärä oli niin ikään normaalilla tasolla. Tarkastusten tuloksia koskevien lausuntojen sekä IAEA:n ja komission ydinmateriaalivalvonnan toteuttamista koskevien päätelmien perusteella vuoden 2023 lopussa ei ollut keskeneräisiä asioita.

STUKin edellisen strategiakauden, vuosien 2018–2022, aikana saatu kokemus osoitti, että muutokset voivat olla nopeita myös tavanomaisella ydinainekentällä. Ydinteollisuuden ja työympäristön muutoksia ei olisi voinut ennakoida vuonna 2018. Siksi nykyinen lähestymistapa on rullaava strategia, jotta resurssit voidaan mukauttaa ympäristössä tapahtuviin muutoksiin. Suomalaiset ydinvoiman tutkimusorganisaatiot VTT ja LUT ovat ilmoittaneet suunnitelmistaan kehittää pienreaktoreita, joita sijoitettaisiin kaupunkialueille kaukolämmön tuotantoa varten. Näiden hankkeiden fasilitointi vaatii lainsäädännön uudistamista. Suomen ydinenergialainsäädännön kokonaisvaltaiseen uudistamisen tähtäävä hanke eteni uuden ydinenergialain säännösten kehittämisvaiheeseen.

Käytetyn ydinpolttoaineen loppusijoituksen valvontainstrumentoinnin kehittäminen säilytti asemansa Suomen ydinmateriaalivalvontajärjestelmän teknisen kehitystyön painopisteenä. Tähän kuuluvat mittausmenetelmät PGET (Passive Gamma Emission Tomography) ja PNAR (Passive Neutron Albedo Reactivity). Joulukuussa 2022 kaivosyhtiö Terrafame vahvisti tavoitteensa edetä kohti uraanin talteenottoa metallituotannossaan tulevina vuosina sekä tätä koskevan investointipäätöksensä. Tämä ydinalan uusi tulokas tuo uusia haasteita Suomen sääntelyviranomaisille, ydinmateriaalitoimisto mukaan lukien. Alustava turvallisuusseloste, johon sisältyy ydinmateriaalivalvonnan käsikirja, oli STUKin arvioitavana vuonna 2023.

Kaikkien nykyiseen täydelliseen ydinkoekieltosopimukseen (CTBT) liittyvien toimien keskeinen tavoite on itse sopimuksen voimaantulo. Tämänkaltaisen myönteisen poliittisen toiminnan edellytys on se, että täydellisen ydinkoekieltosopimuksen järjestön (CTBTO) valvontajärjestelmä toimii asianmukaisesti ja pystyy antamaan kaikille osapuolille varmuuden siitä, että salaisia ydinkokeita on mahdotonta tehdä paljastumatta. Suomen kansallinen tietokeskus FiNDC on sitoutunut omaan rooliinsa tässä yhteisessä pyrkimyksessä, jotta CTBTO:n valvontajärjestelmä voi suorittaa tehtävänsä.

Sammanfattning

Myndighetskontrollen av kärnämnen, kärnämneskontrollen, är förutsättningen för en fredlig användning av kärnenergi. För att fullgöra Finlands åtaganden enligt de internationella avtalen om icke-spridning av kärnvapen – främst fördraget om förhindrande av spridning av kärnvapen – genomförs denna myndighetskontroll i huvudsak av kärnmaterialbyrån vid Strålsäkerhetscentralen (STUK). Utöver detta spelar utrikesministeriet och arbets- och näringsministeriet en central roll i det statliga systemet för bokföring och kontroll av kärnämnen (SSAC). STUK samarbetar på nationellt plan med ministerierna, tullen, gränsbevakningen och andra inhemska intressentgrupper inom områdena för icke-spridning av kärnvapen, exportkontroll och kärnvapennedrustning.

De viktigaste aktörerna i SSAC är de driftansvariga och tillståndshavarna som har det yttersta ansvaret för sina kärnämnen och relaterad kärnteknisk verksamhet. Finland har en ganska betydande kärnkraftsproduktion, men den relaterade kärnkraftsindustrin är ganska begränsad. Merparten av de redovisade kärnämnena (uran, plutonium och torium) i Finland finns vid kärnkraftverken i Olkiluoto och Lovisa. Utöver dessa finns det en redan avstängd och nästan avvecklad VTT:s forskningsreaktor i Esbo med färskt kärnbränsle kvar på platsen. Andra finländska driftansvariga är STUK själv, Helsingfors universitet och VTT:s kärnsäkerhetshus, som är medelstora innehavare, innehavare av kärnämne som genereras som koncentrat eller biprodukter inom utvinningsindustrin och ett dussintal mindre innehavare av kärnämnen.

STUK upprätthåller ett nationellt bokföringssystem för kärnämnen och övervakar att den kärntekniska verksamheten i Finland bedrivs i enlighet med kärnenergilagen och -förord-ningen, Europeiska unionens bestämmelser om kärnämneskontroll och internationella avtal. Syftet med dessa uppgifter är att säkerställa att Finland kan försäkra sig själv och det internationella samfundet om att det inte finns någon kärnteknisk verksamhet eller några kärnämnen som inte har redovisats. Dessutom utvärderar IAEA funktionen av det statliga kontrollsystemet och Europeiska kommissionen deltar i kärnämneskontrollen inom sin jurisdiktion.

Resultaten av bokföringen och kontrollverksamheten inom ramen för STUK:s kärnämneskontroll under 2023 visade fortsatt att de finländska tillståndshavarna tar väl hand om sina kärnämnen. Det fanns inga indikationer på kärnämnen eller kärnteknisk verksamhet som inte hade redovisats, och de ämnen och verksamheter som inspekterades överensstämde med verksamhetsutövarnas redovisningar. De driftansvarigas egna bokförings- och kontrollsystem för kärnämnen gjorde det möjligt för Strålsäkerhetscentralen att fullgöra sina egna skyldigheter enligt de internationella avtalen som gäller kärnämneskontroll.

Arbetsmiljön för STUK och andra aktörer inom den nationella kärnämneskontrollen i Finland stabiliserades gradvis efter de utmanande tiderna under coronapandemin. Medan inspektionsverksamheten och annat arbete på fältet hade utförts nästan normalt under pandemin, återkom internationella evenemang, konferenser och personliga möten 2023. STUK utnyttjade de goda praxis som man lärt sig från hybridarbete och inspektioner på distans. I slutet av året hade STUK genomfört 43 inspektioner och 73 inspektionsdagar, vilket är i linje

med långtidsmedelvärdena. Även antalet internationella inspektioner och inspektionsdagar var på normal nivå. Enligt IAEA:s och kommissionens utlåtanden om inspektionsresultaten och slutsatser om genomförandet av kärnämneskontrollen fanns det inga öppna frågor i slutet av 2023.

Erfarenheterna från STUK:s senaste strategiperiod 2018–2022 visade att snabba förändringar är möjliga även inom det konventionella kärnkraftsområdet. Förändringarna inom kärnkraftsindustrin och i arbetsmiljön hade inte kunnat förutses 2018. Därför är den nuvarande strategin att fortsätta med en rullande strategi för att anpassa resurserna till den förändrliga miljön. De finländska kärnforskningsorganisationerna VTT och LUT har tillkännagett sina planer på små reaktorer som ska placeras i stadsområden för fjärrvärmesyften. Faciliteringen av dessa projekt kräver nya angreppssätt i lagstiftningen. Projektet för en omfattande reform av den finländska kärnenergilagstiftningen gick framåt till utvecklandet av bestämmelser för den nya kärnenergilagen.

Utvecklingen av instrumenteringen för kärnämneskontrollen för slutförvaring av använt kärnbränsle var fortsättningsvis det prioriterade området i det tekniska utvecklingsarbetet inom det finländska systemet för kärnämneskontroll. I detta ingår mätmetoderna PGET (Passive Gamma Emission Tomography) och PNAR (Passive Neutron Albedo Reactivity). I december 2022 bekräftade gruvbolaget Terrafame sitt mål och investeringsbeslut att gå vidare mot uranåtervinning i sin metallproduktion under de kommande åren. Denna nykomling på kärnkraftsområdet innebär nya utmaningar för de finländska tillsynsmyndigheterna, inklusive kärnmaterialbyrån. Den preliminära säkerhetsanalysrapporten som omfattar en kärnämneshandbok bedömdes av STUK under 2023.

Ett viktigt mål för all nuvarande verksamhet i anslutning till fördraget om fullständigt förbud mot kärnsprängningar (CTBT) är att själva CTBT ska träda i kraft. En viktig förutsättning för sådan positiv politisk verksamhet är att övervakningssystemet som används av organisationen för fördraget om fullständigt förbud mot kärnsprängningar CTBTO fungerar och kan försäkra alla parter om att det är omöjligt att genomföra kärnvapenprov i hemlighet utan att det upptäcks. Finlands nationella informationscenter FiNDC har förbundit sig vid sin egen roll i denna gemensamma strävan, så att CTBTO:s övervakningssystem ska kunna utföra sin uppgift att upptäcka kärnsprängningar.

Preface

In 2023, the peaceful use of nuclear energy and nuclear non-proliferation have been more and more in the discussions. What does that mean and how can we in Finland promote non-proliferation in our use of nuclear facilities and in our nuclear activities. And how this is considered when we are talking about safety first?

International agreements and obligations require all states to take necessary actions to ensure peaceful use of nuclear energy non-proliferation. This requires, for example, implementation of the effective IAEA safeguards. When the state is fulfilling these requirements, it can acquire nuclear materials, equipment and information. When these are acquired, there is need for certain secure means and physical protection. After safeguards and security have been taken care of in all use of nuclear energy, safety must be ensured. Thus, without considering of all these three Ss, the use of nuclear energy is not possible. In other words, safeguards and security can be seen as normal actions and prerequisites for all use of nuclear energy, and safety requires overall measures depending on the danger caused to Man and the environment, which leads to safety-first thinking. To summarise, there is no need for safety without safeguards and security. In the new Nuclear Energy Act, this will be highlighted.

When we understand the role of safeguards, it is easier to understand the necessity of safeguards by design (SBD). SBD is essential to ensuring efficient safeguards implementation with the minimal impact on processes. If these measures are considered in the planning and design of a nuclear facility or installation, the safeguards for that facility or installation can be applied with minimum impact and maximum output leading to greater confidence in the peaceful nature of the use of nuclear materials and activities also influencing the overall safeguards approach by the State. In 2023, STUK continued the co-operation in the development of the SBD with FANC by organising a workshop on concepts and provisions in the legal and regulatory framework with the IAEA and the EC and also inviting other countries' representatives to contribute on this important work.

Some other highlights of 2023 include work done in the preparation of the disposal of spent nuclear fuel like the development of the national database "Lost and Found" and the installation of the IAEA and the EC equipment in the EPGR facilities, as well as the finalisation of the national project GOSSER on developing a national safeguards concept for spent nuclear fuel disposal at Olkiluoto.

In 2023, the following persons were working in my section:

- Mr Tapani Honkamaa, Principal Advisor
- Mr Mikael Moring, Senior Inspector
- Dr Olli Okko, Senior Inspector
- Mr Timo Ansaranta, Senior Inspector
- Mr Ville Peri, Inspector
- Mr Topi Tupasela, Inspector
- Dr Anna Lahkola, Senior Inspector (task rotation from the Nuclear Reactor Regulation)
- Ms Riina Virta, Researcher
- Ms Riikka Sillanpää, Thesis worker

In 2024, my aim is to focus on knowledge management and competence building, not only in my section but also nationally and internationally. The co-operation and collaboration in building the necessary expertise and ensuring the continuity of knowledge are things we can also learn from in terms of experiences and sharing good practices. Limited resources require knowledge management. It is important to understand what we already have but also to have a vision of what we will also need in the future. In this task, our own personal development programme (inspector's qualification programme) goes hand in hand with STUK's international programmes and training organised under the ESARDA or, for example, the SATE Master of Safeguards courses, but especially in the work carried out within the various ESARDA working groups. One of the main challenges is and will also be to spread the understanding of safeguards and its objectives to those who are not familiar with them, like designers of new facilities and those who are more familiar with the safety and security.

It is my duty as a section head to ensure that we are able to maintain and develop the national safeguards system, and that we have the necessary expertise to reach our objectives. It is my duty to see that the well-being of the personnel in my section is secured, partly by ensuring that they have motivating tasks and duties.

2024 will be another busy year for us. We have a new European Commission safeguards regulation on the table. We need to continue developing the national legislation and STUK's safeguards regulation. The starting date for the disposal of spent fuel is approaching. In Finland, there are also plans to replace fossil electricity and heat production with small modular reactors. International projects will continue and the need for international co-operation in safeguards is growing. To ensure the peaceful use of nuclear energy and non-proliferation, we need to be agile, but primarily we need to be prepared to do our best. And in this task, I trust my staff.

Marko Hämäläinen
Section Head
Nuclear Materials Safeguards

PS. I would like to give my special thanks to our assistant Ms Sirpa Teviö whose assistance in practical matters has proven essential to us. Keep up the good work, Sirpa.

1 Implementation of nuclear non-proliferation in Finland

The regulatory control of nuclear materials, nuclear safeguards, is a prerequisite for the peaceful use of nuclear energy in Finland. For Finland to have a nuclear industry, most of which consists of nuclear energy production, it must be ensured that nuclear materials, equipment and technology are used only for their declared peaceful purposes. The basis of nuclear safeguards is the national system for the regulatory control of nuclear materials and activities. Nuclear safeguards represent an integral part of nuclear safety and nuclear security and are applied to both large- and medium-sized nuclear industry and to small-scale nuclear material activities. Along with the safeguards, the regulatory process for nuclear non-proliferation includes transport control, export control, border control, international cooperation and monitoring compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT).

Safeguards are applied to nuclear materials and activities that can lead to the proliferation of nuclear weapons. These safeguards include nuclear materials accountancy, control, security and the reporting of nuclear fuel cycle-related activities. The main parties involved in a state nuclear safeguards system are the users of nuclear materials, often referred to as 'licence holders' or more broadly as 'operators', and the state regulatory authority, STUK. A licence holder must take good care of its nuclear materials and the state authority must provide the regulatory control to ensure that the licence holder fulfils the requirements. The control of nuclear expert organisations, technology holders and suppliers in the non-proliferation of sensitive technology is also a growing global challenge. In Finnish legislation, all these operators are dealt with as users of nuclear energy.

Finland has quite significant nuclear power production, but the related nuclear industry is rather limited. Most of the nuclear materials (uranium, plutonium and thorium) in Finland reside at the nuclear power plants at Olkiluoto and Loviisa. Other holders of nuclear materials in Finland possess only a small fraction of the total amount. Most of the applied nuclear research and development activities are carried out to improve the maintenance and safety of the nuclear power plants.

1.1 International safeguards agreements and national legislation

Nuclear safeguards are based on international agreements, the most important and extensive of which is the Treaty on the Non-Proliferation of Nuclear Weapons (Non-Proliferation Treaty, NPT). The Treaty Establishing the European Atomic Energy Community (Euratom Treaty) is the basis for the nuclear safeguards system of the European Union (EU). Finland is bound by both these treaties and also has several bilateral agreements in the area of the peaceful use of nuclear energy. When Finland joined the EU, the bilateral agreements with Australia, Canada and the USA were partly replaced by the corresponding Euratom agreements (see Appendix 3 for the relevant legislation).

Finland was the first state where an INFCIRC/153-type comprehensive Safeguards Agreement with the IAEA entered into force. The original agreement INFCIRC/155 was in force from 9 February 1972. When Finland joined the EU on 1 January 1995, this agreement was suspended and subsequently the Safeguards Agreement between the non-nuclear-weapon Member States of the EU, the Euratom and the IAEA, agreement number INFCIRC/193, entered into force in Finland on 1 October 1995. Finland signed the Additional Protocol (AP) to the INFCIRC/193 in Vienna on 22 September 1998 with the other EU Member States and ratified it on 8 August 2000. The Additional Protocol entered into force on 30 April 2004 once all the EU Member States had ratified it. The scope and mandate for Euratom safeguards are defined in European Commission Regulation No. 302/2005.

After Finland joined the EU as a Member State and thereby subjected itself to the Euratom safeguards, a comprehensive national safeguards system continued to be maintained and further developed. The basic motivation for this is the responsibility assumed by Finland for its safeguards and security under the obligations of the NPT, and to ensure fulfilment of the Euratom requirements.

The national safeguards derive their mandate and scope from the Finnish Nuclear Energy Act and Decree. The operator's obligation to have a nuclear material accountancy system and the right of STUK to oversee the planning and generation of design information for new facilities were introduced from STUK requirements into the Nuclear Energy Decree.

In 2015, the Nuclear Energy Act was amended in such a way that the government decrees on nuclear safety, nuclear waste management, emergency preparedness and nuclear security were replaced by new STUK regulations. In addition, the new STUK regulation on the Safety of Mining and Milling Operations Aimed at Producing Uranium or Thorium also entered into force on 1 January 2016.

As stipulated by the act, STUK issues detailed requirements (the YVL Guides) on safety, security and safeguards that apply to the use of nuclear energy. STUK's safeguards requirements for all users of nuclear energy during all phases of the nuclear fuel cycle are set in Guide YVL D.1 Regulatory Control of Nuclear Safeguards issued in 2013. This guide was updated in 2018, and the latest version was published in 2019. Areas covered in the new comprehensive guide include the obligations and measures stemming from the Additional Protocol for the Safeguards Agreement and from recent developments. All operators must describe their own safeguards system in written form (as a nuclear materials handbook or safeguards manual), in order to facilitate their task of fulfilling their obligations and to guarantee the effective and comprehensive operation of the national safeguards system. In the latest guide, there are also specific national requirements for the disposal of spent nuclear fuel in a geological repository.

In general, nuclear safeguards control applies to:

- nuclear material (special fissionable material and source material)
- nuclear dual-use items (non-nuclear materials, components, equipment and technology suitable for producing nuclear energy or nuclear weapons as specified in INFCIRC/254, Part 1)
- licence holders' activities, expertise, preparedness and competence including information security
- R&D and other activities related to the nuclear fuel cycle as defined in the Additional Protocol
- the design and construction of new nuclear facilities.

1.2 Parties to the Finnish safeguards system

The main parties involved in the Finnish safeguards system are the authorities and operators. Undistributed responsibility for the safety, security and safeguards of the use of nuclear energy rests with the operator. It is the responsibility of STUK as the state regulatory authority to ensure that the licence holders and all other operators in the nuclear field comply with the requirements of the law and the nuclear safeguards agreements. To complement the national effort, international control is necessary in order to demonstrate credibility and the proper functioning of the national safeguards system.

1.2.1 Ministries

The Ministry for Foreign Affairs (MFA) is responsible for national non-proliferation policy and international agreements. The MFA is responsible for the export control of nuclear materials and other nuclear dual-use items, including sensitive nuclear technology. The Ministry of Economic Affairs and Employment (MEAE) is responsible for the supreme command and control of nuclear matters. The MEAE is responsible for the legislation related to nuclear energy and is also the competent authority mentioned in the Euratom Treaty. Other ministries, such as the Ministry of the Interior and the Ministry of Defence, also contribute to the efficient functioning of the national nuclear safeguards system.

1.2.2 STUK

According to Finnish nuclear legislation, STUK is responsible for maintaining the national nuclear safeguards system to prevent the proliferation of nuclear weapons. STUK regulates the operators' activities and ensures that the obligations of international agreements concerning the peaceful use of nuclear materials are met. Regulatory control by STUK includes the possession, use, production, transfer (national and international), handling, storage, transport, export and import of nuclear materials and nuclear dual-use items. STUK oversees Finland's approval and consultation process for inspectors from the IAEA and the European Commission.

The nuclear safeguards work of STUK, executed by its Nuclear Materials Safeguards section, covers the most typical measures of the national authority in the state system of accounting for and control of nuclear material (SSAC), together with many other activities. STUK reviews the operators' reports (operational notifications, inventory reports), inspects their accountancy, facilities, and transport arrangements on site, and performs system audits. STUK runs a verification programme for nuclear activities to assess the completeness and correctness of the declarations by the licence holders. STUK acts proactively to avoid or solve in advance any foreseeable issues that may be raised by the international inspectorates. Nuclear safeguards on a national level are closely linked to other functions of nuclear materials control and non-proliferation: licensing, export control, border control, transport control, combatting illicit trafficking, the physical protection of nuclear materials, monitoring compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT) and the Global Initiative to Combat Nuclear Terrorism (GICNT). Nuclear safety and particularly nuclear security objectives are closely complemented by safeguards objectives. For this reason, the research and regulatory units in the fields of safety, security and safeguards at STUK cooperate within the non-pro-

liferation framework. The scope of non-proliferation work is linked to many organisational units of STUK (Fig. 1).

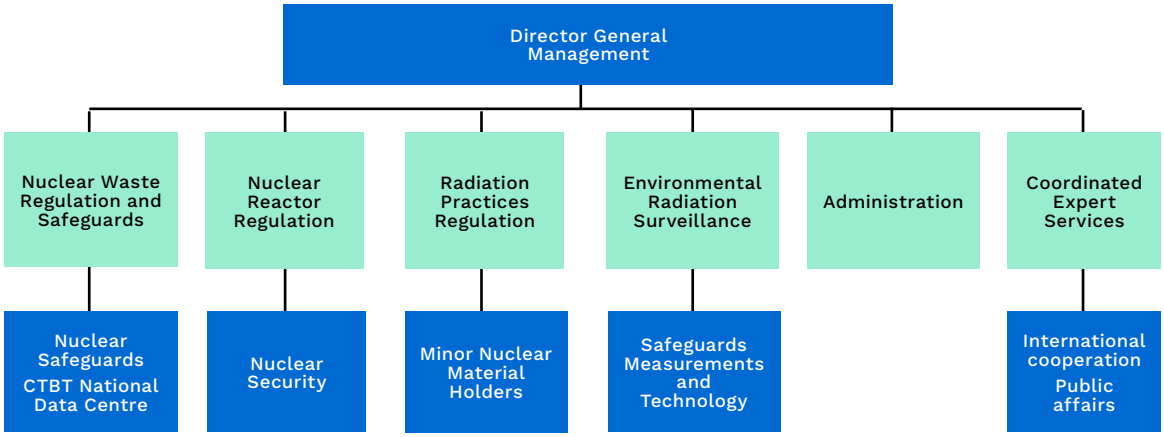

FIGURE 1. Framework to implement nuclear non-proliferation within STUK's organisation.

The distribution of the working hours of the Nuclear Materials Safeguards section in 2023 in the different duty areas is presented in Figure 2. Most of the working hours are invoiced to the operators. The duty areas are divided into direct oversight and inspections (basic operations), support functions including maintenance, development work for the regulatory functions and consultancy, including international cooperation financed by the Ministry for Foreign Affairs or the European Union. State budgetary funding usually constitutes about 5% of the total funding of the section. In 2023, this fraction was larger due to the work done in nuclear legislation renewal and some cooperation projects, such as international Safeguards by Design development. However, the most significant development in the distribution was that the number of hours dedicated to expert services returned to or even exceeded pre-COVID-19 levels. This was because of the strong contribution by STUK's safeguards experts in the cooperation programme between STUK and the African Commission on Nuclear Energy AFCONE to uplift nuclear safeguards and strengthen the nuclear material control systems in Africa.

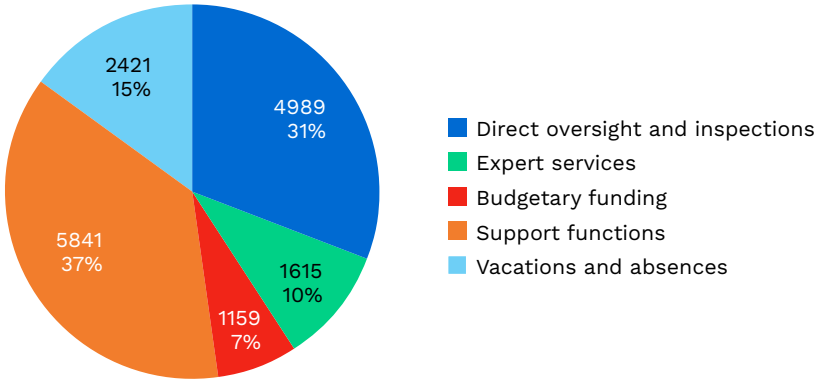

FIGURE 2. The distribution of the working hours of the Nuclear Materials Safeguards section in the various duty areas.

Nuclear non-proliferation is by nature an international domain. STUK therefore actively participates in international nuclear safeguards-related cooperation and development efforts. STUK takes part in the European Safeguards Research and Development Association ESARDA's working groups, executive board and steering committee. Current nuclear projects including the disposal facility have emphasised the need to introduce safeguards requirements at an early stage of facility design. These experiences, among others, are actively shared by STUK with the IAEA, in several international fora and in bilateral cooperation with several countries.

1.2.3 Licence holders and other users of nuclear energy

The essential parts of the national safeguards system are the licence holders and other users of nuclear energy – in nuclear terminology, often called the operators. In Finnish legislation, the term 'use of nuclear energy' encompasses a wide range of nuclear-related activities such as those defined in the Additional Protocol. These operators, in particular the licence holders, perform key functions in the national safeguards system: control of the authentic source data of their nuclear materials in addition to accountancy for nuclear materials at the facility level for each of their material balance areas (MBA). Each licence holder or other user of nuclear energy must operate its safeguards system in accordance with its own nuclear materials handbook or safeguards manual. The requirements of Finnish nuclear energy legislation, the Euratom Treaty and safeguards regulations of the European Union, the Comprehensive Safeguards Agreement and the Additional Protocol are integrated into the handbook to facilitate implementation of safeguards at the site, including the material balance areas. Other operators too, as users of nuclear energy, are required to have a safeguards manual to facilitate safeguards implementation. The nuclear materials handbook or safeguards manual is part of the operator's quality system and is reviewed and approved by STUK.

In Finland, there are over 20 operators responsible for nuclear material accountancy and control. The major material balance areas are listed in Table 1 and described in greater detail below. Most of the nuclear materials in Finland reside at the nuclear power plants at Loviisa and Olkiluoto. The amounts of nuclear materials (uranium, plutonium) in Finland in 1990–2023 are presented in Figures 3 and 4. Currently there are six sites as stated in the Additional Protocol: the two nuclear power plant sites, the geological repository site at Olkiluoto, and three minor sites: VTT Technical Research Centre of Finland, the Radiation and Nuclear Safety Authority STUK and the Laboratory of Radiochemistry at the University of Helsinki.

With the basic technical characteristics (BTC) submitted by a licence holder or another operator as groundwork, the European Commission adopts particular safeguards provisions (PSP) for that licence holder. PSPs are drawn up taking operational and technical constraints into account in close consultation with both the person or undertaking concerned and the relevant member state. Until PSPs are adopted, the person or undertaking must apply the general provisions of Commission Regulation No. 302/2005. A facility attachment (FA) is prepared by the European Commission and the IAEA to describe arrangements specific to that facility, which must be in line with the particular safeguards provisions given to the operator. The status of the regulatory documents for the Finnish material balance areas is shown in Table 1.

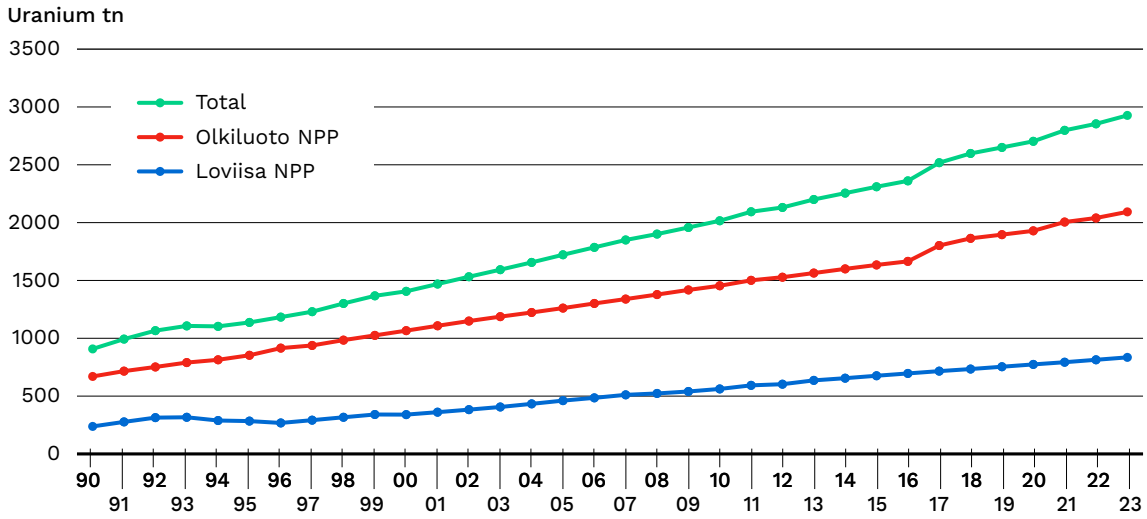

FIGURE 3. Uranium accumulation in Finland in 1990–2023.

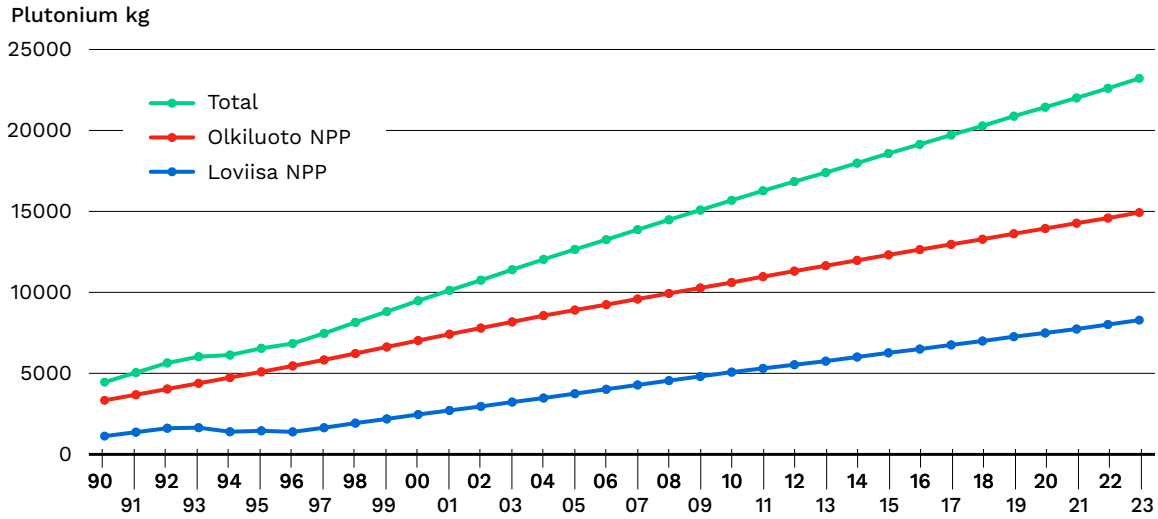

FIGURE 4. Plutonium in spent nuclear fuel in Finland in 1990–2023.

TABLE 1. Status of regulatory documents for material balance areas in Finland at the end of 2023.

MBA, location	BTC, last upd.	Site (AP), founded	PSP, in force	FA, in force	Licence/DiP, in force (from/until)	SG Manual, approved update
WL0V, Loviisa	10.10.2023	SSFLOVI, 8.7.2004	Yes, 4.5.1998	No	Operating, until 31.12.2050	30.6.2022
W0L1, Olkiluoto	22.11.2021	SSFOLKI, 8.7.2004	Yes, 7.6.2007	No	Operating, until 31.12.2038	21.3.2022
W0L2, Olkiluoto	22.11.2021	SSFOLKI, 8.7.2004	Yes, 7.6.2007	No	Operating, until 31.12.2038	21.3.2022
W0LS, Olkiluoto	10.12.2021	SSFOLKI, 8.7.2004	Yes, 7.6.2007	No	Operating, until 31.12.2038	21.3.2022
W0L3, Olkiluoto	7.12.2021	SSFOLKI, 8.7.2004	Yes, 17.12.2019	Yes, 30.1.2020	Operating, until 31.12.2038	21.3.2022
W0LE, Olkiluoto	28.10.2021	SSFPOSI, 31.3.2010	No	No	Construction, from 12.11.2015	11.2.2022
W0LF, Olkiluoto	29.10.2021	SSFPOSI, 31.3.2010	No	No	Construction, from 12.11.2015	11.2.2022
WFV1, Pyhäjoki	3.2.2017	No	No	No	No, construction licence application withdrawn on 24.5.2022	1.10.2021
WRRF, Espoo	16.4.2021	SSFVTTI, 8.7.2004	Yes, 9.7.1998	No	Decommissioning, from 17.6.2021 until 31.12.2030	13.4.2017
WNSC, Espoo	15.10.2021	Included 2017 to SSFVTTI	No	No	Operating, until 31.12.2026	14.12.2021
WFRS, Helsinki	6.2.2023	SSFSTUK, 8.7.2004	No	No	Not required (as an authority)	11.11.2019
WHEL, Helsinki	31.5.2021	SSFHYRL, 8.7.2004	No	No	Operating, until 31.12.2027	9.6.2022
WKK0, Kokkola	13.2.2020	No	No	No	Operating, until 31.12.2024	17.12.2020
WNNH, Harjavalta	14.5.2021	No	No	No	Operating, until 31.12.2029	15.11.2019
WTAL, Terrafame	20.5.2019	No	No	No	Operating until 31.12.2050	19.7.2018
WDPJ, Jyväskylä	2.2.2021	No	No	No	Operating, until 31.12.2024	4.5.2023

Finnish material balance areas and their status on 31.12.2023. MBA (material balance area code), BTC (Basic Technical Characteristics, i.e. Design Information), AP (the Additional Protocol), PSP (Particular Safeguards Provisions set by the European Commission), FA (Facility Attachment prepared by the IAEA), DiP (Decision-in-Principle).

Fortum (MBA WL0V)

The nuclear power plant operated by Fortum Power and Heat Oy is located on Hästholmen Island in Loviisa on the south-east coast of Finland. This first NPP was built in Finland in the 1970s to host two VVER-440-type power reactor units. Loviisa 1 was connected to the electricity grid in 1977 and Loviisa 2 in 1980. These two units share common fresh and spent fuel storages. For nuclear safeguards accountancy purposes, the entire NPP is counted as one material balance area (MBA code WL0V).

Most of the fuel for the Loviisa NPP is imported from the Soviet Union/Russian Federation. The spent fuel of the Loviisa NPP was returned to the Soviet Union/Russian Federation until 1996 and since then has been stored in the interim storage due to a change in Finnish nuclear legislation, which forbids the import and export of nuclear waste in general, including spent fuel.

As per the requirements of the Additional Protocol, the Loviisa NPP site (SSFLOVI) comprises Hästholmen Island as a whole and extends to the main gate on the mainland. Particular safeguards provisions for the Loviisa NPP, which define the European Commission's nuclear safeguards procedures for the facility, have been in force since 1998. A Facility Attachment of the Safeguards Agreement INFCIRC/193 has not been prepared by the IAEA for the Loviisa NPP.

In 2023, Fortum received an extension to the operating licences of Loviisa 1 and Loviisa 2 units until the end of 2050.

Teollisuuden Voima (MBAs W0L1, W0L2, W0L3, and W0LS)

Teollisuuden Voima Oyj (TVO) owns and operates a nuclear power plant on Olkiluoto Island in Eurajoki on the west coast of Finland. The Olkiluoto NPP consists of three operational reactor units, and an interim spent fuel storage. There are four active material balance areas (MBA codes W0L1, W0L2, W0LS, and W0L3) at the Olkiluoto NPP. Olkiluoto 1 was connected to the electricity grid in 1978, Olkiluoto 2 in 1980, and Olkiluoto 3 in 2023.

Presently, the uranium in TVO's nuclear fuel is mainly of Australian, Canadian and Russian origin. This uranium is enriched in the Russian Federation or EU, and the fuel assemblies are manufactured in the EU. Spent fuel is stored in the interim storage at the site until final disposal at the Olkiluoto repository.

TVO owns most of the area of Olkiluoto Island, but the NPP site (SSFOLKI) as per the requirements of the Additional Protocol currently comprises the fenced areas around the reactor units, the spent fuel storage and the storage for low- and intermediate-level waste. Particular safeguards provisions for Olkiluoto 1, 2 and the spent fuel storage have been in force since 2007 and for Olkiluoto 3 since 2019. A Facility Attachment of the Safeguards Agreement INFCIRC/193 has been prepared by the IAEA for the Olkiluoto 3 unit but not for the other units of the Olkiluoto NPP.

Fennovoima

Fennovoima was founded in 2007 as a new nuclear power operator in Finland. The government approved a Decision-in-Principle (DiP) in 2010 for Fennovoima to construct a new nuclear power plant at a new site. In 2015, Fennovoima submitted a construction licence application for one AES-2006 pressurised water reactor at the Hanhikivi site in Pyhäjoki. However, on 29 April 2022, Fennovoima terminated the contract for the delivery of the power plant and

withdrew the construction licence application later in May. The DiP was also terminated because of its validity being tied to the construction licence application. In January 2023, Fennovoima informed the European Commission of the termination of the NPP project. At the same time, the BTC, which had been sent in 2017, and other information for safeguards planning for the NPP became no longer applicable. At the end of 2023, Fennovoima continues as a holder of nuclear information and its possession licence has been extended until the end of 2028. The construction site at Hanhikivi is still in the possession of Fennovoima.

VTT (MBAs WRRF and WNSC)

In Finland, the most significant facility with nuclear materials outside the nuclear power plants has long been the research reactor FiR 1 (MBA code WRRF), which is located in Otaniemi, Espoo and was operated by VTT Technical Research Centre of Finland. The research reactor was the first nuclear reactor built in Finland. In 2012, the Ministry of Employment and the Economy and VTT announced the plan to close down the reactor and launch the decommissioning process. The reactor was shut down in 2015. Irradiated fuel from the reactor was shipped to the United States in December 2020. At the end of 2023, the unirradiated fuel and old nuclear material samples that are regarded as waste remain at WRRF.

VTT received a licence to decommission the facility in June 2021. With its partner Fortum, VTT started preparing the dismantling site in February 2023. Reactor dismantling works began in June 2023. During the dismantling, nuclear-use items are rendered inoperable and removed from the site as waste according to a comprehensive NUI management plan, which was prepared by VTT and approved by STUK in early 2023. All nuclear materials and nuclear-use items will be removed from the facility before the site is deployed for some other purpose.

Particular safeguards provisions that define the European Commission's nuclear safeguards procedures for the facility have been in force for VTT FiR 1 since 1998. A Facility Attachment of the Safeguards Agreement INFCIRC/193 has not been prepared by the IAEA for the research reactor.

A new building, the VTT Centre for Nuclear Safety for experimental nuclear research was built on the Espoo premises of VTT. The MBA code WNSC was assigned to the material balance area in 2015. STUK granted the operating licence in 2016 for the VTT Centre for Nuclear Safety, and the first nuclear materials were moved to the new building in 2017. VTT's nuclear research activities are currently concentrated at the new building. The safeguards control of materials at WNSC continues to operate independently of WRRF with its own handbook, arrangements and responsible persons.

The VTT site (SSFVTTI), as per the requirements of the Additional Protocol, currently consists of the whole building around the research reactor, although there are non-nuclear companies and university premises in the same building, and the building of the Centre for Nuclear Safety.

In addition to handling nuclear materials at FiR 1 and the Centre for Nuclear Safety, VTT is responsible for nuclear information and for reporting on its research and development activities.

STUK (MBA WFRS)

According to the Nuclear Energy Decree, the Radiation and Nuclear Safety Authority (STUK) needs no licence as referred to in the Nuclear Energy Act for operations performed in its capacity as an authority. Nevertheless, STUK follows all the regulations and reporting practices in its capacity as a nuclear material holder. The function of handling and possessing nuclear materials at STUK is situated at a different department to the Nuclear Materials Safeguards section. The safeguards section provides regulatory oversight for this function similarly as for other holders of nuclear materials. Small quantities of nuclear materials are stored by STUK, mainly materials no longer in use and hence taken into STUK's custody. STUK was founded in 1958. STUK's offices, laboratories and other functions have been located in Jokiniemi, Vantaa since 2022. The STUK MBA (WFRS) consists of the STUK headquarters and the 'Central interim storage for small-user radioactive waste' at the Olkiluoto NPP site.

The STUK site (SSFSTUK), as per the requirements of the Additional Protocol, consists of the premises of STUK's headquarters located in Vantaa. The storage at Olkiluoto is included in the NPP's site declaration.

The University of Helsinki (MBA WHEL)

The Laboratory of Radiochemistry at the University of Helsinki (HYRL) uses small amounts of nuclear materials. The laboratory is located on the Kumpula university campus in Helsinki. The current licence holder is the Department of Chemistry. The HYRL site (SSFHYRL), as per the requirements of the Additional Protocol, comprises the whole building housing the laboratory.

Umicore Finland Oy (MBA WKK0)

The extracts of Kokkola Chemicals cobalt purification process contain uranium whose concentration qualifies it as nuclear material under the Finnish Nuclear Energy Act. The Kokkola Chemicals factory is located on the west coast of Finland and holds a licence for operations to produce, store and handle nuclear material. The current operator since December 2019 has been Umicore Finland Oy Kokkola. The extraction of uranium from industrial purification processes has produced so-called pre-safeguarded materials, which are not yet suitable for fuel fabrication or isotopic enrichment and are thus not subject to conventional IAEA safeguards. The operator reports monthly to the European Commission and STUK.

Norilsk Nickel Harjavalta Oy (MBA WNNH)

Norilsk Nickel Harjavalta Oy operates the nickel refining plant at Harjavalta in western Finland. The plant was commissioned in 1959 and expanded first in 1995 and again in 2002. The refinery of Norilsk Nickel Harjavalta employs the technique of the sulphuric acid leaching of nickel products. Uranium residuals have been extracted from the nickel products and stored at the site. The Norilsk Nickel Harjavalta company submitted the basic technical characteristics (BTC) to the European Commission in 2010. In 2010, STUK granted a licence to extract and store less than 10 tonnes of uranium per year. The licence was renewed at the end of 2019 for a new 10-year period. The materials in Harjavalta are also pre-safeguarded and monthly reports are provided to STUK and the European Commission. As per the reports, no uranium extraction took place in 2023.

Terrafame Oy (MBA WTAL)

In 2010, the Talvivaara Sotkamo Ltd mining company announced its interest in investigating the recovery of uranium as a separate product from its sulphide ore body at Talvivaara located in Sotkamo in eastern Finland. The Basic Technical Characteristics (BTC) were submitted to the European Commission in 2010, and the MBA code WTAL is assigned to the future uranium extraction plant that has been constructed as a separate part of the mineral processing plant. During 2015, the state-owned company Terrafame took over the mining and milling operations. At the end of 2016, the use of the uranium extraction plant was again included in the mining and mineral processing planning. STUK granted a licence for the small-scale pilot testing of the mineral processing techniques in December 2017. The licensing process included the approval of Terrafame's nuclear safeguards manual and responsible persons. The application for a full operating licence for the extraction plant was submitted to the government at the end of October 2017 and was processed by the Ministry of Economic Affairs and Employment. STUK delivered its statement on the safety of the uranium extraction plant to the ministry in June 2019. The licence was granted by the government on 6 February 2020 with a period for complaints, and finally endorsed by the Supreme Administrative Court on 24 June 2021. The MBA code WTAL is used in Terrafame's nuclear material accountancy that was initiated with the pilot tests.

According to the nuclear licence conditions, the uranium extraction must be initiated and launched within three years, by the summer of 2024. By the end of 2022, Terrafame confirmed its decision to invest in the commissioning of the uranium recovery with this timeline. During 2023, Terrafame reviewed the comments made by STUK in its safety review in 2019 and updated its safety analysis reports including the safeguards manual to fulfil the material accountancy and control requirements for the recovery plant. This new kind of continuous production of uranium concentrate at the mine will require a new type of nuclear oversight by STUK. After the foreseen start-up phase during 2024 and 2025, the recovery plant is expected to operate at full capacity by 2026 and to produce about 200 tonnes of uranium per year.

Other nuclear material holders

There are 13 minor nuclear material holders in Finland. One of them is an actual material balance area: the University of Jyväskylä, Department of Physics (JYFL, MBA code WDPJ). The nuclear material at JYFL has been derogated and exempted by the European Commission and the IAEA. Other minor nuclear material holders are members of the Catch-All-MBA (CAM), for the purposes of international nuclear safeguards. Many of these have depleted uranium as radiation-shielding material.

Uranium may be concentrated in the mineral processing industry in intermediate or metal products with uranium concentrations that meet the definition of nuclear material. These metal products are typical when, for example, processing sulphide ores with low uranium content, and do not need to be included in the Euratom reporting because of their non-nuclear use. In the process industry, the annual quantities of processed natural uranium are in the order of several kilogrammes or even tonnes. Typically, uranium is extracted from the main products and considered as industrial waste among other extracts. According to the definitions in the Finnish nuclear energy legislation, the production and possession of source material have been licensed by STUK since 2018 after an interpretation and decision by the Ministry of Economic Affairs and Employment in the summer of 2018. Earlier, these kinds

of operators were not licensed by STUK, but a few gold mining companies, for example, have reported their uranium-rich gold production to STUK. Current licence holders are Boliden Kokkola Oy and Boliden Harjavalta Oy for the production and possession of uranium-rich copper cement originating from zinc concentrates, and Dragon Mining Oy for the production of uranium-rich gold concentrates.

Posiva (MBAs W0LE and W0LF)

Posiva Oy is the company responsible for the disposal of spent nuclear fuel in Finland. It was founded in 1995 and is owned by the nuclear power plant operators TVO and Fortum. Posiva will dispose of the spent nuclear fuel, produced by its owners, 400 meters deep in the crystalline bedrock. Posiva was granted a licence by the government in November 2015 to construct a disposal facility. Based on the drawings presented in the application, the preliminary BTCs were prepared for the encapsulation plant (EP) and geological repository (GR) separately and submitted to the European Commission in 2013. The MBA codes assigned to the facilities are W0LE for the encapsulation plant and W0LF for the geological repository. The construction of the geological repository commenced officially in 2016 and the encapsulation plant construction in 2019. From 2003 to 2016, Posiva was building an underground rock characterisation facility called ONKALO® in Olkiluoto, and thus preparing for the construction of the disposal facility. Posiva has since started using the name ONKALO® for the whole disposal facility. The rock characterisation facility is now a part of the geological repository and constitutes the vehicle access ramp, three shafts and the technical support premises. In the IAEA safeguards approaches, it has been suggested that the geological formation should be under safeguards during the whole lifetime of the underground facility, beginning from the pre-operational phase. For this reason, long before becoming a nuclear material holder, Posiva was already required to develop a non-proliferation handbook, such as a nuclear materials handbook, to describe its safeguards procedures and reporting system.

Posiva submitted an operating licence application at the end of 2021. According to the company's current plans, the first canisters with spent nuclear fuel will be deposited in the mid-2020s. Cold tests of the disposal procedures are planned to start in late 2024. Normal verification inspections of nuclear materials cannot be performed once the materials have been permanently disposed of, so procedures related to verification inspections must be clear and necessary safeguards equipment should be installed and operational before the initiation of final disposal.

The installation, still without nuclear materials, constitutes a site according to the Additional Protocol. The Posiva site (SSFPOSI) covers the fenced area around the buildings supporting the construction of the facilities.

Other operators

Nuclear expert organisations, technology holders and suppliers that serve the nuclear and other industries are obliged to ensure that sensitive technology does not get into the hands of unauthorised parties and thereby contribute to nuclear proliferation. In Finland, these organisations and operators are required to apply for a licence for importing, transferring or possessing nuclear information that is under a particular safeguards obligation. The definition of nuclear information in the Nuclear Energy Decree encompasses the software and technology categories, product numbers 0D001 and 0E001, respectively, in the European Community

regime for the control of dual-use items. The regime is discussed in more detail in Chapter 1.5. To ensure effective safeguards control of nuclear information, these operators are required to organise their own safeguards control systems, designate a person responsible for safeguards control in the organisation, prepare a nuclear safeguards manual and report the activities surrounding the licensed information to STUK annually.

The introduction of the Additional Protocol extended the scope of safeguards to the non-proliferation control of nuclear programmes and fuel cycle-related activities. These also include research and development activities, which do not involve nuclear materials but are related to the process or system development of fuel cycle aspects defined in the protocol. Additionally, the United Nations Security Council Resolution 1540 requires every state to ensure that export controls, border controls, material accountancy and physical protection are efficiently addressed, and calls on all states to develop appropriate ways to work with and inform industry and the public of their obligations. The safeguards control of nuclear expert organisations and expertise in the nuclear field to ensure the non-proliferation and peaceful use of sensitive technology and dual-use items is a growing global challenge.

Nuclear safeguards are commonly seen as the traditional nuclear material accountancy and reporting system, the main stakeholders of which are the international, regional and local authorities and the operators. In accordance with the extended non-proliferation regime and the amendments to the Finnish legislation, the universities, research organisations, companies or other operators that have activities defined in the Additional Protocol are under reporting requirements and export control. These operators (mainly VTT Technical Research Centre of Finland and a few universities) as users of nuclear energy are required to prepare a nuclear safeguards manual and to nominate persons responsible for nuclear safeguards arrangements.

1.3 IAEA and Euratom Safeguards in Finland

The IAEA and the European Commission (Euratom safeguards) both have independent mandates to operate in Finland. These two international inspectorates have agreed on cooperation, which aims to reduce the undue duplication of effort. The operators report to the Commission as required by Commission Safeguards Regulation No 302/2005. It is the Commission's duty to control the licence holders' accounting and reporting systems. The Commission must draw up the particular safeguards provisions (PSP) to agree on the means of safeguards implementation, taking account of the operational and technical constraints of the licence holder.

The IAEA safeguards include traditional nuclear safeguards according to safeguards agreement INFCIRC/193, and safeguards activities in accordance with the Additional Protocol, integrated together. While this should not lead to an increase in the number of inspections, it should enable the IAEA to assure itself of the absence of undeclared nuclear activities in a state. In Finland, the integrated safeguards (IS) approach has reduced the rate of IAEA routine interim inspections. The reduction was first seen in 2009 and was a result of the state-level safeguards approach for Finland, which was negotiated during 2007 and 2008. In contrast to the reduction in routine inspections, the IAEA additionally performs 1–3 short-notice inspections per year in a state with a similar set of nuclear installations as Finland. Since 2010, the number of annual IAEA and European Commission inspections has been close to or even below 20 with approximately 25-35 inspection days. The fluctuation in inspection days is mainly

due to the different design information verification (DIV) activities at the final disposal site during each of the years.

At a trilateral meeting (IAEA/EC/STUK) in September 2013, it was agreed that no unannounced inspections with two hours' notice time would be performed in Finland after the beginning of 2014. Thus, currently all random interim inspections are expected to take place with 48 hours' advance notice (see info box). At the reactors, the physical inventory verification includes both pre- and post-PIT inspections. At Loviisa, cask shipments are verified when the core is open. STUK continues with annual routines consisting of approximately 40 field inspections, which enables the effective safeguards implementation of the international inspectorates.

According to the Finnish Nuclear Energy Act, STUK must participate in IAEA and Euratom inspections at Finnish facilities, so STUK has increased preparedness for short-notice and unannounced inspections and complementary access (abbreviated SNUICA). Every working day, one of STUK's inspectors is prepared to attend a possible IAEA or Euratom inspection.

The IAEA sends its statements on inspection results and the conclusion of safeguards implementation according to INFCIRC/193 and the Additional Protocol to the Commission, which amends them with its own conclusions and remarks, and forwards them to STUK. STUK sends the statements and conclusions to the operator in question for information and any required action. The IAEA annually draws conclusions confirming its confidence that all nuclear activities and materials are accounted for and are in peaceful use in Finland.

IAEA regular inspections:

Facilities and spent fuel storages at nuclear power plants (NPPs):

- Physical Inventory Verification (PIV)/Design Information Verification (DIV) 1/year
- Random Interim Inspection (RII) at 48 hours' notice (at least 1/year for Finland)

Research reactor and locations outside facilities (LOF)

- PIV/DIV 1/4–6 years

New reactors, under construction

- DIV and PIV later, as at the NPPs

Repository under construction

- PIV/DIV most likely 1/year

Complementary access at 2/24-hour notification to verify declared activities or to detect undeclared activities.

Euratom carries out additional inspections of the research reactor and MBAs at locations outside facilities (LOFs)

A state's declarations on its nuclear materials and activities are the basis for state evaluation by the IAEA under the obligations of the Additional Protocol. In Finland, the state has delegated its responsibility for these declarations to STUK. STUK has been nominated as a site representative, as per European Commission Regulation No. 302/2005. STUK collects, inspects and reviews the relevant information and then submits the compiled declarations in a timely fashion to the Commission and the IAEA.

Technical analysis methods are one tool for a state nuclear safeguards system to ensure that nuclear materials and activities within the state are in accordance with the licence holders' declarations, and that there are no undeclared activities. Such methods can provide information on the identity of the nuclear materials and confirm that licence holders' declarations are correct and complete with respect to, for example, the enrichment of uranium and the burn-up and cooling time of nuclear fuel. The technical analysis methods in use are non-destructive assay (NDA), environmental sampling and satellite imagery.

The declarations, inspections and other details on cooperation between the Finnish SSAC, the IAEA and the European Commission are discussed regularly. A trilateral meeting is a useful informal forum for every organisation to discuss, share information and clarify state declarations. A meeting is held at least once a year and is usually supplemented by a smaller trilateral meeting. STUK maintains active informal communication between the operators, itself, the IAEA and the Commission in day-to-day safeguards matters such as inspection arrangements.

1.4 Control of uranium and thorium production

Mining and mineral processing operations aiming to produce uranium or thorium are also under regulatory control. In order to carry out these activities, a licence and accounting system to keep track of the amounts of uranium and thorium is required. The scope of operations, annual production and concentration of nuclear material in the process determine the licensing principles. The definitions are given in the Nuclear Energy Act and Decree. The government processes licences for large-scale mining and milling operations aimed at producing uranium or thorium. STUK is the licensing authority for smaller-scale activities, which are processed as the production of nuclear material. A national licence is also required to export and import uranium or thorium ore and ore concentrates. These activities are also controlled by the Euratom Supply Agency and the European Commission. Mining and milling activities and the production of uranium and thorium concentrates must be reported to STUK, the Commission and the IAEA.

1.5 Licensing and export/import control of dual-use goods

In accordance with the Finnish Nuclear Energy Act, other nuclear fuel cycle-related activities in addition to nuclear materials are under regulatory control. A licence is required for the possession, transfer and import of non-nuclear materials, components, equipment and technology suitable for producing nuclear energy (nuclear dual-use items). The list of these other items is based on the Nuclear Suppliers' Group (NSG) Guidelines (INFCIRC/254 Part 1). The licensing authority is STUK. The Ministry for Foreign Affairs is responsible for granting NSG Government-to-Government Assurances (GTGA) when necessary. The ministry usually consults with STUK before giving the assurances. The licence holder is required to provide STUK with a list of the above-mentioned items annually. Moreover, the export, import and transfer of such items must be confirmed to STUK after the action.

Finland's export control system is based on the EU regulation on dual-use items, more precisely called Regulation (EU) 2021/821 of the European Parliament and of the Council of 20 May 2021 setting up a Union regime for the control of exports, brokering, technical assistance, transit and transfer of dual-use items. The latest amendment to the regulation was published in Commission Delegated Regulation (EU) 2023/2616 of 15 September 2023. The new regulation replaced EU Council Regulation (EC) No. 428/2009 of 5 May 2009 and is followed by the stakeholders, even though references to it have yet to be updated in Finnish nuclear legislation. The export of Nuclear Suppliers' Group (NSG) Part 1 and Part 2 items is regulated by the Finnish Act on the Control of Exports of Dual-use Goods. Authorisation is required to export dual-use items outside the European Union as well as for the EU internal transfers of NSG Part 1 items, excluding non-sensitive nuclear materials. The licensing authority for the export of nuclear materials and dual-use items is the Ministry for Foreign Affairs except for ore and materials that contain nuclear waste for which the licensing authority is STUK. Before granting an export licence, the ministry also takes care of NSG Government-to-Government Assurances. The ministry asks STUK's opinion on all applications concerning NSG Part 1 items.

1.6 Control of nuclear material transport

The requirements for the transport of radioactive material are set in the Finnish regulations on the transport of dangerous goods. The requirements are based on the IAEA Safety Standard Regulations for the Safe Transport of Radioactive Material, SSR-6, and their purpose is to protect people, the environment and property from the harmful effects of radiation during the transport of radioactive material. Based on these regulations, STUK is the competent national authority for the regulatory control of the transport of radioactive material.

In addition to the dangerous goods transport regulations, the Finnish Nuclear Energy Act sets specific requirements for the transport of nuclear material and nuclear waste. Generally, a licence granted by STUK is needed for such transport. Usually, transport licences are granted for a fixed period, typically a few years. A transport plan and a transport security plan approved by STUK are mandatory for each consignment of nuclear material or nuclear waste. A certificate of nuclear liability insurance must also be delivered to STUK before transportation. Furthermore, a package may be used for the transport of fissile nuclear material only after the package design has been validated by STUK.

1.7 Nuclear safeguards and security strengthen each other

STUK is the national authority for the regulatory control of radiation and nuclear safety, security and safeguards (3S). All these three regimes have a common objective: the protection of people, society, the environment and future generations from the harmful effects of ionising radiation. As nuclear security aims to protect nuclear facilities' sensitive or classified information, nuclear material and other radioactive material from unlawful activities, it is clear that the majority of the activities that aim at the non-proliferation of nuclear weapons, nuclear materials and sensitive nuclear technology contribute to nuclear security. Physical and information security measures at nuclear facilities and for nuclear materials including technology, sensitive information and knowledge also contribute to non-proliferation by providing the deterrence, detection and delay of and response to nuclear security events. At the same time, nuclear material accountancy and detection measures may supplement security measures through a deterrence effect.

2 Safeguards activities in 2023

2.1 The regulatory control of nuclear materials

In 2023, STUK fulfilled its inspection plan and finished the year with 73 inspection days and 43 inspections of material balance areas, sites and other operators. The number of inspections reached the general objective of 40 inspections per year. The inspection palette was again diverse with normal on-site inspections and hybrid inspections where some participants were on site and the rest joined in virtually from the office or from home.

Inventory reports and the following verification confirmed that nuclear materials remained in their intended peaceful use and under safeguards control. The accumulation of nuclear material at the facilities is shown in Figures 3 and 4 and the verified nuclear material inventories at the end of 2023 are shown in Tables A2 and A3 in Appendix 1.

The implementation of the IAEA's integrated safeguards since 2008 reduces the rate of routine inspections of the international inspectorates but includes short-notice random inspections. In 2023, the number of international inspections was lower than in the previous years. Two reasons for this could be identified. First, preparations for final disposal of spent fuel at the Olkiluoto spent fuel storage and Posiva's facilities were mostly carried out as technical visits. Second, the number of short-notice inspections was lower than in the previous few years. The IAEA launched three short-notice inspections in Finland during the year. The inspections contained one short-notice random inspection (SNRI) at the Olkiluoto spent fuel storage and one at the Loviisa nuclear power plant. Additionally, a complementary access inspection according to the Additional Protocol was performed at Metso Outotec Research Center in Pori. The development of the number of inspections and inspection person-days in material balance areas are presented in Figures 5 and 6, respectively. Inspections by STUK, the IAEA and the European Commission in 2023 are presented in Appendix 2.

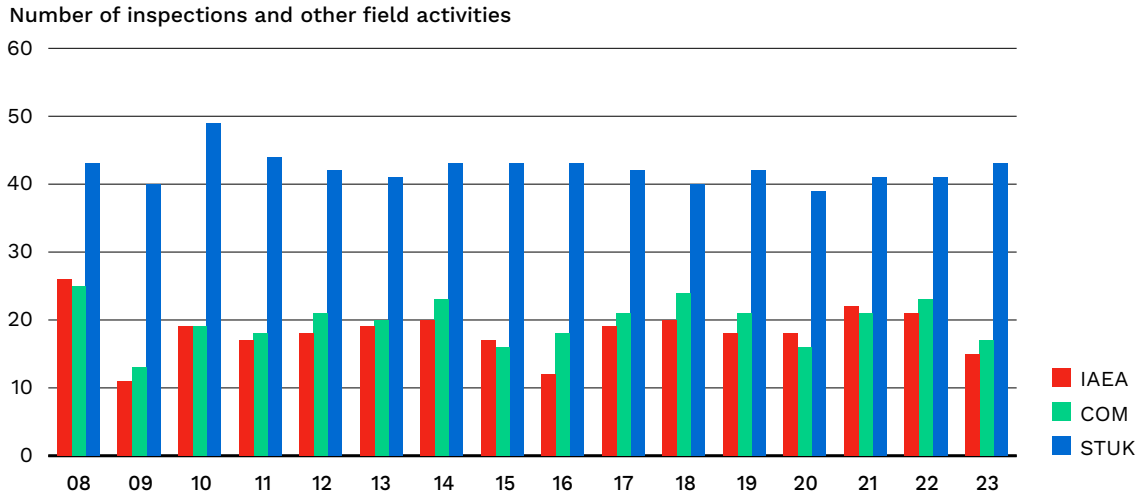

FIGURE 5. The number of inspections from 2008 to 2023.

The IAEA and the Commission provided STUK with statements on inspection results and the conclusions of safeguards implementation in 2023. There were no required actions from the Finnish operators. There were no outstanding questions from the IAEA or the Commission at the end of 2023. There were no indications of undeclared materials or activities, and the inspected materials and activities were in accordance with the operators' declarations.

The implementation of safeguards in Finland was addressed at two trilateral meetings. The first meeting was held between the IAEA, the European Commission and the Finnish authorities and operators at STUK in March. The meeting offered a possibility for the Finnish operators to discuss their latest activities and plans with their peers and the inspectorates. The operators also had the opportunity to both give and receive feedback on the safeguards implementation at their facilities. The previous trilateral meeting with operators had been held on the last week before the first COVID-19 lockdown in Finland in March 2020. Another trilateral meeting was held between STUK, the IAEA and the European Commission in Vienna in September 2023. Finnish delegates also met with the IAEA and EC at STUK's headquarters in Vantaa in March and in Olkiluoto in August on the implementation of safeguards for final disposal of spent fuel. In addition to the inspection routines, STUK continued with two annual safeguards meetings with the staff responsible for the major nuclear materials holders' safeguards. After good experiences of hybrid and remote meetings, many of these were still held virtually.

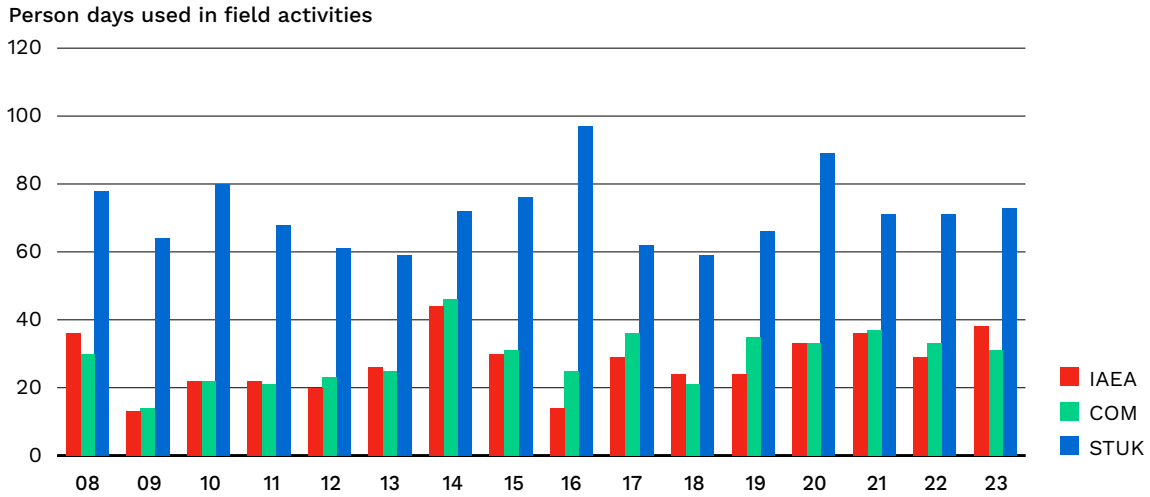

FIGURE 6. Inspection person days from 2008 to 2023.

2.2 General safeguards activities

2.2.1 Additional Protocol declarations

In 2023, STUK compiled licence holders' reports using the PR3 software provided by the IAEA. STUK submitted the annual updates for national declarations according to articles 2.a.(iii) and 2.a.(viii) on 24 March 2023 and the declarations according to articles 2.a.(i), 2.a.(iv), 2.a.(x) and 2.b.(i) on 11 May 2023. Furthermore, STUK submitted the quarterly declarations on exports that are due in February, May, August and November.

2.2.2. Approvals of new international inspectors

In 2023, a total of 15 IAEA and 8 Commission inspectors, newly appointed, were approved to perform inspections at nuclear facilities in Finland.

2.2.3 Nuclear dual-use items, export licences

In 2023, the Ministry for Foreign Affairs requested a STUK contribution in the processing of 45 export licences for NSG Part 1 items. The licence applicants were NPP operator companies TVO and Fortum, and the VTT Technical Research Centre of Finland. The exports were targeted at a range of countries: several EU countries, Japan, UK, USA, Argentina, Brazil, Mexico, Turkey, China, Vietnam, Indonesia and Philippines.

2.2.4 Transport of nuclear materials

In 2023, fresh nuclear fuel was imported to Finland from Spain, Sweden and the Russian Federation (Appendix 1, Table A1). In relation to these imports, STUK approved eight transport plans and four transport packaging designs. There were three inspections of fresh nuclear fuel consignments in 2023.

Fresh nuclear fuel transports were also made through Finland to other EU countries in 2023. These fuel batches are in transit while on Finnish territory and remain outside of the accountancy and reporting duties of the Finnish operators. STUK approves the transport plans for the transiting nuclear fuel consignments.

2.2.5 International transfers of nuclear material

In 2023, TVO reported to STUK about its international fuel contracts, fuel transfers and fuel shipments. Based on the document inspection findings on TVO's international nuclear material transfer accountancy and control carried out in 2023, STUK concluded that TVO had complied with its safeguards obligations when purchasing the nuclear fuel and managing its international nuclear material transfers. The next audit of TVO's international nuclear material transfers is scheduled for spring 2024.

In 2023, Fortum created a control, accountancy and reporting system for its international nuclear material transfers. STUK approved Fortum's nuclear materials manual on international transfers and inspected the system during a KTO system inspection in November.

2.3 Safeguards implementation at the operators

2.3.1 Loviisa nuclear power plant

In total, STUK performed nine safeguards inspections at the Loviisa NPP in 2023. A joint interim and site safeguards inspection was performed on 2 February. STUK, the IAEA and the European Commission performed an inventory verification inspection prior to the physical inventory taking (pre-PIT) before the reactor outages, on 15 August, and after the outages (post-PIT) together with a design information verification (DIV) on 11–12 October. After reloading the reactor cores, STUK identified the fuel assemblies in the cores and visually verified the number of fuel assemblies in the loading ponds. The Loviisa 2 core was inspected on 28 August and the Loviisa 1 core on 17 September. In November, STUK performed a KTO system inspection and, together with IAEA and EC, an NDA verification inspection of spent nuclear fuel with the PGET instrument. In 2023, one random interim inspection was carried out at Loviisa.

In 2023, STUK granted Fortum two import licences for the import of nuclear technology.

On the basis of its own assessment and on the IAEA and Commission inspection results, STUK concluded that Fortum's Loviisa NPP complied with its nuclear safeguards obligations in 2023.

2.3.2 Olkiluoto nuclear power plant

In 2023, STUK granted TVO four import licences for fresh nuclear fuel for the operating units and three licences to import and possess non-fuel items.

The operating reactor units Olkiluoto 1, 2 and 3 and the spent fuel storage of the Olkiluoto power plant were subject to 18 safeguards inspections in 2023, including safeguards-related technical activities. In cooperation with the European Commission and the IAEA, STUK performed the inspections that comprise the physical inventory verification of the reactor units and the spent fuel storage, both before and after the annual outages, on 28-31 March and 6-8 June, respectively. STUK performed a core verification inspection of the reactor units 1 and 2 before the reactor core lid was closed. The new Olkiluoto 3 unit was in operation throughout the year, and it did not have refuelling outage during 2023.

STUK took part in a random interim inspection initiated by the IAEA at the spent fuel storage. STUK performed an interim safeguards inspection at both units and the spent fuel storage. STUK also carried out an NDA campaign with the PGET and PNAR equipment in October.

STUK together with TVO, the IAEA and the EC furthered the planning of safeguards implementation for fuel that will be transported to the underground repository. All fuel will be verified with NDA measurements at a wet storage pond before going to the transfer cask. Additional safeguards equipment is needed to provide the continuity of knowledge on the fuel during transport to the repository. In 2023, STUK continued inspecting TVO's plans and

arrangements for the NDA measurements and other necessary steps in the final disposal process results, STUK concluded that TVO's Olkiluoto NPP complied with its nuclear safeguards obligations in 2023.

2.3.3 The Hanhikivi nuclear power plant project

STUK's oversight is focusing on the nuclear information that is in possession of the stakeholders of the cancelled Hanhikivi NPP project, including Fennovoima, RAOS Project and a few subcontractors. They still have valid contractual reasons to possess information. Some stakeholders destroyed information in 2023 and possession licences have either been withdrawn or have expired. The work still is ongoing to reach out some licence holders so that unnecessary licences can be cancelled.

2.3.4 VTT

The operator VTT Technical Research Centre of Finland, its main dismantling subcontractor Fortum and STUK started discussions on the principles and processes of handling nuclear-use items during the decommissioning of the research reactor FiR 1 in May 2022. VTT continued the detailed planning of the processing of nuclear-use items and equipment during the rest of the year and submitted a comprehensive plan to STUK for approval in January 2023. The guiding principles in the plan are to integrate the write-off process of nuclear-use items into the dismantling steps and give STUK access to an up-to-date nuclear-use item database. The contaminated or activated nuclear-use items will be rendered inoperable as nuclear material, removed from the nuclear-use item inventory and transferred to Fortum, which will handle them as nuclear waste. Some equipment is removed from the inventory in working condition. STUK approved this procedure as an exception considering the minimisation of radiation dose to dismantling workers and the disposal of that equipment in the facility for low- and intermediate-level waste in Loviisa. STUK also ensured that no international obligations restricted the disposal of the material. VTT also informed STUK and the European Commission of its plans on the handling of the remaining nuclear materials in its programme of activities.

At the end of 2023, most nuclear-use items at FiR 1 had already been dismantled. VTT maintained the database of nuclear-use item dismantling and provided STUK with photos and additional reports of special cases. The advance planning and approval of procedures greatly reduced the anticipated workload on STUK's side. VTT reported separately on the dismantling and write-off of non-radioactive nuclear-use items that are not transferred to Fortum but handled as ordinary waste.

STUK and the European Commission carried out nuclear material inventory verification inspections at the Centre for Nuclear Safety on 21 June and at FiR 1 on 22 June. At FiR 1, STUK also inspected the accountancy and work documentation of nuclear-use items that had been dismantled and verified items visually. In April, STUK approved the appointment of a new deputy responsible person for safeguards for FiR 1. VTT also named a new deputy responsible person for safeguards for the Centre for Nuclear Safety in 2023. In May, STUK processed VTT's routine special report on nuclear material that had been found during the clean-up of laboratories.

STUK had approved VTT's handbook on the safeguards control of nuclear information and R&D in October 2022 with requirements to further update the handbook by March 2023. After changes in responsible persons for safeguards of nuclear information and R&D, VTT sent an updated handbook to STUK for approval in September 2023. Based on the delayed submission of the handbook, delayed reporting on new responsible persons and other factors, STUK sent an inquiry to VTT on the organisation and management of safeguards of nuclear information and R&D. VTT answered the inquiry and provided another update to its handbook on time in December 2023. Further concerns on the management of nuclear information and R&D at VTT were addressed in an inspection carried out by STUK in January 2024.

Based on its assessment and inspection results, STUK concluded that VTT's FiR 1 reactor and Centre for Nuclear Safety complied with their nuclear safeguards obligations in 2023. VTT did not satisfactorily fulfil all its obligations on nuclear information and R&D in 2023. However, STUK determined that the corrective actions taken by VTT during the year were sufficient. STUK will verify in 2024 that VTT has followed the plans, which it has presented to STUK on further actions to strengthen its safeguards system for nuclear information and R&D.

2.3.5 STUK

STUK's operating unit responsible for handling nuclear materials (MBA WFRS) complied with its reporting obligations in 2023. STUK carried out a safeguards inspection on 22 March and another on 20 June, together with the IAEA and the EC. It can be concluded that the operating unit at STUK fulfilled the requirements for national safeguards arrangements in 2023.

2.3.6 University of Helsinki

STUK carried out a safeguards inspection at the University of Helsinki on 31 May. In addition to the inventory verification, new staff for safeguards were interviewed and a new deputy manager was consequently approved by STUK. Technical details in the internal control of nuclear material within the university were focused on during the inspection, and a separate licence was granted to the Department of Physics for the possession and handling of small amounts of nuclear materials as further described below.

On the basis of its assessment and inspection results, STUK concluded that the University of Helsinki complied with its nuclear safeguards obligations in 2023.

2.3.7 Minor nuclear material holders

In 2023, STUK inspected the annual and inventory change reports from the minor nuclear material holders. One operator had given up its inventory, ceased operations with nuclear materials and requested closure of its CAM area from the European Commission in 2022. The closure was confirmed by the EC in February 2023. STUK approved one handbook prepared by a CAM member. The old CAM area for the Department of Physics at the University of Helsinki was re-established and an operating licence was granted for the possession and handling of small amount of nuclear material at the X-ray and acceleration laboratories.

On the basis of its assessment, STUK concluded that the minor nuclear material holders complied with their nuclear safeguards obligations in 2023.

2.3.8 Front-end fuel cycle operators

At Umicore Finland Oy's plant in Kokkola and Norilsk Nickel Harjavalta Oy's plant in Harjavalta, there were no inventory changes or authority inspections in 2023. At both installations, the operators reported on their planned activities and monthly inventories according to safeguards requirements. At Kokkola, uranium-rich impurities were observed in the imported cobalt concentrates and returned to the shipper. A special report was prepared by the quality assurance and submitted to STUK. On the basis of its assessment, STUK concluded that these operators complied with their nuclear safeguards obligations in 2023.

The metal processing industry was required to be licensed for its uranium-rich intermediate products in 2017 as described in Chapter 1.2. Following its obligations, the zinc and copper production unit of the Boliden company reported that it had processed 944.9 kg of natural uranium originating from zinc concentrates in 2023. The uranium ends up in waste streams during the processing. Dragon Mining reported 35.7 kg of uranium in its gold production at its Sastamala mineral processing unit originating from the Jokisivu mine. The uranium, of source material grade, is not used in industrial processes. STUK concluded that these operators complied with their nuclear safeguards obligations in 2023.

In 2023, Terrafame continued its monthly reporting, which had been initiated in 2019 after storing the first uranium extracts. After the decision of the Supreme Administrative Court on 24 June 2021, the licence to build the uranium extraction plant was endorsed. According to the licence conditions, the plant must be commissioned within three years, i.e., at the latest in 2024. During 2023, the new licence holder made preparatory works at the uranium extraction plant and submitted the updated safety analysis report including safeguards manual to STUK in October 2023. The approval of these documents is expected in 2024, as well as the cold and hot test at the uranium recovery plant. STUK concluded that Terrafame complied with its nuclear safeguards obligations in 2023.

2.3.9 The disposal facility for spent nuclear fuel

The construction of the encapsulation plant (EP) and the geological repository (GR) has been proceeding according to plan. The encapsulation building was completed in 2022, and the installation of fuel handling equipment was continued during 2023. At the geological repository, the excavation of the central tunnels and the first set of deposition tunnels in the deposition area were finalised. The construction work for the infrastructure of the technical premises involved a large workforce underground, even limiting daytime access for visitors.

Two major technical meetings between the IAEA, the EC, STUK, Posiva and TVO were held to finalise the technical details of the safeguards implementation of the disposal. This work is almost finished and Posiva has implemented the equipment infrastructure requirements (EIR) in its construction drawings, and preparatory work (such as cabling) for the equipment installations is almost complete. Several (almost monthly) smaller technical meetings were also held on these issues between the four parties. The first equipment installations by the IAEA were made in February 2023, with another equipment installation campaign in July. Installations are due to continue in Q1 2024 and this Safeguards-by-Design process can be expected to continue during the construction of the installations.

In June 2023, STUK carried out a DIV inspection while following a test on using a mobile robot "robot dog" for inspection activities. The Commission's Joint Research Centre (JRC/Ispra) has developed a four-leg robot that is able to move itself autonomously in rough terrain. Its capabilities were tested in the disposal tunnels and in the vicinity of disposal holes (Figure 7). In November 2023, the IAEA and Commission carried out a design information verification to verify the underground premises constructed since the previous inspection in 2022. In addition, the status of the construction of the encapsulation plant was verified and the hoist and ventilations buildings with shaft connections underground were visited.

On the basis of its assessment and inspection results, STUK concluded that Posiva complied with its nuclear safeguards obligations in 2023.

FIGURE 7. Testing team and the robot dog in Onkalo (pictures from Posiva).

2.3.10 Other operators

Research organisations and universities provided STUK with their annual declarations on research and development work. After its review, STUK prepared the annual declaration based on the Additional Protocol to the IAEA within the time limit of 15 May.

The IAEA carried out a Complementary Access at the Metso (former Outotec) Research Center in Pori on 30 March 2023 to resolve questions relating to the correctness and completeness of information provided pursuant to article 2 and to resolve an inconsistency relating to information addressed in an IAEA letter in April 2022. The main focus was on the processing of uranium-bearing minerals as divulged in publicly available information. Although the stakeholder is not a licensee according to the Finnish nuclear energy legislation, the IAEA's questions were answered and the CA was successfully facilitated and carried out by the IAEA and European Commission. Finally in December 2023, the IAEA considered the addressed questions resolved.

3 Development work in 2023

3.1 Development of working practices

STUK's previous strategy period started in 2018 and ended in 2022. Flexibility and effectiveness as a regulator and expert organisation and increased emphasis on operator responsibility were some of the guiding strategical principles in that period. Looking back at the major developments during the past five years, the effectiveness of day-to-day work was disrupted both positively and negatively by the COVID-19 pandemic that spread to Finland in 2020. On one hand, STUK's safeguards staff and the other stakeholders in the Finnish national safeguards system quickly learned new and flexible ways to work, for example enabling remote and hybrid work, meetings and inspections, which reduced the need to travel and left more time for other activities. On the other hand, remote working reduced face-to-face discussions between inspectors and opportunities to meet with international colleagues, which are important ways to distribute knowledge and experiences. The pandemic also challenged STUK's Nuclear Materials Safeguards section to assess the required frequency of in-person inspections to reach conclusions on whether operators had complied with their obligations. The continuing emphasis on and oversight of the operators' own safeguards accounting and control systems enabled STUK to adjust the timing and scope of inspections without compromising the overall picture. Simultaneously, good contacts between the stakeholders allowed for safe and efficient arrangement of the required inspections. As experienced during these 5 years, a fixed strategy period was replaced by a rolling strategy, i.e., the strategic plans are reviewed annually, and updated according to observed needs and changes in the nuclear field, for example the emerging small modular reactors and related technology.

At the end of 2022, the section had ensured resources to answer the increased demands of safeguarding the final disposal of spent fuel, as a PhD student and a master's student were approved to continue their work in the section in 2023. So, in 2023, the Nuclear Materials Safeguards section consisted of a section head, seven inspectors who are responsible officers for the facilities, installations and other nuclear material or nuclear-related activities, one researcher of the PGET method and a worker writing a master's thesis aimed at developing a database for disposal. Measures in inspector development include job rotation both within the section and between the departments and the better handling of workload by pivoting from a system based on responsible officers and deputies towards pairs of responsible officers for facilities.

International cooperation was on a steady rise after the worst years of the pandemic, especially in safeguards training. The section continued to take advantage of opportunities to learn from and teach national and international institutions and experts in webinars, seminars, training courses and conferences. Part of this approach is a contribution to the international multidisciplinary tasks supporting safeguards, safety and security. For STUK, each chance to present best practices and challenges from the Finnish national safeguards system is also a chance for introspection, finding recurring patterns in the system and learning from successes and failures.

3.2 Comprehensive renewal of the Finnish nuclear legislation

In 2023, the project to comprehensively renew the Finnish nuclear legislation advanced to the phase of the preparation of requirements and provisions on a legislative level. The work to renew nuclear safeguards provisions in the legislation and regulations started in 2022 with a review of the current regulation structure and an assessment of which requirements would be elevated to the new Nuclear Energy Act. Currently, many of the binding practical provisions on nuclear safeguards are given in the Guide YVL D.1. In the future, binding provisions will be found in the Nuclear Energy Act, governmental decree concerning safeguards or STUK's binding regulation on safeguards. In keeping with the overall objective and requirement to include binding and all-encompassing provisions at a high level of legislation, the plan is to provide a separate chapter for nuclear safeguards in the Nuclear Energy Act. The Nuclear Materials Safeguards section aims at improving the structure and comprehensibility of the nuclear safeguards provisions. Easy-to-understand and easy-to-implement safeguards requirements in legislation and regulations contribute towards a more efficient and effective implementation of safeguards in all nuclear projects. In December 2023, the European Commission announced its proposal for the update of the 2005 regulation. This renovation will be under evaluation in the Working Group for Atomic Questions in 2024, and the results will be implemented in the new nuclear energy legislation as appropriate.

3.3 Support programme for the IAEA safeguards

The Finnish Support Programme for the IAEA Safeguards (FINSP) is financed by the Ministry for Foreign Affairs and coordinated by STUK. The objective of FINSP is to provide the IAEA with support in well-managed tasks related to the development of safeguards verification methods, safeguards concepts and IAEA inspector training. At the end of 2023, FINSP had 13 active tasks. Some of the tasks are presented here, focusing on those that involved several members of the Nuclear Materials Safeguards section.

In June, STUK held a Training and Mentoring workshop for eleven trainees from a scholarship programme at the IAEA. The workshop was the continuation of a similar workshop that was held in 2020, 2021 and 2022. The workshop was held in person in Vienna. The objective of the training remained the same: firstly, to share best practices from the Finnish SSAC with newcomers, and, secondly, to offer mentoring opportunities to the trainees. STUK expects to continue this kind of support in the future. STUK received significantly more specific feedback, which will enable it to develop the materials and structure of the workshop to suit the interests of the trainees. Overall, the experience was positive.

Small reactors for the central heating purposes of urban cities have been intensively studied by VTT Technical Research Centre of Finland and Lappeenranta-Lahti University of Technology (LUT). The commercial work for VTT is being managed through a VTT spin-off company established in 2023, called Steady Energy. Safeguards-by-Design–related challenges of these reactors (LDR-50 and LUTHER) are discussed with the IAEA through a specific support programme task. Designer from VTT visited the IAEA in November and presented their plans; and safeguards concepts were discussed. The goal is that, with the help of these discussions, safeguards can be taken into account already in the design of the plant. Effec-

tivity and efficiency are crucial for the feasibility of the concept for the small-scale reactors and their operating costs per unit should be fairly low. It is essential to raise awareness about safeguards within the energy sector that is not familiar with the nuclear prerequisites.

On 20–24 November 2023 FINSP and the IAEA arranged the "Interregional Training Course on Implementation of National Requirements for Nuclear Power Programmes". The course is oriented towards the countries that are planning to initiate or expand their Nuclear Power Programmes. Participants were from Egypt, Ghana, Nigeria, Uzbekistan, Poland and Turkey. The course provided a comprehensive overview of the basic concepts of Radiation and Nuclear Safety (3S), safety standards and familiarisation with the legislation and regulations. Participants also had the opportunity to learn about the practical operation of the Olkiluoto nuclear power plant during a site visit on 23 November. For many, the visit to an operating nuclear power plant was a highlight of the course and a memory that will live on. Participants gave positive feedback on the course, emphasising the value of interactive elements. However, they expressed a desire for a deeper understanding of exercises and more time to work on them. Both the IAEA and STUK will address this feedback in future discussions.

The main challenge of the year was the organisation of NDA training course for the IAEA inspectors. Initially the plan was to provide two courses, both for 12 participants. Due to delays in provision of ground permits at the NPP, access for most of the trainees could not be arranged. Consequently, another course had to be cancelled and discussions to rectify the situation for the further courses have been held.

3.4 Spent fuel disposal and GOSSER R&D project

The disposal of spent fuel requires that safety, data security and other security arrangements and the safeguards required to prevent the proliferation of nuclear weapons be properly implemented on a national level. For this purpose, STUK launched the GOSSER project (Geological Disposal Safeguards and Security) to finalise the Finnish concept of safeguarding the geological disposal of spent nuclear fuel in 2016. Projects GOSSER I and GOSSER II lasted a total of eight years, from 2016 to 2023. The first project stage developed a national safeguards concept for the spent nuclear fuel disposal at Olkiluoto and conducted necessary research and development for the purpose. The second project concentrated on developing the concept further.

According to the national safeguards concept prepared in the first stage of the project, all fuel must be verified in a comprehensive manner with the available system comprising a PGET (Passive Gamma Emission Tomography) and PNAR (Passive Neutron Albedo Reactivity) verifier. The NDA concept and ownership has been discussed with the EC and the IAEA. Common understanding exists that the measurement data will be shared with all parties.

In the second phase of the project, safeguards methodologies of the two tools were tested extensively and developed to the level where safeguards implementation will be straightforward. Further development and testing needs exist, which require adequate resourcing, but the risk of negative technical surprises is now limited.

Two sets of PGET and PNAR measurements were performed in 2023. A measurement campaign, featuring both instruments, was held in October 2023 at Olkiluoto. Another campaign was organised at Loviisa in November. 2023 was the last year of the GOSSER project. Remaining developments have been identified and include further development of the NDA methods. Further developments are needed, especially for remote operation. The IAEA has

developed a new software package for automated remote data acquisition for PGET and it was tested both at Olkiluoto and Loviisa. The software requires some improvements. PNAR, in turn, needs automated cadmium slider movement. A solution was designed in 2023 and its implementation is underway.

Several publications relating to the NDA development of PGET were published in 2023. The development of inspection criteria will also be developed. STUK has also developed a database, which will store safeguards-relevant information on the fuel and verification data. The database, called Lost&Found, is designed to be an integral part of the disposal process, not only serving as a storage of the measurement data but also as an interface to operational analysis tools and the management of workflow. Lost&Found can be also used to distribute information between the inspectorates and operators. Testing of this database for operational work is an on-going task.

Final report of GOSSER is available at https://www.julkari.fi/handle/10024/148643.

3.5 International cooperation for Nuclear Non-Proliferation

The state's regulatory authority plays an important role in implementing safeguards on a national level and in contributing to and participating in international fora to share experiences and interact with other parties. Participating in international events with a suitable contribution is also the best training for safeguards inspectors. Resources are limited so the selection of the events is important.

International cooperation and events kept being affected by the COVID-19 pandemic during 2020–2022. After the difficult first years of the pandemic, events were successfully held live, both in hybrid forms and virtually in videoconferencing. The new communication methods have made participation in short events abroad easier. This has also allowed for wider participation by STUK.

International organisations ESARDA and INMM

STUK is a member of the European Safeguards Research and Development Association (ESARDA) and has appointed experts to its committees and most of the working groups. STUK is a board member of the ESARDA Executive Board and the Editorial Committee. At the end of 2023, a STUK expert was the Chair of the Export Control Working Group and another the Chair of the Implementation of Safeguards Working Group. The IS group and the Final Disposal WG's arranged a joint meeting on safeguarding the disposal facilities on STUK premises in September with a possibility to visit to Olkiluoto disposal site. The FD WG convened at the Visitors' Centre in Olkiluoto and the IS WG convened at STUK in Vantaa.

The INMM and ESARDA organised their annual meetings jointly at Austria Center in Vienna in May 2023. This was one of the largest ESARDA symposiums, and was strongly influenced by INMM practices. STUK and Finnish stakeholders held presentations at the symposium and took part in several panel discussions. STUK's role in improving safeguards in Africa was highlighted, and in the closing session STUK's Director of Nuclear Waste Regulation and Safeguards presented the regulatory oversight concept for the final disposal project in Finland.

Co-operation with other state authorities

Safeguards by Design is an approach wherein international safeguards are considered early in any design process of a nuclear facility. In a broader sense, it is awareness of the impact and importance of safeguards to the nuclear operator, designer and authority communities. STUK and the Belgian nuclear safety authority FANC had organised a two-day workshop with the IAEA and the EC on the Safeguards by Design (SBD) concept in April 2021. Furthermore, STUK and FANC had presented a white paper on the benefits and possible further improvement of the implementation of the SBD concept at a side event of the IAEA General Conference in September 2021. STUK and FANC continued their cooperation by organising a workshop on the SBD concept and provisions in the legal and regulatory framework in March 2023. The workshop was held at the Belgian embassy in Vienna and was attended by representatives from the IAEA, EC and 11 different state regulatory authorities. The summary and conclusions of the workshop were jointly prepared by STUK and FANC and published in the ESARDA Connector journal in December. The workshop and its findings were both a natural continuation from the work started in the white paper and an important benchmarking opportunity for STUK experts in anticipation of the renewal of the Finnish nuclear legislation.

Together with the Swedish authority SSM, STUK organised an annual bilateral SG meeting in February 2023. At this meeting, current SG topics such as the status of safeguards implementation in spent fuel disposal projects were presented and discussed.

Uplifting safeguards in Africa

At the 66th IAEA General Conference in September, STUK and the African Commission on Nuclear Energy AFCONE agreed on a five-year cooperation programme to improve nuclear safeguards and strengthen the nuclear material control systems in Africa. Its main objective is to support both the African state authorities and AFCONE itself in the development of effective nuclear safeguards and effective systems of accountancy and control of nuclear materials in Africa. The support and training events and other cooperation kicked off in 2023 (Figure 8). The programme is financed by European Union and Ministry of Foreign Affairs of Finland. It began in April 2023 and three separate training events were held twice in South-Africa and once in Namibia. African countries participating in the programme were South Africa, Namibia, Zambia, Ruanda, the Democratic Republic of Congo, Ghana, Comoros, Niger, Morocco, Algeria, Botswana, and Tanzania.

FIGURE 8. First training meeting between STUK and AFCONE of the 5-year cooperation programme.

Safeguards education

In 2023, STUK contributed to the second SATE Master of Safeguards programme, which again is a one-year course specialising in safeguards. The programme first ran from October 2021 to October 2022 and was organised by the university Politecnico di Milano and the European Nuclear Education Network (ENEN). In 2021-2023 STUK experts produced lecture materials and gave lectures for the course. In August and September, STUK hosted two master students from the programme on a three-week training course on inspector work and the Finnish SSAC. STUK's safeguards experts also supervised and reviewed the final project work of the students.

NSG – Nuclear Suppliers Group

The Nuclear Suppliers Group (NSG) is a multilateral export control regime and a group of nuclear supplier countries that seek to prevent nuclear proliferation by controlling the export of materials, equipment and technology that can be used to manufacture nuclear weapons. It has 48 participating governments. Finland is represented on the NSG forum by the Ministry for Foreign Affairs (MFA) and STUK is supporting the MFA in their tasks.

GICNT – Global Initiative to Combat Nuclear Terrorism

Nuclear Security activities often include cooperation between multiple authorities. Nuclear Security also has a strong international aspect. The Global Initiative to Combat Nuclear Terrorism, GICNT, established in 2006, is one of the most important international fora for nuclear security. Currently 89 states and six international organisations are participating in the work of GICNT. Member states' nuclear security capabilities and cooperation are developed, for example, by holding exercises. Finland has actively participated in events in nuclear security outside the scope of the GICNT.

IPNDV – International Partnership for Nuclear Disarmament Verification

The International Partnership for Nuclear Disarmament Verification (IPNDV) was established on the initiative of the United States in 2014. The other participants of IPNDV come from both nuclear-weapon states and non-nuclear-weapon states. A third phase of IPNDV started at the beginning of 2020. The IPNDV develops methods and procedures for the verification of nuclear disarmament. Finland has been participating in the IPNDV since its inception.

STUK's Safeguards Section is actively participating in the educational task, but NSG, GICNT and IPNDV have been more on the political level Additional information on STUK's international cooperation in safeguards and non-proliferation described in this chapter is presented in the annual report "Highlights of International Cooperation for Safety, Security and Safeguards in 2023". The report is available online at https://www.julkari.fi/handle/10024/148660.

4 National Data Centre for the Comprehensive Nuclear-Test-Ban Treaty (FiNDC)

The Comprehensive Nuclear-Test-Ban Treaty (CTBT) is an important part of the international regime for the non-proliferation of nuclear weapons. The CTBT bans any nuclear test explosions in any environment. This ban is aimed at constraining the development and qualitative improvement of nuclear weapons, including the development of new advanced types of nuclear weapons.

The CTBT was adopted by the United Nations General Assembly and was opened for signature in New York on 24 September 1996. It will enter into force after it has been ratified by the 44 states listed in its Annex 2. These 44 states participated in the 1996 session of the Conference on Disarmament and possess nuclear power or research reactors.

A global verification regime is being established in order to monitor compliance with the CTBT. The verification regime consists of the following elements: the International Monitoring System (IMS), a consultation and clarification process, on-site inspections and confidence-building measures. The Provisional Technical Secretariat (PTS) of the CTBT Organisation (CTBTO) is co-located with the IAEA in Vienna International Centre (VIC). The IMS is more than 90% ready with 315 out of 337 stations installed by the end of 2023. The worldwide station network provides data access to more than 140 countries through the International Data Centre (IDC) run by the PTS in Vienna. In addition to monitoring compliance with the treaty, the data from the IMS is used in disaster mitigation. The CTBTO actively provides data to the global Tsunami Warning System and, since 2012, it has been a member of the Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE) and a co-sponsor of the Joint Radiation Emergency Management Plan of the International Organisations (JPLAN) led by the IAEA. Within this framework, the CTBTO is responsible for gathering and providing close-to-real-time radionuclide monitoring data to the IAEA and other participating organisations.

Finland signed the CTBT on its inaugural day in 1996 and ratified it less than three years later. In addition to complying with the basic requirement of the CTBT of not carrying out any nuclear weapons tests, Finland actively takes part in the development of the verification regime.

In the CTBT framework, the Finnish national authority is the Ministry for Foreign Affairs. STUK has two roles: it operates the Finnish National Data Centre (FiNDC) and one of the 16 radionuclide laboratories in the IMS (RL07). The most important function of the FiNDC is

to inspect data received from IMS and inform the national authority about any indications of a nuclear test explosion. The radionuclide laboratory contributes to the IMS by providing support in radionuclide analyses and in the quality control of the radionuclide station network. On 19 December, the laboratory celebrated its 20th anniversary as a certified laboratory by holding a half-day seminar, with guests invited from Finnish partners, as well as from the CTBTO/PTS. The third major national collaborator is the Institute of Seismology at the University of Helsinki, which runs an IMS seismology station (PS17 in Sysmä) and provides interpretation for waveform events in the IMS system.

In 2023, the CTBT got two new signatories and two new ratifications, while the Russian Federation unfortunately withdrew its ratification, reducing the number of Annex-2 state ratifications from 36 to 35. While the withdrawal by Russia certainly has detrimental effects for international peace, its practical effects on the CTBTO and the IMS have seemed minor as Russia has continued its presence within the working organs of the organisation and Russian IMS stations have continued to deliver data as normal.

Comprehensive Nuclear-Test-Ban Treaty (CTBT) Status (31 December 2023)

In 2023, Somalia signed and the Solomon Islands and Sri Lanka ratified the treaty. The Russian Federation withdrew its ratification.

- CTBT Member States 187
- Total Ratifications 177
- Annex-2 Ratifications 35

4.1 International cooperation the foundation of CTBT verification

Before the opening of the CTBT in 1996, the world had seen more than 2,000 nuclear tests. In the more than 25 years since then, there have been only eight, six of which were by the DPRK. Since 2017, no nuclear testing has been detected by the network or otherwise, although satellite detection of activities at the DPRK test site in Punggue-Ri created rumours of a forthcoming test by DPRK several times, including in 2023. This is a strong indicator of the de facto strength of the treaty that has yet to come into force.

In 2023, international cooperation largely returned to normal after the COVID-19 pandemic. Working Group B (WGB) meetings were already fully attended in Vienna with only some remote participation. During the year, the CTBT arranged hybrid workshops where the FiNDC participated actively. By participating in the work of WGB and its subsidiaries (workshops and expert groups), the FiNDC can provide technical expertise to the CTBTO, while also attending to Finnish national interests.

4.2 The analysis pipeline a well-established daily routine

The FiNDC routinely analyses all particulate radionuclide measurement data generated at IMS radionuclide stations across the world. The analysis pipeline for the air filter monitoring data is linked to the LINSSI database and equipped with an automated alarm system to enable efficient and fully automated screening of the data. The operational stations generated more than 800 gamma spectra per day for the FiNDC analysis pipeline to handle. The pipeline is well-established and has been running stably for many years. Radioxenon measurements are especially important for CTBT verification because xenon, as a noble gas, may also leak from underground tests, which seldom release particulate matter. The CTBT is in the process of updating its IMS xenon measurement systems to new technologies. The IDC has also developed new and well-functioning tools to analyse xenon measurement data from these new systems and is providing these tools to interested NDCs. FiNDC continued the process of migrating its xenon data analysis capabilities to the systems provided by the IDC.

Xenon radioisotopes released from medical isotope production facilities and NPPs are regularly measured all around the globe. Anthropogenic nuclides with CTBT relevance, mainly 99Tc, 131I from medical isotope production and 137Cs from the Chernobyl and Fukushima fallouts, are regularly measured at some particulate stations.

5 Summary

In 2023, STUK continued its regulatory authority role in the Finnish SSAC. It supervised the use of nuclear materials, regulated the operators' activities and verified that the obligations of international agreements concerning the peaceful use of nuclear materials and activities were met. Most of the practical work comprised reviewing operator applications, reports and notifications, but also conducting periodic and ad hoc inspections for safeguards purposes. STUK prepared the national reports according to the safeguards agreement and its additional protocol. These activities, alongside continuously parallel development activities and international cooperation in the fields of safeguards and non-proliferation, are described in this report.

In the field, STUK continued with national safeguards measures and activities on 73 inspection days and in 43 inspections. Since 2010, the number of annual IAEA and European Commission inspections has been around 20. Active preparations for final disposal keep the number of international inspections at a higher level than the short-term average. The implementation of the IAEA integrated safeguards since 2008 in force in Finland reduces the total number of annual routine inspections of the international inspectorates but includes short-notice random inspections. The Nuclear Materials Safeguards section has an inspector on duty for short-notice inspections.

As usual, most safeguards inspections in 2023 were conducted on the material balance areas of the Finnish nuclear power plants (NPP), nine at Loviisa NPP and 18 at Olkiluoto NPP. The number of short-notice inspections according to the IAEA state-level approach for Finland was smaller than usual: two short-notice random inspections were conducted at the NPPs one at the Olkiluoto spent fuel storage and another at Loviisa. Additionally, a complementary access was performed at Metso Outotec Research Center. STUK performed one non-destructive assay measurement campaign at both NPPs. The approaching final disposal of nuclear fuel is one of the key issues in safeguards. Inspection activity at Posiva in Olkiluoto remained high with four inspections and three other visits, and 15 inspection days by STUK. The IAEA and the Commission carried out site surveys and technical visits while installing safeguards equipment instead of inspections to be included in the statistics. The accountancy inspections and physical inventory verifications at the VTT Research Reactor FiR 1 and Centre for Nuclear Safety were performed by the Commission and STUK after the physical inventory takings in May and June, as usual. The accountancy inspection at the University of Helsinki was carried out in May by STUK. STUK's new premises and safeguards practices were inspected by STUK's safeguards section in March, and in June together with the Commission.

The results of STUK's nuclear safeguards inspection activities continued to demonstrate that the Finnish licence holders take good care of their nuclear materials. The inspected materials and activities were in accordance with the operators' declarations. Questions regarding the operators' declarations were resolved. In their statements on inspection results and the conclusion of safeguards implementation in 2023, the IAEA and European Commission confirmed that there were no outstanding questions at the end of 2023. By means of their nuclear materials accountancy and control systems, the operators enabled Finland to fulfil its own obligations under the international agreements relevant to nuclear safeguards and non-proliferation.

The work to update the Finnish nuclear legislation kicked off properly in 2022 and continued during 2023. STUK's safeguards staff started a comprehensive review of the current legislation from the safeguards point of view. As safeguards provisions are currently focused on the STUK regulations, i.e., YVL Guide level, the work started with gathering and justifying views on which provisions to elevate to binding legislation and the Nuclear Energy Act. In December 2023, the European Commission announced its proposal for the update of the 2005 regulation. This will be reflected in the legislative workload in 2024.

Safeguards development work continued at STUK in 2023. The main development project is the GOSSER project to develop the practical safeguards implementation of the national safeguards concept for the spent fuel disposal. The project continued with successful measurement campaigns and other R&D work. Formally, the project ended in 2023, but the practical work will continue with the progress of the disposal project.

A major goal of all current Comprehensive Nuclear-Test-Ban Treaty (CTBT)-related activities is the entry into force of the CTBT itself. To reach this goal, major steps must be taken in the political arena, and an important prerequisite for positive political action is for the verification system of the CTBTO to be functioning and able to assure all parties that it is impossible to carry out a clandestine nuclear test without being detected. The FiNDC is committed to its own role in the common endeavour so that the verification system of the CTBTO can accomplish its detection task. While still incomplete, the verification system has clearly demonstrated its ability to detect nuclear tests.

The outcome of the supervision and activities conducted in 2023 is that implementation of nuclear non-proliferation in Finland has achieved its objectives.

6 Publications

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7 Abbreviations and acronyms

AP
Additional Protocol to the Safeguards Agreement

BTC
Basic Technical Characteristics

CA
Complementary Access

CTBT
Comprehensive Nuclear-Test-Ban Treaty

CTBTO
Comprehensive Nuclear-Test-Ban Treaty Organization

CV
Verification of fuel in the reactor core

DiP
Decision-in-Principle

DIV
Design Information Verification

DPRK
Democratic People's Republic of Korea

DU
Depleted uranium

EC
European Commission

EIR
Equipment Infrastructure Requirements

EP
Encapsulation Plant

ESARDA
European Safeguards Research and Development Association

EU
European Union

Euratom
European Atomic Energy Community

FA
(1) Facility Attachment according to the Safeguards Agreement (INFCIRC/193), or
(2) Fuel Assembly

FiNDC
Finnish National Data Centre for the CTBT

FINSP
Finnish Support Programme to the IAEA Safeguards

FiR 1
Shutdown TRIGA Mark II type research reactor under the responsibility of VTT in Espoo, Finland

GICNT
Global Initiative for Combating Nuclear Terrorism

GR
Geological Repository

HEU
High-enriched uranium, 20% or more of U-235

IAEA
International Atomic Energy Agency

IMS
International Monitoring System of the CTBTO

INFCIRC
Information Circular (IAEA document type, e.g. INFCIRC/193, Safeguards Agreement, or INFCIRC/140, the Non-Proliferation Treaty)

INMM
Institute of Nuclear Materials Management

IPNDV
International Partnership for Nuclear Disarmament Verification

IS
Integrated Safeguards

KTO
STUK's periodic inspection programme for facilities in operation

LEU
Low-enriched uranium, less than 20% of U-235

LINSSI
An SQL database for gamma-ray spectrometry

LOF
Location Outside Facilities

LUT
Lappeenranta-Lahti University of Technology

MBA
Material Balance Area

MEAE
Ministry of Economic Affairs and Employment

MFA
Ministry for Foreign Affairs

NDA
Non-Destructive Assay

NPP
Nuclear Power Plant

NPT
The Treaty on the Non-proliferation of Nuclear Weapons (INFCIRC/140, "Non-Proliferation Treaty")

NSG
Nuclear Suppliers' Group

OECD
Organisation for Economic Co-operation and Development

ONKALO®
Originally underground rock characterisation facility (for the disposal of spent nuclear fuel), now officially the whole underground final disposal facility

PGET
Passive Gamma Emission Tomography

PIT
Physical Inventory Taking

PIV
Physical Inventory Verification

PNAR
Passive Neutron Albedo Reactivity

PSP
Particular safeguards provisions

PTS
Provisional Technical Secretariat (to the Preparatory Commission of the CTBT)

Pu
Plutonium

R&D
Research and Development

RCVD
Robotized Cerenkov Viewing Device

RII
Random Interim Inspection

RKT
STUK's inspection programme relating to the review of the construction licence application

RL07
Radionuclide Laboratory in the CTBT IMS network hosted by STUK (FIL07)

RTO
STUK's construction inspection programme (CIP)

SA
Subsidiary Arrangements

SBD
Safeguards by Design, a concept of early adoption of international safeguards in nuclear projects and awareness of safeguards in the nuclear community

SMR
Small Modular Reactor

SNRI
Short Notice Random Inspection

SNUICA
Short notice and unannounced inspections and complementary access, on-call inspector

SSAC
State system of accounting for and control of nuclear material

Th
Thorium

TVO
Teollisuuden Voima Oyj

U
Uranium

UI
Unannounced Inspection

VTT
VTT Technical Research Centre of Finland Ltd

WGB
Working Group B (of the CTBTO)

YVL Guide
Regulatory Guide on Nuclear Safety (STUK requirements on safety, security and safeguards, in Finnish Ydinvoimalaitosohje)

Appendix 1
– Nuclear materials in Finland 2023

TABLE A1. Summary of fresh nuclear fuel receipts in 2023.

To	From	FA	LEU (kg)
Olkiluoto 1, W0L1	Spain	200	30 168
Olkiluoto 2, W0L2	Sweden	108	18 913
Olkiluoto 3, W0L3	–	–	–
Loviisa NPP, WL0V	Russian Federation	168	21 523

FA = fuel assembly; LEU = low-enriched uranium.

TABLE A2. Fuel assemblies on 31 December 2023.

MBA	FA/SFA *)	LEU (kg)	Pu (kg)
Olkiluoto 1, W0L1	1 413/729	242 577	1 189
Olkiluoto 2, W0L2	1 203/619	203 282	994
Olkiluoto 3, W0L3	325/0	173 455	0
Olkiluoto, spent fuel storage, W0LS	8 770/8 770	1 473 277	12 745
Loviisa NPP, WL0V	7 155/6 409	834 151	8 285

MBA = material balance area, FA = fuel assembly, SFA = spent fuel assembly
*) Fuel assemblies (FA) in the core are accounted as fresh fuel assemblies
(Loviisa NPP 301 FAs per reactor and Olkiluoto NPP 500 FAs per reactor in units 1 and 2 and 241 FAs in unit 3)

TABLE A3. Total amounts of nuclear materials on 31 December 2023.

MBA	Natural U (kg)	Enriched U* (kg)	Depleted U (kg)	Plutonium (kg)	Thorium (kg)
W0L1	–	242 637	–	1 190	–
W0L2	–	203 335	–	995	–
W0L3	–	173 455	23.5	< 0.001	–
W0LS	–	1 412 830	–	12 745	–
WL0V	–	834 516	–	8 285	< 0.001
WRRF	92.9	6.28	0.085	< 0.001	0.001
WNSC	0.307	2.23	0.227	< 0.001	0.045
WHEL	1.53	0.293	0.008	0.002	1.08
WFRS	1.60	0.537	120	< 0.001	0.507
WTAL	1.36	–	–	–	–
WKK0	77.8	–	–	–	–
WNNH	3 588	–	–	–	–
Minor holders	0.206	< 0.001	643	< 0.001	0.283

MBA = material balance area, WRRF = VTT Research Reactor, WNSC = VTT Centre for Nuclear Safety, WHEL = University of Helsinki, WFRS = STUK, WTAL = Terrafame Oy in Sotkamo, WKK0 = Umicore Finland Oy in Kokkola, WNNH = Norilsk Nickel Harjavalta Oy, U = uranium. *) Less than 150 g total of high-enriched uranium, mainly used in detectors.

Appendix 2
– Safeguards field activities in 2023

			Inspections			Inspection person days		
MBA/operator	**Date**	**Inspection type**	**IAEA**	**COM**	**STUK**	**IAEA**	**COM**	**STUK**
WL0V	2.2.	Interim inspection and site check			2			2
SSFOLKI	21.2.	Site inspection			1			3
W0LE	20.2. and 24.2.	Site inspection and IAEA equipment installations			2			2
W0LS	7.3.	Field activities			1			1
WFRS	22.3.	Site inspection, interim inspection and DIV			2			2
W0L1, W0L2	28.–29.3. and 31.3.	Pre-PIT	2	2	2	3	2	3
Metso Outotec	30.3.	CA	1	1	1	2	1	2
W0LS	4.4.	RII	1	1	1	1	1	1
W0L1	23.4.	OL1 CV			1			1
WL0V	4.5.	RII	1	1	1	1	1	1
W0L2	15.5.	OL2 CV			1			1
WHEL	31.5.	PIV			1			1
University of Helsinki, Department of Physics, CAM SF0291CA	31.5.	DIV			1			1
W0L1, W0L2, W0L3, W0LS	6.–8.6.	Post-PIT PIV	4	4	4	3	3	6
W0LF	7.6.	DIV			1			2
WFRS	20.6.	DIV, PIV	1	1	1	1	1	2
WNSC	21.6.	PIV		1	1		1	2
WRRF	22.6.	PIV and inspection of decommissioning of nuclear-use items		1	2		1	2
W0LS	28.6.	Interim inspection, camera card replacement	1		1	1		1
W0LE	5.7. and 14.7.	IAEA equipment installations			1			3
WL0V	15.8.	Pre-PIT	1	1	1	1	1	1
WL0V	28.8.	LO2 CV			1			1
W0LS	5.–7.9.	Technical activities (site survey)			1	8		4
W0LE	8.9.	Technical activities (site survey)			1	3		2
WL0V	17.9.	LO1 CV			1			1
WL0V	11.–12.10.	Post-PIT PIV, DIV	1	1	1	2	2	2

			Inspections			Inspection person days		
MBA/operator	**Date**	**Inspection type**	**IAEA**	**COM**	**STUK**	**IAEA**	**COM**	**STUK**
W0LS	23.–27.10.	Verification (PGET, PNAR)			1			5
WL0V	6.–7.11.	System inspection (KTO)			1			6
W0LE, W0LF	7.–10.11.	DIV	2	2	2	12	16	6
W0L1, W0L2, W0L3, W0LS	16.11.	Interim inspection			4			1
WL0V	23.–24.11. and 27.11.	Verification (PGET)		1	1		1	5
Total			15	17	43	38	31	73

Appendix 3
– International agreements relevant to the peaceful and safe use of nuclear energy in Finland

Valid legislation, treaties and agreements concerning safeguards of nuclear materials and other nuclear items in Finland (Finnish Treaty Series, FTS):

Treaties and international organisations to which Finland is a party:

Treaty on the Non-proliferation of Nuclear Weapons; adopted in London, Moscow and Washington on 1 July 1968 (1970), INFCIRC/140 (FTS 11/70).

The Treaty establishing the European Atomic Energy Community (Euratom Treaty), 25 March 1957:

- Regulation No 5, amendment of the list in Attachment VI, 22 December 1958
- Regulation No 9, article 197, point 4 of the Euratom Treaty, on determining concentrations of ores, 2 February 1960.

The Comprehensive Nuclear-Test-Ban Treaty (FTS 15/2001). This treaty was ratified by Finland on 15 January 1999 but will not enter into force before it is ratified by all 44 states listed in Annex II of the Treaty.

International Atomic Energy Agency (since 1958).

Nuclear Energy Agency of the OECD (since 1976).

International Energy Agency (since 1992).

Safeguards Agreements based on the Non-Proliferation Treaty:

The Agreement with the Kingdom of Belgium, the Kingdom of Denmark, the Federal Republic of Germany, the Republic of Ireland, the Italian Republic, the Grand Duchy of Luxembourg, the Kingdom of Netherlands, the European Atomic Energy Community and the International Atomic Energy Agency in Implementation of Article III, (1) and (4) of the Treaty on Non-Proliferation of Nuclear Weapons (INFCIRC/193), 14 September 1973. Valid for Finland from 1 October 1995.

The Protocol Additional to the Agreement between the Republic of Austria, the Kingdom of Belgium, the Kingdom of Denmark, the Federal Republic of Germany, the Hellenic Republic, the Republic of Ireland, the Italian Republic, the Grand Duchy of Luxembourg, the Kingdom of Netherlands, the Portuguese Republic, the Kingdom of Spain, the Kingdom of Sweden, the

European Atomic Energy Community and the International Atomic Energy Agency in Implementation of Article iii, (1) and (4) of the Treaty on Non-Proliferation of Nuclear Weapons, 22 September 1998. Entered into force on 30 April 2004.

Finland is a party to the following international conventions among others (the year when the convention entered into force for Finland is given in brackets):

Convention on the Physical Protection of Nuclear Material; opened for signature in Vienna and New York on 3 March 1980 (1989).

Amendment to the Convention on the Physical Protection of Nuclear Material; as amended on 8 July 2005 (2016).

Convention on Early Notification of a Nuclear Accident; opened for signature in Vienna on 26 September 1986 (1987).

Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency; opened for signature in Vienna on 26 September 1986 (1990).

Convention on Third Party Liability in the Field of Nuclear Energy; adopted in Paris on 29 July 1960 (1972).

Convention Supplementary to the Paris Convention of 29 July 1960 on Third Party Liability in the Field of Nuclear Energy; adopted in Brussels on 31 January 1963 (1977).

Convention Relating to Civil Liability in the Field of Maritime Carriage of Nuclear Material; adopted in Brussels on 17 December 1971 (1991).

The 1988 Joint Protocol Relating to the Application of the Paris Convention and the Vienna Convention; adopted in Vienna on 21 September 1988 (1995).

Convention on Nuclear Safety; opened for signature in Vienna on 20 September 1994 (1996).

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, adopted on 29 September 1997 in Vienna (2001).

Nordic Mutual Emergency Assistance Agreement in Connection with Radiation Accidents; adopted in Vienna on 17 October 1963 (1965) Agreement on common Nordic guidelines on communications concerning the siting of nuclear installations in border areas; adopted on 15 November 1976 (1976).

The Agreement between Finland and Sweden on the guidelines to be followed while exporting nuclear material, technology, or equipment, 4 March 1983 (FTS 20/1983).

Agreements relating to early notification of nuclear events and exchange of information on safety of nuclear facilities with Denmark (1987), Norway (1987), Sweden (1987), Germany (1993), the Russian Federation (1996) and Ukraine (1996).

Convention on Environmental Impact Assessments in a Transboundary Context (Espoo, 1991)

As of 1 January 1995, Finland has been a member of the European Atomic Energy Community (EAEC or Euratom). Consequently, the following agreements are applied in Finland:

The Agreement between the Government of Republic of Finland and the Government of Canada concerning the uses of nuclear materials, equipment, facilities and information transferred between Finland and Canada (FTS 43/76). Substituted to the appropriate extent by the Agreement with the Government of Canada and the European Atomic Energy Community (Euratom) in the peaceful Uses of Atomic Energy, 6 October 1959, as amended.

The Agreement between the Government of Republic of Finland and the Government of Australia concerning the transfer of nuclear material between Finland and Australia (FTS2/80). Substituted to the appropriate extent by the Agreement between the Government of Australia and the European Atomic Energy Community (Euratom) for cooperation in the peaceful uses of nuclear energy, 5 September 2011.

The Agreement for Cooperation with the Government of the Republic of Finland and the Government of the United States concerning Peaceful Uses of Nuclear Energy (FTS 37/92). Substituted to the appropriate extent by the Agreement for Cooperation in the Peaceful Uses of Nuclear Energy with European Atomic Energy Community and the USA, 12 April 1996.

Agreement between the Government of Japan and the European Atomic Energy Community for co-operation in the peaceful uses of nuclear energy, 24 February 2006.

Agreement Between the European Atomic Energy Community and the Cabinet of Ministers of Ukraine for Cooperation in the Peaceful Uses of Nuclear Energy, 28 April 2005.

Agreement for Cooperation in the Peaceful Uses of Nuclear Energy Between the European Atomic Energy Community and the Government of the Republic of Kazakhstan, 4 December 2006.

Agreement for cooperation in the peaceful uses of nuclear energy between the European Atomic Energy Community (Euratom) and the Government of the Republic of Uzbekistan, 6 October 2003.

Agreement for cooperation in the peaceful uses of nuclear energy between the European Atomic Energy Community (Euratom) and the Government of the Argentine Republic, 11 June 1997.

Agreement between the Government of the Republic of South Africa and the European Atomic Energy Community (Euratom) for Cooperation in the Peaceful Uses of Nuclear Energy, 31 July 2013.

Agreement between the Government of the United Kingdom of Great Britain and Northern Ireland and the European Atomic Energy Community for Cooperation on the Safe and Peaceful Uses of Nuclear Energy, 30 December 2020.

Bilateral Safeguards Agreements made by Finland:

Agreement between the Government of the Republic of Korea and the Government of the Republic of Finland for Cooperation in the Peaceful Uses of Atomic Energy, entered into force on 1.1.2015 (FTS 5/2015).

Agreement with the Government of the Russian Federation and the Government of the Republic of Finland for Cooperation in the Peaceful Uses of Atomic Energy, entered into force on 6.4.2015 (FTS 32/2015).

Agreement on Cooperation in the Field of Peaceful Uses of Atomic Energy Between the Government of the Kingdom of Saudi Arabia and the Government of the Republic of Finland, entered into force on 3.6.2017 (FTS 48/2017).

Agreement with the Government of the United Kingdom of Great Britain and Northern Ireland and the Government of the Republic of Finland for Co-operation in the Peaceful Uses of Atomic Energy (FTS 16/69). Articles I, II, III and X expired on 20 February 1999.

Agreement with the Government of the Russian Federation (the Soviet Union signed) and the Government of the Republic of Finland for Co-operation in the Peaceful Uses of Atomic Energy (FTS 39/69). Articles 1, 2, 3 and 11 expired on 1.12.2004.

Agreement between the Government of the Kingdom of Sweden and the Government of the Republic of Finland for Co-operation in the Peaceful Uses of Atomic Energy 580/70 (FTS 41/70). Articles 1, 2 and 3 expired on 5.9.2000.

Agreement on implementation of the Agreement with Finland and Canada concerning the uses of nuclear materials, equipment, facilities and information transferred between Finland and Canada (FTS 43/84).

List of figures

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