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Ville Peri (ed.)

Implementing nuclear non-proliferation in Finland

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

Annual report 2022

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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 who have 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 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 12 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 2022 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 year

2022 was an anniversary for Finnish safeguards, as it marked 50 years since Finland became the first state to sign a comprehensive safeguards agreement in February 1972.

The working environment of STUK and other stakeholders in the Finnish national safeguards framework gradually stabilised in 2022 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 meetings only started making a return in 2022. STUK took advantage of good practices learned from hybrid work and remote inspections. STUK finished the year with 41 inspections and 71 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 in 2022, the IAEA required two actions from Finnish operators. The actions were resolved.

STUK's latest strategy period ended in 2022. In safeguards, key developments during the strategy period were the implementation of flexible working methods and active cooperation with and engagement of the operators' safeguards responsible personnel. The year 2022 was also an appropriate time for the end of the strategy period, as it was the time when new working methods learned during the pandemic met old routines to which the personnel could again return. STUK's headquarters moved to a new office building in Jokiniemi, Vantaa, where the safeguards section soon found its place. 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. In particular, this involves the passive gamma emission tomography and 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 during the coming years. This nuclear newcomer introduces new challenges to the Finnish regulators including the Nuclear Materials Safeguards section.

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

Ydinmateriaalivalvonta eli ydinmateriaalien viranomaisvalvonta on ydinenergian rauhanomaisen käytön edellytys. Säteilyturvakeskuksen Ydinmateriaalit-toimisto vastaa viranomaisvalvonnasta, jolla täytetään Suomen kansainvälisistä ydinsulkua koskevista sopimuksista johtuvat velvoitteet. Ydinsulun perustana on ydinsulkusopimus. Suomen kansallisessa ydinmateriaalien valvontajärjestelmässä keskeisiä viranomaisia ovat myös Ulkoministeriö ja Työ- ja elinkeinoministeriö. STUK tekee yhteistyötä ministeriöiden, Tullin, Rajavartiolaitoksen ja muiden viranomaisten kanssa ydinsulun, vientivalvonnan ja ydinaseriisunnan aloilla.

Suomalaiset toiminnanharjoittajat ja luvanhaltijat ovat keskeisiä toimijoita Suomen kansallisessa valvontajärjestelmässä. Toiminnanharjoittajilla on lopullinen vastuu ydinmateriaaleistaan ja niitä koskevasta toiminnasta. Suomessa on merkittävää ydinenergian tuotantoa, mutta siihen liittyvä teollisuus on verraten vähäistä. Suuri osa ydinaineista on Olkiluodon ja Loviisan ydinvoimalaitoksilla. Lisäksi Espoossa on suljettu tutkimusreaktori, jonka alueella säilytetään edelleen tuoretta polttoainetta. Muita suomalaisia toiminnanharjoittajia ovat esimerkiksi STUK, Helsingin yliopisto ja VTT:n ydinturvallisuustalo. Myös eräillä suomalaisilla toimijoilla metallinjalostus- ja kaivosteollisuudessa on hallussaan ydinaineita. Lisäksi Suomessa toimii 12 toiminnanharjoittajaa, joilla on hallussaan vähäisempiä ydinainemääriä.

STUK ylläpitää kansallista ydinaineiden kirjanpitojärjestelmää ja varmistaa, että ydinalalla toimitaan ydinenergialain ja -asetuksen, EU:n ydinmateriaalivalvontasäännösten ja kansainvälisten sopimusten mukaisesti. Näin pyritään siihen, että Suomi valtiona pystyy vakuuttamaan itsensä sekä kansainvälisen yhteisön siitä, ettei maassa ole ilmoittamattomia ydinmateriaaleja tai niihin liittyviä toimintoja. Kansainvälinen atomienergiajärjestö IAEA arvioi kansallisen valvontajärjestelmän toimintaa. Lisäksi Euroopan komissio valvoo toimivaltansa alla olevia ydinaineita.

Tulokset STUKin ydinmateriaalivalvonnasta vuonna 2022 osoittavat, että suomalaiset toiminnanharjoittajat ovat huolehtineet ydinmateriaaleistaan ja niitä koskevista velvoitteista. Ilmoittamattomista aineista tai toiminnasta ei ollut viitteitä. Tarkastetut aineet ja toiminnot vastasivat toiminnanharjoittajien ilmoituksia. Toiminnanharjoittajien omat valvontajärjestelmät tukivat STUKin valvontaa ja edesauttoivat sopimusvelvoitteiden täyttämistä. Vuosi 2022 oli Suomessa ydinmateriaalivalvonnan juhlavuosi, sillä silloin tuli kuluneeksi 50 vuotta siitä, kun Suomi ensimmäisenä maana maailmassa allekirjoitti valvontasopimuksen IAEA:n kanssa.

STUKin ja muiden suomalaisten sidosryhmien toimintaympäristö rauhoittui vuonna 2022 haastavan COVID-19-pandemian väistyessä. Tarkastukset ja muu kenttätoiminta onnistuivat pandemian aikana lähes normaalisti, mutta kansainväliset tapahtumat, konferenssit ja kokoukset jatkuivat kunnolla vasta viime vuoden aikana. STUK hyödynsi pandemian aikana saatuja oppeja etä- ja hybriditarkastuksista. Vuonna 2022 STUK teki suomalaisille

toiminnanharjoittajille 41 tarkastusta 71 tarkastuspäivänä. Luvut vastaavat pitkän aikavälin keskiarvoja. Myös kansainvälisiä tarkastuksia oli tavanomainen määrä. IAEA ja Euroopan komissio antoivat tarkastustoiminnastaan tekemissään johtopäätöksissä suomalaisille toiminnanharjoittajille kaksi toimintakehotusta, joihin vastattiin vuoden 2022 aikana.

STUKin viimeisin strategiakausi päättyi vuonna 2022. Ydinmateriaalivalvonnassa joustavien työskentelytapojen käyttöönotto ja aktiivinen yhteydenpito toiminnanharjoittajien vastuuhenkilöiden kanssa olivat tärkeitä kehityskohteita. Vuosi 2022 oli osuva aika strategiakauden päättymiselle, koska tällöin STUKissa päästiin yhdistämään pandemian aikana opittuja uusia työskentelytapoja tuttuihin rutiineihin. STUKin muutto uusiin toimitiloihin Vantaan Jokiniemessä oli yksi vuoden 2022 haasteista. Ydinenergialain kokonaisuudistus eteni lainkohtien luonnosteluvaiheeseen.

Ydinpolttoaineen loppusijoituksessa tarvittavan ydinmateriaalivalvontalaitteiston kehitys oli edelleen yksi Suomen valvontajärjestelmän kehityksen kohokohdista. Keskeisiä verifiointimenetelmiä ovat passiivinen gammaemissiotomografia ja passiivinen neutronialbedoreaktiivisuusmittaus. Joulukuussa 2022 kaivosyhtiö Terrafame ilmoitti päätöksestään investoida uraanin talteenottoon metallinjalostusprosessista tulevien vuosien aikana. Tämän toiminnan valvonta on yksi uusista STUKin ja muiden viranomaisten suorittaman ydinmateriaalivalvonnan haasteista.

Yksi ydinkoekieltosopimukseen (CTBT) liittyvien aktiviteettien päätavoitteista on sopimuksen voimaantulo. Ydinkoekielto-organisaation (CTBTO) verifiointijärjestelmän toimivuus on tärkeä edellytys kyseiselle poliittiselle edistysaskeleelle. Järjestelmän on pystyttävä vakuuttamaan kaikki osapuolet siitä, että ydinkokeen suorittaminen salassa muilta on mahdotonta. Suomen kansallinen tietokeskus FiNDC on sitoutunut omaan rooliinsa verifiointijärjestelmän osana.

Sammanfattning

Kärnmaterialkontroll, det vill säga myndighetskontroll av kärnämne, är en förutsättning för fredlig användning av kärnenergi. Strålsäkerhetscentralens kärnämnesbyrå ansvarar för den officiella tillsynen, som fullgör Finlands förpliktelser vilka följer av internationella avtal om icke-spridning av kärnvapen. Fördraget om icke-spridning av kärnvapen är det huvudsakliga icke-spridningsavtalet för kärnvapen. Utrikesministeriet och arbets- och näringsministeriet är också centrala myndigheter i Finlands nationella kontrollsystem. STUK samarbetar med ministerier, tullen, gränsbevakningsväsendet och andra myndigheter inom områdena icke-spridning av kärnvapen, exportkontroll och kärnvapennedrustning.

Finska operatörer och licenshållare är nyckelaktörer i Finlands nationella kontrollsystem. Operatörerna har det slutliga ansvaret för sina kärnmaterial och de aktiviteter som är relaterade till dem. Det finns en betydande kärnenergiproduktion i Finland, men den relaterade industrin är begränsad. En stor del av kärnämnena finns vid kärnkraftverken i Olkiluoto och Lovisa. Dessutom finns en stängd forskningsreaktor i Esbo, där färskt bränsle fortfarande lagras. Andra finländska operatörer är STUK, Helsingfors universitet och VTT:s center för kärnsäkerhet . Vissa finländska aktörer inom metallraffinerings- och gruvindustrin har också kärnmaterial. Dessutom finns det 12 operatörer i Finland som har mindre mängder kärnämnen i sin ägo.

STUK upprätthåller det nationella redovisningssystemet för kärnmaterial och säkerställer att kärnkraftsindustrin fungerar i enlighet med kärnenergilagen och kärnenergiförordningen, EU:s kärnämneskontrollföreskrifter och internationella överenskommelser. Detta syftar till att säkerställa att Finland som stat kan övertyga sig själv och det internationella samfundet om att det inte finns några odeklarerade kärnmaterial eller därmed sammanhängande verksamheter i landet. Internationella atomenergiorganet IAEA utvärderar hur det nationella kontrollsystemet fungerar. Europeiska kommissionen övervakar kärnmaterialen under dess jurisdiktion.

Resultaten av STUK:s kärnämnesövervakning år 2022 visar att finländska operatörer har skött sina kärnämnen och sina skyldigheter. Det fanns inga indikationer på odeklarerade ämnen eller aktiviteter. De granskade ämnena och aktiviteterna motsvarade verksamhetsutövarnas deklarationer. Operatörernas egna kontrollsystem bidrog till STUK:s kontroll och fullgörandet av avtalsförpliktelser. År 2022 var ett jubileumsår för kärnämneskontroll i Finland, då det var 50 år sedan Finland som första land i världen skrev ett kontrollavtal med IAEA.

Verksamhetsmiljön för STUK och andra finländska intressenter stabiliserades 2022 när den utmanande COVID-19-pandemin avtog. Inspektioner och andra fältoperationer lyckades nästan normalt under pandemin, men internationella evenemang, konferenser och möten fortsatte inte ordentligt förrän förra året. STUK utnyttjade lärdomarna under pandemin när det gäller fjärr- och hybridinspektioner. År 2022 genomförde STUK 41 inspektioner på sammanlagt 71 inspektionsdagar vid finländska operatörer. Siffrorna motsvarar långtidsgenomsnittet. Också antalet internationella inspektioner var det vanliga. IAEA och Europeiska kommissionen gav i sina slutsatser från sin inspektionsverksamhet två uppmaningar till finska operatörer vilka genomfördes under 2022.

STUK:s senaste strategiperiod avslutades 2022. Införandet av flexibla arbetssätt inom kärnämneskontroll och aktiv kommunikation med operatörernas ansvariga var viktiga utvecklingsmål. År 2022 var en lämplig tidpunkt för slutet av strategiperioden, då de nya arbetssätten som lärts in under pandemin kunde kombineras med bekanta rutiner igen.

STUK:s flytt till nya lokaler i Ånäs, Vanda var en av utmaningarna 2022. Den övergripande reformen av kärnenergilagen fortgick mot utformningen av kraven i kärnenergilagen.

Utvecklingen av den apparatur för skydd av kärnämnen som behövs för slutförvaringen av kärnbränsle var fortfarande en av höjdpunkterna i utvecklingen av Finlands kärnämneskontrollsystem. Viktiga verifieringsmetoder är passiv gammaemissionstomografi och passiv neutronalbedo-reaktivitetsmätning. I december 2022 tillkännagav gruvbolaget Terrafame sitt beslut att investera i uranutvinning inom metallraffineringsprocessen under de kommande åren. Kontrollen av denna verksamhet är en av de nya utmaningarna för kärnämnesskydd som genomförs av STUK och andra myndigheter.

Ett av huvudmålen för aktiviteter relaterade till fördraget om förbud mot kärnvapenprov (CTBT) är fördragets ikraftträdande. Att organisationen för förbud mot kärnvapens (CTBTO) verifieringssystem fungerar är en viktig förutsättning för de politiska framstegen i fråga. Systemet måste kunna övertyga alla parter om att det är omöjligt att genomföra ett kärnvapenprov i hemlighet. Finlands nationella informationscenter FiNDC har förbundit sig vid sin egen roll som en del av verifieringssystemet.

Preface

The peaceful use of nuclear energy is every state's right, and nuclear non-proliferation is an obligation. To meet the objectives, implementation of safeguards is a necessity. This is guiding our work especially in the renewal of nuclear legislation, which is ongoing.

In 2022, the effects of the COVID-19 were easing, but we faced unexpected new upheaval when Russia unlawfully attacked Ukraine. How this will affect co-operation in a long run remains to be seen, but one consequence has been that nuclear power companies all over Europe are now trying to seek also new suppliers of nuclear fuel. Another consequence of the war has been the need to find replacements for energy production since co-operation with the Russia in this field is seen as practically impossible. The outcome of this has been the speeding up, for example, of small modular reactor (SMR) projects. SMRs had already been proposed earlier to replace coal in energy production in Finland, but in 2022 they were in spotlight all over the world. These small reactors are thought to be much safer, but there are still some concerns and one of those is the implementation of safeguards: What is required, how can safeguards be implemented and what would this mean from a non-proliferation point of view in general?

The highlights of 2022

- Returning to in-person meetings (with a hybrid option) that are more productive and minimise misunderstanding.
- The enhancement of international co-operation between STUK and other stakeholders, and also with the IAEA and EC.
- The creation of mutual understanding on how safeguards for the final disposal facilities will be implemented with the IAEA and European Commission with minimal impact on operation.
- National readiness for safeguards implementation for final disposal has developed rapidly: 1) we have developed necessary methods for the verification of spent fuel, 2) we have developed specifications for the database where information required for disposal will be saved.

In 2022, 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 Henri Niittymäki, Senior Inspector
- Mr Ville Peri, Inspector
- Mr Topi Tupasela, Inspector
- Ms Riina Virta, Researcher
- Ms Riikka Sillanpää, trainee
- Mr Vertti Laitinen, person undergoing non-military service

It has been great to follow the young future experts Riikka and Vertti working together with the above-mentioned database specifications under the guidance of Riina and Tapani. The enthusiasm of youth was striking, and I cannot praise enough the co-operation of our older experts with the younger future experts when working in pairs or in smaller groups, which creates a solid base for knowledge management and competence building in the longer term. The combination of the staff I had in 2022 with the help of our assistant Ms Sirpa Teviö made it possible for STUK to achieve its objectives in safeguards implementation, about which you can read more in the report edited by Ville. Great work from all of you!

From my personal point of view, 2022 was my first year as Chair of the European Safeguards Research and Development Association Implementation of Safeguards Working Group (ESARDA IS WG). We had two meetings, where we could also meet in-person too, while still offering the possibility to contribute to the work of the group virtually. First we met during the ESARDA six-monthly Luxembourg meeting in May, and later in November we had a hybrid meeting hosted by SUJB, the Czech State Regulatory Authority. These meetings are excellent places to exchange experiences and develop ideas on how to enhance safeguards implementation both nationally and internationally. In this context, we have had different themes to be studied and, as a result of one of the studies, we have launched SBD co-operation with the Belgian State Regulatory Authority FANC, to which we have also invited other members of the IS WG to take part. Finally, it is my plan to invite my ESARDA IS WG colleagues to STUK next year to learn what we and our operators are doing, and what our current topics of safeguards implementation are.

So, what else can we expect from 2023? There is a lot going on in safeguards both nationally and internationally. Nationally we are accelerating our work with new nuclear legislation in Finland and new STUK safeguards regulation. We have to keep developing our competencies and capabilities, and to prepare ourselves for the disposal of spent nuclear fuel, which is already expected to start by the end of 2024 already. International cooperation is increasing and intensifying, both bilaterally and multilaterally. Nuclear non-proliferation and ensuring the peaceful use of nuclear energy requires co-operation, collaboration, and proactivity. We will be busy, but I am sure that the work we are doing will engage and satisfy us.

Marko Hämäläinen
Section Head
Nuclear Materials Safeguards

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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, to ensure the non-proliferation of sensitive technology, is also a growing global challenge. In the 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 resides 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. That date in 2022 was therefore the 50th anniversary of the agreement, which made the whole year a celebration of nuclear safeguards in Finland. 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 the 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 of 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 in order 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-proliferation framework. The scope of non-proliferation work is linked to many organisational units of STUK (Fig. 1).

The distribution of the working hours of the Nuclear Materials Safeguards section in 2022 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. That was also the case in 2022. The distribution of working hours in 2022 was similar to the previous year, which shows that the working environment is stabilising after the most turbulent years of the COVID-19 pandemic.

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 new-build 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.

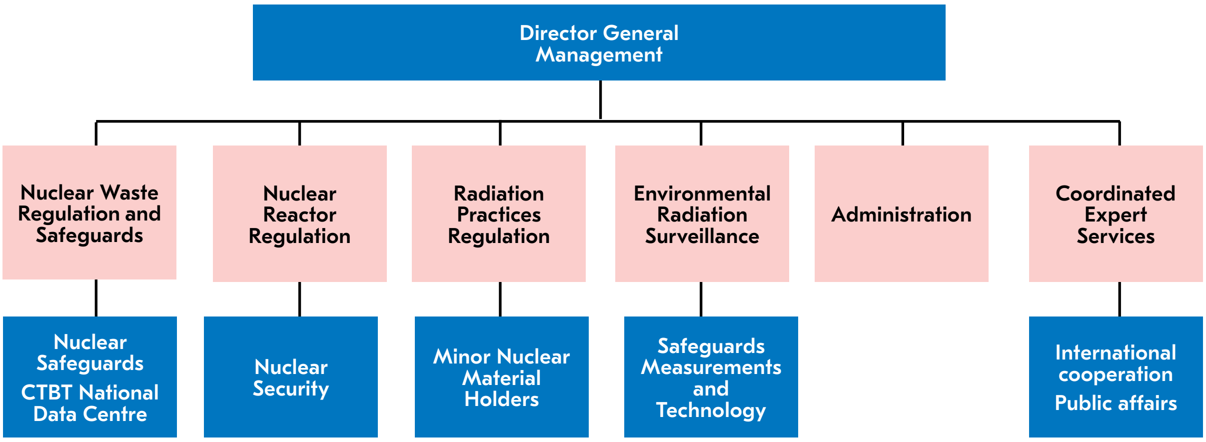


FIGURE 1. Framework to implement nuclear non-proliferation within STUK's organisation.

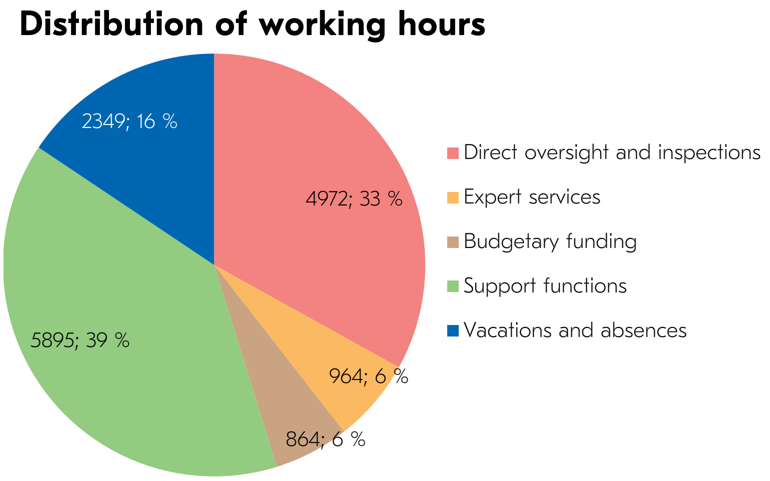


FIGURE 2. The distribution of the working hours of the Nuclear Materials Safeguards section in the various duty areas.

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 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 1990–2022 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.

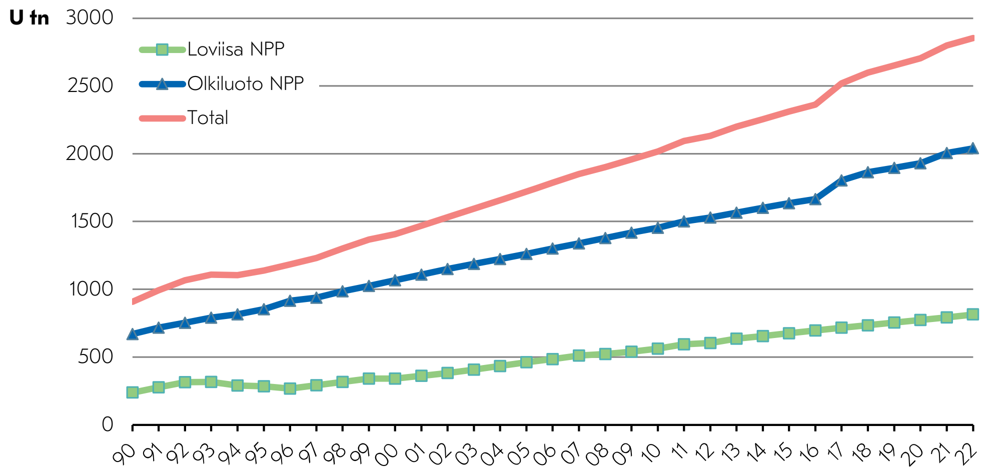


FIGURE 3. Uranium accumulation in Finland in 1990–2022.

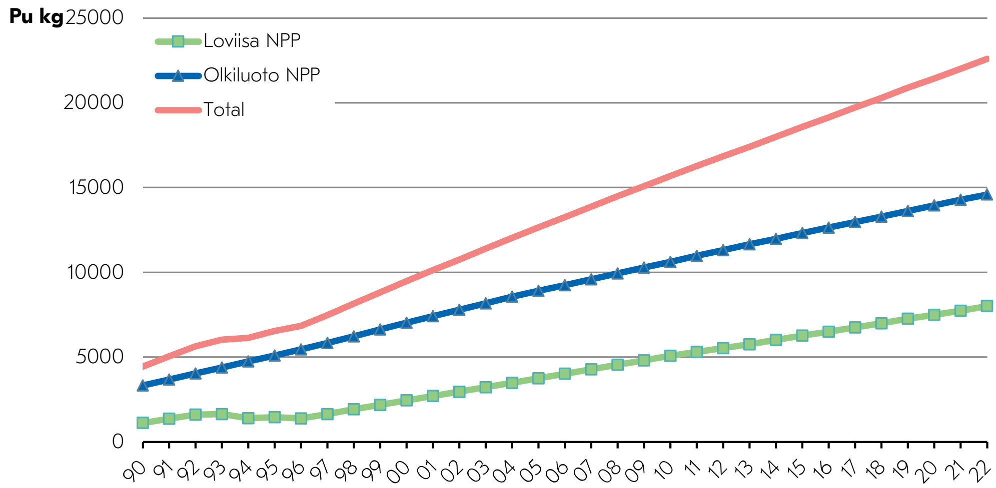


FIGURE 4. Plutonium in spent nuclear fuel in Finland in 1990–2022.

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.

TABLE 1. Status of regulatory documents for material balance areas in Finland at the end of 2022.

MBA, location	BTC, last upd.	Site (AP), founded	PSP, in force	FA, in force	Licence/DiP, in force (from/until)	SG Manual, approved update
WLOV, Loviisa	7.7.2022	SSFLOVI, 8.7.2004	Yes, 4.5.1998	No	Operating, LO1 until 31.12.2027, LO2 until 31.12.2030	30.6.2022
WOL1, Olkiluoto	22.11.2021	SSFOLKI, 8.7.2004	Yes, 7.6.2007	No	Operating, until 31.12.2038	21.3.2022
WOL2, Olkiluoto	22.11.2021	SSFOLKI, 8.7.2004	Yes, 7.6.2007	No	Operating, until 31.12.2038	21.3.2022
WOLS, Olkiluoto	10.12.2021	SSFOLKI, 8.7.2004	Yes, 7.6.2007	No	Operating, until 31.12.2038	21.3.2022
WOL3, Olkiluoto	7.12.2021	SSFOLKI, 8.7.2004	Yes, 17.12.2019	Yes, 30.1.2020	Operating, until 31.12.2038	21.3.2022
WOLE, Olkiluoto	28.10.2021	SSFPOSI, 31.3.2010	No	No	Construction, from 12.11.2015	11.2.2022
WOLF, 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	14.12.2022	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
WKKO, 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	24.9.2018

Finnish material balance areas and their status on 31.12.2022. 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).

Major nuclear installations in Finland

Loviisa nuclear power plant

Plant unit	Start-up	National grid	Nominal electric power (gross/net, MW)	Type, supplier
Loviisa 1	8 Feb 1977	9 May 1977	531/507	Pressurised water reactor (PWR), Atomenergoexport
Loviisa 2	4 Nov 1980	5 Jan 1981	531/507	Pressurised water reactor (PWR), Atomenergoexport

Fortum Power and Heat Oy owns the Loviisa 1 and 2 plant units located in Loviisa.

Olkiluoto nuclear power plant

Plant unit	Start-up	National grid	Nominal electric power (gross/net, MW)	Type, supplier
Olkiluoto 1	2 Sep 1978	10 Oct 1979	920/890	Boiling water reactor (BWR), Asea Atom
Olkiluoto 2	18 Feb 1980	1 Jul 1982	920/890	Boiling water reactor (BWR), Asea Atom
Olkiluoto 3	21 Dec 2021	12 March 2022	Approx. 1600 (net)	Pressurised water reactor (EPR), Areva NP

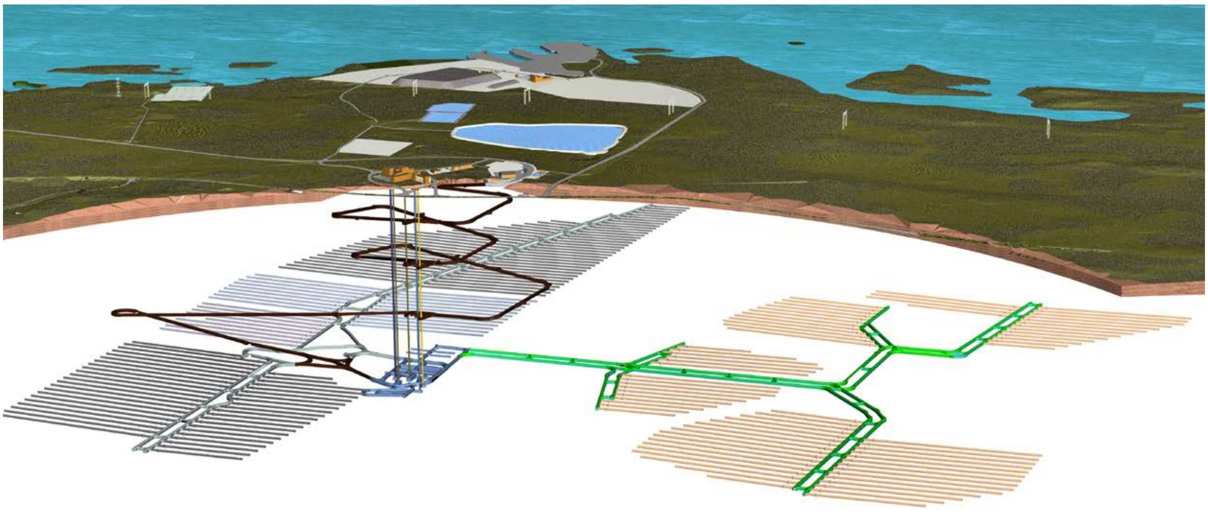
Teollisuuden Voima Oyj owns the Olkiluoto 1 and 2 plant units located in Olkiluoto, Eurajoki, and the Olkiluoto 3 plant unit plant unit that is in the nuclear commissioning phase.

Hanhikivi nuclear facility project

Plant unit	Supplemented Decision-In-Principle approved	Nominal electric power, net (MW)	Type, supplier
Hanhikivi 1	5 Dec 2014	Approx. 1200	Pressurised Water Reactor (PWR), ROSATOM

Hanhikivi nuclear power plant FH1 was a power plant project of Fennovoima. When the project failed, STUK terminated the safety assessment of the construction licence application, but it will continue to pursue oversight of the information pertaining to safety and nuclear materials until the information is returned or disposed of.

Olkiluoto encapsulation plant and geological repository



The planned facility under construction will consist of a surface facility for the encapsulation of spent nuclear fuel and a geological repository for disposal of the fuel at a depth of appr. 420 metres.

FiR I research reactor

Facility	Thermal power	In operation	Fuel	Triga fuel type
TRIGA Mark II research reactor	250 kW	March 1962 – June 2015	Reactor core consists of 80 fuel rods which contain 15 kg of uranium	Uranium–zirconium hydride combination: 8% uranium, 91% zirconium and 1% hydrogen

The FiR 1 research reactor, operated by VTT Technical Research Centre of Finland, was commissioned in March 1962. VTT stopped using the reactor in June 2015 and placed it in permanent shutdown. VTT submitted the operating licence application for the decommissioning phase to the Government in June 2017. The licence was granted in June 2021.

Fortum (MBA WLOV)

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 WLOV).

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. The Facility Attachment of the Safeguards Agreement INFCIRC/193 has not been prepared by the IAEA for the Loviisa NPP.

Teollisuuden Voima (MBAs WOL1, WOL2, WOLS, and WOL3)

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 two operational reactor units, one unit under commissioning, and an interim spent fuel storage. There are four active material balance areas (MBA codes WOL1, WOL2, WOLS, WOL3) at the Olkiluoto NPP. Olkiluoto 1 was connected to the electricity grid in 1978 and Olkiluoto 2 in 1980. The Finnish Government granted a licence to construct a new nuclear reactor, Olkiluoto 3, in 2005. An operating licence for the new unit was granted to TVO on 7 March 2019. The Olkiluoto 3 reactor core was loaded with fuel elements, and first criticality was reached during 2021. The unit is scheduled to start regular production in March 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, and the Olkiluoto 3 construction site. 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 (MBA WFV1)

Fennovoima was founded in 2007 as a new nuclear power operator in Finland. The government approved a Decision-in-Principle 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 terminated as well 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 2022, Fennovoima had no nuclear materials in its possession but continues as a holder of nuclear information.

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 FiR1 (MBA code WRRF), which is located in Otaniemi, Espoo, and has been 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 2022, only the unirradiated fuel and some nuclear material samples remain at WRRF. VTT received a licence to decommission the facility in June 2021. VTT expects to start dismantling the reactor with its partner Fortum in the spring of 2023. During the dismantling, nuclear-use items will be rendered inoperable and removed from the site. 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 FiR1 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.

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 and was located in Roihupelto, Helsinki, from 1994 to 2022. STUK's offices, laboratories and other functions were moved to a new building in Jokiniemi, Vantaa, during the first half of 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 WKKO)

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 current aim is to transfer the uranium-containing residuals abroad and adjust the processes to avoid extraction of uranium in the storage tanks in the future. 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 currently 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 reported monthly to STUK and the European Commission.

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.

During 2022, the company was focusing on the production of other metals than uranium with main focus on battery chemicals. 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 will review the comments made by STUK in its safety review in 2019 and update its safeguards manual to fulfil the material accountancy and control requirements for the recovery plant. This new kind of continuous productions of uranium concentrate at the mine will require new type of nuclear oversight by STUK. After the foreseen start-up phase, the recovery plant is estimated to operate at full capacity by 2026, when it is expected to produce about 200 tonnes of uranium per year.

Other nuclear material holders

There are 12 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 concentration that fulfil 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 the interpretation and decision of 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 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 WOLE and WOLF)

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 WOLE for the encapsulation plant and WOLF 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 Posiva'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 early 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 20 with approximately 25 inspection days. The fluctuation 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 materias are accounted for and are in peaceful use in Finland.

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.

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)

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, yearly production at the facility and concentration of nuclear material in the mineral determine the licensing process. 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 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) 2023/66 of 21 October 2022. 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 2022

2.1 The regulatory control of nuclear materials

For STUK inspectors, the beginning of 2022 was still a time of adapting to the new normal as COVID-19 restrictions on gatherings and travel were lifted. The national recommendations for remote working ended at the end of February, but it was advisable to shift to a combination of in-office and remote work gradually. The travel restrictions were first reduced and finally ended at the end of June. These allowed for inspections and non-mandatory technical activities to continue without special arrangements. Since 2019, the year 2022 was the first one when the scheduling of in-person events posed a larger challenge than the actual possibility to arrange them. Hybrid and remote meetings and inspections were kept in use, as they both had shown to be suitable for safeguards inspection work during the pandemic.

STUK fulfilled its inspection plan with minor adjustments and finished the year with 71 inspection days and 41 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 at the 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 2022 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 2022, the number of international inspections stayed at its expected level slightly above the long-term average. The IAEA launched six short-notice inspections in Finland during the year. The inspections contained two short-notice random inspections (SNRI) each at Olkiluoto 1 and the Olkiluoto fuel storage and one at the Loviisa nuclear power plant. Additionally, a complementary access inspection according to the Additional Protocol was performed at the University of Jyväskylä. 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 2022 are presented in Appendix 2.

The IAEA and the Commission provided STUK with statements on inspection results and the conclusions of safeguards implementation in 2022. The statements included two remarks and required actions: the declaration of sample storage cells at VTT's Centre for Nuclear Safety and the declaration of the export of autoclaves. Both actions and the open action from 2021 were resolved in the declarations made in 2022. No further actions were required from the Finnish operators. There were no outstanding questions from the IAEA or the Commission at the end of 2022. 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 a trilateral meeting with the IAEA and the European Commission during the IAEA General Conference in September 2022 in Vienna. It was the first such meeting to be held in person since March 2020. Finnish delegates also met with the IAEA and EC in Vantaa in September 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 major nuclear materials holders' safeguards responsible staff. After good experiences of hybrid and remote meetings, many of these were still held virtually.

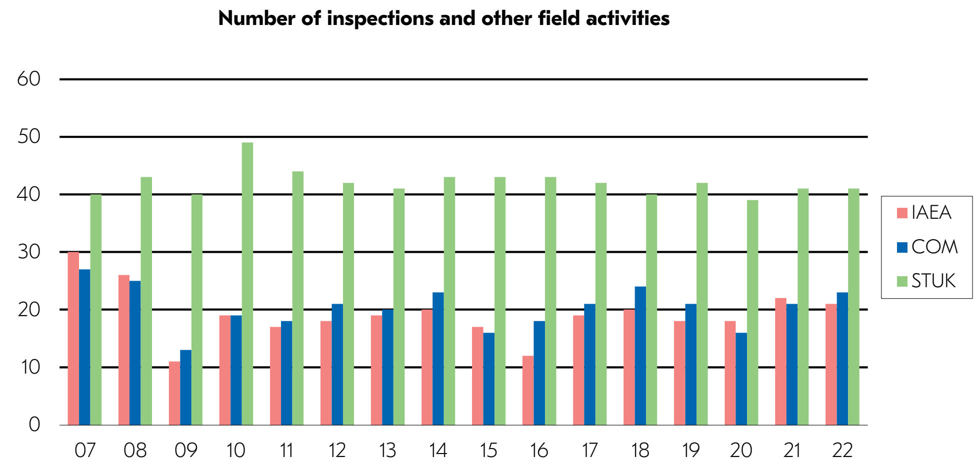


FIGURE 5. The number of inspections from 2007 to 2022.

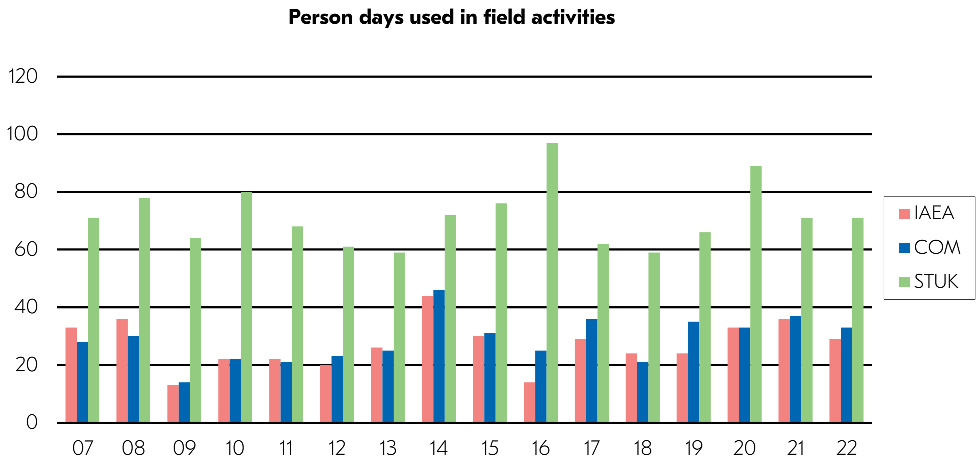


FIGURE 6. Inspection person days from 2007 to 2022.

2.2 General safeguards activities

2.2.1 Additional Protocol declarations

In 2022, 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 30 March 2022 and the declarations according to articles 2.a.(i), 2.a.(iv), 2.a.(x) and 2.b.(i) on 12 May 2022. Furthermore, STUK submitted the quarterly declarations on exports that are due in February, May, August and December. STUK also prepared an additional declaration, according to articles 2.a.(ix) and 2.b.(i), concerning previous R&D and the exports of UF-6 sampling autoclaves in the past that were re-considered as being subject to the Additional Protocol.

2.2.2 Approvals of new international inspectors

In 2022, a total of 25 IAEA and 10 Commission inspectors, newly appointed, were approved to perform inspections at nuclear facilities in Finland.

2.2.3 Nuclear dual-use items, export licences

In 2022, the Ministry for Foreign Affairs requested a STUK contribution in the processing of 36 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, Iceland, Australia, Japan, New Zealand, Norway, Switzerland, UK, USA, Canada, Argentina, Brazil, Mexico, Algeria, UAE, Peru, Singapore, Taiwan, South Korea, Ukraine, Turkey, and China.

2.2.4 Transport of nuclear materials

In 2022, 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 three transport plans and one transport packaging design. There were two inspections of fresh nuclear fuel consignments in 2022.

2.2.5 International transfers of nuclear material

In 2022, TVO reported to STUK about its international fuel contracts, fuel transfers and fuel shipments. Based on the document inspection findings and on two audits of TVO's international nuclear material transfer accountancy and control carried out in 2022, STUK concluded that TVO had complied with its safeguards obligations when purchasing the nuclear fuel and managing its international nuclear material transfers. Other operators purchase fuel as an end-product, so their accountancy does not need to cover the purchase chain abroad.

2.3 Safeguards implementation at the operators

2.3.1 Loviisa nuclear power plant

In total, STUK performed seven safeguards inspections at the Loviisa NPP in 2022. A joint interim and site safeguards inspection was performed on 7 April. In July, STUK carried out an NDA verification inspection of fresh nuclear fuel. 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 27 July, and after the outages (post-PIT) together with a design information verification (DIV) on 25–26 October. After reloading of 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 26 August and the Loviisa 1 core on 25 September. In 2022, one random interim inspection was carried out at Loviisa.

In 2022, STUK granted Fortum two import licences for the import of nuclear technology and software.

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 2022.

2.3.2 Olkiluoto nuclear power plant

In 2022, STUK granted TVO two import licences for fresh nuclear fuel for the two operating units and ten licences to import and possess non-fuel items. STUK approved an application concerning appointing a new person as deputy of the safeguards responsible person for the Olkiluoto power plant area.

The operating reactor units Olkiluoto 1 and 2 and the spent fuel storage of the Olkiluoto power plant were subject to 19 safeguards inspections in 2022, including safeguards-related technical activities. In addition, the accountancy of the uranium batches in TVO possession abroad was inspected twice in 2022. 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 5–7 April and 21–22 June, respectively. STUK performed a core verification inspection of both reactor units before the reactor core lid was closed. Furthermore, there was one additional core verification by STUK at Olkiluoto 1 after an unplanned short outage.

STUK took part in three random interim inspections initiated by the IAEA, one at Olkiluoto 1, another at the spent fuel storage and another targeted at both the above. 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 August.

At Olkiluoto 3, a physical inventory verification and design information verification inspection was carried out by the IAEA, EC and STUK in April. STUK also performed an interim inspection at Olkiluoto 3 in November.

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. STUK inspected TVO's plans and arrangements for the NDA measurements and other necessary steps in the final disposal process in October. The inspection was performed within the KTO system inspection programme. Detailed planning of these devices and procedures will continue in 2023.

Based on its own assessment and on the IAEA and Commission inspection results, STUK concluded that TVO's Olkiluoto NPP complied with its nuclear safeguards obligations in 2022.

2.3.2 The Hanhikivi nuclear power plant project

Since Fennovoima terminated the plant delivery contract for the Hanhikivi NPP on 29 April 2022 and withdrew its construction licence application in May, both the design and licensing work of the NPP and works at the Hanhikivi 1 site with the plant supplier RAOS Project have ended. Especially later in the year, STUK's oversight focused on the nuclear information that is in possession of the stakeholders of the cancelled Hanhikivi NPP project, including Fennovoima, RAOS Project and several subcontractors. At the end of 2022, some of this information had already been destroyed.

STUK made an inspection to RAOS Project's office in June 2022. The inspection was already planned before the delivery contract was terminated so the scope of the inspection was changed. However, this did not affect the goal of the inspection which was to ascertain that the nuclear information was stored and handled according to Finnish legislation and to verify that international obligations made by Finland were fulfilled. Based on the inspection, STUK set requirements for the RAOS Project to clarify the guidelines regarding handling of export-controlled nuclear information in its nuclear material handbook.

In 2022, STUK granted one licence within the Hanhikivi project. The licence was granted to Elomatic Oy, a subcontractor in the project, for transfer of controlled nuclear information.

Based on its assessment and the inspection results, STUK concluded that the operators in the cancelled Hanhikivi NPP project complied with their nuclear safeguards obligations in 2022.

2.3.4 VTT

At VTT Technical Research Centre of Finland, most of the detailed plans for the decommissioning of the research reactor FiR1 were finalised in 2022. Representatives from STUK, VTT as the operator and Fortum as the company responsible for the dismantling of the reactor met in May to discuss the principles of rendering inoperable and the subsequent write-off of nuclear-use items and equipment during the decommissioning process. During the rest of the year, VTT in cooperation with Fortum prepared a comprehensive plan to integrate the write-off process of nuclear-use items into the dismantling steps. The contaminated or activated nuclear-use items are to be transferred to Fortum, which will handle them as nuclear waste. The plan was submitted to STUK for review in January 2023. VTT has informed STUK and the European Commission on its plans on the handling of the remaining nuclear materials in its programme of activities.

STUK, the European Commission and the IAEA carried out nuclear material inventory verification inspections at FiR1 on 31 May and at the Centre for Nuclear Safety on 1 June. In addition to the inventory verification, the inspectors verified the facilities that have been dismantled or are under decommissioning at FiR1. VTT's site declaration was updated to include the sample storage spaces at the Centre for Nuclear Safety as hot cells to answer the remarks made on the complementary access inspection in September 2021. In May, STUK approved VTT's special report on the possession of nuclear information after the expiration of the corresponding licence. Based on the requirements set in the approval, VTT updated its handbook on the safeguards control of nuclear information and R&D in August. STUK approved the updated handbook in October.

In 2022, STUK granted two licences to VTT related to the import, possession and transfer of nuclear information.

Based on its assessment and inspection results, STUK concluded that VTT complied with its nuclear safeguards obligations in 2022.

FIGURE 7. STUK inspector taking an environmental sample during the DIV inspection at WRRF. Photo: VTT.

2.3.5 STUK

STUK's operating unit responsible for handling nuclear materials (MBA WFRS) complied with its reporting obligations in 2022. STUK and EC carried out a safeguards inspection on 23 June 2022, after STUK had moved to new offices in Vantaa. Before moving its local nuclear material storage to the new location, STUK transferred major parts of its nuclear materials as retained waste to the waste storage in Olkiluoto. It can be concluded that the operating unit at STUK fulfilled the requirements for national safeguards arrangements in 2022.

2.3.6 University of Helsinki

STUK and EC carried out a safeguards inspection at the University of Helsinki on 2 June. The operator's bookkeeping practices had been improved since the previous inspection in 2021. However, technical details in the internal control of nuclear material within the university were focused on during the inspection.

On the basis of its assessment and inspection results, STUK concluded that the University of Helsinki complied with its nuclear safeguards obligations in 2022.

2.3.7 Minor nuclear material holders

In 2022, STUK inspected the annual and inventory change reports from the minor nuclear material holders. The reporting obligations for one installation were suspended by the EC after the operator had given up its inventory, ceased operations with nuclear materials and requested closure from EC in 2021. Another operator gave up its inventory, ceased operations with nuclear materials and requested closure of its CAM area from EC in 2022. STUK approved two handbooks prepared by minor holders. Additionally, STUK took part in the Physical Inventory Verification and in the Complementary Access carried out by the IAEA and EC at the University of Jyväskylä in June and December, respectively.

On the basis of its assessment, STUK concluded that the minor nuclear material holders complied with their nuclear safeguards obligations in 2022.

2.3.8 Front-end fuel cycle operators

In 2021, Umicore Finland Oy concluded a contract to export uranium extracts to France, with the aim of getting rid of the uranium-containing material. The first consignments were sent in summer 2021. During 2022 the amount of uranium extract was reduced to 77 kg waiting for the final shipment in 2023.

At Norilsk Nickel Harjavalta Oy's plant in Harjavalta, there were no inventory changes nor authority inspections in 2022.

At both installations, the operators reported on their planned activities and monthly inventories according to safeguards requirements. On the basis of its assessment, STUK concluded that these operators complied with their nuclear safeguards obligations in 2022.

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 1,120 kg of natural uranium originating from zinc concentrates in 2022. The uranium ends up in waste streams during the processing. Dragon Mining reported 9.5 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 2022.

In 2022, 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. STUK inspected the mining site on 14 December and verified the nuclear materials inventory. The holder of the new licence announced on 21 December that it has completed a feasibility study and decided to start preparing the operations for the uranium recovery. STUK concluded that Terrafame complied with its nuclear safeguards obligations in 2022.

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, and the installation of fuel handling equipment was launched during 2022. At the geological repository, the excavation of the central tunnels and the first set of deposition tunnels in the deposition area were practically finalised. The construction work for the infrastructure of the technical premises involved a large workforce underground, even limiting daytime access for visitors. The construction areas were segregated to avoid or limit possible COVID-19 infections.

In March 2022, IAEA DDG safeguards visited Finland at the Ministry of Economic Affairs and Employment, to facilitate further discussions on the safeguards implementation for the EPGR. Following this visit, STUK drafted a technical understanding document that was further revised by the EC and the IAEA. The final version of the document was agreed on between STUK, EC and IAEA at a meeting at STUK in September 2022. In addition, four major technical meetings between the IAEA, the EC, STUK, Posiva and TVO were held (three of them remotely) 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 started preparational work (such as cabling) for the equipment installations. Several almost monthly smaller technical meetings were also held on these issues between the four parties. The first equipment installations by the IAEA will be done in Q1 2023. This Safeguards-by-Design process can be expected to continue during the construction of the installations.

In November 2022, the IAEA and Commission carried out a design information verification to verify the underground premises constructed since the previous inspection in 2021. 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. During the inspection, it was noted that most of the cabling for the IAEA/EC surveillance equipment was in place, waiting for the installation to be performed in 2023.

On the basis of its assessment and inspection results, STUK concluded that Posiva complied with its nuclear safeguards obligations in 2022.

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.

3 Development work in 2022

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 for distribution of 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. By the end of 2022, the working methods at STUK's Nuclear Materials Safeguards section had developed significantly towards the objectives set in the strategy.

The last year of the strategy period was defined by the stabilisation of the working environment, not only in the abstract sense but also in physical terms. During the spring, STUK headquarters moved to a newly built building in Jokiniemi, Vantaa, just two train stops from the Helsinki International Airport. The new premises provide modern open space offices, while employees had to forfeit the luxury of a personal office room, or even desk. This also required the transfer to an almost completely digital office environment and in this process hundreds of shelf meters of old paper material were destroyed. Settling down in the new office brought back some of the face-to-face meetings and discussions, which had been missed during the years of mostly remote work. In 2022, the safeguards section kept taking advantage of the best practices of hybrid work while increasingly meeting at the office. When there, the safeguards inspectors mostly convened to work in the same office space. Working close to each other with the open-door principle has for long been one of the good practices in information exchange and integration of new inspectors at STUK safeguards.

At the end of 2022, the Nuclear Materials Safeguards section consisted of a section head, one researcher and seven inspectors who are responsible officers for the facilities, installations and other nuclear material or nuclear-related activities. 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. At the end of 2022, the section had ensured new resources to answer the increased demands of both international cooperation and the final disposal of spent fuel, as one new inspector and a master's thesis worker were joining the section at the beginning of 2023. 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.

In 2022, the project to comprehensively renew the Finnish nuclear legislation advanced to the phase of the preparation of requirements and provisions on the legislative level. The work to renew nuclear safeguards provisions in the legislation and regulations started 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 YVL Guide 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.

3.2 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. Some of the tasks are presented here, focusing on those that involved several members of the Nuclear Materials Safeguards section. More details on the support programme are available in the annual report describing FINSP activities, which can be found online at https://www.julkari.fi/handle/10024/146673.

In June, STUK held a Training and Mentoring workshop for nine trainees from a scholarship programme at the IAEA. The workshop was the continuation of a similar workshop that was held in the previous year. This time, however, the workshop was held in person in Vienna. Compared to the previous workshops, the engagement between STUK experts and the trainees improved markedly and 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. 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. The training was held within the scope of the Support Programme. STUK expects to continue this kind of support in the future.

The Safeguards-by-Design–related cooperation within the FINSP continued with the IAEA. In 2022, the focus of that cooperation was on the small reactors proposed for the central heating purposes of urban cities in Finland. Representatives of the Lappeenranta-Lahti University and VTT Technical Research Centre of Finland visited the IAEA in November and presented their preliminary plans and safeguards concepts.

In August, FINSP, together with TVO, organised a field test for IAEA to test their new Robotized Cerenkov Viewing Device (RCVD) in the spent fuel storage at Olkiluoto. RCVD is an autonomously navigating robot designed to increase the efficiency and effectiveness of spent fuel verification in wet storages. During the field test, more than 1,000 spent fuel assemblies were successfully recorded.

The verification of fuel placed in a repository is expected to be a safeguards challenge, and several indirect methods have been proposed for that purpose. The initiative of applying muons for the purposed is currently being considered under the Member State Support Programme (MSSP) framework.

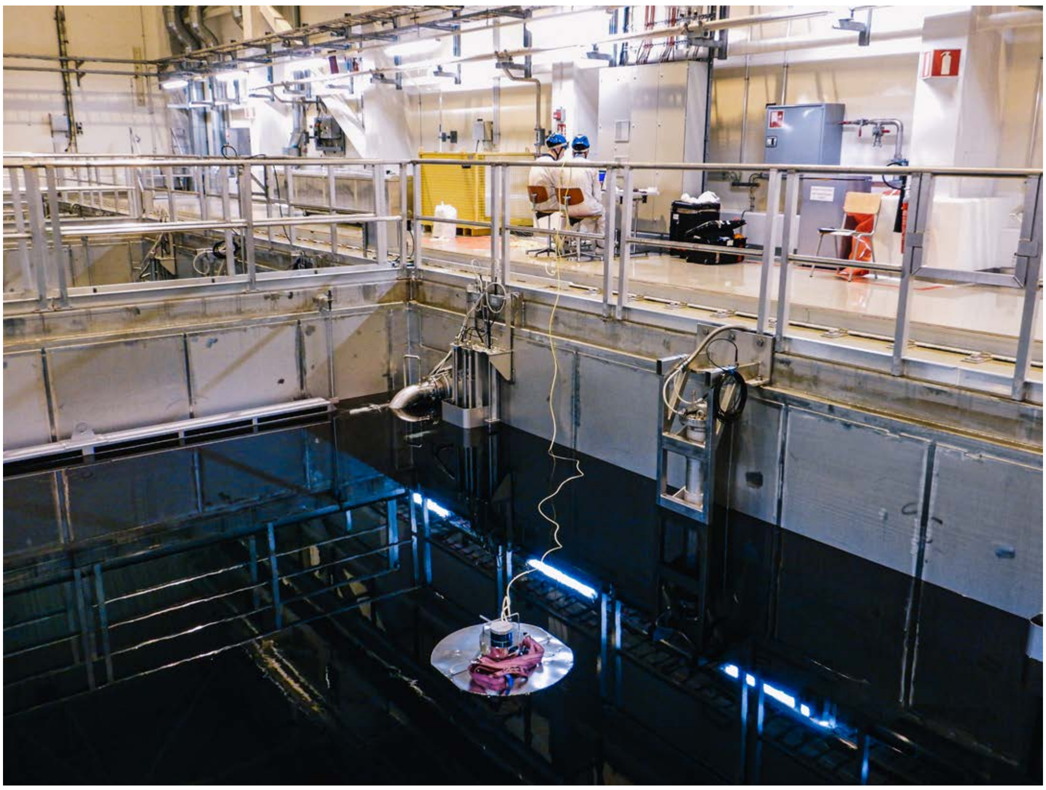


FIGURE 8. A test run with the Robotized Cerenkov Viewing Device at the Olkiluoto spent fuel storage. Photo: TVO.

On 28 Nov–2 Dec, FINSP and the IAEA arranged the course "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 Argentina, Armenia, Bangladesh, Egypt, Hungary, Jordan, Kenya, Nigeria, Poland, Poland, Romania, Saudi Arabia, Slovakia and Türkiye. In addition, one observer from Estonia attended the course. During the course, the IAEA presented the important processes required at a national level, Thereafter, STUK and some Finnish operators presented how they are implemented in Finland. The course included a visit to the Olkiluoto nuclear site.

3.3 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. The first project period ended in 2018 and a final report was prepared to describe the national safeguards concept for spent fuel disposal in Finland. The continuation project covered the years 2019–2022.

According to the national safeguards concept prepared, it is proposed that all fuel be verified in a comprehensive manner with the available system comprising a PGET and PNAR (Passive Neutron Albedo Reactivity) verifier. The NDA concept and ownership are being discussed with the EC and the IAEA. A principal agreement exists that the measurement data will be shared with all parties.

The R&D of PGET and PNAR were continued in 2022. A measurement campaign, featuring both instruments, was held in August 2022 at the Olkiluoto spent fuel storage. During the campaign, PGET and PNAR measurements of spent nuclear fuel were conducted together with the IAEA and EC. Several publications relating to the NDA development of PGET were published in 2022 (Virta et al., 2022).

GOSSER work continues in 2023. The R&D is being done in the areas of PGET analysis development and modelling PGET in air conditions. The IAEA is seeking for opportunities under the MSSP framework to perform PGET measurements for spent nuclear fuel assemblies. STUK is also developing a database, which will store safeguards-relevant information on the fuel and verification data (Honkamaa, et al, 2022). The database, called Lost&Found, will be developed in 2023 and will be used as a part of the disposal process. Lost&Found can be also used to distribute information between the inspectorates and operators.

3.4 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 in 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 the participation in short events abroad easier than earlier. This has also allowed for a wider participation from 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 2022, a STUK expert was the Chair of the Export Control Working Group and another the Chair of the Implementation of Safeguards Working Group. ESARDA's annual meeting was organised in person in Luxembourg but allowing remote participation in May 2022. STUK's experts contributed to the meeting with several presentations and in panel discussions. ESARDA WGs also met in hybrid mode in November to discuss current topics more precisely. STUK experts took part in the Implementation of Safeguards Working Group meeting in Prague.

IAEA Safeguards Symposium

The IAEA organised the "Symposium on International Safeguards: Reflecting on the Past and Anticipating the Future" at the beginning of November in Vienna. The symposium is held every four years. Over 700 participants from more than 100 different countries participated, among them several experts from STUK. The 2022 Symposium was a special event, as it was one of the first major gatherings in the international safeguards community after the lifting of most travel restrictions. It was also an anniversary event, marking 60 years of IAEA safeguards, 50 years of comprehensive safeguards agreements and 25 years of additional protocols. STUK and Finnish stakeholders held presentations at the symposium and took part in panel discussions. The anniversary event was particularly special for the Finnish participants, as Finland was the first state to sign a CSA in 1972.

Co-operation with other state authorities

Safeguards by Design in 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 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 in 2022, planning and preparing a workshop to be held in spring 2023 on the SBD concept and provisions in the legal and regulatory framework.

Together with the Swedish authority SSM, STUK also organised an annual bilateral SG meeting in February 2022. At this meeting, current SG topics such as the status of safeguards implementation in spent fuel disposal projects were presented and discussed. Due to COVID-19 restrictions, it was not possible to meet in person, but organising the meeting virtually made it easier to participate and contribute with all the safeguards section staff.

Services for authorities abroad

In September, STUK in cooperation with training experts from the IAEA organised a technical visit for safeguards experts from three countries: Jordan, Saudi Arabia and Türkiye. The technical visit was held within the IAEA's COMPASS programme, which aims at capacity-building for states' SSACs and SRAs. The visit was aimed at officials and experts responsible for implementing international safeguards at the national regulatory authorities and at key facilities in the states. The objective of the visit was to build expertise and discuss best practices and experiences in setting up and developing a national safeguards system. Building and maintaining the SSAC was examined from various perspectives during the visit. The programme included an excursion to Olkiluoto to hear the TVO's and Posiva's point of view on SSAC processes and visit the spent fuel encapsulation facility and geological repository.

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 uplift nuclear safeguards and strengthen the nuclear material control systems in Africa. The programme was launched during the IAEA Safeguards Symposium in November. 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 will kick off in 2023.

Safeguards education

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

NPT Preparatory Committee

The Non-Proliferation Treaty entered into force in 1970. The NPT Treaty includes more than 190 countries around the world. The Treaty Review Conference is held every five years, the latest one before the COVID-19 pandemic in 2015. After the next conference was first postponed by one year from 2020 and later from 2021, it was finally held in New York in August 2022. STUK and the MEAE were responsible for safeguards expert support to the Finnish delegation. During the Review Conference, Finland held a side event called "ONKALO – The first spent nuclear fuel repository in Finland". The next conference will be held in 2026.

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 in the NSG forum by the Ministry for Foreign Affairs. NSG meetings were again cancelled due to the travel restrictions related to the COVID-19 pandemic.

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 participate in the work of GICNT. Member states' nuclear security capabilities and cooperation are developed, for example, by holding exercises. In 2022, GICNT activities were at a standstill due to the war in Ukraine. Finland 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 tasks in IPNDV have always been connected to the development of technological verification methods. In 2022, two in-person meetings were organised within IPNDV. STUK also implemented a neutron measurement campaign with the University of Jyväskylä in STUK's irradiation hall. The data were analysed and presented at the December IPNDV Plenary Meeting in Australia.

Additional information

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 2022". The report is available online at https://www.julkari.fi/handle/10024/146673.

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 the 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 312 out of 337 stations installed at the end of 2022. 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 are 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.

Comprehensive Nuclear-Test-Ban Treaty (CTBT) Status (31 December 2022). In 2022, Equatorial Guinea, Gambia, São Tomé and Príncipe, Timor-Leste and Tuvalu ratified and Dominica both signed and ratified the treaty

- **CTBT Member States 186**
- **Total Ratifications 176**
- **Annex 2 Ratifications 36**

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 quality control of the radionuclide station network. 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 of waveform events in the IMS system.

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 20 years since then, there have been only eight, six of which were by the DPRK. Since 2017, no clandestine 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 during 2022. This is a strong indicator of the de facto strength of the treaty that has yet to come into force.

Still in 2022, international cooperation was somewhat hampered by the continuation of the COVID-19 pandemic. The February meeting of Working Group B (WGB) was mostly remote. In August, the meeting was already fully attended in Vienna, with only some remote participation. In the autumn, the CTBT arranged remote workshops where FiNDC also 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.

In June 2022, the Executive Secretary of the PTS visited Finland. During his two-day visit, the ES held a meeting with the Finnish foreign minister, held a speech at a public seminar at the institute of Seismology, visited the FiNDC and the laboratory (RL07) at STUK and made a field trip to the Finnish primary seismic station PS17 in Sysmä.

FIGURE 9. The Executive Secretary of the PTS Rob Floyd (centre) and Special Assistant to the ES Sabine Bauer visiting the emergency response centre of STUK with the Permanent Representative of Finland to the CTBTO, Ambassador Pirkko Hämäläinen (right). Director General of STUK Petteri Tiippana (left) and Director of Department for Coordinated Expert Services of STUK Karim Peltonen are presenting. Photo: STUK.

4.2 The analysis pipeline a well-established daily routine

The FiNDC routinely analyses all 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. In 2022, FiNDC and the Finnish laboratory moved their servers and the data link from Vienna to the Finnish governmental IT provider VALTORI, and at the same time the data link was transferred from satellite to VPN over the internet with 4G backup. 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 NDC. The operational stations generated more than 1,000 gamma and beta-gamma spectra per day for the FiNDC analysis pipeline to handle. The pipeline is well-established and has been running stably for many years.

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

5 Summary

In 2022, the 50th anniversary year of Finland signing the first comprehensive safeguards agreement in the world, 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 71 inspection days and in 41 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 2022 were conducted on the material balance areas of the Finnish nuclear power plants (NPP), seven at Loviisa NPP and 19 at Olkiluoto NPP. The number of short-notice inspections according to the IAEA state-level approach for Finland was again higher than usual: two short-notice random inspections were conducted at Olkiluoto 1 and Olkiluoto spent fuel storage and one at Loviisa. Additionally, a complementary access was performed at the University of Jyväskylä. 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 three inspections and 11 inspection days by STUK. Those were complemented by the KTO system inspection conducted by STUK at TVO, which focused on TVO's plans and readiness for final disposal. The accountancy inspections and physical inventory verifications at the VTT Research Reactor FiR1 and Centre for Nuclear Safety were performed after the physical inventory takings in May and June, as usual. The accountancy inspection at the University of Helsinki was also carried in June.

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 2022, the IAEA and European Commission required two actions from Finnish operators in which they requested additions to their Additional Protocol declarations. These actions were resolved in 2022. 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 working environment of the Nuclear Materials Safeguards section of STUK stabilised in 2022. Good practices learned from hybrid work in the previous two years were kept in use as the section met increasingly often at the office, which moved to a new building in Jokiniemi, Vantaa, in the spring. Inspectors continued to work mostly remotely but in-person team meetings and development days brought long-awaited change to routine work from home, as did new opportunities in international cooperation, training and seminars. Developments in flexible working methods and continuously taking care of the wellbeing of the safeguards staff were in line with the objectives of STUK's strategy period which ended in 2022.

The work to update the Finnish nuclear legislation kicked off properly in 2022. 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 YVL Guide level, the work started with gathering and justifying views on which provisions to elevate to binding legislation and the Nuclear Energy Act.

Safeguards development work continued at STUK in 2022. 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.

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 detection. 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 2022 is that implementation of nuclear non-proliferation in Finland has achieved its objectives.

6 Publications

Honkamaa T, Virta R, Sillanpää R, Laitinen V, Moring M, Tupasela T. Designing a Database for Spent Nuclear Fuel Verification Prior to Geological Disposal. Symposium on International Safeguards: Reflecting on the Past and Anticipating the Future, 31 October – 4 November 2022, Vienna, Austria. Accessible online: https://iaea.event.do/#/e/5551/f/39937/s/250646.

Okko O. Towards Uranium Milling in Finland, Symposium on International Safeguards: Reflecting on the Past and Anticipating the Future, 31 October – 4 November 2022, Vienna, Austria. Accessible online: https://iaea.event.do/#/e/5551/f/35965/s/250493.

Virta R, Bubba TA, Honkamaa T, Moring M, Siltanen S, Tupasela T, Dendooven P. Improved quality of the activity and attenuation images of spent nuclear fuel reconstructed from Passive Gamma Emission Tomography data. Symposium on International Safeguards: Reflecting on the Past and Anticipating the Future, 31 October – 4 November 2022, Vienna, Austria. Accessible online: https://iaea.event.do/#/e/5551/f/35965/s/250640.

Virta R, Bubba TA, Moring M, Siltanen S, Honkamaa T, Dendooven P. Improved Passive Gamma Emission Tomography image quality in the central region of spent nuclear fuel. Scientific Reports, 12, 12473, 2022. https://doi.org/10.1038/s41598-022-16642-0.

Virta R. Helsingin yliopiston Tiedekulma, Uuden tiedon klubi: Kurkistus ydinpolttoaineen sisälle, 20.4.2022. https://www.youtube.com/watch?v=Mw1crdyPtWI.

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), (2) Fuel Assembly

FiNDC
Finnish National Data Centre for the CTBT

FINSP
Finnish Support Programme to the IAEA Safeguards

FiR1
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 2022

TABLE A1. Summary of fresh nuclear fuel receipts in 2022.

To	From	FA	LEU (kg)
Olkiluoto 1, WOL1	Spain	100	18 083
Olkiluoto 2, WOL2	Sweden	108	18 882
Olkiluoto 3, WOL3	–	–	–
Loviisa NPP, WLOV	Russian Federation	180	22 568

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

TABLE A2. Fuel assemblies on 31 December 2022

MBA	FA/SFA *)	LEU (kg)	Pu (kg)
Olkiluoto 1, WOL1	1 336/746	227 914	1 214
Olkiluoto 2, WOL2	1 341/767	225 457	1 223
Olkiluoto 3, WOL3	325/0	173 455	0
Olkiluoto, spent fuel storage, WOLS	8 401/8 401	1 412 830	12 151
Loviisa NPP, WLOV	6 987/6 223	814 422	8 012

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 313 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 2022

MBA	Natural U (kg)	Enriched U* (kg)	Depleted U (kg)	Plutonium (kg)	Thorium (kg)
WOL1	–	227 974	–	1 214	–
WOL2	–	225 511	–	1 224	–
WOL3	–	173 455	23.5	< 0.001	–
WOLS	–	1 412 830	–	12 151	–
WLOV	–	814 423	–	8 012	–
WRRF	92.9	6.28	0.165	< 0.001	0,001
WNSC	0.282	2.23	0.143	< 0.001	0.044
WHEL	1.53	0.293	0.008	0.002	1.08
WFRS	1.60	0.537	120	< 0.001	0.507
WTAL	1.36	–	–	–	–
WKKO	77.8	–	–	–	–
WNNH	3 588	–	–	–	–
Minor holders	0.208	< 0.001	658	< 0.001	0.263

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, WKKO = 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 2022

			Inspections			Inspection person days		
MBA/operator	**Date**	**Inspection type**	**IAEA**	**COM**	**STUK**	**IAEA**	**COM**	**STUK**
TVO	16.2.	International NM transfers			1			2
WLOV	16.2.	RII	1	1	1	1	1	1
WOLS	24.2.	RII	1	1	1	1	1	1
WOLE	30.3.	Technical activities, site survey				2	2	1
WOLS	31.3.	Technical activities, site survey				2	2	1
WOL1, WOL2, WOL3	5.–7.4.	Pre-PIT PIV (WOL1, WOL2) and PIV, DIV (WOL3)	3	3	3	3	6	3
WLOV	7.4.	Interim inspection, site			1			1
WOL2	30.4.	OL2 CV			1			1
Posiva	24.–25.5.	System inspection (RTO)			1			8
WRRF	31.5.	PIV, DIV	1	1	1	1	1	1
WNSC	1.6.	PIV	1	1	1	1	1	1
WHEL	2.6.	PIV		1	1		1	1
WOL1	3.6.	CV			1			1
RAOS Project Oy	14.–15.6.	System inspection with nuclear security			1			4
WOL1, WOL2, WOLS	21.–22.6.	Post-PIT PIV, DIV	3	3	3	3	3	3
WDPJ	22.6.	PIV	1	1	1	1	1	1
WFRS	23.6.	PIV		1	1		1	1
WOL1	14.7.	CV			1			1
WLOV	26.7.	Verification (Upu)			1			1
WLOV	27.7.	Pre-PIT PIV	1	1	1	1	1	1
WOLS,WOL1	29.7.	RII	2	2	2	2	2	2
WOLS	15.–19.8.	Verification (PGET and PNAR)			1			10
WLOV	26.8.	CV			1			1
WOL1, WOL2	29.8.	Surveillance equipment maintenance	2	2	2	2	2	2
WLOV	25.9.	CV			1			1
TVO	11.–12.10.	System inspection (KTO)			1			6
WOL1	18.10.	RII	1	1	1	1	1	1
WLOV	25.–26.10.	PIV, DIV	1	1	1	2	4	2
TVO	23.11.	International NM transfers			1			2

			Inspections			Inspection person days		
MBA/operator	**Date**	**Inspection type**	**IAEA**	**COM**	**STUK**	**IAEA**	**COM**	**STUK**
W0L1, W0L2, W0L3, W0LS	29.11.	Interim			4			4
W0LE, W0LF	29.–30.11.	DIV	2	2	2	4	2	2
WDPJ	2.12.	CA	1	1	1	2	1	2
WTAL	14.12.	PIV, DIV with nuclear safety inspection			1			1
Total			21	23	41	29	33	71

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 January 15, 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 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 and 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).

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