# United states cooperative nuclear

# facilities and safeguards experience

# (NFASE) with THE CNSC and Euratom

Working together to showcase international nuclear safeguards implementation.

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**Abstract**

The U.S. Department of Energy’s Office of Nonproliferation and Arms Control collaborated with its partners in Canada and the European Atomic Energy Community (Euratom) to advance awareness and acceptance of safeguards for Advanced and Small Modular Reactors (A/SMRs) and safeguards by design (SBD) principles. During cooperative technical exchanges, several U.S. based A/SMR developers and vendors participated in a Nuclear Facilities and Safeguards Experience (NFASE), where they learned how the IAEA works with regional and national regulators to apply safeguards in non-nuclear weapons states. In Canada, vendors learned that considering operational safeguards requirements early in the design and production process (SBD) can mitigate additional cost or design changes necessary to comply with international requirements. Building on Canadian expertise with developing safeguards methods for on-line refueled reactors, these technical exchanges allowed designers that intend to use circulating fuel, like molten salt or pebble-based fuels, to interact with subject matter experts and regulators with knowledge of similar accountancy methods. In Europe, participants saw the efficient cooperation between national authorities, Euratom and the IAEA. In both experiences, participants learned that early engagement with customers and local regulators, and adoption of SBD principles, are key to identifying and mitigating development and deployment risks. This paper will share impressions from participants of these cooperative efforts, identify lessons learned from international collaborations between U.S. and Canadian/European partners, and discuss how these exchanges contributed to the strategic objectives of each partner.

## INTRODUCTION

Through the Nuclear Facilities and Safeguards Experience (NFASE), U.S. developers of Advanced and Small Modular Reactors (A/SMRs) and associated fuel cycles, experienced how international nuclear safeguards requirements are implemented by the International Atomic Energy Agency (IAEA) in facilities in non-nuclear weapons states. Introducing U.S. developers to operators and regulators increased their understanding of operational safeguards and reinforced the need for safeguards by design (SBD).

NFASE is an effort led by DOE/NNSA’s Advanced Reactor International Safeguards Engagement (ARISE) program. In 2024, ARISE worked closely with the Canadian Nuclear Safety Commission (CNSC) and the European Atomic Energy Community (Euratom) Safeguards directorates for the Canadian and European NFASE respectively.

ARISE aims to prepare U.S. A/SMR vendors and other stakeholders to meet the highest non-proliferation standards, which are required to compete in a global nuclear market. ARISE has 3 main lines of effort, all of which NFASE contributes to:

* Engage with advanced nuclear industry to help them understand - and embrace - international nuclear safeguards,
* Build a knowledge base and capacity among the U.S. advanced nuclear community,
* Prepare stakeholders for new technologies and business models.

The CNSC, as Canada’s safeguards regulatory authority, has a long-standing commitment to the peaceful uses of nuclear energy which includes supporting the effective and efficient implementation of safeguards in Canada and around the world. Through its pre-licensing vendor design review (VDR) process the CNSC has encouraged Canadian vendors’ early integration of safeguards into their designs and welcomed the opportunity to share Canadian safeguards experiences with U.S. developers. The CNSC is supporting the development of safeguards approaches for proposed SMR designs through the Canadian Safeguards Support Program task with the IAEA and has submitted preliminary design information for the proposed construction of Canada’s first SMR to be built at the existing Darlington site. The CNSC supports international engagement and collaboration on safeguards to ensure its consistent and wide-spread implementation.

The Euratom Treaty, establishing the European Atomic Energy Community (Euratom), lays down the foundation for the peaceful use of nuclear materials and technologies in the European Union. It also establishes a supranational nuclear material supervision system, known as ‘Euratom safeguards’, under the responsibility of the European Commission. The Euratom Treaty explicitly requires the Commission to ensure non-diversion of civil nuclear materials from their intended uses and compliance with the safeguards obligations assumed by the Euratom Community under the relevant international agreements. In this regard, the Euratom Community and its Member States are parties to multilateral Safeguards Agreements and their related Additional Protocols with the IAEA concluded in implementation of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). Euratom Safeguards cooperates with the IAEA in implementing safeguards under these agreements.

Euratom Safeguards supports the principle of SBD and cooperates closely with EU National Authorities and operators to implement cost efficient safeguards, including, where appropriate, with the IAEA.

### Audience

NFASE is primarily aimed at stakeholders in the U.S. advanced nuclear industry. The U.S. has more proposed A/SMR designs than any other single country, but it has very limited recent experience building nuclear infrastructure both in the U.S. or abroad. The program strives to both reach producers/developers of advanced reactors directly (push) and indirectly through other partners in the fuel cycle (pull).

As Canada uses CANDU reactors for power generation, the Canadian experience was a great opportunity to learn how international safeguards are implemented in a reactor with circulating fuel. Therefore, this NFASE is regarded as most useful for U.S.-based designs with similar fuel proposals (pebble bed and molten salt reactors), which will likely require online fuel monitoring systems for safeguards purposes. The European experience is more relevant for developers using more traditional, light water-based designs.

Each NFASE had a different group of participants with broad backgrounds, from reactor designers to regulatory experts. What all participants had in common, is that they support the deployment of advanced nuclear internationally.

### Visited Facilities:

Canada NFASE

All facilities included in the Canada NFASE are located within a 2-hour drive from Toronto, which allowed the group to stay in one hotel for the entire week with a briefing room for meetings at the start and the end of the week. The tours included item facilities (research and power generation) and bulk facilities (fabrication and conversion), which allowed participants to learn about different international safeguards implementation tools.

* Darlington Nuclear Generating Station – a power plant with 4 CANDU-850 reactors and associated spent fuel waste management facility. This location is also the current site for the Darlington SMR project, a GE BWRX-300 unit,
* Cameco Fuel Fabrication Facility – fabricating CANDU fuel bundles from UO2 powder received from the Port Hope Conversion Facility (PHCF),
* Cameco Port Hope Conversion Facility – converting UO3 to UO2 (for CANDU fuel fabrication) and UF6 (for foreign export to enrichment plants),
* McMaster Research Reactor – a pool-type research reactor on the McMaster University campus; also the location of the on-going feasibility study for the future deployment of Ultra Safe Nuclear Corporation (USNC) Modular Micro Reactor (MMR).

Europe NFASE

These facilities are all located in Western Europe, which required the group to travel between locations. The four facilities are a mix of item facilities (power generation) and bulk facilities (enrichment and fabrication). Visiting facilities at three stages of the nuclear fuel cycle allowed for detailed discussion about designs and consequences for safeguards implementation. This increased understanding and built transferable knowledge, applicable to A/SMR designs on safeguards implementation. Including visits to regulator offices really focused the whole experience on safeguards regulation and implementation.

* Urenco, Almelo, the Netherlands, uranium enrichment,
* Westinghouse, Västeräs, Sweden, fuel fabrication,
* Vattenfall, Forsmark, Sweden, 3x1000 MWe BWR,
* European Commission, DG Energy, Luxembourg.

At Forsmark, the close proximity to the Swedish Nuclear Fuel and Waste Management Company (SKB) allowed their participation as well. The team from SKB provided an overview on safeguards in spent fuel geological repository. In addition, two researchers from the Nuclear Safeguards Programme at Uppsala University presented their research on safeguarding future nuclear energy systems.

### Resources

With the forecasted expansion of nuclear power, non-proliferation is a shared responsibility between governments and nuclear industry. The NFASEs are carried out on a cost share basis; the U.S. government funded the overall logistics, and experts to develop and deliver educational resources. The visited governments contributed in-kind by hosting and leading the tours, and the participating industry entities covered their travel costs and incidentals during the visits. All organizations are committed to ensuring safeguards are considered at every step in the process of design and deployment of novel nuclear technologies.

As an NPT signatory, the U.S. is committed to sharing nuclear technology for peaceful uses. In doing so, the U.S. seeks to uphold the highest standards of non-proliferation. Educating U.S. industry on international nuclear safeguards is one of the ways the U.S. demonstrates its commitment to NPT Articles 3 and 4.

##  EXPERIENCE

The two NFASE events allowed industry representatives involved in advanced nuclear development to see up-close how international safeguards are implemented in the day-to-day operation of various nuclear facilities. The variety of the nuclear installations (from conversion, enrichment, fuel fabrication, power generation and spent fuel repository) allowed for a comparison between different approaches and enabled the participants to consider different solutions for their own designs. The facility visits, briefings by company safeguards managers and the open discussion really emphasised how safeguards contribute to the prevention of diversion or misuse of nuclear material, and how various measures (remote monitoring, inspections, verification of accountancy) ensure a continuity of knowledge.

### Canada NFASE

Participants arrived in Toronto on Sunday, August 4 and meetings started the following day. Monday consisted of presentations to provide background information to the participants. The agenda on Monday covered an overview of international safeguards and how they are implemented in Canada. Canada is one of the most intensive countries for IAEA safeguards, so we had the IAEA explain their role and some of their activities in the country.

Participants visited four different nuclear facilities with different safeguards approaches. During these visits, the participants saw IAEA equipment throughout the facilities and had a chance to discuss the specific safeguards approach with the facilities’ operators. After each visit, the group debriefed to answer any outstanding questions.

On Friday, the group met for half a day to have an open discussion on what they had learned throughout the week and how they could apply this into their design. The IAEA participated virtually and gave an overview on SBD and industry’s role.

### Europe NFASE

Participants arrived in Almelo on Sunday, September 22 and attended an initial meeting with presentations from Euratom Safeguards and IAEA Safeguards Operations C on the application of safeguards in Europe. From Monday to Thursday, participants visited three different nuclear facilities with different safeguards approaches. During these visits, the participants saw joint Euratom/IAEA equipment throughout the facilities and had a chance to discuss the specific safeguards approach with the facility’s operators. After each visit, the group debriefed to answer any outstanding questions.

On Tuesday, the group had an opportunity to visit the offices of the European Commission, DG Energy, and meet Safeguards experts from Euratom Safeguards to learn about safeguards implementation in the EU. Participants appreciated learning about the cooperation between the IAEA and the European Commission, and about the unique role of DG Energy as a regional safeguards authority. The European Industrial Alliance on SMRs was presented for information. Participants learned that early engagement with the regulator is a legal requirement under the Euratom treaty projects, and that DG Energy can impose sanctions on operators that are not in compliance with their safeguards obligations.

Similar to the Canadian NFASE, there was a closing session at the end of the week. This session included the IAEA, a presentation from U.S. subject matter experts on design information questionnaire and allowed for open discussion and outstanding questions.

### Feedback

Overall, feedback was extremely positive. Participants repeatedly praised this effort throughout the week in Canada, stating that it was highly educational and enjoyable.

Participants appreciated the openness and high level of knowledge from operators, and their willingness to answer questions related to safeguards implementation at each facility. Participants valued the presentations before each tour, providing an overview of the facility and how international safeguards are implemented. This helped focus the tours on safeguards equipment and measures.

Participants understand the importance of SBD and appreciate the possibility to engage with regulatory authorities but emphasised the need for predictability. While they recognise that safeguards approaches might vary in different countries, they stressed the need for practical information (e.g., dimensions of cameras and storage cabinets, or power and connectivity requirements of specialised safeguards equipment) so they can incorporate those into their designs.

##  LESSONS LEARNED

NNSA has funded similar trips in the past for graduate students under the Nuclear Facilities Experience (NFE). We are leveraging lessons learned from NFEs throughout the years and are working with the NFE management team. Even with this experience, we expected to learn from both NFASEs, as they target a different audience than the NFE, and involve close coordination with different counterparts in the host countries.

There are lessons we learned through NFASE that can be applied to other educational opportunities. In no particular order, the three main lessons are:

1. Participants: initially, we thought we wanted to target technical experts. Both trips proved that having a broader audience with different backgrounds benefited the overall experience and the breadth and depth of the discussions.
2. Having both the regulators and operators in the same room painted a complete picture of the safeguards implementation process.
3. Timing is important. Everyone will need time to process requests and approvals. For many people involved in safeguards, it is not their full-time job, so there will be conflicting priorities.

##  CONCLUSION

Overall, both NFASEs were successful in educating advanced nuclear industry on international safeguards. The participants embraced and understood the importance of safeguards, SBD, and early and frequent conversations with relevant stakeholders.

We want to reiterate the importance of SBD and how it can mitigate risks in the future. For many developers, SBD includes early, and frequent conversations with the IAEA, which gets to our next point: the importance of collaboration. The NFASEs are only the beginning of the collaboration between NNSA, CNSC, and Euratom. We will highlight future work that we plan to do together to normalize the conversation around non-proliferation and ensure the highest standards of non-proliferation as nuclear power grows worldwide.

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