Safeguards

Application of Safeguards by Design to Advanced Reactors

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Topics covered in this presentation

- ✓ Background: IAEA nuclear safeguards
- ✓ Safeguards considerations for advanced reactors
- ✓ Safeguards by design

Role of IAEA nuclear safeguards

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→ IAEA provides independent verification

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Scope of material and technology under safeguards depends on the **specific safeguards agreement** between each country and the IAEA

Types of safeguards agreements

Item-Specific Safeguards Agreement

- Safeguards apply to specific items, e.g., nuclear material, facilities, equipment (INFCIRC/66/Rev.2)
- States not currently under the NPT (safeguards system prior to the NPT)

Comprehensive Safeguards Agreement (CSA)

- Safeguards apply to all nuclear material in all peaceful activities in a State (INFCIRC/153 (Corr.))
- Non-Nuclear-Weapons States (NNWS) under the NPT, and States party to Nuclear Weapons Free Zone treaties

Voluntary Offer Agreement (VOA)

- Safeguards apply to nuclear material in facilities that the State has offered for safeguards and have been selected by the IAEA
- Nuclear-Weapon States (NWS) under the NPT

Additional Protocols may be concluded for each type of agreement

Safeguards vs. proliferation resistance

Proliferation resistance:

"…that characteristic of a nuclear energy system that impedes the diversion or undeclared production of nuclear material or misuse of technology by the Host State seeking to acquire nuclear weapons or other nuclear explosive devices."*

Safeguards provide independent verification ("safeguardability" is one aspect of proliferation resistance)

* Evaluation Methodology, Generation IV International Forum Working Group on Proliferation Resistance and Physical Protection (GIF-PRPPWG), https://www.gen-4.org/gif/jcms/c_40411/proliferation-resistance-physical-protection-working-group-prppwg

Independent verification: in-field activities

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Nuclear Material Accountancy

- To verify State's declaration of nuclear material **inventory and flow** (e.g. item counting, weighing, non-destructive assay)
- Can involve **remote monitoring of unattended equipment**

Containment and Surveillance

- To maintain **continuity-of-knowledge** (e.g. cameras, seals, measurements) between inspections
- Can involve **remote monitoring of unattended equipment**

Design Information Verification

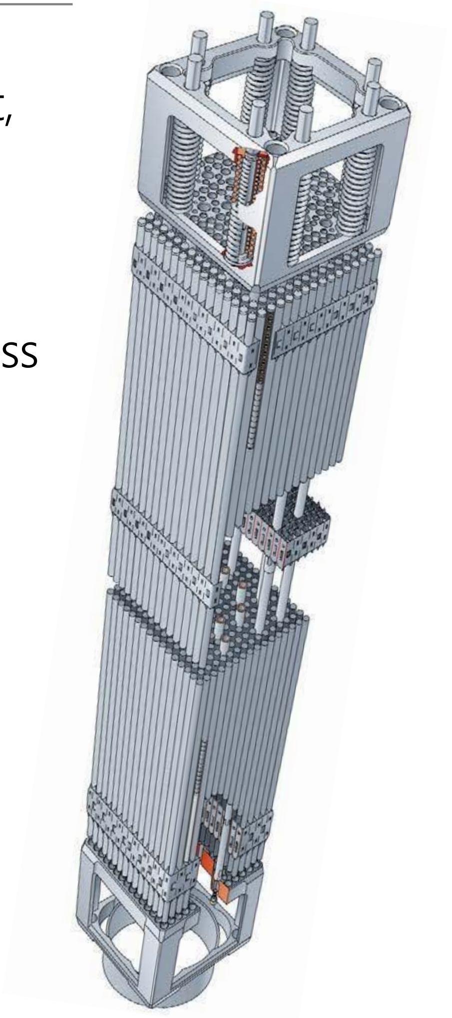
- To verify State's **declared facility design** (construction, operation, modification or decommissioning)

Environmental Sampling, and Complementary Access to other locations

- To assure **"completeness" of declaration**: i.e., absence of undeclared nuclear material or activities

Safeguards considerations for advanced reactors

- **New fuels and fuel cycles:** Th/U-233, RepU, MOX, TRU fuels, higher enrichment, pyroprocessing, other new processes
- **New reactor designs:** molten salt, fast reactors, pebble bed, …
- **Longer operation cycles:** continuity of knowledge between refuelling, high excess reactivity of core (accommodation for undeclared irradiation)
- **New supply arrangements:** factory sealed cores, transportable power plants, transnational arrangements (need for design verification and sealing)
- **New spent fuel management:** storage configurations, waste forms
- **Diverse operational roles:** district heating, desalination, hydrogen + electricity
- **Remote, distributed locations:** access issues, lack of "unannounced" visit deterrence, cost-benefit issues



- **IAEA verification capabilities must be ready**

Important aspects for future safeguards

- **Unattended monitoring systems** (UMS) and **remote data transmission** (RDT)
- **Digital connectivity** coverage in remote areas (reliable, high bandwidth, secure)
- **Safeguards seals** on factory-sealed, transportable cores
- **Design verification**, particularly under transnational supply arrangements
- **New safeguards approaches**, including (potentially) customized Agency or joint-use instrumentation (e.g., thermal power monitor for microreactors, process monitoring)
- **State-level issues:** managing effective/efficient safeguards for a fleet of small, remote facilities
- **Training** for safeguards authority in emerging nuclear energy States

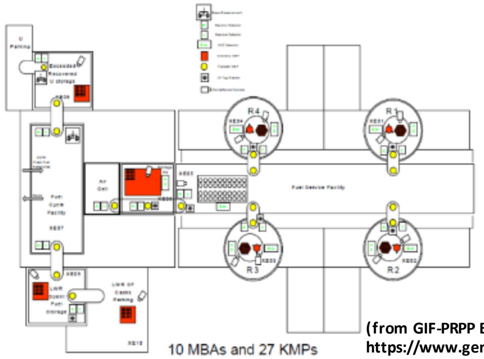
- **All of these need time for development: "Safeguards by Design" is critical**

What is safeguards by design? (SBD)

- The **integration of safeguards considerations into the design process** (new or modified facility, at any stage of the nuclear fuel cycle), from initial planning through design, construction, operation, waste management and decommissioning

- **Awareness** by all stakeholders (State, designer, operator, regulator, other IAEA departments) of IAEA safeguards obligations, and opportunities for **early discussion with the IAEA Department of Safeguards**.

- A **voluntary process** that neither replaces a State's obligations for early provision of design information under its safeguards agreement, nor introduces new safeguards requirements.



10 MBAs and 27 KMPs

(from GIF-PRPP ESFR Case Study, 2009: https://www.gen-4.org/gif/jcms/c_9365/pr-pp)

SBD: integration into the design process

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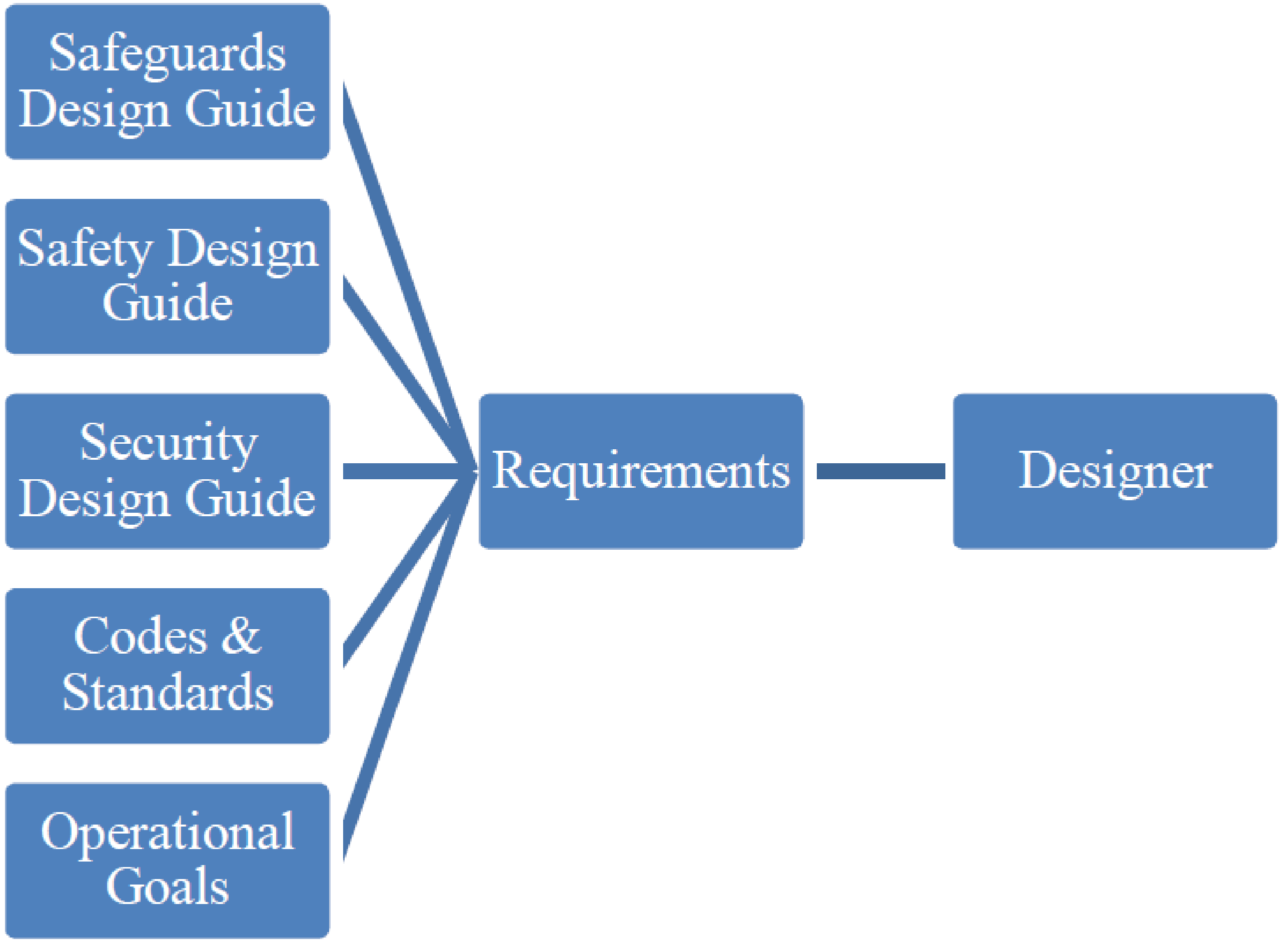

Benefits of safeguards by design

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- ✓ Reduce **operator burden** by optimizing inspections
- ✓ Reduce need for **retrofitting**
- ✓ Facilitate **joint-use equipment**
- ✓ **Increase flexibility** for future safeguards equipment installation
- ✓ Enhance possibility to use facility design/operator **process info**
- ✓ **Reduce risk** to scope, schedule, budget, and licensing
- ✓ Possible **marketing advantages**?

➢ **SBD benefits all parties involved, not just the IAEA**

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Challenges in implementing SBD

- IAEA lacks a **direct channel of communication** to designers, particularly at the earliest stages of design when greatest SBD potential exists.
- Designers lack a **uniform understanding** of safeguards requirements.
    - Many nuclear designers are new to the industry, often relatively small with limited scope of capabilities
    - Many nuclear design companies are located in Nuclear-Weapon States, where IAEA safeguards are typically of concern when exports are anticipated (lack of "safeguards culture")
- Safety and economics are priority design drivers; safeguards **not seen as a design driver** at all – of relevance toward end of build process
- **Inconsistent licensing practice** in addressing safeguards requirements
- **Proprietary / commercial concerns**

IAEA SBD activities

- **SMR Member State support program tasks**
  - Russia, South Korea, US, Canada, Finland, France, China
  - Extendable to other States
  - goal is to work with Member States to:
    - raise awareness of safeguards with technology designers
    - evaluate design aspects that could impact safeguards
    - investigate safeguards implementation strategies
    - identify potential design changes to facilitate safeguards

- **Internal IAEA collaborations:** SBD Working Group (Safeguards, Nuclear Energy, Nuclear Safety and Security), and other internal collaborations as needed

- **External engagements:** Raising awareness with stakeholders

Safeguards

How can stakeholders help?

Regulators:

- **Raise awareness** of safeguards requirements, and the potential benefits of SBD to all licensees and potential new licensees
- Make safeguards considerations a **requirement of pre-licensing review**
- **Encourage three-way discussion** with State safeguards authority, designer, IAEA

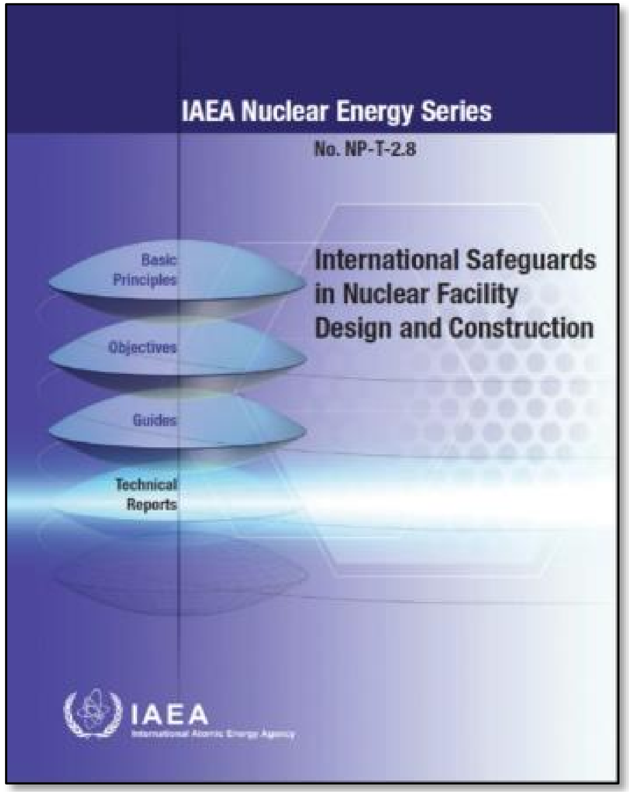
NGOs, R&D community:

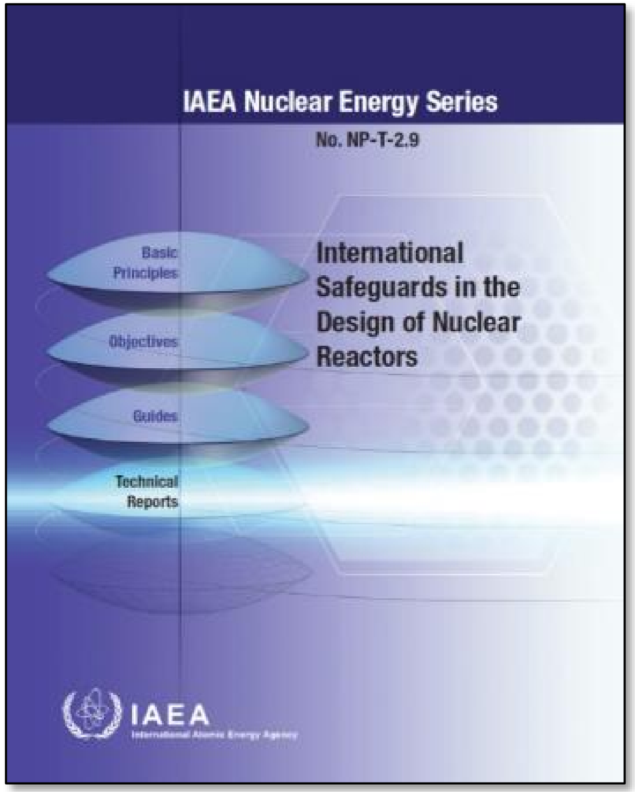
- **Raise awareness** of safeguards requirements and SBD through industry seminars and other events (invite safeguards experts/IAEA)

Developers of advanced reactors:

- **Increase awareness** of safeguards requirements and potential impact of State's safeguards obligations on operation of a facility
- **Incorporate safeguards considerations** along with safety, security, economics, and other factors when making design decisions
- **Engage in early SBD discussions** with State safeguards authority, IAEA, or other safeguards experts

Safeguards by design (SBD) guidance





www.iaea.org/topics/assistance-for-states/safeguards-by-design-guidance

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Thank you for your attention!

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Dr. Jeremy Whitlock has over 26 years' experience as a scientist and manager in the Canadian and international nuclear community. Since January 2017 he has worked in the Department of Safeguards at the International Atomic Energy Agency (IAEA) in Vienna, helping to ensure that States meet their obligations under the Nuclear Non-proliferation Treaty (NPT). Prior to that he worked at Chalk River Laboratories as a reactor physicist and later a manager of nuclear non-proliferations and safeguards R&D (since 2015 Chalk River Laboratories has been operated by Canadian Nuclear Laboratories).

Dr. Whitlock received a B.Sc. in Physics from the University of Waterloo (1988), and an M.Eng. and PhD in Engineering Physics (reactor physics) from McMaster University (1995).

Dr. Whitlock is a Past President and Fellow of the Canadian Nuclear Society. He is also a public speaker and author on nuclear issues, including a *The Canadian Nuclear FAQ* (www.nuclearfaq.ca), a personal website of frequently-asked questions (FAQs) on Canadian nuclear technology.

Dr. Whitlock lives in Vienna, Austria, and feels that canoes are the closest humans have come to inventing a perfect machine.

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