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Technical solutions in the sphere of atomic energy and evolution of non-proliferation regime

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The IAEA safeguards system

Safeguards is a complex of technical measures that the IAEA takes in relation to nuclear facilities and nuclear material to prevent the existence of:

- undeclared* nuclear material and types of activities in a state.
- undeclared** production or processing of nuclear material at declared facilities.
- diversion*** of declared nuclear material.

* undeclared nuclear material was not declared and placed under safeguards not pursuing the IAEA requirements

**undeclared nuclear activities refer to nuclear activities or activities adjacent to it which the IAEA was not informed about violating requirements

*** diversion is the use of fissionable or other materials, facilities or equipment to reach any military purpose

Legal framework of the IAEA safeguards

Agreements		
Comprehensive Safeguards Agreement (CSA)	Voluntary Offer Agreement	Item-specific safeguards agreement
NNWS	NWS	Israel, India and Pakistan
INFCIRC/153	INFCIRC/175, 288, 290, 327, 369	INFCIRC/66/Rev.2

Additional agreements	Agreement on the IAEA privileges and immunities
Protocol	
Small quantities protocol (GOV/INF/276/Annex B)	Additional protocol (INFCIRC/540)

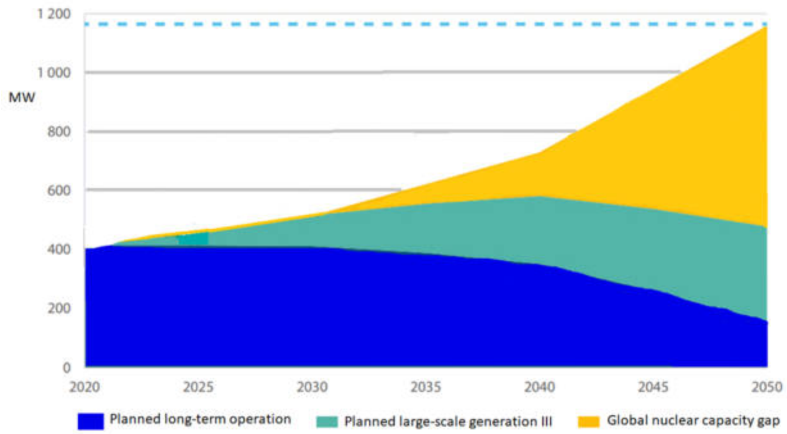
Basic approaches to apply the IAEA safeguards to land-based nuclear facilities were formed in the 1960s

Small modular reactors in ARIS data base

There are approximately **50** designs SMRs.

It is relatively **2/3** of all reactor designs in ARIS

Challenges for application of the IAEA safeguards to SMR



The NEA Small Modular Reactor Dashboard, 2023
https://oecd-nea.org/upload/docs/application/pdf/2023-02/7650_smr_dashboard.pdf

New tasks in the sphere of ensuring the non-proliferation regime

- Sharp increase of the number of objects to be safeguarded
- Operation in remote locations
- Limited access to fuel at the operation site

Risks of applying safeguards to SMR

- Possibility of decrease of safeguards effectiveness because of procedures and equipment are not applicable
- Untimely exchange of information
- Irrational use of the IAEA resources

Technical features of SMRs from the point of view of the IAEA safeguards

- Innovative reactor units are assumed to be used in embarking countries;
- Innovative types of nuclear fuel: (molting salt, thorium etc.);
- Particular features of fuel: pyroprocessing, ceramic metal alloy etc.

International cooperation on adaptation of approaches for applying of the IAEA safeguards to innovative projects

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Activities of designers and scientific institutions:

- Generation IV International Forum. Proliferation Resistance and Physical Protection Working Group
- Simplified Approach for Proliferation Resistance Assessment (France)
- Proliferation Resistance Optimization (USA)
- The IAEA Member State Support Programme

GEN IV International Forum
Expertise | Collaboration | Excellence

IAEA
International Atomic Energy Agency
Atoms for Peace and Development

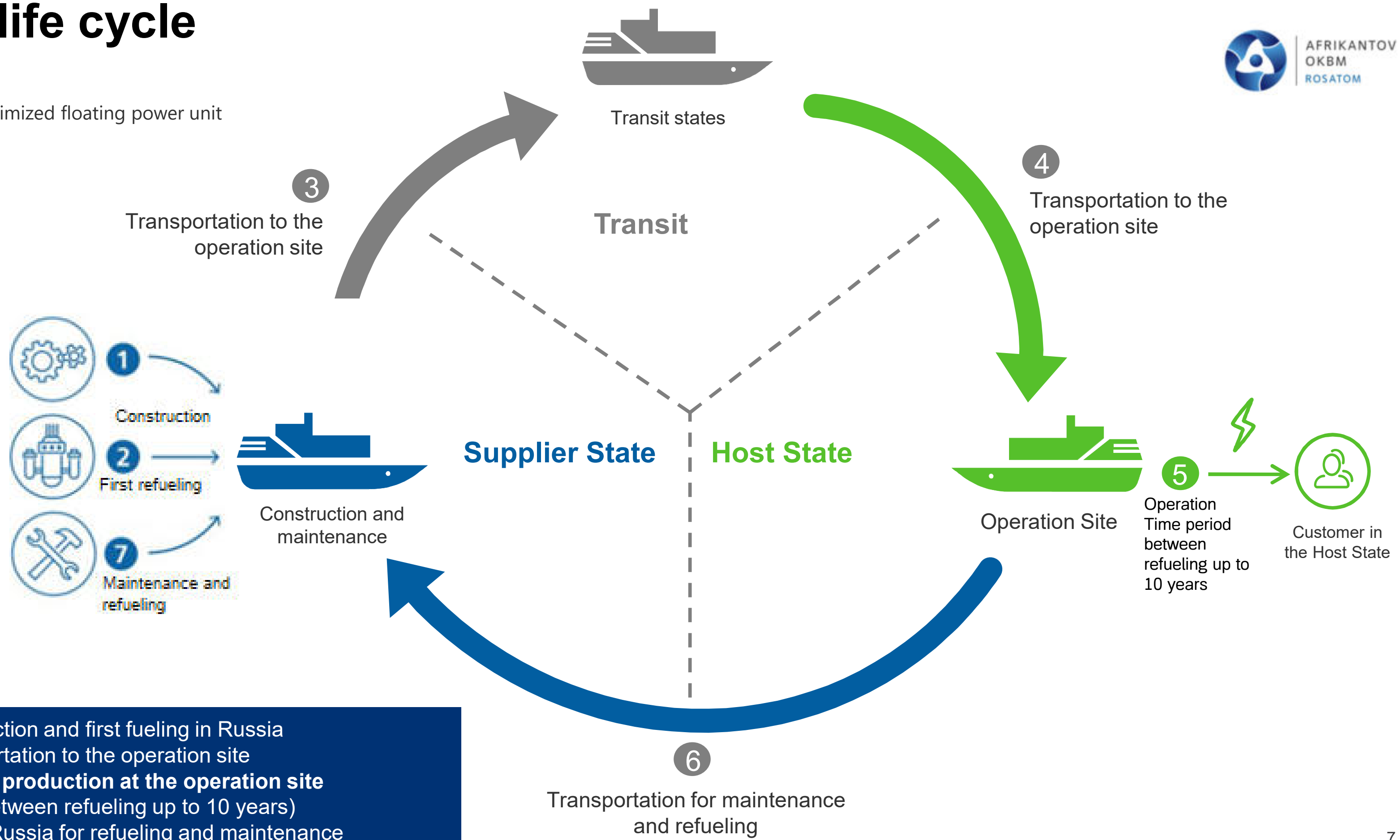
Features of transportable SMRs. Example of technical solution — optimized floating power unit

OFPU is developed on the basis of reference solutions ensured by the experience of operation of multi-purpose nuclear icebreakers with reactor units of RITM series

- Innovative reactor RITM-200M of integral type with a low possibility to install a target for irradiation
- Absence of access to nuclear fuel during operation
- Fuel campaign up to 10 years, reactor core is refueled as a whole in Russia
- Compact arrangement of compartments
- Pressurization and sealing of reactor
- Absence of refueling machine and fuel storage on board
- Absence of fuel management on board of OFPU and at the operation site

OFPU life cycle

* OFPU — optimized floating power unit



1, 2 – Construction and first fueling in Russia
3, 4 – Transportation to the operation site
5 – Electricity production at the operation site
(time period between refueling up to 10 years)
6 – Return to Russia for refueling and maintenance
7 – Refueling and maintenance in Russia

Adaptation of approach for appling IAEA safeguards to SMRs: technical aspects

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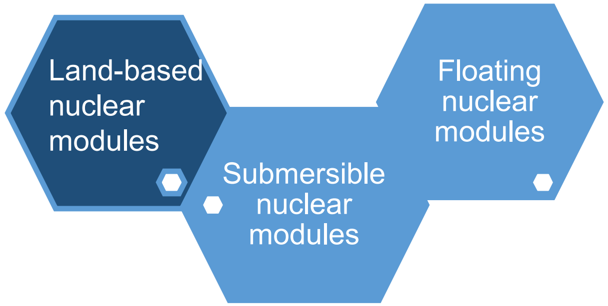

Technology allows to implement the scenario with the use of factory fueled SMR

New universal approach for transportable (land-based, submersible, floating) nuclear modules

Challenges for transportable SMR requiring solution

- Coordination of activities for several states participating in the project
- Reference and developed approach only for pressurized water reactors, operated at land-based nuclear power plants of large capacity
- Mobility of objects to which the IAEA safeguards are expected to be applied
- Restricted spectrum of opportunities for the use containment and surveillance equipment
- Necessity of new containment and surveillance equipment development for ensuring the verification of fuel
- This verification could be accomplished only in several years, because of absence of access
- Access to nuclear fuel only in the Supplier State

Adaptation of technical and legal approaches for ensuring non-proliferation regime as well as development of an updated approach are required for deployment of innovative transportable facilities with new features

Features of application of the IAEA safeguards taking into consideration series production

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Safeguards approach 1

Safeguards approach 2

Safeguards approach 3

Safeguards approach X

Safeguards approach X

Safeguards approach X

- ❖ There is a necessity for conventional NPPs of large capacity to develop a specialized system of ensuring safeguards, because every case has original buildings, specification of equipment and its arrangement.

- ❖ Design of nuclear floating power unit is the same for every operation site
- ❖ Adaptation of operation site is performed via onshore structures especially designed for it

Safeguards-by-design approach allows to take into account requirements of safeguards already at the stage of design to increase effectiveness of their application at further stages

Standard approach

Conventional nuclear power plants have a unified algorithm of ensuring the IAEA safeguards which can be adjusted to particular NPP buildings	Floating nuclear power units may have an identical algorithm of application of the IAEA safeguards due to their series production, because all vessels have the same material balance area and key measurement points whatever the site is

Ensuring the IAEA safeguards for transportable nuclear power plants. Approach development

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Instruments ensuring non-proliferation regime:

Synchronization of nuclear material verification with safeguards by design approach solutions	Rational use of containment and surveillance measures equipment	Optimized algorithms for accomplishment of verifications

Use of reference experience and creation of example documents and guides for control of ensuring the non-proliferation regime

Potential contribution from the Supplier State

Submitting information on the algorithm for fuel management	Cooperation with the IAEA on the use containment and surveillance equipment with regard to: • Mobility of objects; • Long period of non-stop use in the Host State; • Limited access to fuel	Submitting information on specificity of compartments arrangement

Adaptation of approach for application of IAEA safeguards to SNPP: legal aspects

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Standard approach

Existing legal instruments (Comprehensive Safeguards Agreements, Voluntary Offer Agreements, etc.) allow to apply the IAEA safeguards to nuclear material in the framework of transportable SMR, factory fueled in the Supplier State.
At the same time development of particular legal aspects is required

The following procedures in the framework of a facility attachment to Comprehensive Safeguards Agreement and Voluntary Offer Agreement can be considered:

- Approved procedure of implementing nuclear material verifications in the Supplier State and the Host State;
- Approved procedure of transition of information between the Supplier State and the Host State;
- Approved procedure of accounting nuclear facility in the Host State and the Supplier State from the point of view of the IAEA safeguards.

Mobility factor for transportable nuclear power plants with regard to nuclear material accounting

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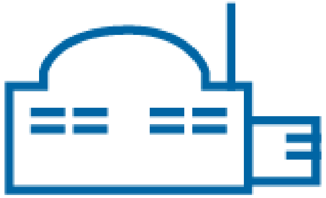

One unified material balance area only in the Host State

Material balance area in the Supplier State during:

- commissioning;
- maintenance;
- decommissioning.

Material balance area in the Host State during:

- operation.

Nuclear facility has only one material balance area during the whole lifecycle

From the legal point of view nuclear facility has 2 different material balance areas in one physical space in the country where it is operated

Standard approach	
Nuclear material verification for land-based nuclear power plants of large capacity is fulfilled at the operation site where one material balance area is situated.	Documents of the IAEA for floating nuclear power units will be formed for a material balance area in the Supplier State as well as in the Host State taking into account their mobility. Formal fact of nuclear material transition will be documented.

Conclusions:

- ✓ Development of nuclear technologies entails adaptation of nuclear law ensuring innovative projects.

- ✓ Technical features of transportable SMRs allow to operate them in the Host State and taking into account that they fueled in the Supplier State. This scenario requires adaptation of technical instruments for realization of the IAEA safeguards.

- ✓ Cooperation between the IAEA and Supplier States is needed for development of approach for application of the IAEA safeguards to innovative SMRs.

Thank you for your attention!