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Status of RITM Technology Development and Deployment

Tatiana TAGIROVA

Specialist of Business Development Department
Afrikantov OKBM

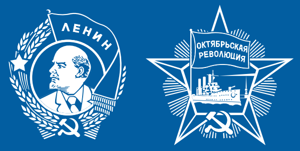
Afrikantov OKBM –

Scientific and Production Center of Nuclear Engineering of the Rosatom State Corporation

Date of foundation
27 December 1945

The company has a well-developed efficient infrastructure with a full production and technical cycle from design, manufacture and testing to comprehensive delivery of products to the customer and provision of their service support throughout the entire life cycle.

Afrikantov OKBM, as the chief designer and complete supplier of reactor installations, is a reliable and responsible partner in solving scientific, technical and production tasks of any complexity.



REWARDS:

1960 — Order of Lenin
1985 — Order of October Revolution

PRESERVING TRADITIONS, WE CREATE THE FUTURE

ROSATOM: keeping the pace

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Rosatom success history

33+6 units

In the overseas NPP portfolio (large and SMR units)

10 countries

Hungary
Paks II NPP
VVER-1200

China
Xudapu NPP
VVER-1200

China
Tianwan NPP
VVER-1200

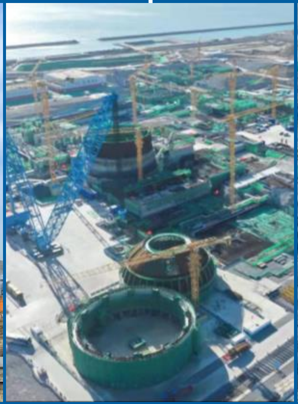
Turkiye
Akkuyu NPP
VVER-1200

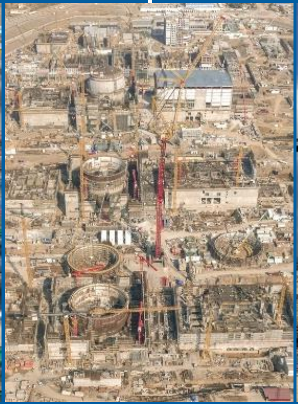
Egypt
El-Dabaa NPP
VVER-1200

India
Kudankulam NPP
VVER-1000

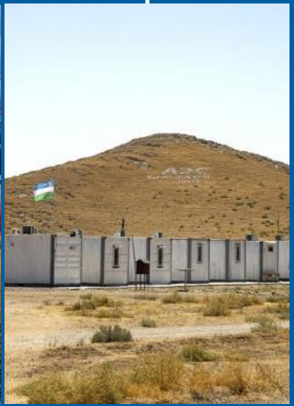
Bangladesh
Rooppur NPP
VVER-1200

Uzbekistan
SMR NPP
RITM-200N







Development and experience in operation of marine reactor units

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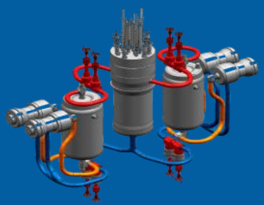
OK-150



90 MW
Thermal Power

OK-900, OK-900A

159 MW

KLT-40, KLT-40M, KLT-40S

135 – 150 MW

RITM-200

175 MW

RITM-400

315 MW

Decommissioned:
Lenin (3 OK-150 / 2 OK-900),
Arktika, Sibir, Rossiya, Sovetsky
Soyuz (all with 2 OK-900A)

In operation:
Nuclear icebreakers: 50 let Pobedy, Yamal (2 OK-900A);
LASH Sevmorput (1 KLT-40);
Nuclear icebreakers: Taymyr, Vaygach (KLT-40M);
FPU “Akademik Lomonosov” (2 KLT-40S);
Nuclear icebreakers: Arktika, Sibir, Ural, Yakutiya (2 RITM-200)

Under construction:
Nuclear icebreakers: Chukotka, Leningrad,
Stalingrad (2 RITM-200);
Nuclear icebreaker with increased power
capacity (2 RITM-400)

Reference design of the FPU “Akademik Lomonosov”

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- The solutions proven in the icebreakers design are applied for the floating power units
- The design is prepared in conformity with the Russian Federation regulatory documentation for nuclear ships and floating units.

2 KLT-40S power units

Ship characteristics:

144 m	length
22 516 t	displacement
5,6 м	draft

40 years — Service life

2,5-3 years — Refueling interval

0,7 — Capacity factor

70 MW — Electric power

up to 146 Gkal/h — Thermal power

Operation experience of the FPU “Akademik Lomonosov”

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May 2020
FPU “Akademik Lomonosov” was commissioned

The first FPU refueling was conducted in 2024 with the use of fuel handling equipment placed on the FPU board

Supply of electricity to **MORE THAN 60%** of consumers in the Chukotka area **in 2024** and plans to increase the energy supply

UP TO 70% in 2025

Over 1 BILLION KWH of electricity has been generated:

- **127 MILLION KWH in 2020;**
- **175 MILLION KWH in 2021;**
- **250 MILLION KWH in 2024**

Emissions of carbon dioxide equivalent in excess of **300 THOUSAND TONS** into the atmosphere have been prevented

https://www.rosenergoatom.ru/stations_projects/sayt-pates/press-tsentr/novosti/47677/

Experience of reactor units operation

KLT-40 series
Reference solutions:

2 nuclear icebreakers

1 LASH

RITM series
Reference solutions:

8 RITM-200
reactor units in operation on 4 nuclear icebreakers

4 nuclear icebreakers are under construction

Equipment lifetime to repair	▲ x2,6
Service life to repair	▲ x1,6
Core stored energy	▲ x2 – x3
Continuous operation period	▲ x3,2
Weight of two reactor within the containment	▼ x1,7
Area within the containment	▼ x2,6

Floating Power Units with RITM series reactors

FPU characteristics

				
Product range	**FPU** **First-of-a-kind project**	**FPU-106**	**FPU-180**	**FPU-100**
	FPU **“Akademik Lomonosov”**	**for the Russian market**	**for the Russian market**	**for the international market**
Ship type	**Non-self-propelled moored vessel**			
Length x width x draft (m)	144 x 30 x 5,6	143,3 x 30 x 5,5	191,7 x 32,6 x 7	120 x 32,4 x 7
Displacement	22 516 t	21 261 t	41 104 t	21 395 t
Reactor type	2 x КЛТ-40С	2 x РИТМ-200С	2 x РИТМ-400	2 x РИТМ-200М
Electric power (transfering on shore)	70 MW	106 MW	175 MW	100 MW
Refueling interval	2,5-3 years	5-7 years	5-6 years	up to 10 years
Service life	40 years	40 years	40 years	60 years
Personnel (taking into account compatibility)	366 employees	128 employees	128 employees	128 employees

FPU-100 with RITM-200M reactor unit for the International market

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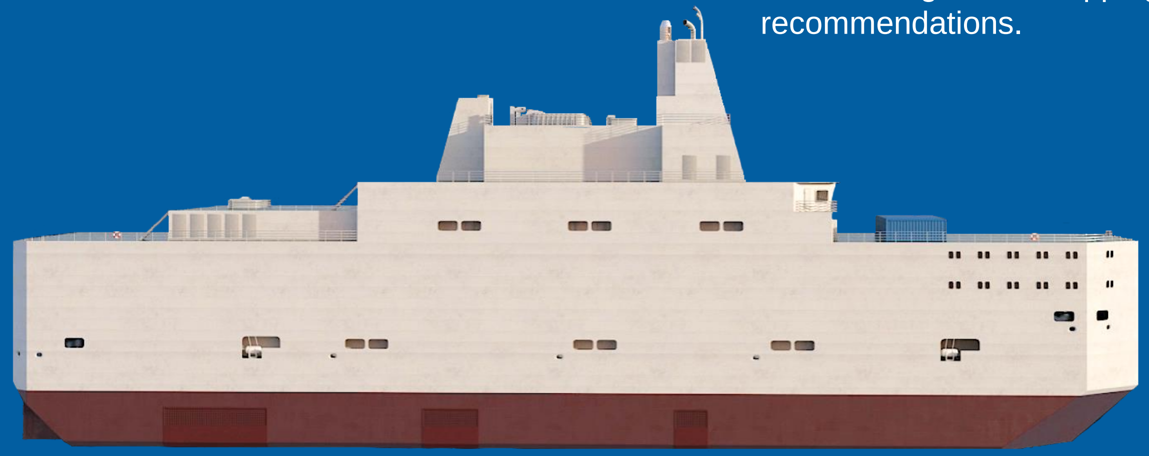
- Reactor basic design was developed in **2024**
- Basic design of the FPU-100 to be completed in the 4th quarter of **2025**

GUARANTEED stability to external impacts according to the requirements of the regulatory documents of the reactor and the requirements of the Russian Maritime register of shipping and IAEA recommendations.



Less than

20%

Fuel enrichment

Ship characteristics:

120 m	length
21 395 t	displacement
7 m	draft

2 RITM-200M reactor units

60 **years**

Service life

up to

10 **years**

Refueling interval

106 **MW**

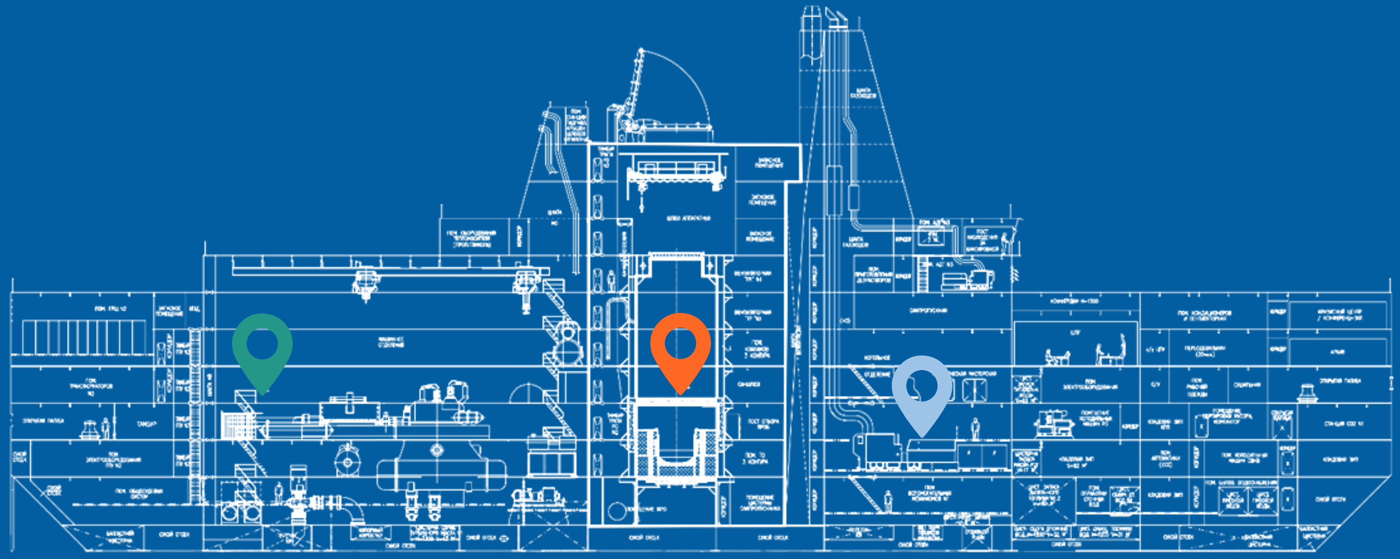
Electric power

Reference solutions:

8 RITM-200 reactors units are in operation on 4 nuclear icebreakers

3 nuclear icebreakers are under construction

FPU-100 configuration with RITM-200M reactor unit



Machine compartments
(2 steam turbines and auxiliary equipment)

Reactor units

Diesel generators
(reserve power sources)

- Absence of nuclear fuel handling on board the FPU and at operation site
- Absence of a living quarters module
- Reduced dimensions
- No refueling equipment or fuel storage on board
- Refueling activities performed only at a specialized plant in Russia and possibility simultaneously with ship repair

FPU-100 life cycle

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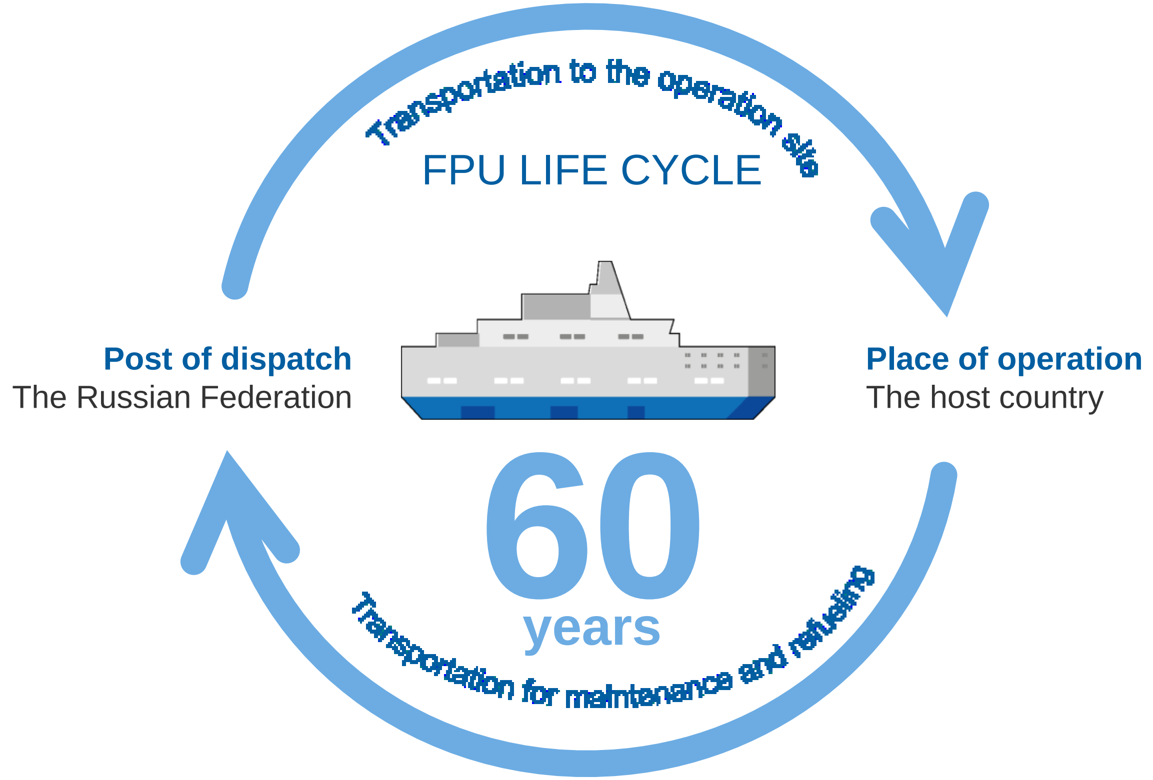
Place of operation — **«green lawn»**

No equipment for handling nuclear fuel both on board and at the operation site

All fuel operations are performed only at a specialized enterprise in the Russian Federation

- Building and operation
- Maintenance and refueling
- Handling with nuclear waste



- Consumer in the host country
- On-site power generation (up to 10 years)
- Possible relocation of the FPU to another operation site

The key provisions of the RITM safety concept

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Internal self-protection

- **Self-limiting of energy releases and self-extinguishing of the reactor unit** (negative feedback loops of temperature, steam and integral power reactivity coefficients)
- **Using natural physical processes** (injection of the regulating body of the compensating group into the active zone of the reactor unit under the action of its own weight, natural circulation in the primary pipe and the pipe of the passive cooling system)
- **Limiting the pressure and temperature in the reactor unit and heating rate** (high heat storage capacity of the reactor unit)
- **Limiting the scale of leak of the primary pipe** (integral concept of the reactor unit, small diameter of primary circuit pipelines, constricting devices

Combination of active and passive safety systems

- **A two-channel structure with internal redundancy for building systems** that ensure security
- **Active systems** ensure safety during all types of design- and beyond design-basis accidents if the power is on
- **Passive systems** ensure the reactor plant safety **in a blackout** in case of beyond-design basis accidents
- Ensuring safety on passive principles in accidents with a primary circuit leak for **at least 72 hours***

Severe Accident Management

- **A complex of systems that ensures the retention of the core meltdown inside the reactor vessel** and limits the radioactive releases

*for projects of FPUs with RITM-200N and RITM-200M

Conclusions

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01

The development of reactors of the RITM series for floating nuclear power units is based on the experience of designing and operating marine reactor plants

02

Proven technical solutions of the RITM series provide the possibility to significantly (compared to large pressurized water reactors) increase the refueling period, maximum – up to 10 years, with fuel enrichment less than 20%

03

The safety of the FPU at all stages of the life cycle, including transportation, is confirmed by the Safety Analysis Report

04

The existing IAEA requirements do not contain restrictions for the deployment of designs based on floating power units in the near future. As experience is gained, it is possible to develop special recommendations for FPU

05

Maritime law should be amended in accordance with IAEA safety standards to ensure its application to floating power units

06

Floating power units can become the basis for the development of regions and lead to a significant reduction in emissions of CO_2

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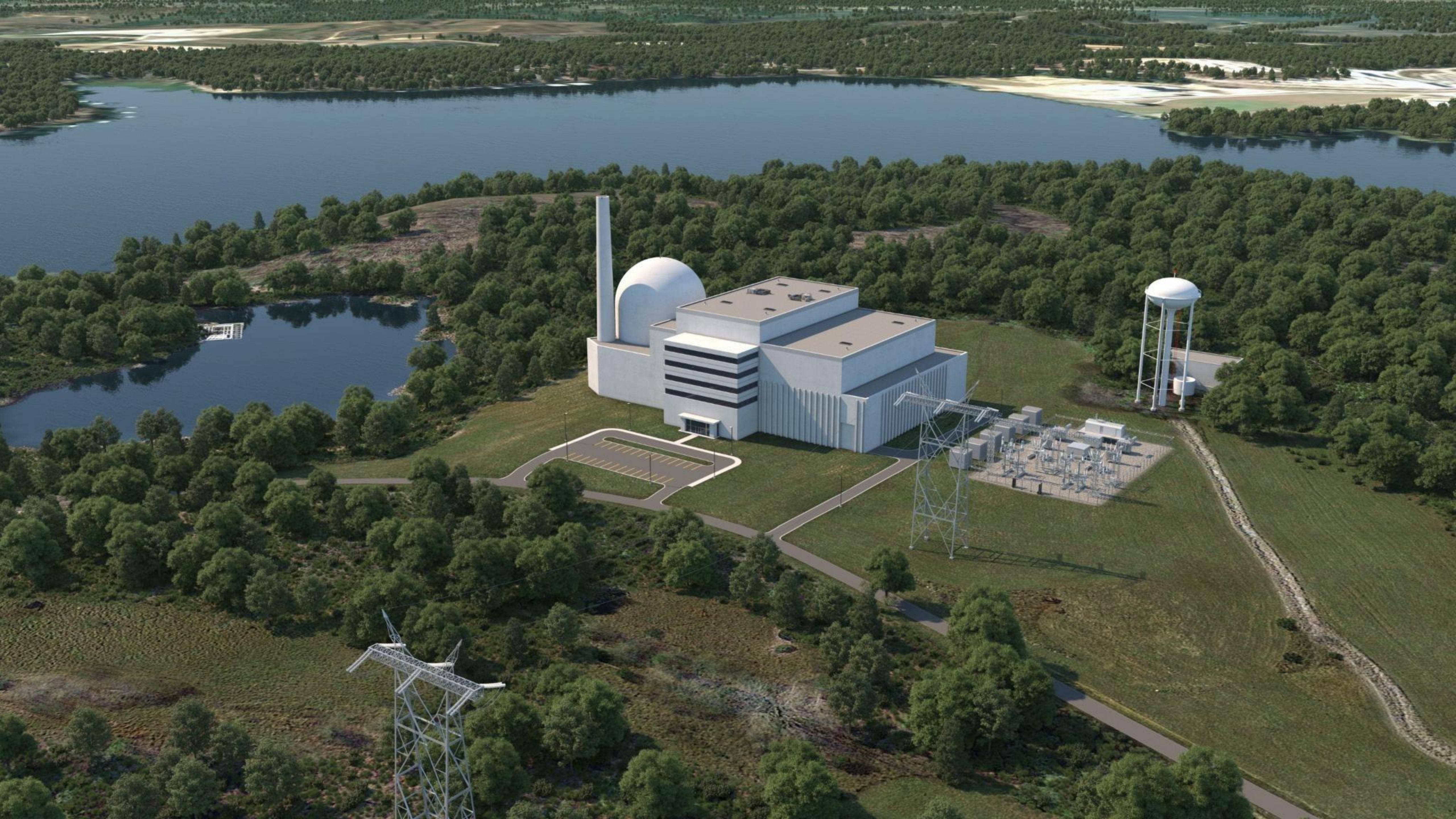
Thank you for your attentions!

Power to Lift the Future

Lithium-Fluoride Reactor Technology Considerations for Maritime Applications

International Atomic Energy Agency
14 May 2025

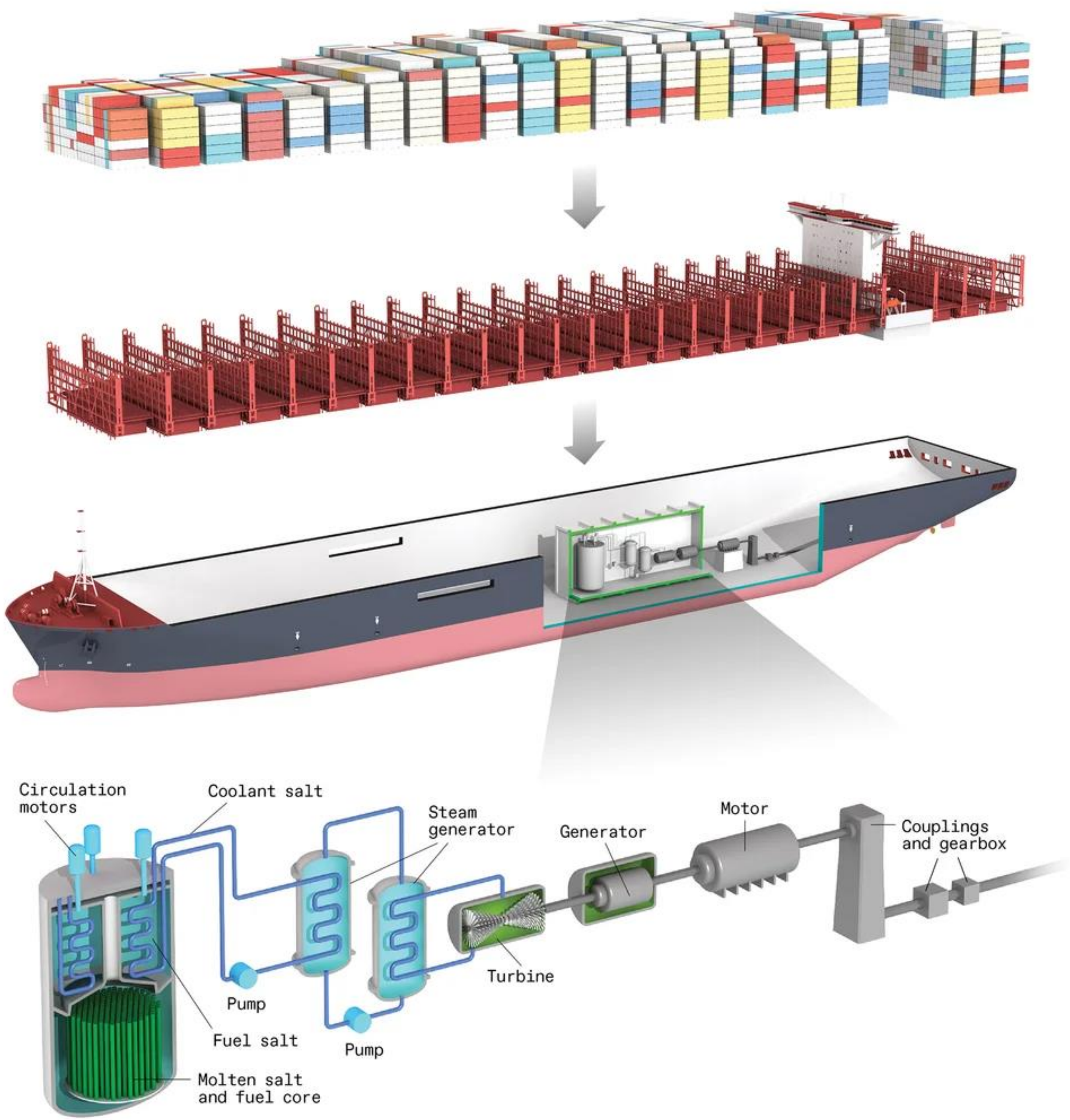

571

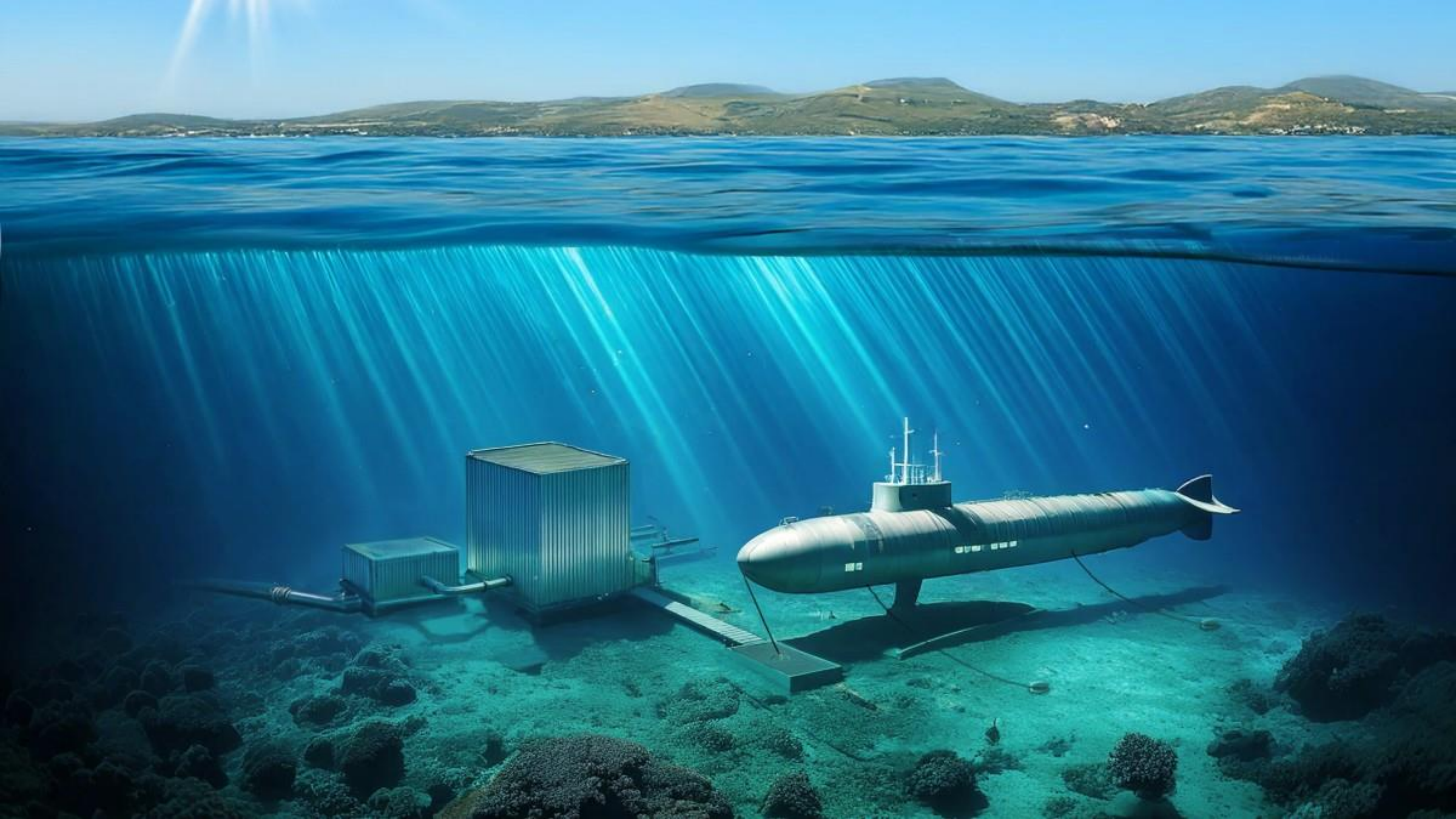



Rivers flowing into the Mississippi
Calgary
ALB.
Regina
SASK.
CANADA
UNITED STATES
N.D.
MINN.
Great Falls
Milk
Missouri
MONT.
Yellowstone
Little Missouri
Billings
Fargo
Ottawa
Toronto
N.Y.
Minneapolis
Croix
St.
Chippewa
Wisconsin
WIS.
Missouri
James
Minnesota
Mississippi
Bighorn
Powder
Rapid City
Cheyenne
S.D.
Sioux Falls
Milwaukee
Detroit
Cleveland
Allegheny
Niobrara
Des
Iowa
Rock
Chicago
WYO.
NEB.
IOWA
Des Moines
Davenport
IND.
OHIO
PENN.
North Platte
Pittsburgh
Salt Lake City
Platte
Omaha
Moines
Illinois
Columbus
MD.
Platte
Republican
Indianapolis
Washington
Denver
South
Missouri
Scioto
Ohio
Cincinnati
W.VA.
COLO.
Smoky
Hill
Kansas
Kansas City
St Louis
Kaskaskia
Wabash
Ohio
Louisville
Kanawha
Richmond
VA.
Pueblo
Osage
ILL.
KY.
Arkansas
MO.
Green
Wichita
KANS.
Cimarron
Verdigris
Neosho
N.C.
Cumberland
Nashville
Charlotte
Black
Mississippi
TENN.
Canadian
White
Oklahoma City
ARK.
Memphis
Tennessee
Albuquerque
S.C.
Arkansas
Little Rock
Washita
N.M.
OKLA.
Atlanta
Phoenix
Red
Yazoo
GA.
Ouachita
ALA.
Dallas
MISS.
Shreveport
Red
El Paso
TEX.
UNITED STATES
MEXICO
Jacksonville
Atchafalaya
LA.
Baton Rouge
New Orleans
Houston
San Antonio
Gulf of Mexico
0
100
200
300
400
500 Miles


SIEMENS
SIEMENS


Flibe
Flibe


Circulation motors
Coolant salt
Steam generator
Generator
Motor
Couplings and gearbox
Turbine
Pump
Fuel salt
Pump
Molten salt and fuel core



Thank You

IAEA
International Atomic Energy Agency
Atoms for Peace and Development

IAEA Activities in Transportable Nuclear Power Plants

Hussam Khartabil – INPRO Section, IAEA

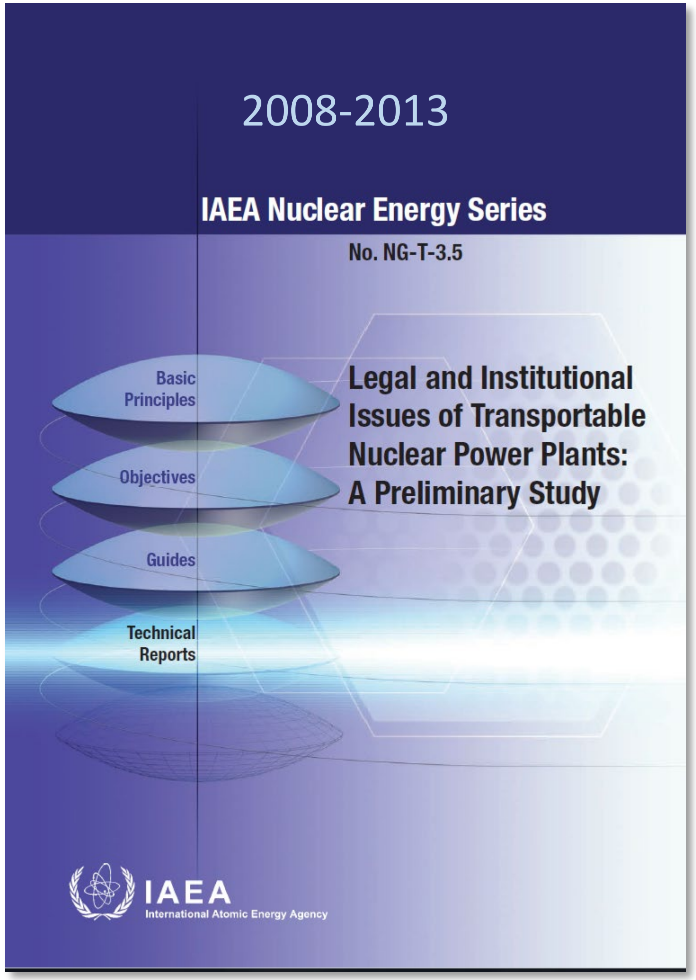
Contents

- **What is a TNPP?**
- **IAEA Activities**
  - **Past, recent, ongoing**
- **Key Findings**

What is a TNPP?

From IAEA Publication NES No. NG-T-3.5

- Factory manufactured and transportable (or relocatable)
- With or without fuel
  - If fuelled ➔ tested/commissioned (brought to criticality)
- With or without the balance of plant
- Transported on rail, truck or barge to the selected site
  - within the manufacturer’s country or in a different country
- Does not operate during transport
  - If fuelled, considered reactor in shut down condition
- Returned to the factory after its design life for decommissioning



IAEA Activities – 1st TNPP Study

Two Options (export deployment):

1. Factory fuelled and tested/commissioned
   - **Supplier** maintains, refuels and decommissions
2. Factory tested (no nuclear fuel)
   - **Host** State maintains, fuels and refuels

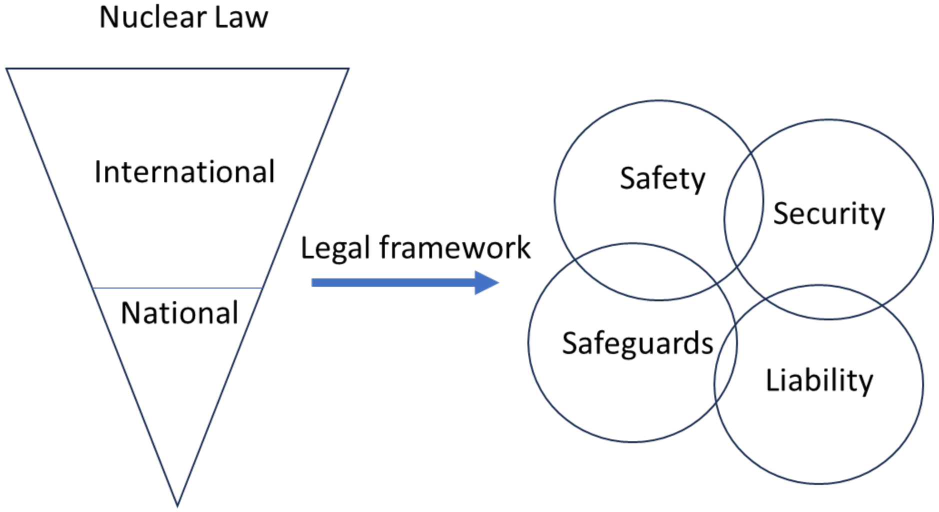
Two scenarios:

A. Supplier State is operator

B. Host State is operator

Host State is regulator under both scenarios

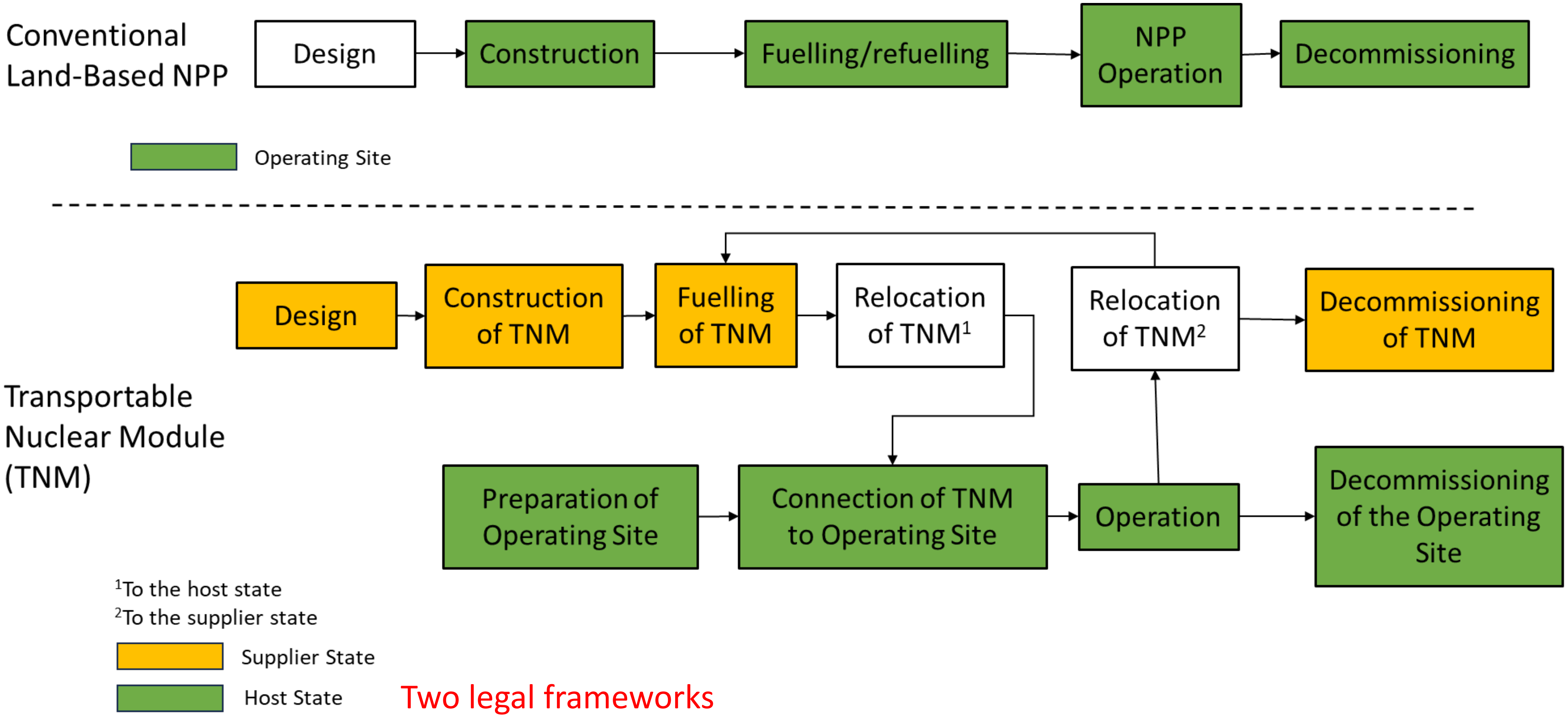
Focus on Legal and Institutional Issues



*Finding: **factory fueled TNPP** option has gaps and insufficient coverage in the international nuclear law and in the non-binding international norms ➔ 2nd TNPP study*

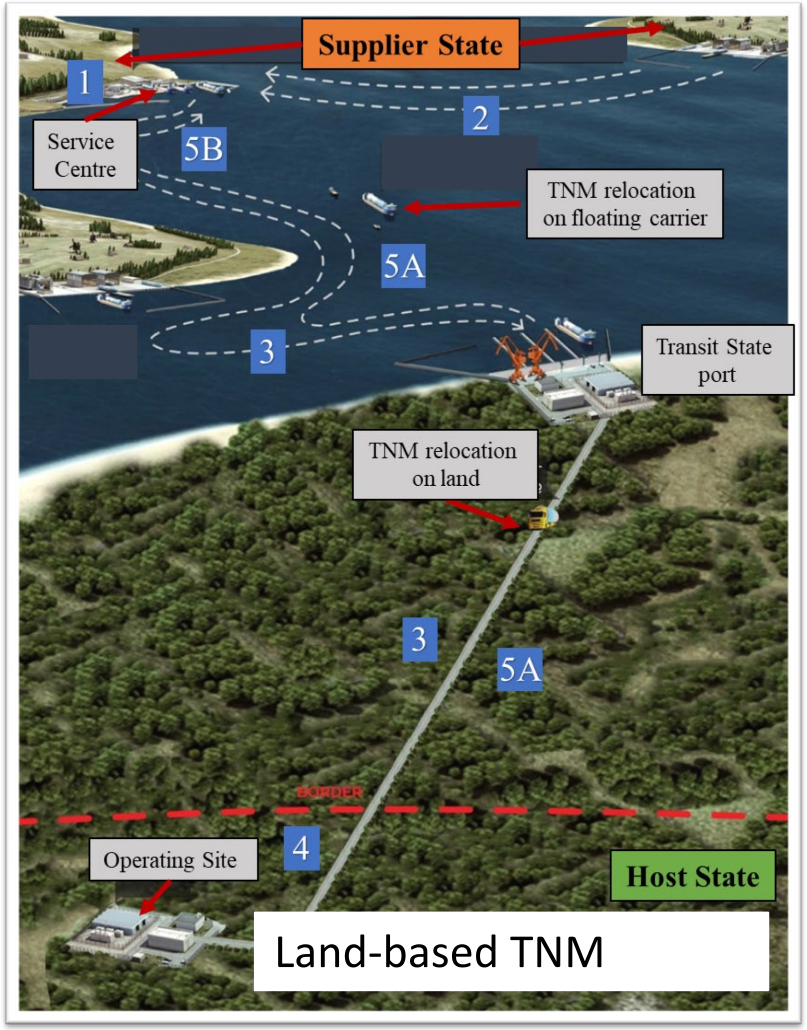
Conventional NPP vs. Factory Fuelled TNPP

Transportable Nuclear Module (**TNM**): factory **fuelled and commissioned** reactor (SMR or microreactor) that can be transported as **complete or near complete system**



Two legal frameworks

Deployment Scenarios



Stage 1. Design and Construction of the TNM

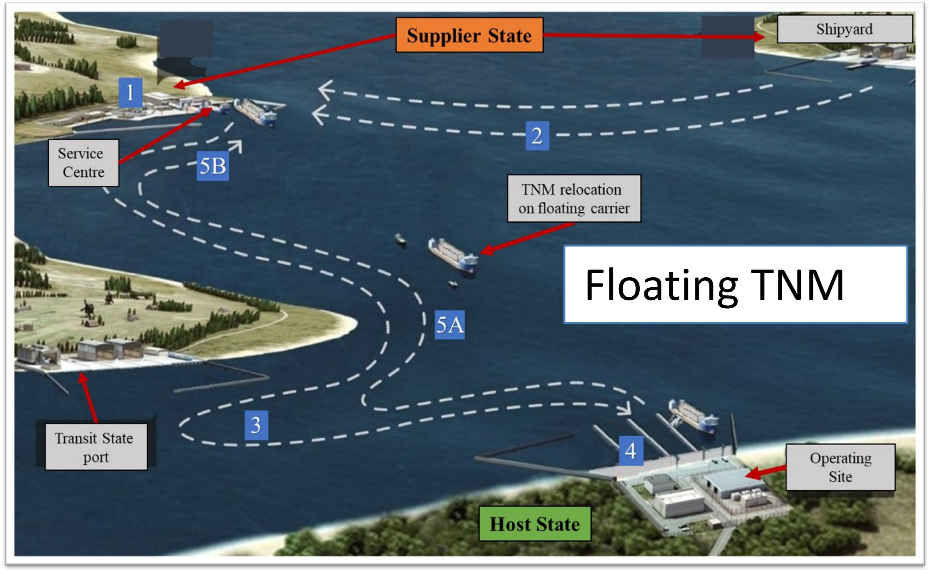
Stage 2. Delivering fuel and first fuel loading into TNM

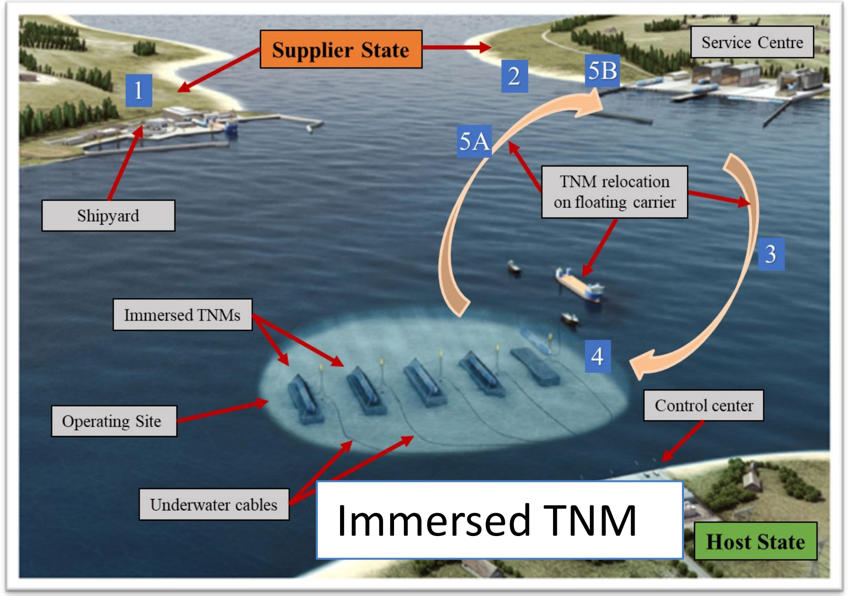
Stage 3. Relocation of the TNM to the Operating Site

Stage 4. TNM Operation

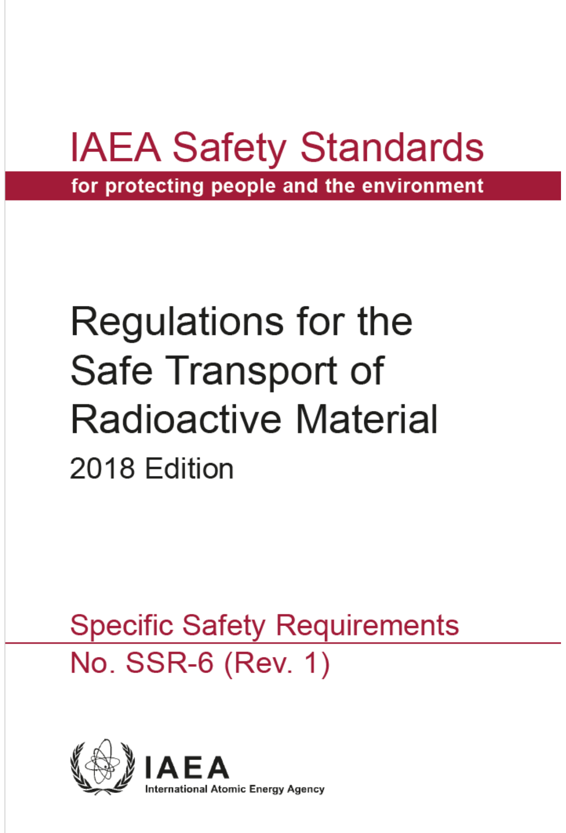
Stage 5A. TNM relocation and refuelling

Stage 5B. Decommissioning of TNM



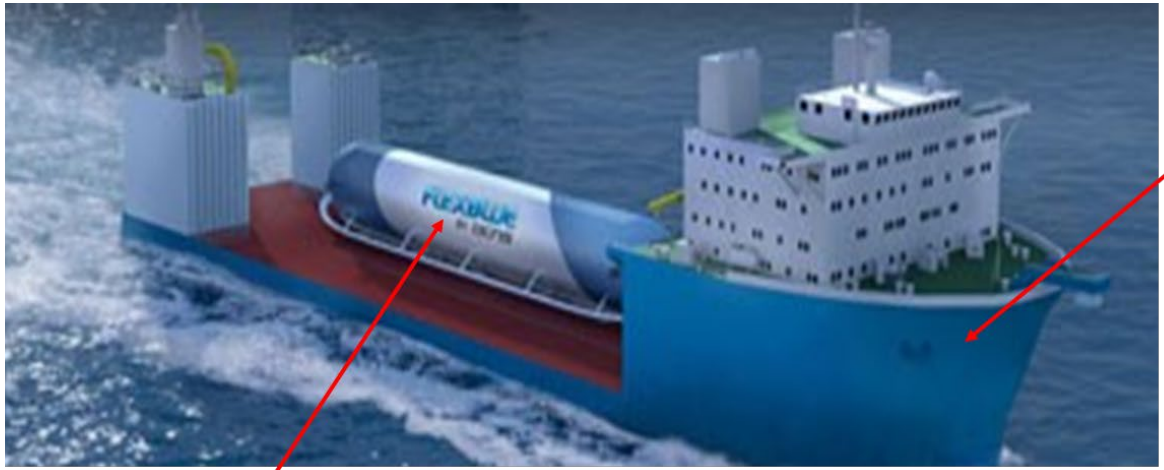


Example of gap in international legal instruments: Transport



Safety requirements for the transport of radioactive material by all modes of transport. Safety is assured by **packaging**

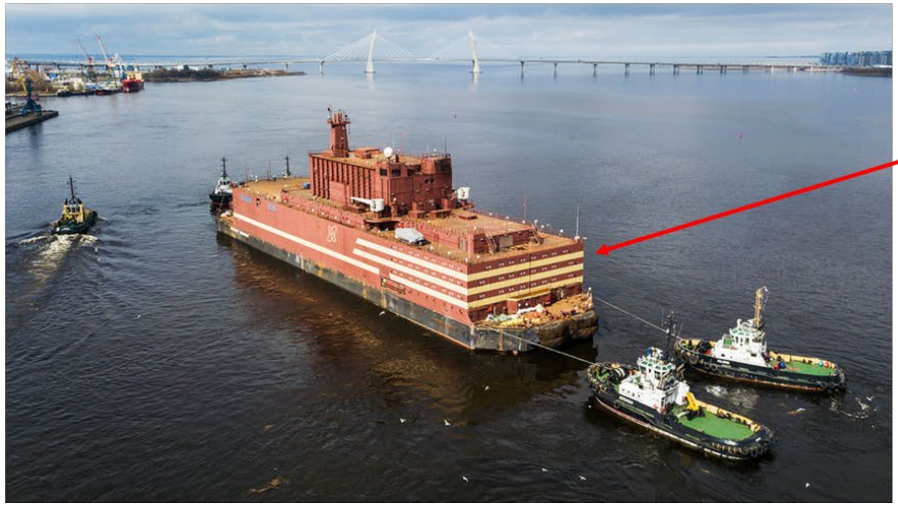
TNM Examples



Cargo (Bulk) Ship

Land-based TNM – land and possibly sea transport

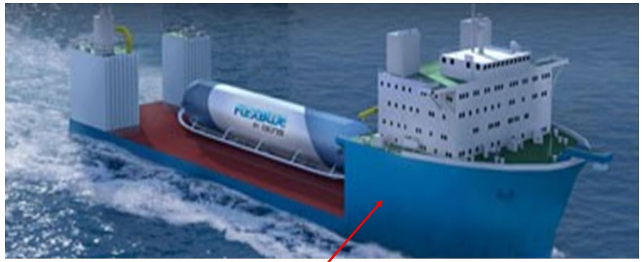
Immersed TNM or TNPP



Floating TNM or TNPP or FNPP

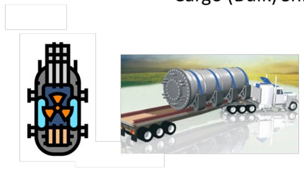
Transport of TNM

- Transport using packages specified in SSR-6 may not be possible, particularly for large size TNMs
- For transport by sea: no code for design of ships to transport nuclear reactors with irradiated fuel
  - There is a code for nuclear powered ships (needs updating) + INF code for **packaged** nuclear material

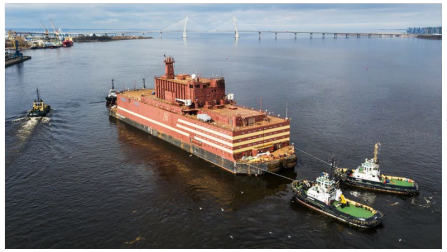


Transport using cargo ship (immersed or land-based TNM)

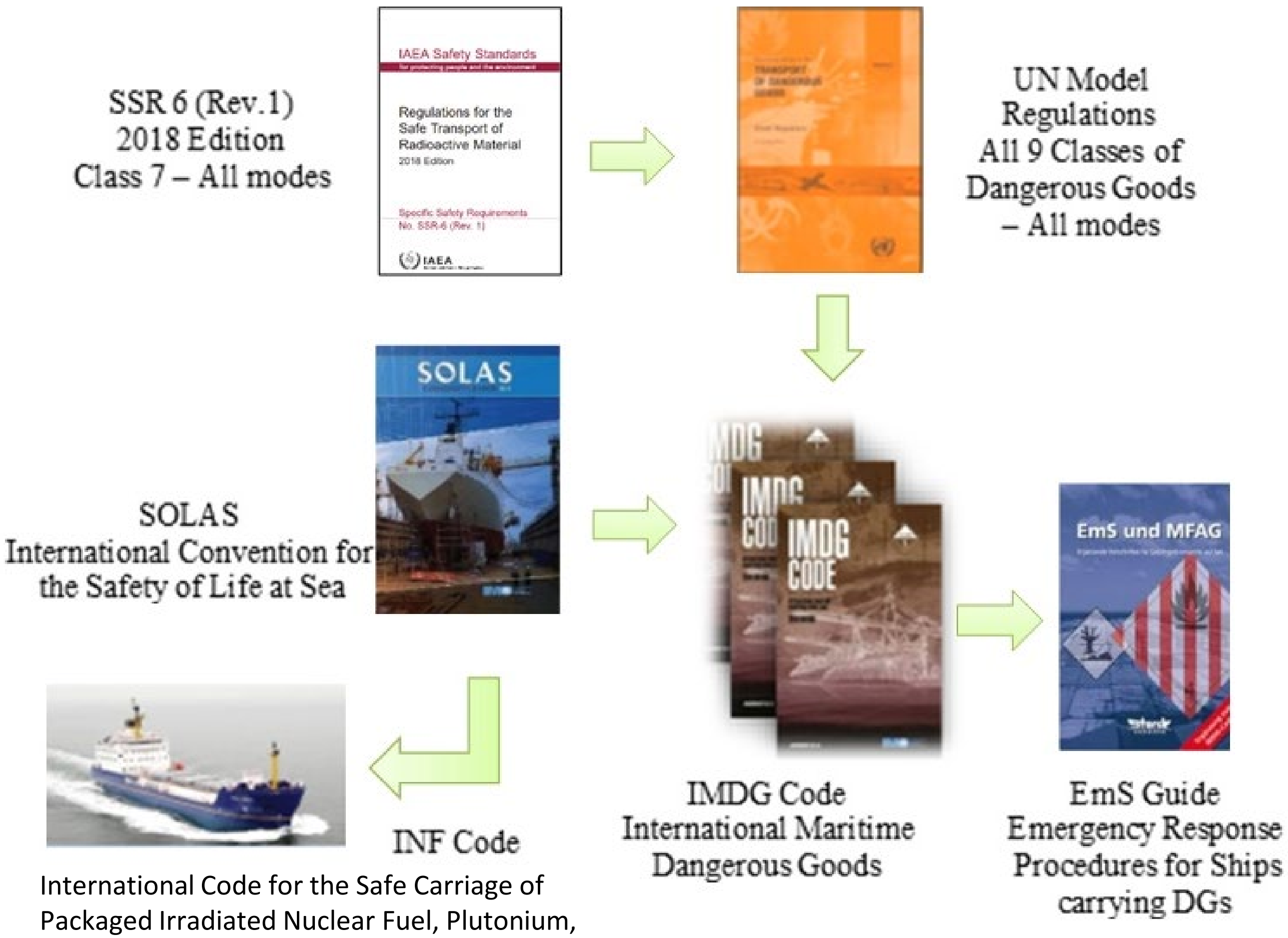
Cargo (Bulk) Ship



(Land-based TNM)



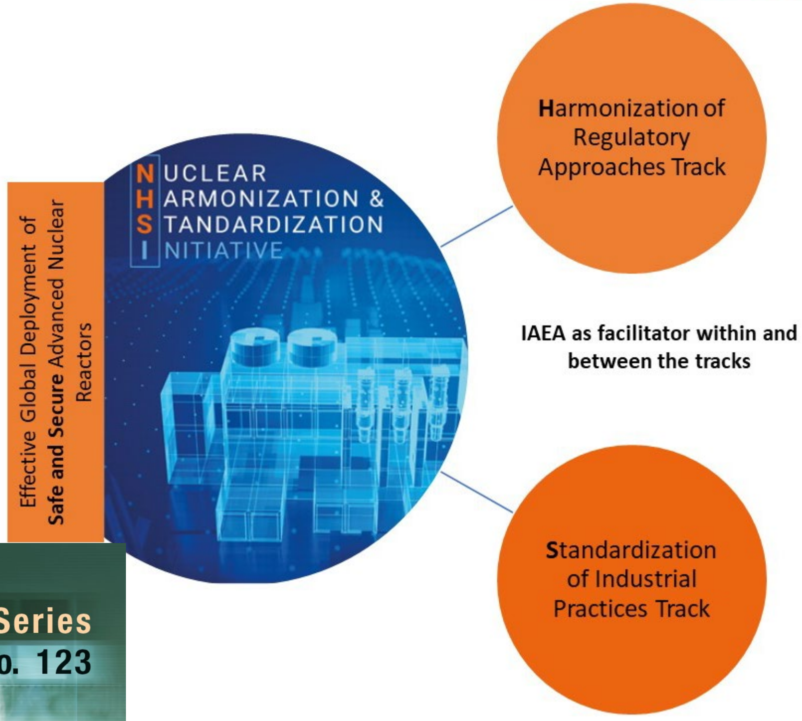
Towing using tug boats (floating TNM)

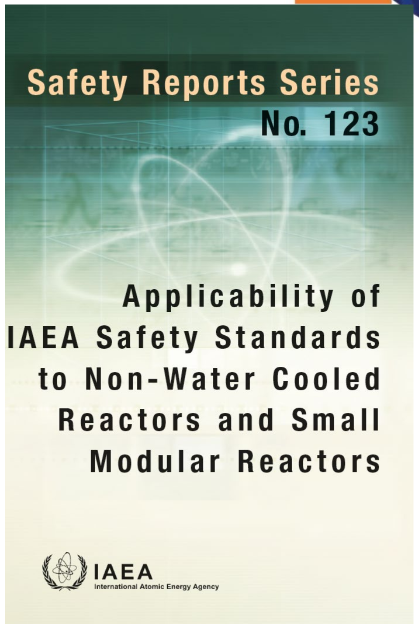


International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium, and High-Level Radioactive Wastes on Board Ships.

Recent and Ongoing Activities to Address Gaps

- IAEA FNPP Symposium, November 14 -15, 2023
- Nuclear Harmonization and Standardization Initiative
- Advanced Reactors Information System (ARIS)
- Applicability of IAEA Safety Standards to Non-Water Cooled Reactors and Small Modular Reactors, SRS No. 123 (2023)
    - Includes TNPPs
- Design Safety and Security Considerations for Floating Nuclear Power Plants
- Transport Safety Standards Committee created working group on TNPPs
- 3S (safety, security, safeguards) by design





Key Findings

- International legal framework has limited applicability due to TNM unique features such as transportability
  - TNM life cycle is implemented under the jurisdiction of two legal frameworks (Supplier and Host States) ➔ cooperation and close interaction necessary
- Some gaps in legal framework may be covered by Intergovernmental Agreements
  - Pilot Projects (FOAK) will bring new practical information for further deployment of TNMs
- TNM relocation by road or sea may be possible using existing legal framework
  - Depends on TNM size/design but challenges remain – may need a different approach
- There is currently no regulatory framework for the relocation of “large” TNM that cannot be packaged based on SSR-6 requirements
- IAEA-International Maritime Organization (IMO) cooperation needed to address TNM relocation by sea

Thank you

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