Development of Floating Reactor Technologies

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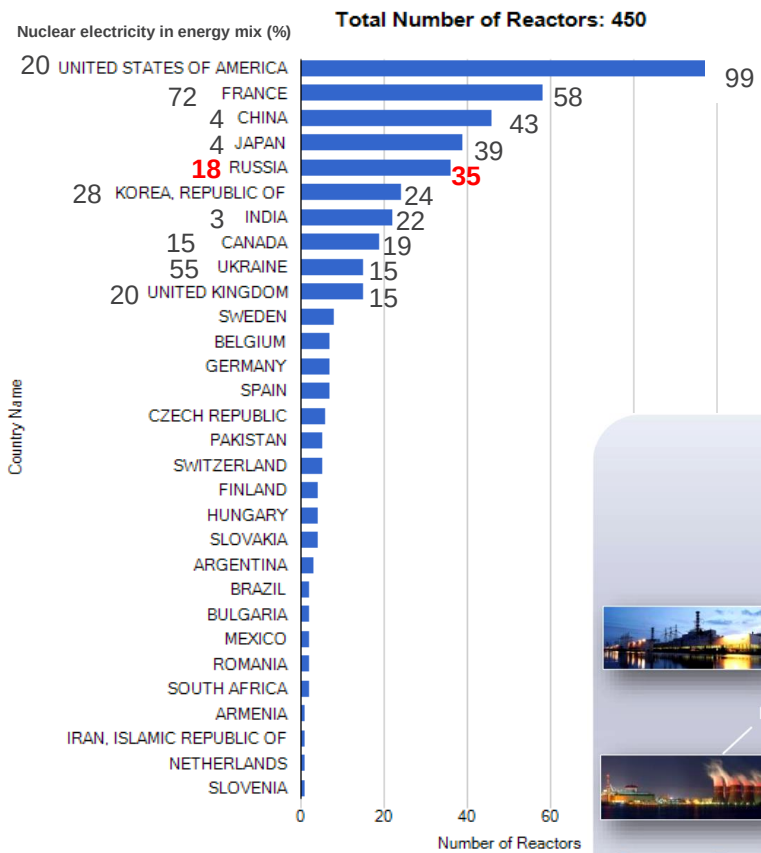
Russian Nuclear Power in a Nut Shell
Early SMRs



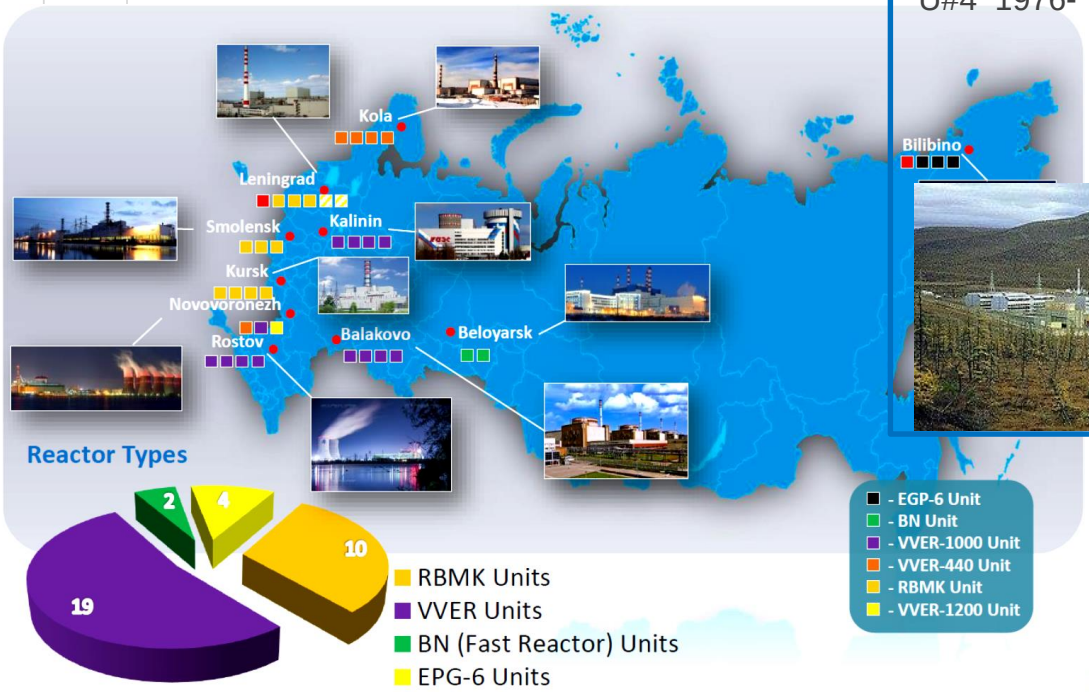
Nuclear Power Reactors

Under Construction	Operational	Long-Term Shutdown	Permanent Shutdown
6	35	0	8

Annual Electrical Power Production

Total Electricity Production (including Nuclear)	Nuclear Electricity Production
1070922.40 GW.h (Gross, 2018)	191331.49 GW.h (Gross, 2018)

Total Net Electrical Capacity
27, 9 GWt el



Bilibino NPP

4 units
Reactor type: EGP-6
Thermal Power: 65 MW
Electric Power: 12 MW
Cogeneration
U#1 1974-2019
U#2 1974-
U#3 1975-
U#4 1976-

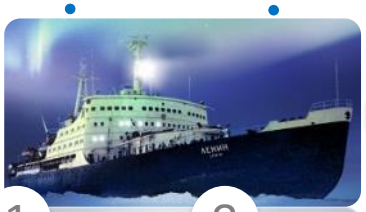
From PRIS (Power Reactor Information System
https://pris.iaea.org/pris/)

Nuclear Icebreakers

Commissioning

* OK-150 is replaced by OK-900

1959 "Lenin"



1 OK-150

1970* "Lenin"

2 OK-900

1975 "Arktika"

2 OK-900A

1977 "Sibir"

2 OK-900A

1985 "Rossiya"

2 OK-900A

1988 "Sevmorput"

2 OK-900A

1989 "Sovetskiy Soyuz"

2 OK-900A

1989 "Taymyr"

3 KLT-40M

1990 "Vaygach"

3 KLT-40M

1992 "Yamal")

2 OK-900A

2007 "50 Let Pobedy"

2 OK-900A

3 nuclear icebreakers of the Project 22220 are currently under construction

4 RITM-200

First in the World Floating NPP

2 x KLT-40S Reactors

Electrical capacity	Up to 77 MW
Thermal capacity	300 MW
Fuel enrichment	< 20%
Fuel cycle	3 years
Design life	40 years
Mobility	towed

April 2019

Comprehensive testing of the FPU was completed

June 2019

Operation license is issued

September 2019

FNPP arrived at Pevek – the place of its operation

End of 2019

FNPP is planned to be connected to the grid

RITM series reactors – the latest development that incorporates all the best features from its predecessors

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Rosatom small reactors evolution

50 MW(e)

RITM-200 Reactor

RITM-200 reactor is the further development of small reactors based on **400 reactor-years** experience of Rosatom

6 RITM-200 reactors are already manufactured and successfully installed on Arktika, Sibir and Ural icebreakers

- Two **RITM-200** reactors provide **81 000** shaft horsepower
- **Variable** draught from **8.5** to **10.5** meters
- Able to break through ice up to **3** meters
- **Arktika, Sibir** and **Ural** icebreakers to enter operation in **2020**, **2021** and **2022** respectively

FNPP: optimized mobile solution for coastal areas power supply

TECHNICAL PARAMETERS	
Electrical capacity	100 MW
Fuel cycle	up to 10 years
Design life	60 years
Displacement	12 000 tons
Length	112 m
Beam	25 m
Draught	4.5 m

2×RITM-200M

OPTIMIZATION RESULTS COMPARED WITH FNPP AKADEMIK LOMONOSOV

by 28 **m** – length reduction

by 5 **m** – beam reduction

by 9 000 **t** – displacement reduction

30**%** – electrical capacity increase

Electricity

Heat

Desalination

Sketch of Floating NPP Characteristics

Characteristic	FNPP with two RP	
	KLT-40S	RITM-200M
Electric power (el.), MW	38.5x2	50x2
Staff ratio, per/$MW_э$ (for FPU)	0.8	0.5
FNPP/FPU construction unit cost, rel.unit/MW(el.)	1/1	~ 0.58/0.5
Energy prime cost, rel.un/MW*h	1	0.85

RITM Characteristics

Characteristic	Value
Nominal heat power, MW	175
Primary circuit operating pressure, MPa	15.7
Primary coolant temperature at the inlet /outlet of the core, °C	276/314
Coolant flow rate through the core, t/h	3250
Steam rate, t/h	280
Steam temperature,°C	295
Steam pressure, MPa	3.82
Enrichment (%)	19.7
Neutron fluence at the end of service life, n/cm^2	$1.3 \cdot 10^{20}$

Key principles of the FNPP safety

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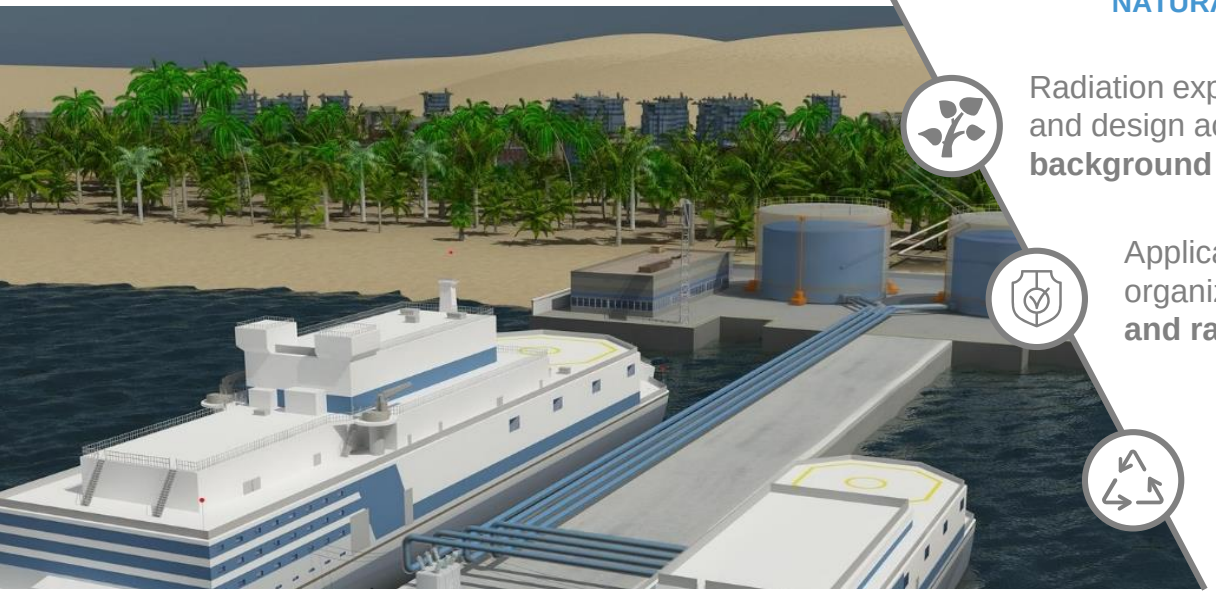
ENSURED nuclear and radiation safety

NO RADIATION EXPOSURE

RESISTANT TO EXTERNAL IMPACTS



GUARANTEED resistance against external events

NATURAL

MAN-CAUSED

PITCHING & ROLLING

Radiation exposure on population during normal operation and design accident **has no impact on natural radiation background level**

Application of the nuclear safety technical and organizational measures **excludes nuclear and radiation accidents**

No necessity for compulsory evacuation measures planning zone

Optimized FNPP is a solution for coastal areas power supply

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ALL BENEFITS OF NUCLEAR POWER:

- **A continuous base-load power supply** within a 60-year life
- **Synergy with the renewable energy sources**
- **Effective cost management** due to fixed total electricity cost throughout a 60-year life
- **Multipurpose application** including water desalination, district heating

ADDITIONAL SPECIFIC ADVANTAGES OF FNPP

- **Short period of construction** works at the site
- **No decommissioning** at the site
- **Long fuel campaign** (up to 10 years)
- **Flexible life-time period**

Onshore NPP based on RITM Series SMR

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SMR

2×57 MWe – 114 MWe

2 RITM-200 Reactors

Modularity available

TECHNICAL PARAMETERS

Electrical capacity	114 MW (2 x 57 MW)
Thermal capacity	330 MW (2 x 165 MW)
Refueling cycle	up to 6 years
Design life	60 years
Availability factor	90%
Plant area	15 acres (0.06 km^2)
Construction period	3 - 4 years

ELECTRICITY

HEAT

DESALINATION

H_2

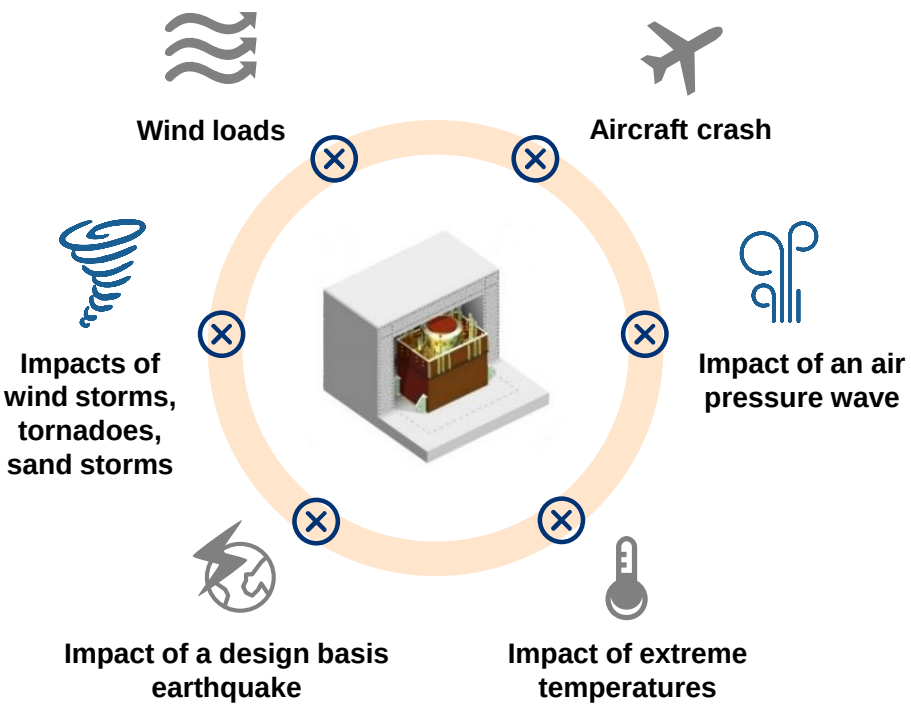
HYDROGEN

FLEXIBLE, TAILOR-MADE SMALL NPP SOLUTION BASED ON **RITM SMR** IS DESIGNED TO ADDRESS A WIDE RANGE OF CUSTOMER DEMANDS

Key principles of the land-based SMR NPP safety

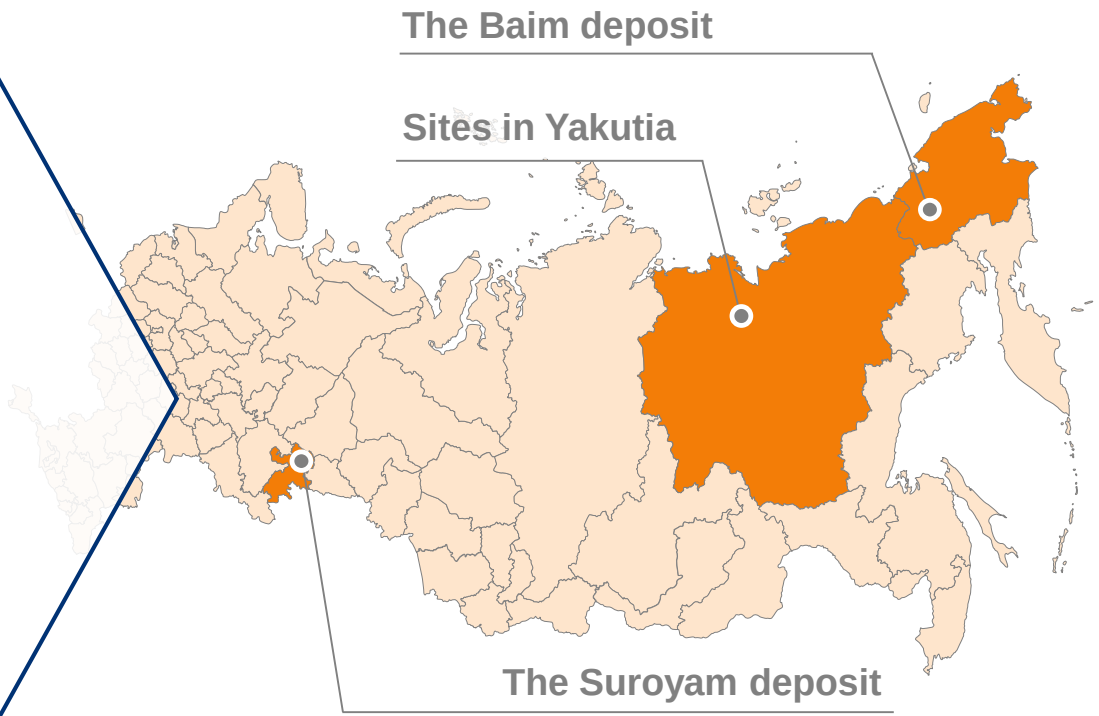
ROSATOM ACCIDENT MANAGEMENT SYSTEM INCLUDES **A SET OF ACTIONS** TO ADDRESS A **BEYOND DESIGN BASIS ACCIDENT**

- TECHNOLOGY INCORPORATES POST-FUKUSHIMA REQUIREMENTS
- A SYSTEM OF TECHNICAL AND ADMINISTRATIVE PROTOCOLS
- EFFICIENT SAFETY SYSTEMS: REACTOR CONTROL, CORE COOLING AND SHUTDOWN SYSTEMS
- DEFENSE-IN-DEPTH PRINCIPLE
- LOW VULNERABILITY DUE TO SMALL SIZE
- USE OF REFERENCED TECHNOLOGIES AT EVERY STAGE OF LIFECYCLE
- ACCOUNTING FOR MAXIMUM POTENTIAL EXTERNAL IMPACTS
- EXTENSIVE USE OF PASSIVE PROTECTION ELEMENTS



Status of FOAK onshore NPP based on RITM-200 reactors

- ONSHORE SMR NPP IN-DEPTH **CONCEPTUAL DESIGN DEVELOPED**
- **R&D WORK ON FUEL** WITH UNDER 20% ENRICHMENT LEVEL FOR RITM-200 REACTORS **IS UNDERWAY**
- ROSATOM IS CONSIDERING **SEVERAL LOCATIONS FOR THE DEPLOYMENT OF THE FIRST LAND-BASED SMR NPP** IN RUSSIA
- **2027** – COMMERCIAL DEPLOYMENT OF FOAK LAND-BASED SMR NPP



Thank You for Your Attention