



HEAT AND POWER SOURCES BASED ON NUCLEAR SHIPBUILDING TECHNOLOGIES

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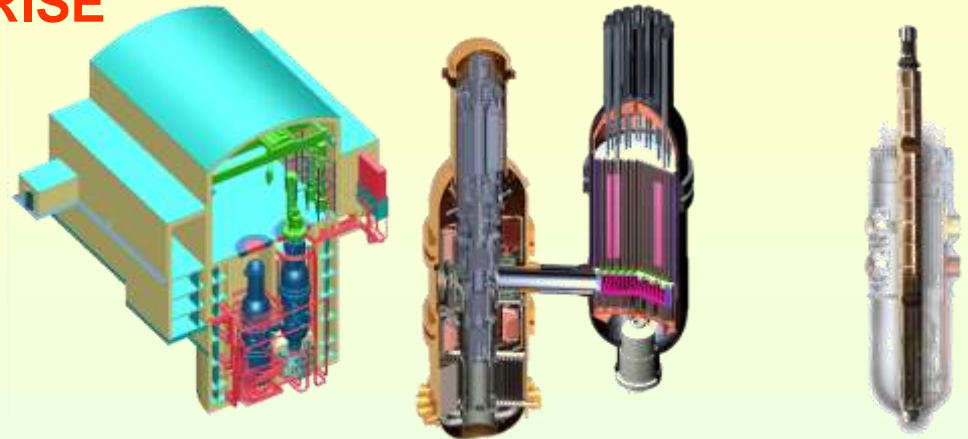


MAIN FIELDS OF OKBM ACTIVITY

1947 FOUNDATION OF THE ENTERPRISE



MARINE REACTOR PLANTS FOR THE NAVY



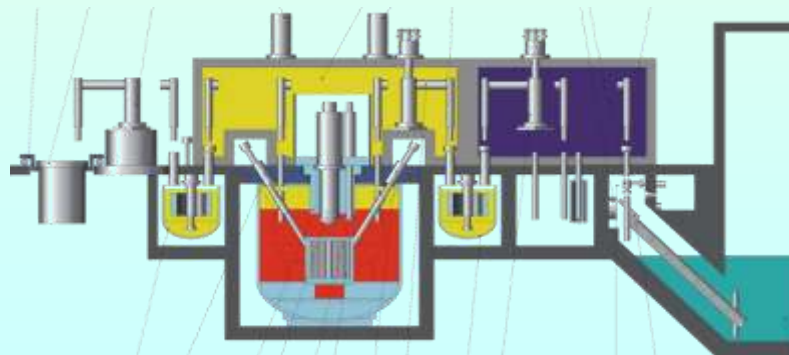
HIGH-TEMPERATURE GAS-COOLED REACTORS FA



MARINE REACTOR PLANTS FOR THE CIVIL FLEET



FAST REACTORS



NUCLEAR FUEL HANDLING EQUIPMENT



UNIFIED EQUIPMENT FOR NPP (PUMPS, FANS)

JSC "OKBM AFRIKANTOV" STRUCTURE

DESIGN DEVISION



- ✿ DEVELOPMENT OF PLANTS AND EQUIPMENT OF NUCLEAR POWER COMPLEX

RESEARCH AND TESTING COMPLEX



- ✿ SCIENTIFIC RESEARCH AND FULL-SCALE TESTS

PRODUCTION FACILITIES



- ✿ FABRICATION OF PILOT EQUIPMENT FOR NUCLEAR POWER INDUSTRY

SMALL NPP BASED ON NUCLEAR SHIPBUILDING TECHNOLOGIES

APPLICATION OF PROVEN TECHNOLOGIES OF SHIP-BASED MODULAR REACTORS

- OPERATION EXPERIENCE OF SHIP-BASED REACTORS OVER 6500 REACTOR/YEARS
- LONG-TERM EXPERIENCE IN DESIGNING AND FABRICATION OF SHIP-BASED MODULAR REACTORS
- APPLICATION OF PREVIOUS R&D RESULTS



APPLICATION OF PWR REACTORS OPERATION TECHNOLOGY AND EXPERIENCE

- APPLICATION OF NPP OPERATION TECHNOLOGY AND EXPERIENCE FOR DISTRICT HEATING
- INTERNATIONAL REQUIREMENTS FOR SAFETY

APPLICATION OF SMALL NUCLEAR POWER SOURCES



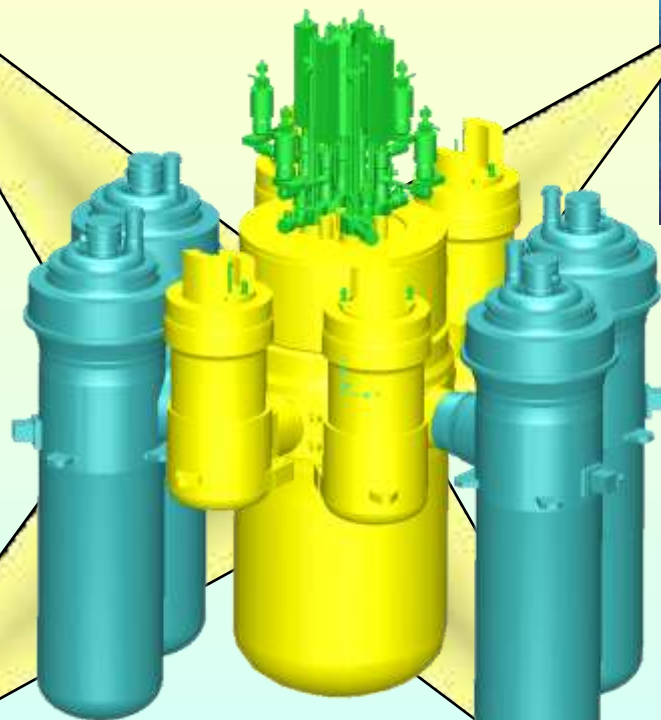
FLOATING PLANTS FOR ELECTRICITY AND HEAT SUPPLY FOR HARD-TO-REACH COASTAL AREAS OR OIL AND GAS PRODUCTION



FLOATING NUCLEAR POWER-DESALINATION COMPLEXES



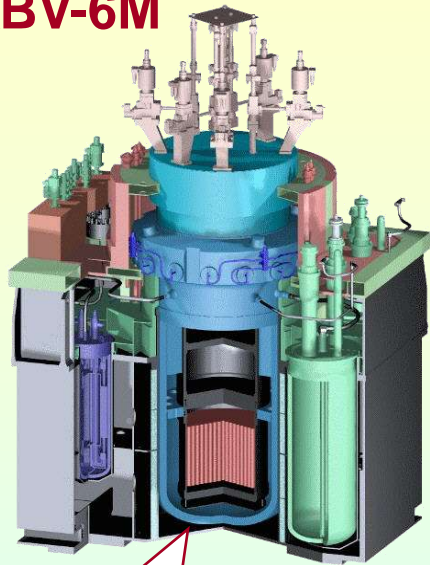
AUTONOMOUS POWER SUPPLY OF MARINE OIL-PRODUCING PLATFORMS



GROUND PLANTS FOR AUTONOMOUS POWER SUPPLY

REACTOR TYPES FOR NUCLEAR POWER SOURCES

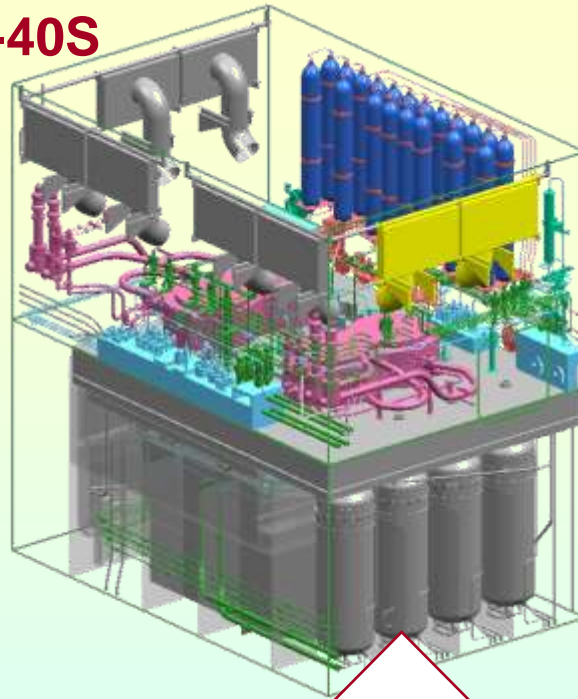
ABV-6M



**THERMAL POWER
16...54 MW
ELECTRICAL POWER
3.5...10 MW**

COMPACT INTEGRAL REACTOR

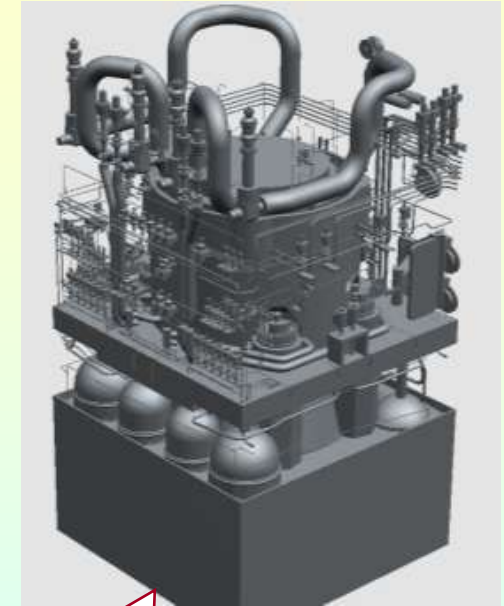
KLT -40S



**THERMAL POWER
150 MW
ELECTRICAL POWER
38.5 MW**

**COMMERCIAL MODULAR
REACTOR FOR NUCLEAR ICE-
BREAKERS AND SHIPS**

RITM-200



**THERMAL POWER
175 MW
ELECTRICAL POWER
~45 MW**

COMPACT DESIGN

MAIN CHARACTERISTICS OF FLOATING AND GROUND PLANTS

CHARACTERISTICS	FLOATING CO-GENERATION PLANT		GROUND CO-GENERATION PLANT
	ABV-6M	KLT-40S	ABV-6M
NUMBER OF RP	2	2	2
RP THERMAL POWER, MW	2×38	2×150	2×38
ELECTRICAL POWER IN CONDENSATION MODE, MW	2×8.6	2×38.5	2×8.6
ELECTRICAL POWER IN CO-GENERATION MODE, MW	2×6	2×19.4	2×6
HEAT SUPPLY, GCAL/H	2×12	2×70	2×12
REFUELING PERIODICITY, YEARS	once every ten years	once every three years	once every ten years
HOURS OF POWER OPERATION PER YEAR, H	7500...8000		

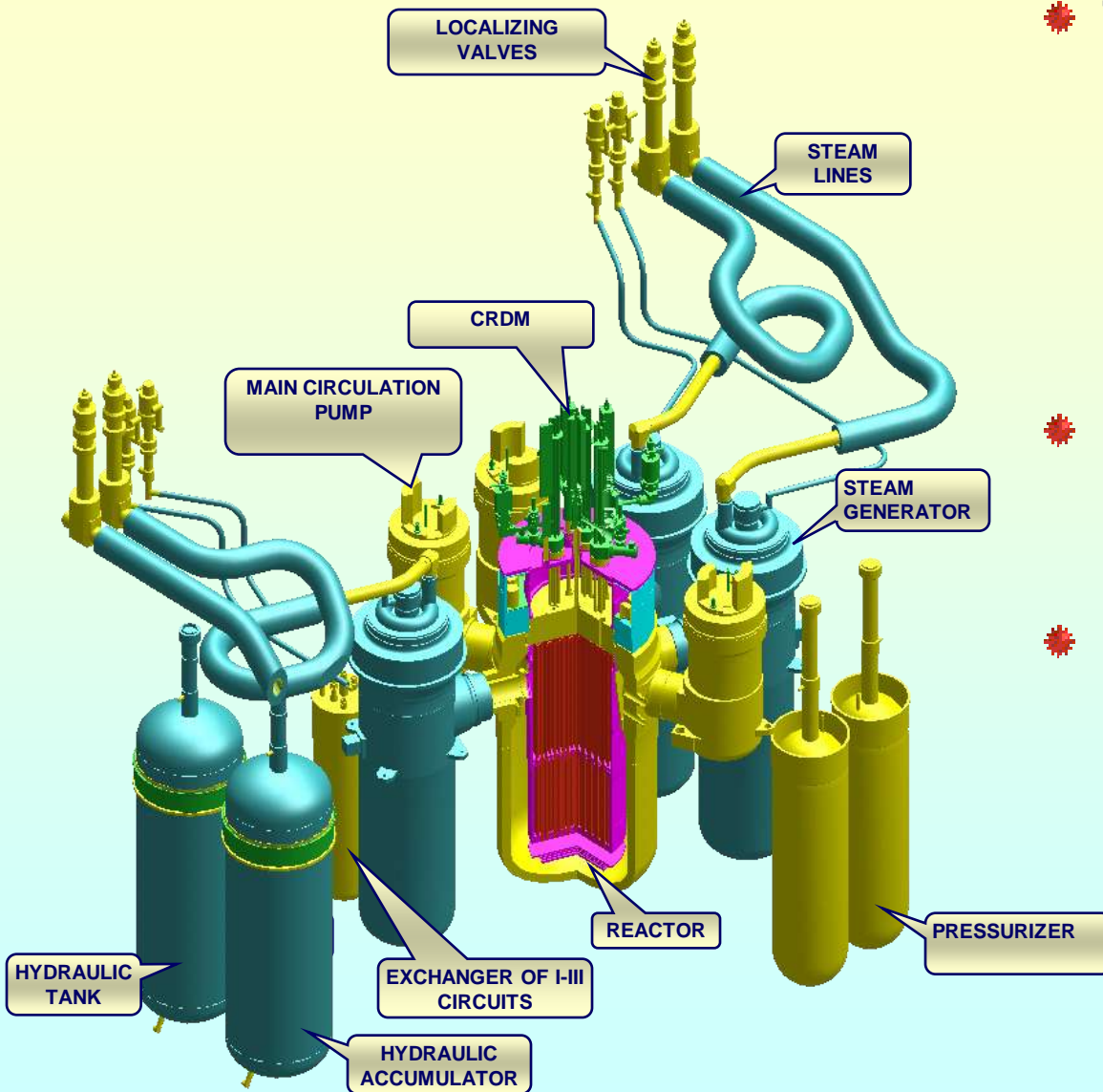
FLOATING NPPs – A NEW GROUP OF POWER SOURCES

- ✿ **AUTONOMOUS POWER UNIT IS MOUNTED ON NON-SELF-PROPELLED BARGE OR ON PONTOON SYSTEM**
- ✿ **COMPLETELY FABRICATED AT THE SHIPBUILDING YARD**
- ✿ **SUPPLIED TO THE CUSTOMER ON A TURNKEY BASIS AFTER ACCEPTANCE TESTS**
- ✿ **TRANSPORTED TO THE SITE BY WATER**
- ✿ **LONG-TERM OPERATION WITHOUT REFUELING OR REPAIR**
- ✿ **TOTAL SERVICE LIFE OF THE POWER UNIT IS 40 YEARS**
- ✿ **POSSIBILITY OF CHANGING THE POWER UNIT BASING SITE**

FLOATING NPP SAFETY UNDER EXTERNAL IMPACTS

- ❁ WATER AREA PROTECTION AGAINST UNAUTHORIZED ACCESS OF WATER VESSELS AND FLOATAGE
- ❁ PLANT FLOODABILITY IS PROVIDED BY DIVIDING THE HULL INTO WATER-PROOF COMPARTMENTS AND IS DEMONSTRATED AT FLOODING OF ANY TWO NEIGHBORING COMPARTMENTS. WHEN ANY TWO NEIGHBORING COMPARTMENTS ON ANY BOARD ARE FLOODED, THE MAXIMUM HEEL DOES NOT EXCEED 3%
- ❁ REACTOR PLANT PROTECTION AT FNPP COLLISION WITH OTHER VESSELS IS PROVIDED BY REACTOR ARRANGEMENT IN THE MIDSHIP BODY ABOVE DOUBLE BOTTOM
- ❁ MULTI-LAYER UPPER DECKING OF THE PLANT SUPPRESSES THE KINETIC ENERGY OF A FALLING AIRCRAFT OWING TO SPECIAL DESIGN MEANS DISTRIBUTING THE BLOW FORCE OVER A LARGER AREA
- ❁ FNPP IS MAINTAINED IN NORMAL CONDITIONS AT STORM-FORCE WIND OF 80 M/S
- ❁ SEISMIC STABILITY AND PROTECTION AGAINST STORM WAVES AND EARTHQUAKE WAVES ARE PROVIDED BY NATURAL OR ARTIFICIAL BARRIERS (ISLANDS, CAPES, BREAKWATERS) OR BY FNPP OFFSHORE ARRANGEMENT

LAYOUT OF MAIN KLT-40S RP EQUIPMENT



- ❖ **TWO-LOOP PLANT WITH PRESSURIZED REACTOR WHICH IS CONNECTED BY THE COAXIAL NOZZLE SYSTEM TO COIL-TYPE STEAM GENERATORS (4 PCS) AND PRIMARY CIRCUIT CIRCULATION PUMPS (4 PCS)**

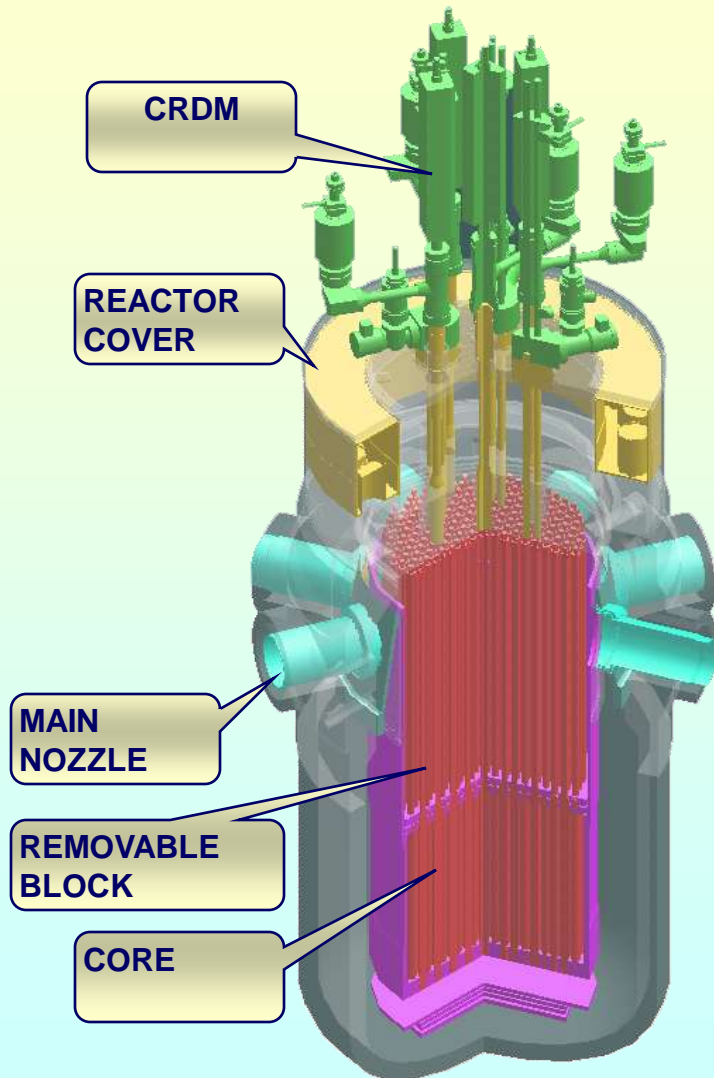
- ❖ **SUPPLY TO CONSUMERS**

- ❖ **ELECTRIC POWER** 20...70 MW
- ❖ **HEAT** 50...140 GCal/h

- ❖ **DESALINATION COMPLEX**

- ❖ **NOMINAL OUTPUT FOR DESALINATED WATER, m³/day** 100000
- ❖ **POWER, MW(el)** 2x35

KLT-40S REACTOR



◆ REACTOR TYPE	VESSEL-TYPE PRESSURIZED WATER
◆ THERMAL power, MW (t)	150
◆ FUEL TYPE	CORE, MEETING NON-PROLIFERATION REQUIREMENTS, DEVELOPED ON THE BASIS OF LONG-TERM OPERATION EXPERIENCE OF ICE-BREAKER CORES
◆ FUEL ENRICHMENT, %	<20
◆ REFUELING CYCLE, YEARS	3
◆ SERVICE LIFE, YEARS	40

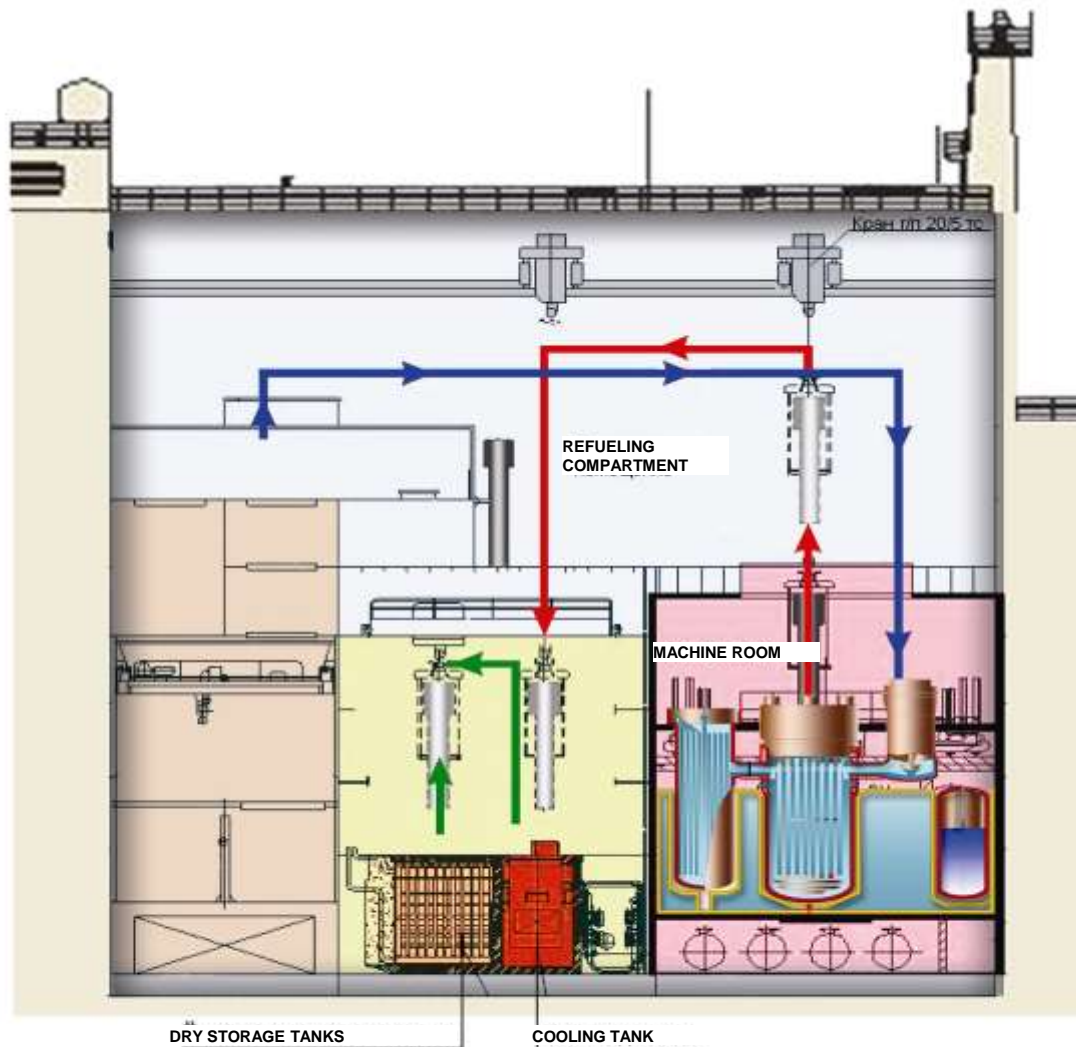
FLOATING NPP BASED ON KLT-40S POWER UNIT



LENGTH, M	140.0
WIDTH, M	30.0
BOARD HEIGHT, M	10.0
DRAUGHT, M	5.6
DISPLACEMENT, T	21 000

COMMISSIONING DEADLINE FOR THE FIRST-OF-A-KIND FLOATING NUCLEAR CO-GENERATION PLANT - 2012
PRODUCTION TIME OF A COMMERCIAL FLOATING NUCLEAR CO-GENERATION PLANT – 2.5 YEARS

SPENT FUEL HANDLING

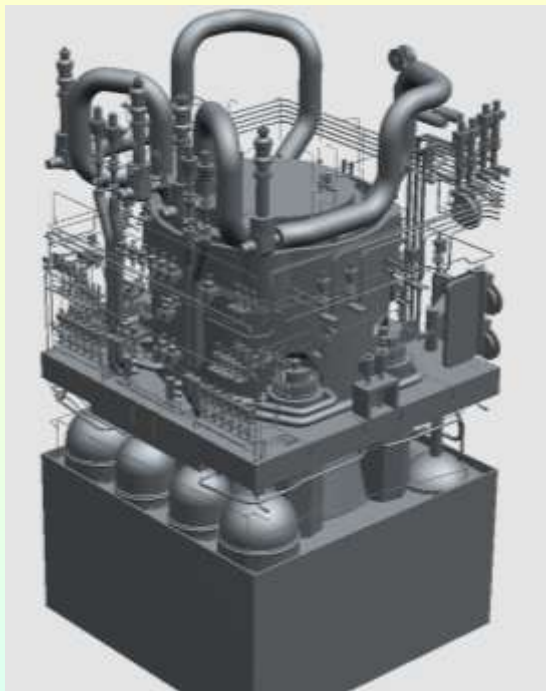


- Transportation of spent fuel from reactor to cooling tank
- Transportation of fresh fuel cassette to reactor
- Transportation of spent fuel from cooling tank into canisters of dry storage tank



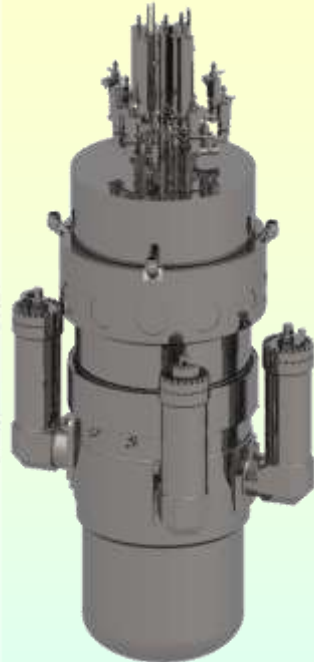
RITM-200 STEAM GENERATING UNIT AND LAYOUT

RP EQUIPMEN LAYOUT



- ★ **MASS OF RP IN CONTAINMENT** – 1100t
- ★ **OVERALL DIMENSIONS (LxBxH)** – 6 x 6 x 15.5 m

SG Unit



- ★ **INTEGRAL PRESSURIZED WATER REACTOR WITH FORCED CIRCULATION OF PRIMARY COOLANT AND EXTERNAL GAS PRESSURIZATION SYSTEM FOR MULTI-PURPOSE ICE-BREAKERS**

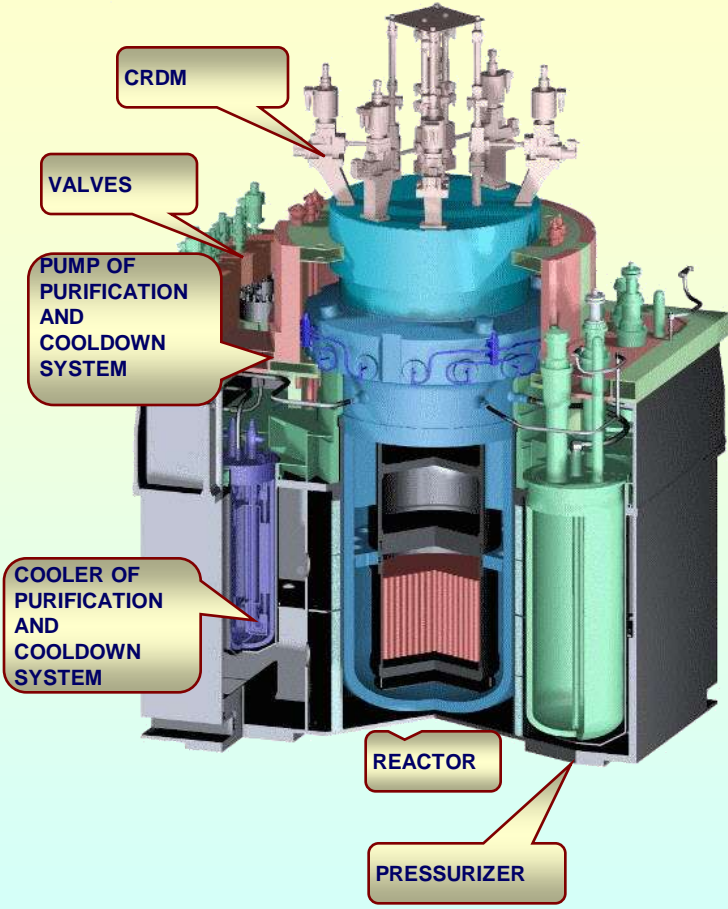
★ THERMAL POWER, MW	175
★ FUEL ENRICHMENT, %	<20
★ REFUELING INTERVAL, years	7
★ SERVICE LIFE, years	40

- ◆ **FINAL DESIGN OF THE ICE-BREAKER – 2009**

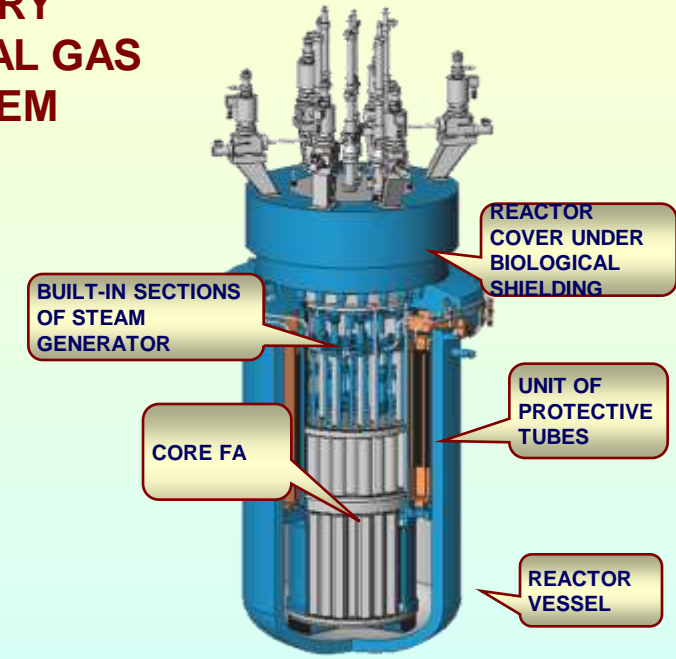


RP could be used also for stationary and floating power units

ABV-6M STEAM GENERATING UNIT AND REACTOR



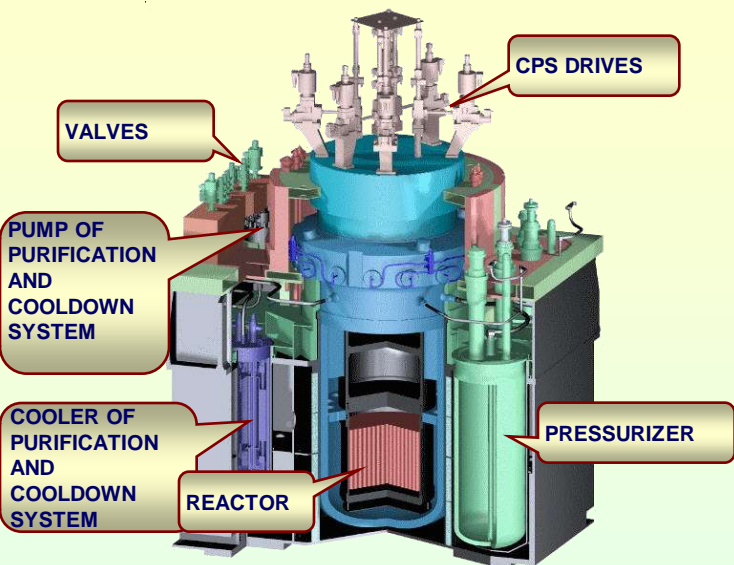
- ✦ INTEGRAL PRESSURIZED WATER REACTOR WITH NATURAL CIRCULATION OF PRIMARY COOLANT AND EXTERNAL GAS PRESSURIZATION SYSTEM



- ✦ RP MAIN EQUIPMENT IS ARRANGED AS A SINGLE STEAM-GENERATING AGGREGATE ON METAL-WATER SHIELDING TANK

<ul style="list-style-type: none"> ✦ THERMAL POWER, MW 	to 45
<ul style="list-style-type: none"> ✦ FUEL TYPE, 	STANDARD FA OF KLT-40S CORE
<ul style="list-style-type: none"> ✦ FUEL ENRICHMENT, % 	<20
<ul style="list-style-type: none"> ✦ REFUELING INTERVAL, years 	10
<ul style="list-style-type: none"> ✦ SERVICE LIFE, years 	60

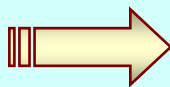
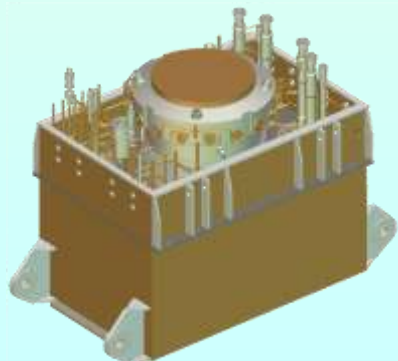
ABV-6M REACTOR PLANT



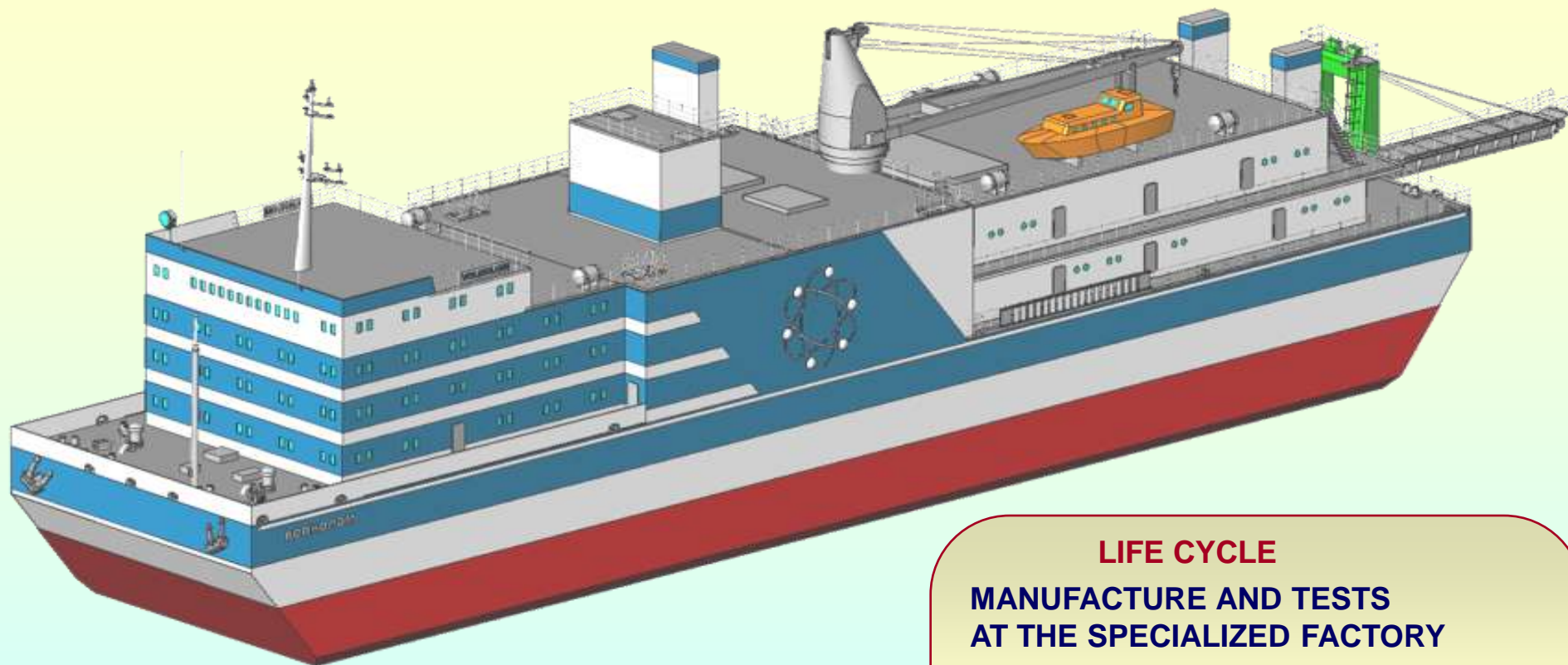
COMPETITIVE ADVANTAGES

- ✳ INTEGRAL REACTOR WITH 100% NATURAL CIRCULATION OF COOLANT
- ✳ UNIFIED STEAM-GENERATING AGGREGATE FOR GROUND AND FLOATING NPP
- ✳ MINIMUM INTERFACES WITH SHIP SYSTEMS

- ✳ **MASS OF STEAM-GENERATING AGGREGATE** 200 t
- ✳ **LENGTH** 5 m
- ✳ **WIDTH** 3.6 m
- ✳ **HEIGHT** 4.5 m



FLOATING NPP WITH ABV-6M REACTOR



MAXIMUM LENGTH, m	97...140
WIDTH, m	16...21
BOARD HEIGHT, m	10
DRAUGHT, m	2.5...2.8
DISPLACEMENT, t	from 8700

LIFE CYCLE

**MANUFACTURE AND TESTS
AT THE SPECIALIZED FACTORY**

TRANSPORTATION

**OPERATION WITHOUT REFUELING
ON SITE**

TRANSPORTATION

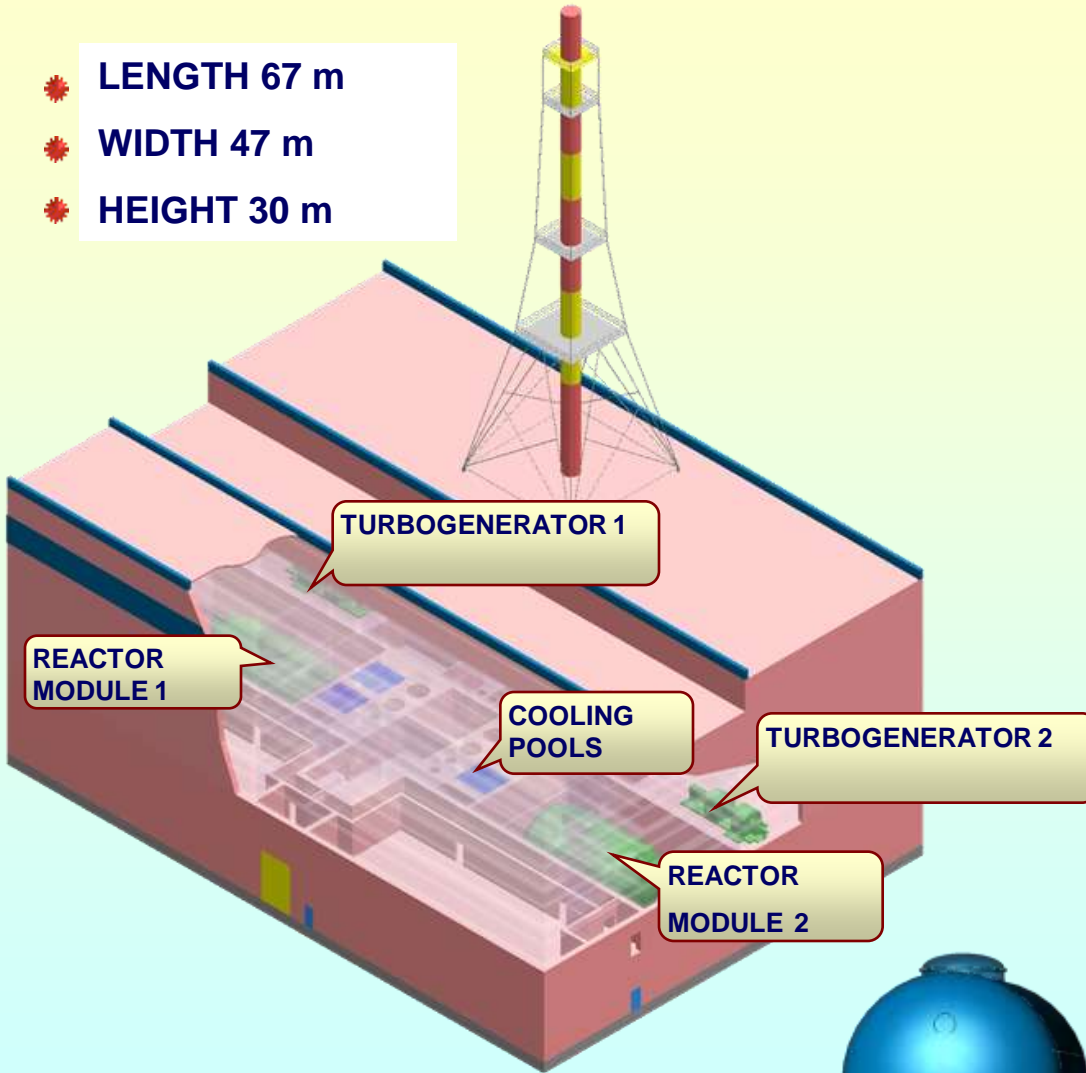
**REPAIR AND REFUELLING
AT THE SPECIALIZED FACTORY**

TRANSPORTATION

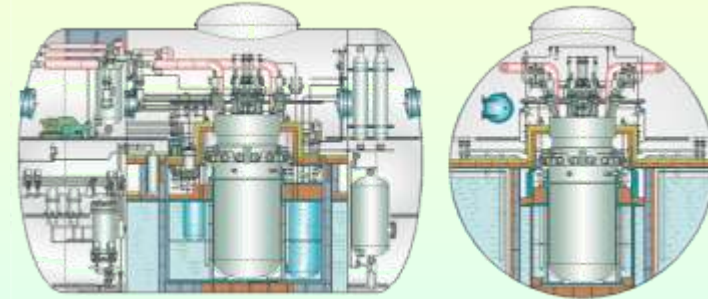
DISPOSAL OF THE POWER UNIT AND RP

MAIN BUILDING OF GROUND NPP WITH ABV-6M REACTOR

- ✿ LENGTH 67 m
- ✿ WIDTH 47 m
- ✿ HEIGHT 30 m



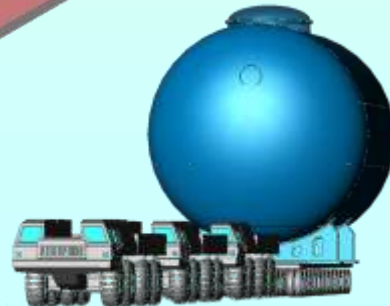
ALL MAIN BUILDING STRUCTURES ARE DESIGNED TO WITHSTAND LOADS ON BUILDINGS OF SEISMIC STABILITY CATEGORY I, WITH ACCOUNT OF AIRCRAFT CRASH, AIR SHOCK WAVE AND A MAGNITUDE 7 EARTHQUAKE



MASS OF REACTOR MODULE	600 t
LENGTH	13 m
DIAMETER	8.5 m

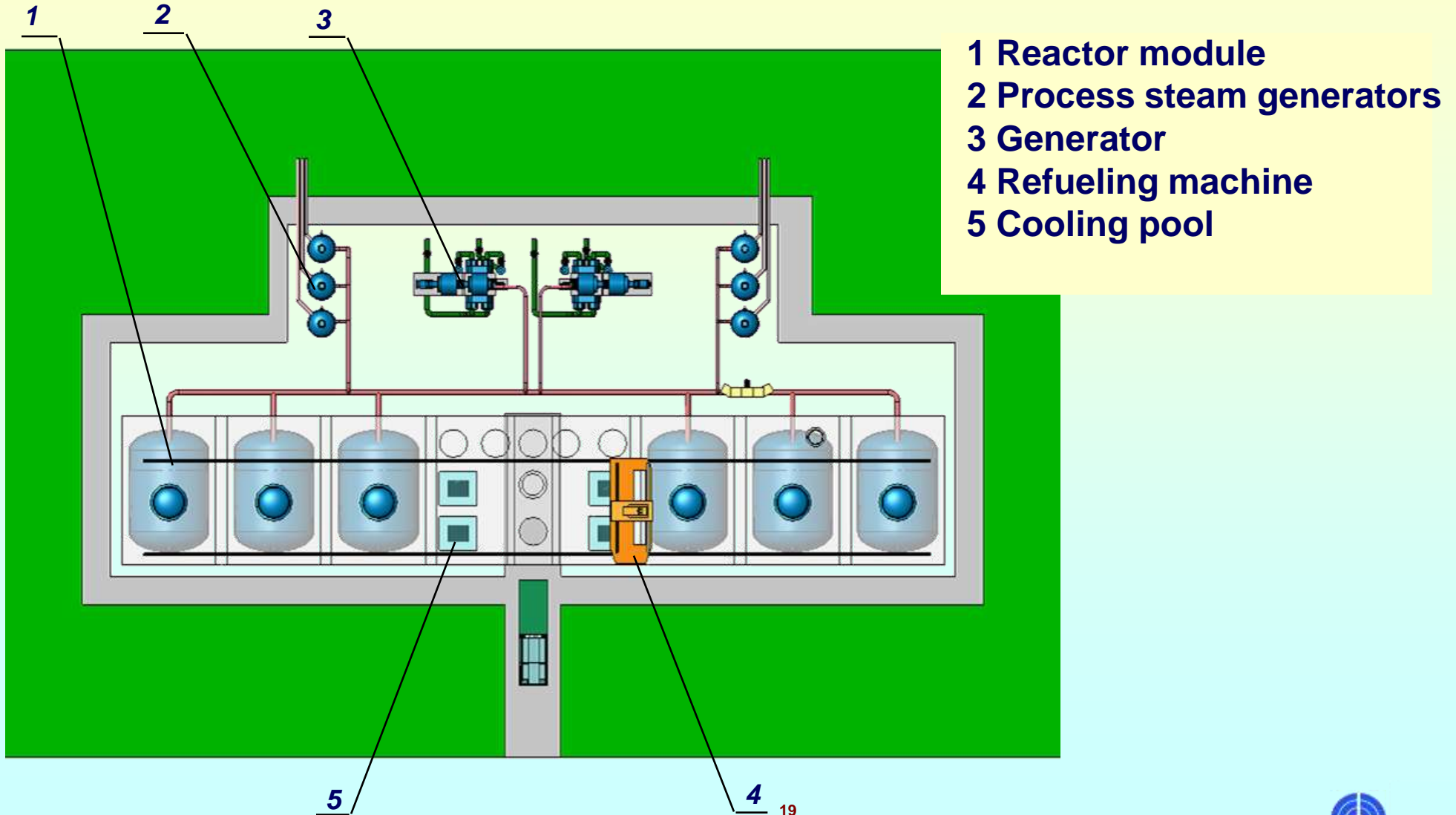
- ✿ ABV-6M RP GROUND OPTION IS A STAND-ALONE, READY-TO-OPERATE MODULE
- ✿ THE MODULE PRESSURE VESSEL FUNCTIONS AS A CONTAINMENT

MODULE TRANSPORTATION TO CONSTRUCTION SITE



NUCLEAR POWER-TECHNOLOGICAL PLANT (ABV-6M)

GENERATION OF ELECTRIC POWER AND PROCESS HEAT FOR INDUSTRIAL ENTERPRISES AND HOUSING SETTLEMENTS

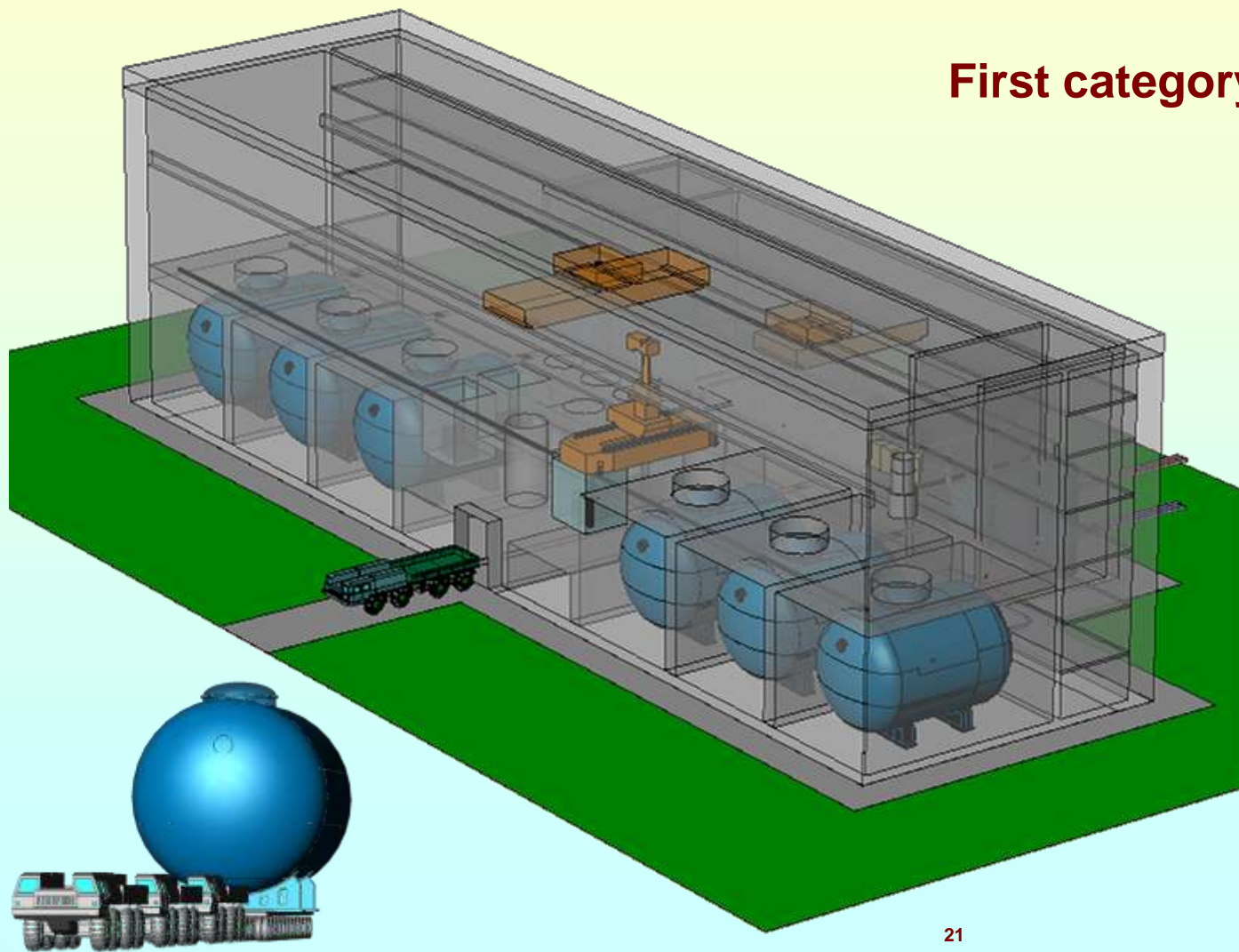


MAIN CHARACTERISTICS OF THE POWER-TECHNOLOGICAL NPP

Characteristics	Value
Number of ABV-6M reactor units	6
Number of process steam generators	6
Number of turbogenerators	2
Steam output, t/h	6 x 53
Steam for house loads, t/h	53
Secondary steam for customers, t/h	265
Electric power of turbogenerators, MW	2 x 4.25
Parameters of primary steam: - pressure, MPa - temperature, °C	3.2 290
Parameters of secondary steam for customers: - pressure, MPa - temperature, °C	3.0 260

POWER-TECHNOLOGICAL NPP(ABV-6M)

The nuclear power plant is assembled of reactor modules (reactor plants in the containment). Modules with reactor plants are supplied by the manufacturer on a turn-key basis



First category of seismic stability

AIRCRAFT CRASH:

- ◆ MASS, T 5.7
- ◆ VELOCITY, M/S 100

AIR SHOCK WAVE:

- ◆ BLAST PRESSURE, KPA 30
- ◆ DURATION, S 1

EARTHQUAKE:

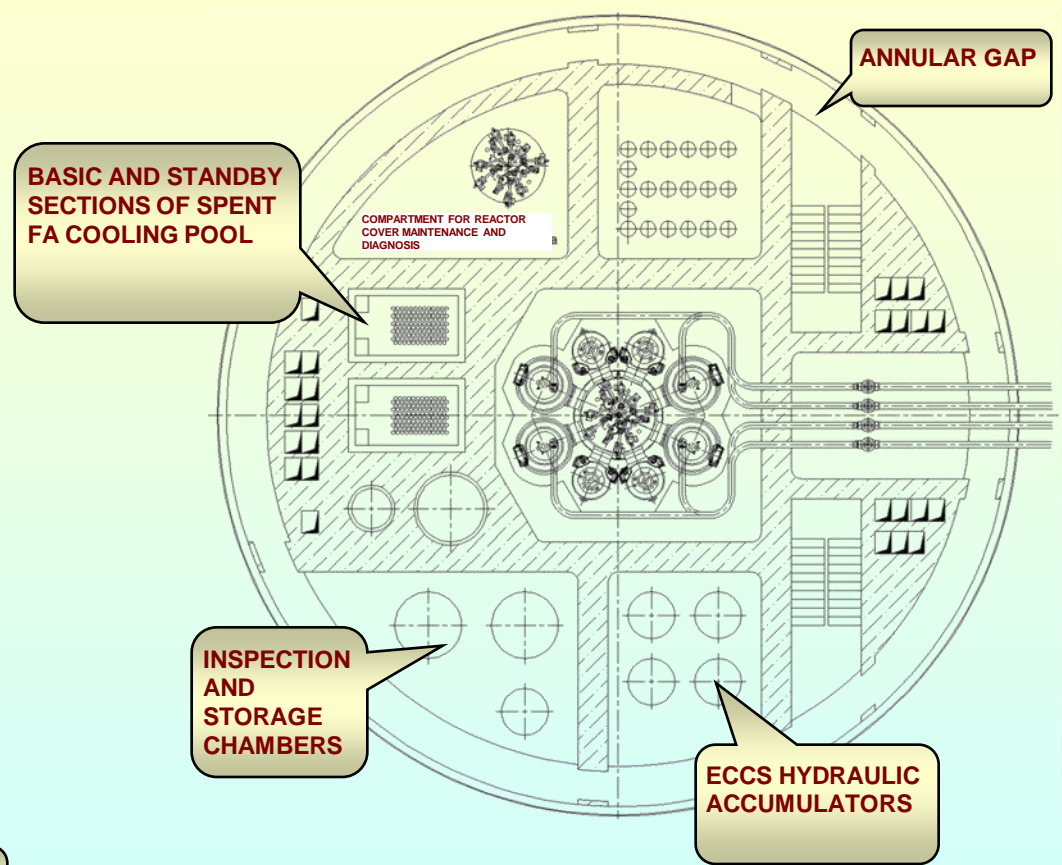
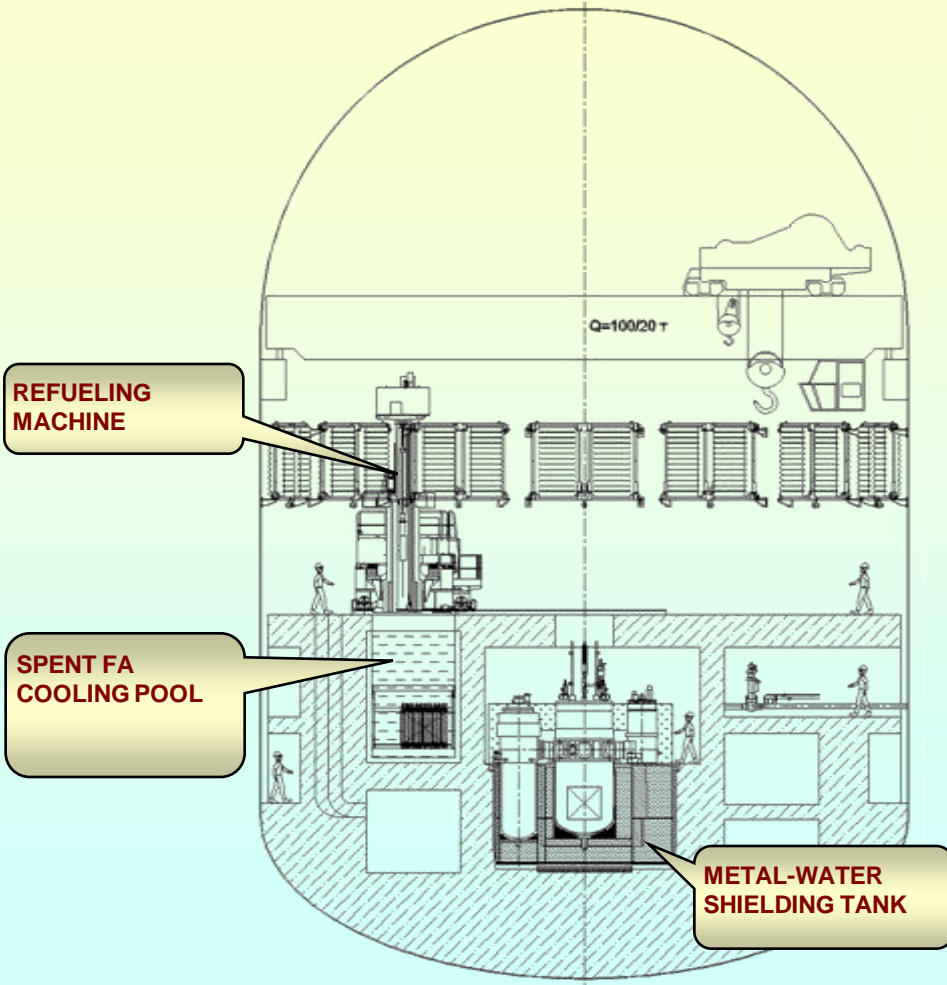
- ◆ MAXIMUM DESIGN EARTHQUAKE
8 MAGNITUDE
- ◆ DESIGN EARTHQUAKE
7 MAGNITUDE

(as per MSK-64)

MAIN BUILDING

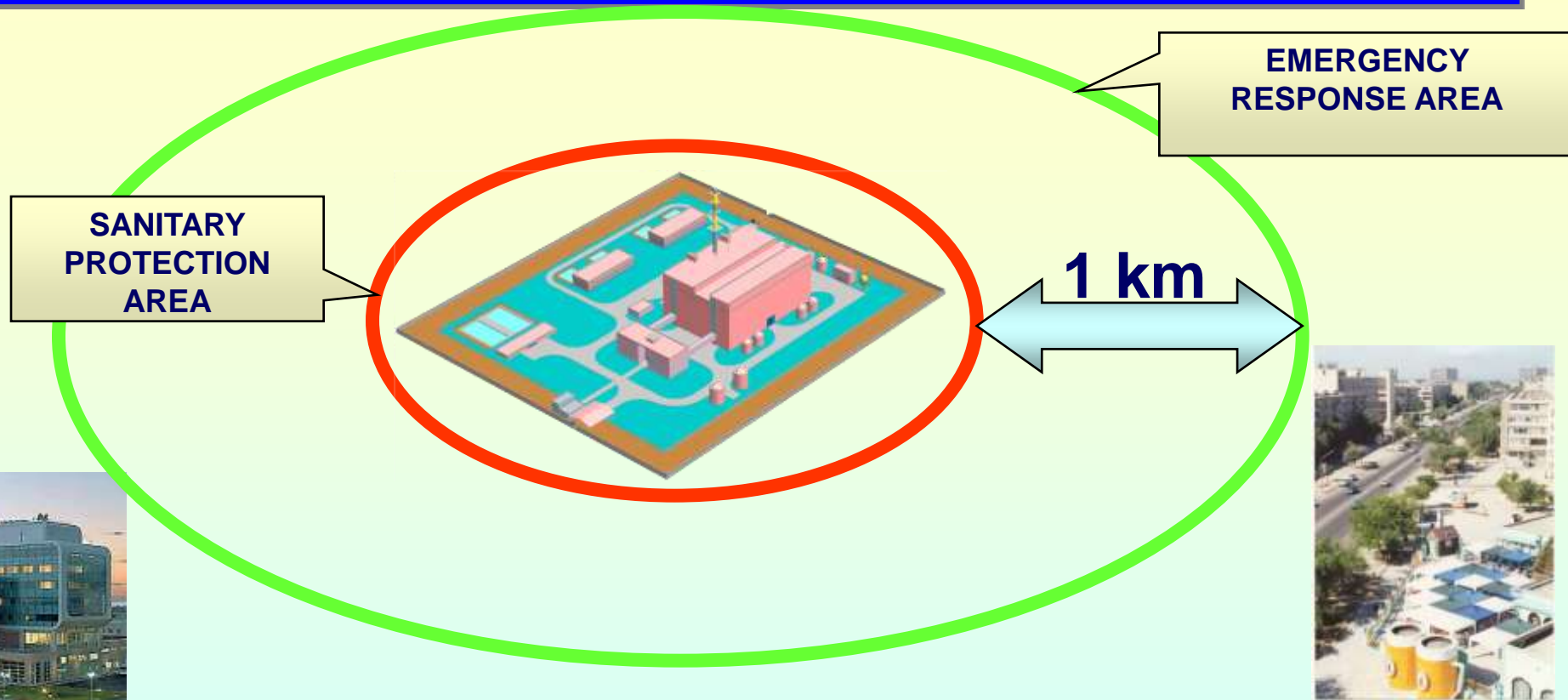
- ✿ Length 100 m
- ✿ Width 25 m
- ✿ Height 25 m

LEAK-TIGHT CONTAINMENT OF A GROUND NPP WITH KLT-40S RP



- ✿ **Diameter** 24 m
- ✿ **Height** 36 m
- ✿ **Mass** 300 t
- ✿ **Volume, gross** 15600 m³

RADIATION AND ENVIRONMENTAL SAFETY



POPULATION EXPOSURE DOSE RATE
- **UNDER NORMAL OPERATION – 0.01%**
- **UNDER LARGEST-BREAK LOCA - 5%**
OF NATURAL BACKGROUND RADIATION

**POPULATION EXPOSURE DOSE IN
BEYOND-DESIGN BASIS ACCIDENT WITH
SEVERE CORE DAMAGE DOES NOT
EXCEED 5 mSv**

COST EFFICIENCY BASIS OF SMALL NPP

- * FACTORY FABRICATION, MINIMAL STARTUP-ADJUSTMENT REQUIRED ON SITE, SIMPLIFIED SYSTEMS AND STRUCTURES**
- * LOW FUEL COMPONENT, LARGE LIFETIME AND SERVICE LIFE, MINIMUM SHIFT PERSONNEL**
- * COMMON MAINTENANCE INFRASTRUCTURE PROVIDING CORE RELOADING, SPENT FUEL HANDLING AND DISPOSAL**
- * LONG-TERM PERIOD OF CONTINUOUS WORK, LONG FUEL LIFE**
- * SIMPLICITY OF DECOMMISSIONING DUE TO MOBILITY OF POWER UNIT (FLOATING OR GROUND)**
- * SAVING OF ORGANIC POWER SOURCES (PROFIT FROM THEIR SALE ON DOMESTIC AND FOREIGN MARKET)**
- * REDUCTION OF EMISSIONS AND RELEASES INTO THE ENVIRONMENT**

CONCLUSION

- ✿ **MAIN ADVANTAGES OF SMALL NPPs ARE CONDITIONED BY THEIR MOBILITY, SERIAL FACTORY CONSTRUCTION, LONG SERVICE LIFE, AVAILABLE MAINTENANCE BASIS, MINIMUM CAPITAL AND OPERATION COSTS**
- ✿ **REACTOR PLANTS DEVELOPED BY OKBM ON THE BASIS OF SHIPBUILDING TECHNOLOGIES FOR POWER UNITS WITH UNIT ELECTRIC POWER OF 3-40 MW AND HIGHER (TO 600 MW) CAN BE SUPPLIED COMMERCIALY UNDER CONDITIONS OF EXISTING FACTORY COOPERATION**
- ✿ **BASIC PROPERTIES**
 - ✿ **HIGH RELIABILITY PROVEN BY OPERATION EXPERIENCE OF MARINE PROPULSION RPs;**
 - ✿ **COMPLIANCE WITH THE MODERN INTERNATIONAL SAFETY REQUIREMENTS;**
 - ✿ **COMPLIANCE WITH THE NUCLEAR MATERIALS NON-PROLIFERATION CRITERIA.**

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