ROSATOM

ROSATOM INTEGRATED OFFER: LARGE-SCALE NPPs

ROSATOM

CONTENTS

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ROSATOM INTEGRATED

IS A SET OF SOLUTIONS AND SERVICES DESIGNED BY ROSATOM TO PROVIDE **COMPREHENSIVE SUPPORT TO THE NATIONAL NUCLEAR PROGRAM** IN THE CUSTOMER COUNTRY **FROM A SINGLE SUPPLIER**

ROSATOM GROUP OF COMPANIES

M OFFER

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RUSATOM ENERGY PROJECTS

IS THE ONE-STOP-SHOP FOR
RUSATOM ENERGY PROJECTS PARTNERS
THAT MAKES THE WHOLE RANGE
OF PRODUCTS AND SERVICES
AVAILABLE TO THE CUSTOMER

RUSATOM ENERGY PROJECTS
ROSATOM

CUSTOMER

RUSATOM ENERGY PROJECTS
ENABLES **DIRECT INTERACTION**
BETWEEN CUSTOMER COUNTRIES
AND ROSATOM COMPANIES

ROSATOM IS A RELIABLE PARTNER FOR LARGE-SCALE NUCLEAR PROJECTS IMPLEMENTATION

HUMAN RESOURCES DEVELOPMENT
training professionals for nuclear program development and safe operation of NPPs

PUBLIC ACCEPTANCE
raising public awareness of nuclear energy

NUCLEAR INFRASTRUCTURE DEVELOPMENT
preparing the customer country to host a nuclear facility

INDUSTRIAL SOLUTION
enabling local suppliers envolvement into national nuclear project

ENERGY SOLUTION
based on VVER-1200 state-of-the-art technology

NUCLEAR PROGRAM STRATEGY DEVELOPMENT

INFRASTRUCTURE DEVELOPMENT

MENT FROM A TO Z

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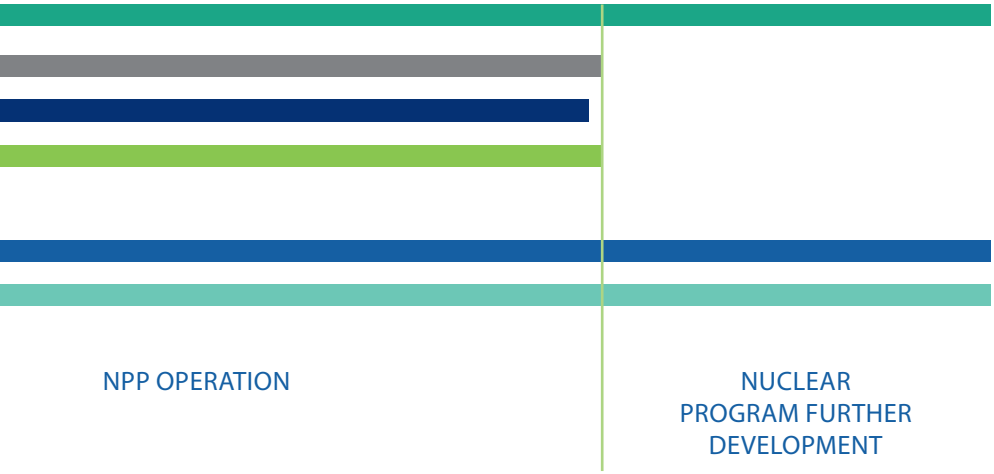
ROSATOM SUPPORTS ITS CUSTOMERS THROUGHOUT THE WHOLE CIVIL NUCLEAR PROGRAMME

FUEL SUPPLY
uninterrupted fuel supply throughout NPP lifecycle

OPERATION & MAINTENANCE
managing safe operation and cost-effective power generation at NPPs

BACK END
providing eco-friendly solutions for spent nuclear fuel and radwaste treatment as well as nuclear facilities decommissioning

Rosatom expertise is backed by **>75 years of experience** of Russian civil nuclear industry



WHAT?

Nuclear infrastructure is a 'check list' to make sure your country is compliant and ready to host nuclear technologies.

WHY?

Nuclear infrastructure comprises 19 crucial issues to be developed by the newcomer country in order to ensure:

- safe NPP operation;
- safety at nuclear fuel cycle facilities;
- customer country is ready to efficiently respond to very unlikely emergency situations.

WHO?

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Rosatom assistance
Services for the project's lifecycle

Government assistance
National program of nuclear technologies development

IAEA

IAEA assistance
Facilitation of safe, secure and sustainable nuclear technologies

National Nuclear Infrastructure for several types of facilities

- Stakeholder involvement
- Site and supporting facilities
- Environmental protection
- Emergency planning
- Nuclear security
- Nuclear fuel cycle
- Radioactive waste management
- Industrial involvement
- Procurement
- Metrology
- Planning

UCTURE

ROSATOM

IS **THE FIRST THING TO START WITH** WHEN DEVELOPING THE NATIONAL NUCLEAR PROGRAM

- Regulatory framework
- National position
- Nuclear safety
- Management
- Funding and financing
- Legal framework
- Safeguards
- Radiation protection
- Electrical grid
- Human resource development

According to IAEA the country is fully responsible for its nuclear infrastructure development

NOT SURE HOW TO START?
NO PROBLEM! ROSATOM'S **TAILORED ACTION PLAN IS READY**…

Rosatom supports and navigates its customers on their way to successfully establishing nuclear infrastructure

ROSATOM: NI ASSESSMENT 1

ROSATOM: NI DEVELOPMENT PLANNING 2

ROSATOM: ASSISTANCE IN NI DEVELOPMENT 3

PHASE 1	PHASE 2	PHASE 3

IAEA REQUIREMENTS TO NI DEVELOPMENT

IAEA

COUNTRY IS READY
TO OPERATE ITS FIRST NPP

PUBLIC ACCEPTA

STILL NOT SURE?

ROSATOM ASSISTS ITS PARTNERS IN RAISING DOMESTIC LEVEL OF PUBLIC ACCEPTANCE AT **3 MAJOR STAGES**

3 **RAISING**

2 **PLANNING**

1 **ANALYSING**

PUBLIC ACCEPTANCE IS AN IMPORTANT TOOL TO SUPPORT CONTINUOUS NUCLEAR POWER GENERATION AND ITS PEACEFUL USE

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NCE

- Public outreach
- Social media activities
- Crisis communications
- Celebrations and special events
- Mass media activities
- Response to nuclear energy opponents

ROSATOM PROVIDES **PR SOLUTION** FOR CUSTOMERS THROUGHOUT THE WHOLE NATIONAL NUCLEAR PROGRAM

TRANSPARENCY IS THE MAIN TOOL: **Rosatom success**

- **6 nuclear information centers** globally
- Success stories in **20 countries**
- **Technical tours** to the real NPPs plants

HUMAN RES DEVE

WHAT PERSONNEL?

ROSATOM offers a full range of Human Resources Development options and solutions that incorporate the company's extensive experience.

HOW TO TRAIN?

COMPREHENSIVE HUMAN RESOURCES DEVELOPMENT PLAN FOR PARTNER COUNTRIES

PERSONNEL CATEGORIES

NPP PERSONNEL
Training for job position

CONSTRUCTION- ENGINEERING PERSONNEL
Project management team
Project Management Training Program

SCIENTIFIC & RESEARCH PERSONNEL*
Research Knowledge System

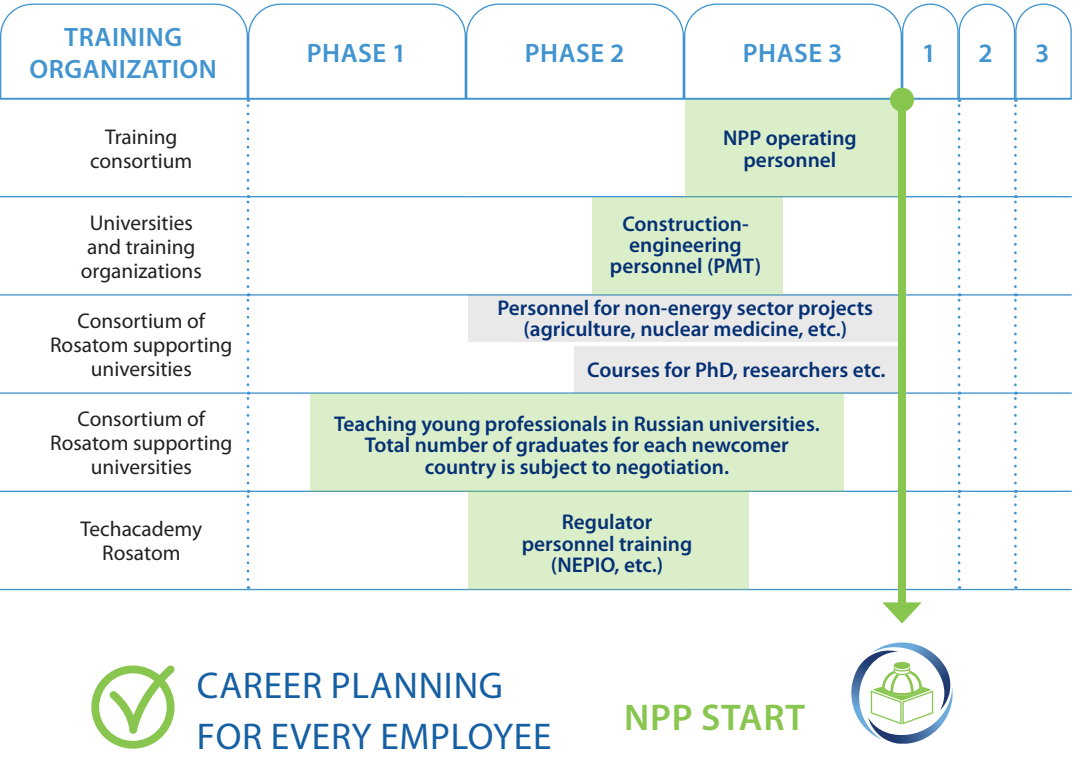
YOUNG SPECIALISTS AND PROFESSORS
Higher Education System

NUCLEAR INFRASTRUCTURE PERSONNEL
NI Training Program

**the category is not a part of NPP project solution, but can be included in Rosatom HRD Offer*

OURCES
LOPMENT

ROSATOM'S KEY APPROACH to personnel training **EMBRACES ALL STAGES OF HUMAN RESOURCES DEVELOPMENT**: from higher specialized education (technical college or university) to training for specific positions ranging from regular members of staff to top managers.



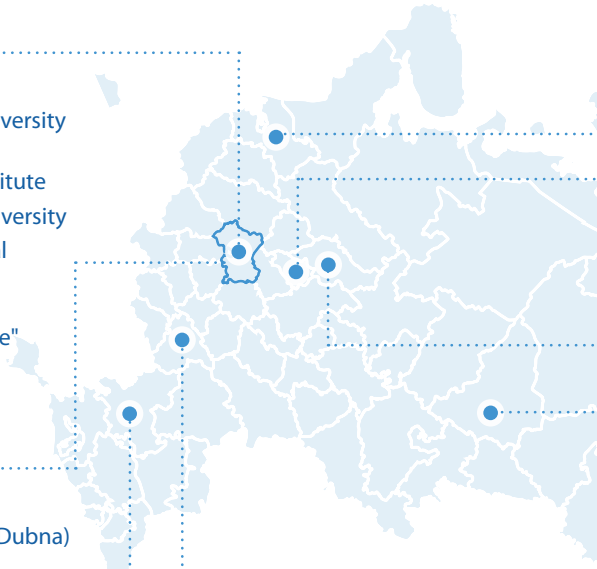
EDUCATION AND INTERNSHIPS

WELCOME TO RUSSIA!

Rosatom offers **NUCLEAR EDUCATION IN RUSSIA**. All the training programs incorporate the considerable expertise of major Russian universities that focus on educating future nuclear specialists.

MOSCOW

- National Research University MEPhI
- National Research Moscow State University of Civil Engineering
- Pushkin State Russian Language Institute
- Bauman Moscow State Technical University
- D. Mendeleev University of Chemical Technology of Russia
- National Research University "Moscow Power Engineering Institute"
- National University of Science and Technology MISiS



MOSCOW OBLAST

- MEPhI production area (Obninsk)
- Joint Institute for Nuclear Research (Dubna)

VOLGODONSK

- MEPhI production area

NOVOVORONEZH

- Training center with an up-to-date simulator

ION IPS TRAINING

more than **1400 students** from **40 countries** received training in leading Russian universities*

** in 2016*

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WAYS OF COOPERATION:

- Joint educational programs
- Academic exchanges (professors, students, interns)
- Train-the-trainer for faculty staff
- Joint scientific projects
- Open lectures, conferences, seminars, seasonal schools, etc.
- Translation and publication of study materials

SAINT PETERSBURG

- Saint Petersburg State University
- Peter the Great St.Petersburg Polytechnic University
- Petersburg Nuclear Physics Institute named after Boris Konstantinov
- National Research Centre 'Kurchatov Institute'

IVANOVO

- Ivanovo State Power Engineering University named after Vladimir Lenin

NIZHNY NOVGOROD

- Lobachevsky State University of Nizhny Novgorod (UNN) National Research University
- Nizhni Novgorod State University named after Rostislav Alexeyev

YEKATERINBURG

- Ural Federal University

NOVOSIBIRSK

- Novosibirsk State University

TOMSK

- National Research Tomsk Polytechnic University

Educational programs *Trainings and internships*

Rosatom is ready for partnership with local companies to ensure efficient NPP project implementation

WHY TO LOCALIZE?

NPP construction results in comprehensive spillover effects for the country's economy:

Public income

Employment

Power sector sustainability

NATIONAL DEVELOPMENT

WHEN TO LOCALIZE?

2 Localization of safety-related equipment is relevant in case of serial npp construction (>5 units)
Depends on local industry readiness

1 Civil works, erection and non-safety equipment – from the beginning (unit 1)
Fast track, well established local infrastructure

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HOW TO LOCALIZE?

Various patterns of cooperation can be considered

Subcontract → **Technical assistance** → **License** → **JV creation**

WHAT TO LOCALIZE?

Level of localization depends on the partner technical qualification, financing model, performance of local suppliers, and applicable certifications.

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Rosatom scope of supply

Local manufacturing & engineering of heavy and specialized equipment

Engineering services and other balance of plant equipment

Non-critical parts and ancillary equipment

Full or partial responsibility for the civil works and erection

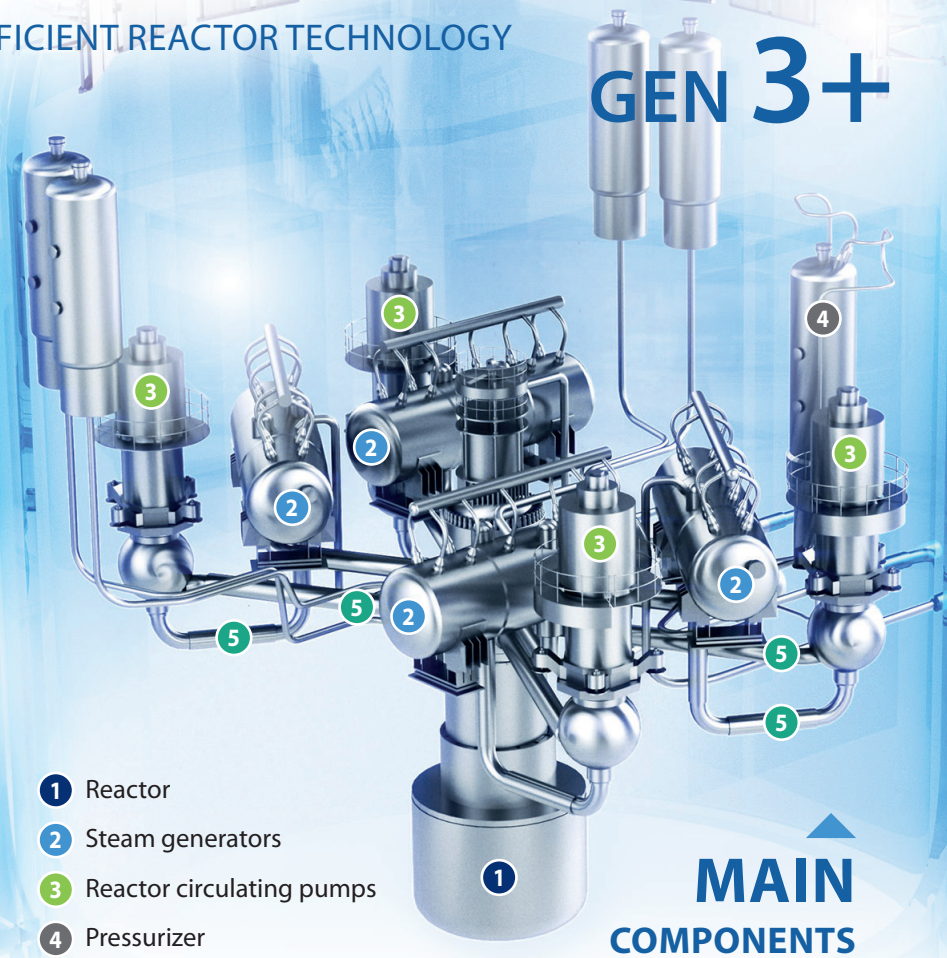
Local labor, construction materials, consumables, tools and materials on site, site infrastructure

EXPANSION OF LOCAL INDUSTRY INVOLVEMENT

ENERG SO

VVER-1200 IS UNIVERSALLY RECOGNIZED AS A STATE-OF-THE-ART, SAFE AND ECONOMICALLY EFFICIENT REACTOR TECHNOLOGY

GEN 3+



1. Reactor
2. Steam generators
3. Reactor circulating pumps
4. Pressurizer
5. Reactor coolant pipeline

MAIN COMPONENTS OF NUCLEAR ISLAND

MORE THAN **80** VVER UNITS
BUILT BOTH IN RUSSIA
AND ABROAD OVER **5 DECADES**

LUTION

Rosatom offers **VVER** – water cooled and water moderated energy reactor technology (pressurized light water reactor) as a **TIME-TESTED** and **HIGHLY REFERENTIAL POWER GENERATION SOLUTION**. This technology combines successful experience in NPP operation with cutting-edge safety standards while meeting the most stringent requirements.

PERFORMANCE INDICATORS

Nominal output*	1 200 MWe
Lifecycle	60+
Efficiency	37%
Own power consumption*	≈ 7.5%
Availability	> 0.9
Maneuverability	100-50-100
Maximum fuel burn-up	up to 70 MW*day/kg U
Safety systems	active + passive
Reference	In commercial operation since Feb, 2017

VVER-1200 DESIGN EVOLUTION

- Double containment
- Design extension conditions management
- Passive heat removal
- Core catcher in an unlikely event of core meltdown

MAIN COMP

NUCLEAR ISLAND

EVOLUTIONARY DESIGN OF REACTOR VESSEL:

- **Extension** of design **service life** of the reactor vessel by **up to 65 years**
- Increase of thermal power output
- Fuel cycle lengths: **12-18 months**

UNIQUE HORIZONTAL STEAM GENERATORS
enable VVER to lose water slower in case of feed water supply failure

MAIN CIRCULATING PUMPS
Two special design features:
main circulating pump hydraulic part bearings are water cooled and water lubricated, not oil lubricated

VVER-1200 – A MIXTURE OF TECHNOLOGICAL HERITAGE AND INNOVATIONS

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ONENTS

TURBINE ISLAND

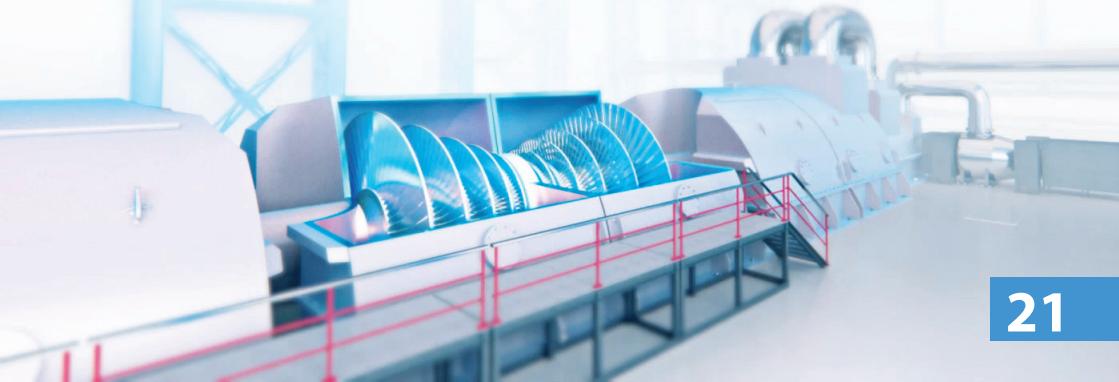
ROSATOM OFFERS A FLEXIBLE AND TAILOR-MADE APPROACH TO TURBINE SELECTION AND ASSISTS PARTNER COUNTRIES IN CHOOSING THE MOST SUITABLE SOLUTION ACCORDING TO VARIOUS PARAMETERS:

TURBINE TYPE:

- High-speed turbines – **3000 rpm**
- Low-speed turbines – **1500 rpm**

COUNTRY OF ORIGIN:

- Russian referenced technologies
- Overseas solutions (GE, Doosan, Skoda Power, Siemens, etc.)



VVER-1

NUCLEAR SAFETY IS OUR TOP PRIORITY. ROSATOM BOASTS OF HAVING PERFECTED ITS COMPLIANCE WITH POST-FUKUSHIMA SAFETY REQUIREMENTS

4 PHYSICAL BARRIERS (Rosatom's Defense-in-Depth principle)

1 barrier
FUEL PELLET
prevents fission products release inside fuel cladding

2 barrier
FUEL CLADDING
prevents fission products release into the primary circuit

3 barrier
PRIMARY CIRCUIT
prevents fission products release into the containment

PREVENTS A RELEASE OF

- Nuclides generated in the process of emission
- Fission products from zirconium tubes
- Fission products from the reactor vessel and the primary coolant

200 GEN 3+ ROSATOM

SAFETY

PROTECTION
from external impacts

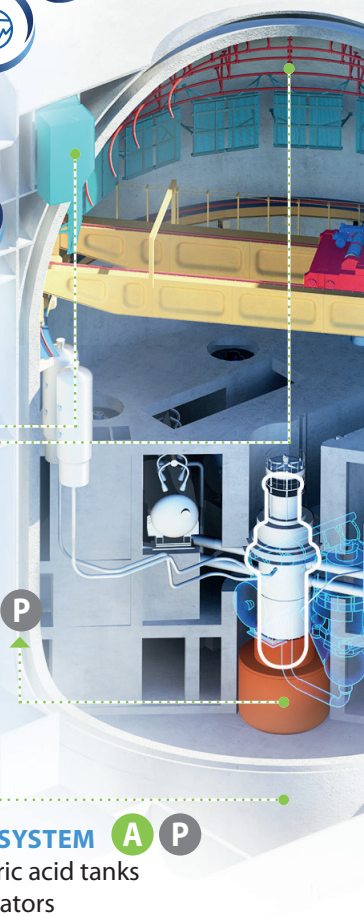
Flooding

Aircraft crash

Earthquake

Tornadoes, storms

Shock waves



4 barrier DOUBLE CONTAINMENT SYSTEM
prevents fission products release into environment

PASSIVE HEAT REMOVAL SYSTEM (P)
provides alternative ultimate heat sink in case of loss of the main one

SPRAY SYSTEM (A)
reduces pressure inside the containment in case of the primary coolant leak

CORE CATCHER (P)
Prevents molten core from leaking out of the containment

HYDROGEN REMOVAL SYSTEM (P)
prevents hydrogen explosion (located at the upper part of containment premises)

EMERGENCY CORE COOLING SYSTEM (A) (P)
- emergency boric acid tanks
- hydro accumulators

both can make-up water in primary circuit

(A) *Active safety system*

(P) *Passive safety system*

GEN 3+

NOVOVORONEZH NPP II, unit 1 (RUSSIA) 2016

"Moscow AEP" design

2 nuclear power plant designs available

"St. Petersburg AEP" design

LENINGRAD NPP II

(RUSSIA) 2018

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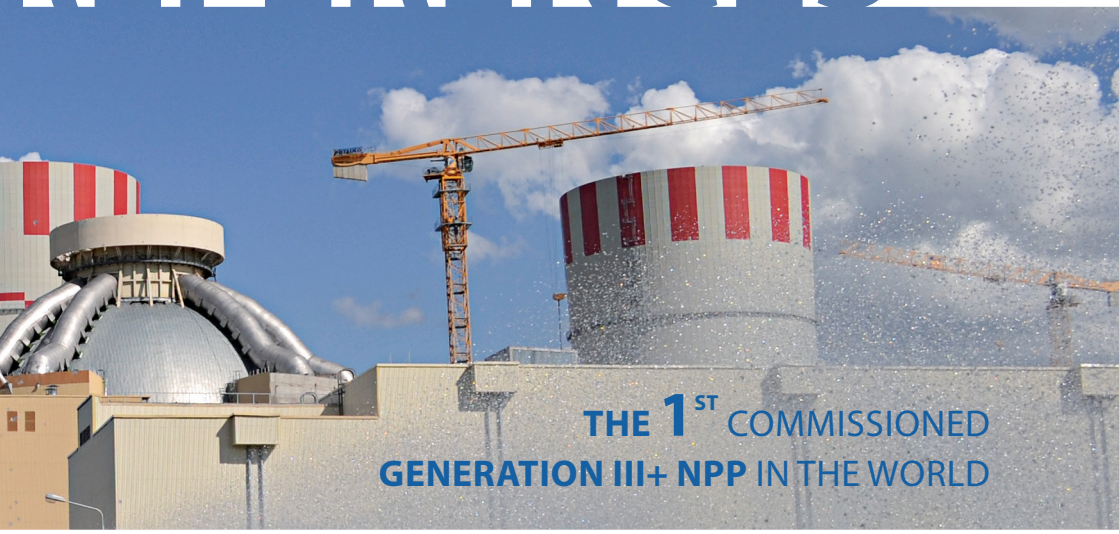
REFERENCES



Depending on customer site requirements

FUEL SUP

WHY ROSATOM FUEL?

- **Every 6th power reactor** in the world runs **on ROSATOM nuclear fuel**
- ROSATOM has **2nd largest uranium reserves** in the world
- ROSATOM ships nuclear fuel using various means of transport
- ROSATOM has **2 fuel production facilities** in eastern and western parts of Russia

THAT IS WHY ROSATOM FUEL

- Reliable **fuel supply throughout NPP service life**
- **No risks for Plant operator** in finding and purchasing NFC Front End products and services
- **Optimized proposal** due to package supply of all front-end nuclear products and services
- **Fuel cycle: 12–18 months**

ROSATOM PROVIDES FUEL
FOR **75 REACTOR UNITS**
IN **14 COUNTRIES**

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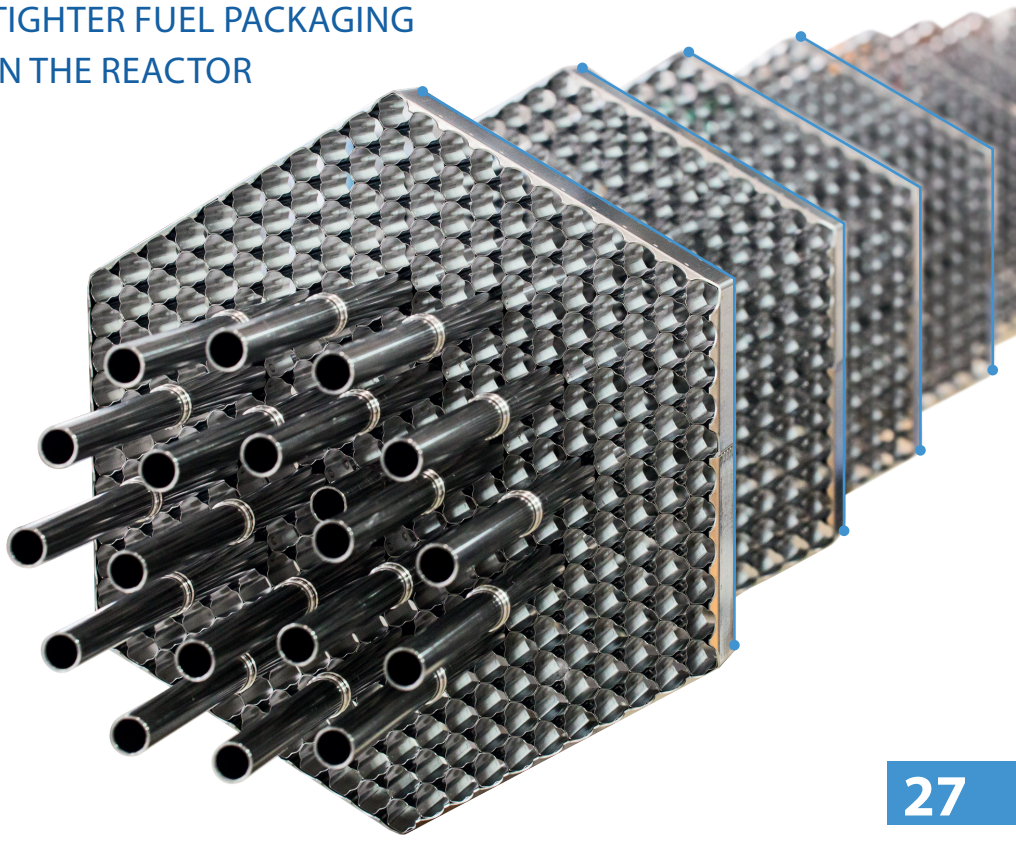
PLY

Rosatom long-term fuel contract is a cost-effective and competitive solution

UNIQUE HEXAHEDRAL FUEL ASSEMBLIES

TIGHTER FUEL PACKAGING IN THE REACTOR



OPERA & MAI

WHAT IS ROSATOM O&M SOLUTION?

ROSATOM BOASTS

OPERATION MANAGEMENT

Technical assistance during NPP commissioning, operation as well as arrangement and performance of preventive maintenance

MAINTENANCE MANAGEMENT

Maintenance and repair of mechanical equipment, electrical equipment, I&C hardware, and metal examination during NPP operation

EXAMPLES OF SUCCESSFUL COOPERATION

METSAMOR NPP (ARMENIA)

TIANWAN NPP (CHINA)

TION

NTENANCE

ROSATOM

VAST EXPERTISE IN PROVIDING NPP O&M SERVICES

EQUIPMENT LIFE MANAGEMENT

Equipment and spare parts supply during NPP commercial operation

MAINTENANCE DOCUMENTS

Assistance in repair documents development

WHY O&M WITH ROSATOM?

- Ensuring safe operation while reducing customer risks
- Convenience due to a single O&M contractor
- Transfer of experience and localization
- O&M contract signed at the beginning of project implementation to plan long-term activities and resources

Rosatom O&M success:

Overseas orders service portfolio **>$1 billion**

Present in **8 international markets**

Holds leading positions in **China**, **Bulgaria** and **Armenia**

SPENT NUCLEAR FUEL AND NUCLEAR WASTE MANAGMENT ISSUES ARE COVERED BY **ROSATOM**
EFFICIENT & FLEXIBLE BACK-END SOLUTION

SNF MANAGEMENT

SNF MANAGEMENT OPTIONS

TEMPORARY TECHNOLOGICAL STORAGE WITH FURTHER RETURN

SNF transfer to Russia for temporary technological storage and FURTHER MANDATORY RETURN to the country

Storage terms and conditions are set out in the foreign trade contract

TEMPORARY TECHNOLOGICAL STORAGE WITH FURTHER REPROCESSING AND RETURN

Return of the reprocessed products to the country

- Return of the reprocessed products after short storage
- Extention of reprocessed products storage period may be additionally agreed

END

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RW MANAGEMENT

WASTE

Radioactive waste generated at the NPP is to be safely disposed on the territory of Partner country

TREATMENT

RUSSIA HAS VAST EXPERIENCE in constructing and operating near-surface repositories for LLW and short-lived RW

REPOSITORY

The construction of a final disposal facility for long-lived RW and HLW is underway **IN RUSSIA AND WORLDWIDE**

DECOMMISSIONING

ROSATOM IS READY TO **SHARE ITS EXPERTISE IN DECOMMISSIONING WITH ITS PARTNERS** TO OFFER TAILOR-MADE SOLUTIONS

NPP decommissioning strategy planning helps to correctly calculate and allocate funds for the final stage of NPP lifecycle

NPP BASED DESALIN

PRODUCT ▶ UP TO **7100** **M³/H** (170 000 M³/DAY) OF POTABLE WATER TO BE PRODUCED BY HYBRID TECHNOLOGY (MED + REVERSE OSMOSIS)*

Government bodies ◀ **KEY CLIENT** ▶ **Local communities, large industrial consumers**

AKKUYU NPP (TURKEY)

ATION COMPLEX

ROSATOM

BENEFITS

- Possibility to produce up to 170 000 m^3/day of desalinated water
- Modular desalination units
- Does not require significant changes in NPP design
- CAPEX and OPEX optimization
- A desalination complex integrated with NPP provides a cost-effective solution due to smart allocation of energy resources and shared infrastructure

ROSTOV NPP (RUSSIA)

** Basic proposal*

HOW TO IMP AN NPP

1

INTERGOVERNMENTAL AGREEMENT ON PEACEFUL ATOM

The signing of an IGA on Peaceful Atom is an indispensable condition for beginning a dialogue on nuclear project implementation between Rosatom and partner country

2

Optional

MOU / PDA ON NPP CONSTRUCTION

Optional documents aimed at identifying the basic parameters of the nuclear project to be implemented in the partner country the partner country

PRESALE CONTRACTS

Preliminary engineering survey

Nuclear Infrastructure assesement and futher development

EPC

- NPP construction
- Commissioning
- First fuel loading

LEMENT PROJECT

ROSATOM

ARE YOU A NEWCOMER COUNTRY?
WE ASSIST **STEP BY STEP**

3

INTERGOVERNMENTAL AGREEMENT ON NPP CONSTRUCTION

The signing of an IGA on NPP construction finalizes the basic nuclear project parameters and launches negotiations on Rosatom Integrated Offer contract package

4

CONTRACTS PACKAGE

4 TAILOR-MADE CONTRACTS

FUEL CONTRACT

Fuel supply throughout NPP entire lifecycle

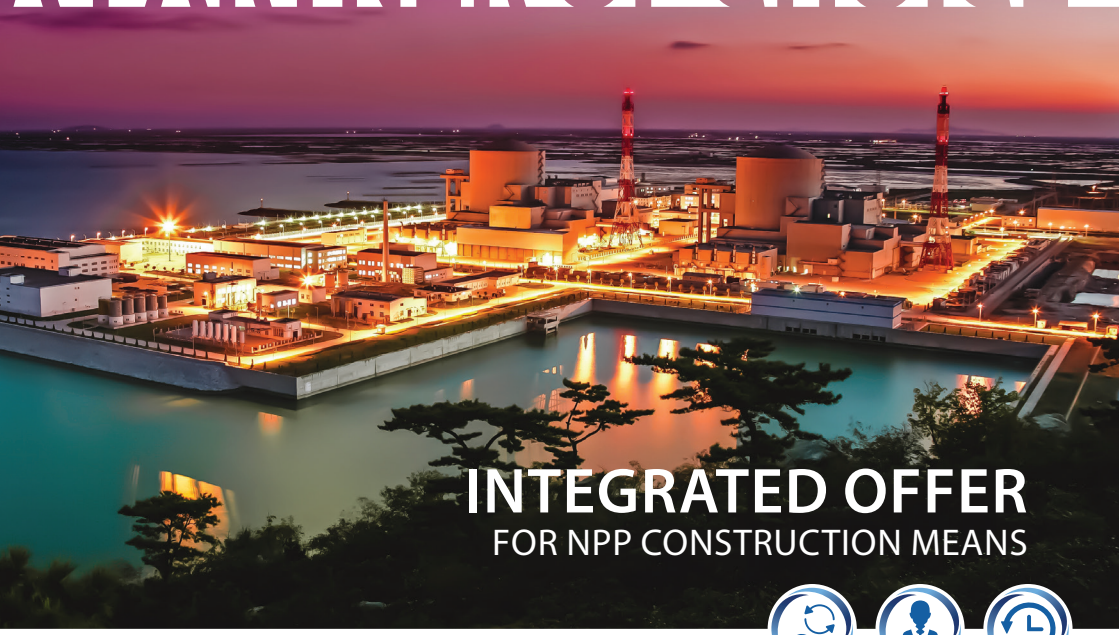
O&M

- Staff training
- NPP operation and maintenance

BACK-END

SNF and RW treatment

ROSATOM – A PARTNER OF CHOICE



INTEGRATED OFFER
FOR NPP CONSTRUCTION MEANS

A **COMPREHENSIVE APPROACH** TO PROJECT IMPLEMENTATION

A **FULL RANGE** OF PRODUCTS AND SERVICES AVAILABLE **FROM A SINGLE SUPPLIER** WITH SOLID EXPERIENCE

PROJECT SUPPORT **THROUGHOUT ITS ENTIRE LIFECYCLE**

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