

#### PILOT & DEMONSTRATION CENTER FOR DECOMMISSIONING OF URANIUM-GRAPHITE NUCLEAR REACTORS



#### **INITIAL STATUS OF COMMERCIAL-SCALE URANIUM-GRAPHITE EI-2 REACOR** EI-2 is a double-purpose commercial type reactor. It was commissioned in 1958 and shut down in 1990. F-R External appearance of EI-2 reactor **EI-2** building Plan size 51,3×52,0 m; Upper section at 31,5 m; Bottom section at 38 m below around level. Underground constructions are made of cast reinforced concrete. **Reactor vault** Plan size 20,6×20,6 m. Upper section 0,00 m; Bottom section at - 21,4 m. одц 🐼 угр 3-D model of EI-2 building 3



#### JUSTIFICATION OF EI-2 DECOMMISSION VARIANT

To justify the decommission variant the following was taken into account:

- all 13 commercial-scale uranium graphite reactors in Russia are located in zones where near surface disposal, underground disposal facilities and radioactive waste disposal sites formed during the defense program realization already exist;

- graphite stacks of uranium-graphite reactors located below ground level;

- passportization data of irradiated graphite, radionuclides location forms;

- Results of calculations which indicated that in-situ entombment decommissioning variant of uranium-graphite reactor demanded less labor and dosimetric costs than liquidation from material, technical and economical point of view.

Scientific justification of mothballing facility for special radioactive wastes creation was completed.

Current physical shape of reactor graphite is the most compact one. Any kind of treatment can cause the radioactive waste volume incensing, its physical form can change which leads to evolving of new risks and costs.



MOST IMPORTANT CRITERIA FOR EI-2 DECOMMISSIONING CONCEPT DEVELOPMENT

1. Optimization approach – radioactive impact during the decommissioning activities must remain as low as possible and achievable taking into account economic and social factors (ALARA principle).

2. Next generation protection approach – forecasting levels of exposure for the next generations shall not exceed the levels currently set in regulatory documents.

3. Multibarrier approach – safety of decommissioning activity shall be maintained by appliance of the barrier systems on the way of ionizing radiation and radioactive material proliferation to environment.



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	BACKGROUND OF EI-2 DECOMMISSIONING
2008	"Decommissioning concept of nuclear facilities, radiation sources and disposal sites" enacted from 30.01.2008 by General director of "Rosatom".
2009	"Conception of decommissioning of uranium-graphite nuclear reactors using radiation safe on-site entombment approach" enacted from 28.12.2009 by order of General Director of "Rosatom" in 2010.
2011	Federal Law N 190-FZ from 2011 «About radioactive waste treatment»
	"Local concept of decommissioning of uranium-graphite nuclear reactors of JSC "Siberian Group of Chemical Enterprises" (SGCE) using radiation safe on-site entombment approach finalized by the Director of Nuclear and Radiation safety Department of "Rosatom" in 2011.
	"Minutes of meeting as of 08.09.2011 about in-situ entombment of EI-2" enacted from 03.10.2011 by the Department of Nuclear and Radiation safety.
2012	Comprehensive engineering and radiation survey, decommissioning project, R&D on materials and safety validation report completed.
	Licensing for decommissioning activities.
	Practical work started.
2015	Completion of all practical works, mothballing facility for special radioactive wastes creation.
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PREDEVELOPME		ISIS
40)	1. Geologic	al research in El-2 zone.
	2. Sorption environmen	capacity of geological t.
	3. Sorption significant I massive ma	parameters for the most ong-lived radionuclide in terial of aquafer.
Axial section of El-2 area	Radionuclide	Allocation coefficient in massive material, m <sup>3</sup> /kg
EP2 location	₃Н	No sorption
	<sup>14</sup> C	No sorption
and a constant of the second	<sup>36</sup> Cl	No sorption
Caller Contraction	<sup>90</sup> Sr	0,30-0,48
I TROUGH	Cs isotopes	6,5-9,3
	U isotopes	0,14-0,21
	<sup>237</sup> Np	0,62-1,5
	Pu isotopes	4,8-6,9
Scheme of EI-2 location relative	Am isotopes	5,5-7,8
to area of groundwater	<sup>244</sup> Cm	5,5-7,8
ОДЦ 🐼 угр discharge	<sup>60</sup> Co	1,6-3,0

Barrier material choice			
Criteria:	Solution:		
Performance stability during the period of nuclear waste potential threat, ecological safety, accessibility.	Natural materials		
High sorption capacity of radionuclides with different by chemical properties, plasticity	Mixture of natural materials on the base of natural clay or clay rock		
Low water conductivity, natural compression, good flowability	Machine processes mixtures with definite humidity and granulometric composition		

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#### **RESEARCH RESULTS**

1. The composition on the base of machine processed mixture of natural clay as the barrier material was developed;

2. On the base of calculative approach it was confirmed that forecasting activity of radionuclides considered  $10^{-3}$  Bq/kg eliminating C-14 and Cl-36 from the area of groundwater discharge to river Tom (modeling timeframe – 10,000 years);

3. It was confirmed that under any events evolution scenario the most mobile C-14 and CI-36 radionuclides will not exceed action level.

4. On the base of these researches which justify safety of in-situ entombment scenario the project of decommissioning of El-2 uranium-graphite nuclear reactor was developed and license was provided to implement this work.

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**TECHOLOGIES** CLASSIFICATION OF TECHNOLOGIES ON THE STAGE OF PROJECT **DEVELOPMENT AND DURING THE DECOMMISSIONING OF EI-2** REACTOR Technologies used Dismantling Barrier Nuclear waste for comprehensive technologies for construction treatment engineering and main and technologies technologies radiation survey accessorv safety accumulated used during the equipment, conservation of during the reactor survey of the buildings and reactor facilities operation time equipment. constructions and content of and buildings, and areas nuclear waste decommissioning disposal facilities одц 🐼 угр 12









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## Back End Business Group Services for SNF, RW Management and Decommissioning



### **Establishment of the Back End Business Group**

- Federal Centre for Nuclear and Radiation Safety (FSUE "FCNRS" \*) was established on 23.08.2007 by the decision of the Russian Government in order to centralize management of SNF and RW projects.
- The Back End Business Group was established by Rosatom decision of 27.06.2012 on the basis of FSUE "FCNRS".
- 100% of the FCNRS shares are owned by the Russian Federation represented by the State Corporation "Rosatom".



\*from October 2013 - JSC "FCNRS"

# FCNRS / Back End Business Group in the Nuclear Fuel Cycle



### Back End Business Group Today (1/1)

Currently the Back End Business Group comprises:

- JSC FCNRS managing company of the Division
- JSC "NPO "Radium Institute by V.G. Khlopin"
- JSC "DNR Center"
- FSUE FNO "Mining and Chemical Combine"
- FSUE "RosRAO"
- FSUE "RADON"
- Personnel
  - > 10 000 people
- Licenses and certificates
  - **23**

I ISO 9001 : 2008 and ISO 14001:2004 + Cor 1 : 2009



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### **Back End Business Group Today (1/2)**

- Production capacities of the Back End Business Group comprise:
  - Research laboratories
  - Hot cell complex to work with kilogram quantities of **SNF**
  - Science and Technology Center for development of pilot plants for RW management
  - > 30 production sites in different regions of Russia
  - Transport fleet



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### **Back End Business Group Key Markets**



#### **Business Areas of the Back End Business Group**

#### SNF management

- 1. Transportation
- 2. Acceptance and accommodation
- 3. Storage
- 4. Reprocessing
- 5. Process solutions and R&D
- 6. New products fabrication (MOX, REMIX)

#### **RW management**

- 1. Collection
- 2. Assortment
- 3. Transportation
- Conditioning
  Storage
- 6. Spent Sealed
- Radioactive Sources (SSRS) management
- 7. Radiation safety services

#### Decommissioning

- 1. Complex engineering & radiation safety audit (CERSA)
- 2. Decontamination of premises / equipment
- 3. Disassembly
- Site mothballing
  Remediation of
- contaminated territories



- 1. R&D
- 2. Development of process solutions
- 3. Development and fabrication of equipment, casks and special transport
- 4. Development of regulatory framework in the field of SNF management









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### **SNF** Management

Enterprises of the Back End Business Group provide a full range of services in the area of spent nuclear fuel management in the Russian and foreign markets















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### **Products and Services for SNF Management**



#### **Operation Services**

Enterprises of the Back End Business Group provide a full range of engineering, information, production and methodological services for SNF management:

- SNF preparation for transportation off site
- transportation (by air, rail, water, road)
- storage (including casks)
- reloading
- reprocessing
- development and introduction of new products
- HLW storage

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### **Products and Services for SNF Management**





#### **Process Solutions, Equipment Supply**

#### **PROCESS DESIGN, R&D:**

- development of process, logistic schemes and solutions
- process design of infrastructure facilities
- generation of permissive documentation package
- development of policies, concepts and strategies

#### **EGUIPMENT SUPPLY:**

- development and fabrication of casks, transportation means and service equipment
- fabrication of equipment for cooling ponds and storage facilities
- transport and process equipment
- supervision installation, commissioning



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### **SNF** Management



#### **Main Customers and Partners**

- Concern "Rosenergoatom" (Russia)
- SE NNEGC "Energoatom" (Ukraine)
- "Paks" NPP (Hungary)
- "Kozloduy" NPP (Bulgaria)
- National Nuclear Center (Kazakhstan)
- Institute of Nuclear Physics in the Academy of Sciences (Uzbekistan)
- National Research Institute for Nuclear Physics and Nuclear Engineering "Horia Hulubei" (Rumania)
- RW Management Enterprise (Poland)
- The Vinča Institute of Nuclear Sciences (Serbia)
- Dalat Nuclear Research Institute (Vietnam)
- Rossendorf Research Centre (Germany) etc.

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### **SNF** Management



#### **Projects/ Main Facts**

- 194 NPS of the Russian Navy were unloaded and sent for interim storage or SNF disposal in the framework of the Program "Disposal of Nuclear Submarines, Nuclear Powered Surface Ships, Nuclear Maintenance Vessels"
- More than 5 000 tons of SNF from NPPs and RRs constructed with the technical assistance of the Soviet Union and the Russian Federation were repatriated in the framework of Intergovernmental Agreements
- Routine unloading and transportation of SFA of Russian NPPs for centralized storage and reprocessing at the Division enterprises
- Unloading, transportation and reprocessing of NPP and NPS defective fuel



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#### **RW Management**

Enterprises of the Back End Business Group provide a full range of services for RW and SSRS management, including collection, transportation, reprocessing, conditioning and long-term storage



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### **Products and Services for RW Management**







#### **Operation Services**

- Collection of RW, SSRS and isotope products
- Assortment and categorization
- Conditioning
- Reprocessing:
  - LRW: filtration, ultra filtration, evaporation;
  - SRW: decontamination, fragmentation, compacting, incineration;
- Transportation
- Container shipping, certification
- Long-term safe storage
- Preparation for disposal





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### **Products and Services for RW Management**







#### Process Solutions, Equipment Supply

- Development and fabrication of packages, casks for RW shipping and storage
- Development and fabrication of transportation means and service equipment
- Process design of the infrastructure facilities
- Refinement of process modes
- Remediation of radiation hazardous areas and site decontamination
- Agreement with the supervision authorities, obtaining permits, certification
- Radiological and ecological monitoring

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### **RW Management**



#### **Main Customers and Partners**

- State Corporation "Rosatom"
- Russian Ministry of Defense
- Moscow Government
- MSU by M.V. Lomonosov
- NRC "Kurchatov Institute"
- JSC Zvezdochka Shipbuilding Center
- AS A.L.A.R.A. (Estonia)
- Belgatom (Belgium)
- Mitsubishi Research Institute Inc. (Japan)
- ENVINET a.s. (Czech Republic)
- United States Department of Energy, DOE (US) etc.





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#### **RW Management**



#### **Projects/ Main Facts**

- Remediation of the industrial site of JSC "Mosrentgen", Moscow region, 2014
- Radiation-remediation works at the site of RRC "Kurchatov Institute", Moscow
- Projects for purification of LRW at the Navy sites, Murmansk
- Supply of equipment for purification of LRW and decontamination of surfaces in the framework of the IAEA projects
- Remediation of the site of JSC "Podolsk Nonferrous Metals Plant" (PZTsM), Moscow region
- Verification of technologies for purification of NPP "Fukushima-1" contaminated water from radioactive tritium

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#### Decommissioning

The Back End Business Group enterprises carry out works on decommissioning of nuclear facilities





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### **Decommissioning Services**





#### **Operation Services**

- Removal of NM and SNF from site
- CERSA
- Process equipment and systems dismantling
- RW removal and conditioning
- Decontamination of contaminated surfaces
- Development of additional engineering safety barriers
- Building structures dismantling
- Decommissioning of RW storage
- Remediation of contaminated areas

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### **Decommissioning Services**



#### **Main Customers and Partners**

- State Corporation "Rosatom"
- JSC "Concern Rosenergoatom"
- FSUE "PA" Mayak"
- JSC "TVEL"
- ANDR (Romania)
- NUKEM Technologies GmbH (Germany)
- AS A.L.A.R.A. (Estonia) etc.



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### **Decommissioning Services**







**Projects/ Main Facts** 

- Works on preparation for decommissioning and actual decommissioning: - PUGR (JSC "DNR Center", FSUE FNO "MCC")
- Works on preparation for decommissioning, Stage 1 of Beloyarsk NPP
- Disposal of RW repositories of "kurgan" and "gasholder" type
- Disposal of cooling towers and unused buildings
- Technical assistance in evaluation of the documentation for decommissioning plan of the VVR-S research reactor "Horia Hulubei" (Romania)
- Preliminary study on decommissioning of reactor compartments of the former military nuclear facility Paldiski and construction of RW burial facility (Estonia)

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### **Decommissioning Services**



#### **Process Services**

- R&D to ensure safety during decommissioning and RW management
- Development of technologies for decommissioning (modeling, mock-up trials)
- Development of process technologies and Method Statements for decommissioning
- Design and manufacture of equipment for remote visual monitoring and works under conditions of high ionizing radiation field
- Services to ensure NRS (radiation monitoring, metrological support of measurements)



### **Decommissioning Services**





#### **Projects/ Main Facts**

- Decontamination technologies for surface and volumetric contamination by various methods
- Technology for creating internal engineering safety barriers by void-free filling of reactor space cavities with barrier material
- Technology for creating external safety barriers for RW storage sites
- Technology for solidification of RW in matrix material
- Technology for dismantling Beloyarsk NPP graphite stack
- Technology for dismantling cooling towers "from below"

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### **Research/ Technologies**



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#### **List of Services**

- R&D in SNF and RW management and decommissioning
- Development of technologies for particular types of work
- Development of design documentation
- Development of concepts, strategies and programs for SNF and RW management and decommissioning

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- Development and fabrication of process equipment
- Process design of SNF and RW facilities
- Isotope products

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### **THANK YOU FOR ATTENTION !**

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