РОССИЙСКАЯ АКАДЕМИЯ НАУК
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Nuclear Safety Institute (IBRAE)

Main Trends in the Development and Provision of Environmental Safety and Efficiency in Nuclear Decommissioning and Backend Technologies

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Safety and Efficiency – Main Trends

- **Cross cutting efficiency. Timely elaboration of engineering solutions for nuclear facilities (NF) at pre-design and design stages followed by their further elaboration during construction and operation.**

- **Legacy. Defining NF final state and the strategy to attain it with due consideration of costs and risks (including radiation risks), selecting the optimum option.**

- **Pragmatism and integrity. Increasing decommissioning efficiency and safety for the selected strategies.**

Planning NF Decommissioning and Backend. Design Requirements

International Recommendations

- The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

SSR-5
- Specific Safety Requirements. Disposal of Radioactive Waste

SSR-2/1
- Safety of Nuclear Power Plants: Design

SSR-2/2
- Safety of Nuclear Power Plants: Commissioning and Operation

…

Regulatory Requirements

170-FZ
- On Atomic Energy Use

190-FZ
- On the Management of Radioactive Waste

NP-091-14
- Safety in Decommissioning of Nuclear Facilities. General Provisions

NP-057-04
- Decommissioning of Nuclear Fuel Cycle Facilities. Safety Rules

NP-012-99
- Decommissioning of Nuclear Power Plants. Safety Rules

NP-055-14
- RW Disposal. Principles, Criteria and General Safety Requirements

…

Decommissioning activities shall be planned **at the design stage** and regularly **updated** based on the best practices

Decommissioning Aspects at the Design Stage

Decommissioning aspect	Legacy facilities		Facilities under construction	RW DF
	Before FTP	After FTP		
Design requirements	✘	✘	✔	✔
Culture of requirement perception	✔	✔	✔	✔
Maturity of engineering solutions	✘	✔	✘	✔
Consideration of international requirements and recommendations	✘	✔	✔	✔
TOTAL:	✘	✔	✔	✔

Defining the Final State and the Strategy for its Attainment: RW

Legacy RW

RW origin and location satisfy the criteria? — Yes / No

Justifying the ratios

RW DF conservation		RW retrieval
Collective effective dose	<	Collective effective dose
Potential exposure risk	<	Potential exposure risk
Costs + overall potential detriment to the environment	<	Costs

Ratios are met? — Yes / No

Yes → **Special RW (in situ disposal)**

No → **Retrievable RW (shall be retrieved and transferred to the National Operator for disposal)**

Addressing the Accumulated Challenges under FTPs

FTP-1

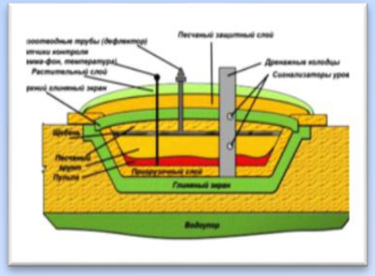
Conservation:
B-1 (start), B-2 (SCC)
V-9 (PA «Mayak»)
Facility-354 (MCC)

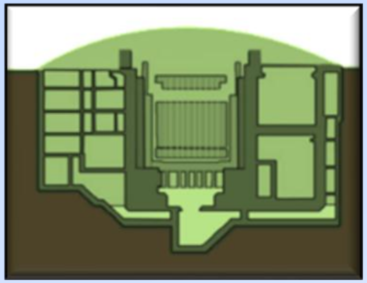
Conservation of production uranium-graphite reactor EI-2 (PDC UGR)
Startup phase (MCC, PA «Mayak»)

RW retrieval:
IPPE, Start, Zvezda, Kurchatov institute (KI), sludge removal from MCC reservoir tanks

Cleaning up the sites of peaceful nuclear explosions,
RIAR,
PZCM, Novotroitsk and others

- Commissioning RBMK and VVER SNF storage facilities
- Developing infrastructure for RR SNF off-site shipment
- First start-up complex of PDC (MCC)





FTP-2

B-1 (completion), B-25, SF (SCC)

V-17 (PA «Mayak»)

Tailings at NCCP

Slurry storage (Kirovo-Chepetsk chemical plant)

ADE-3,4,5 (PDC UGR)

AV-1, AV-2 (PA «Mayak»)

AD, ADE-1,2 (MCC)

Rosenergoatom, Minpromtorg, RosRAO, Atomflot, KI facilities

Ongoing efforts at MCC

Retrieval of accumulated sludge at «PA «Mayak»

Clean-up of radioactively contaminated sites:

RosRAO, NCCP, VNIITF, PA «Mayak», RIAR,

FMBA sites, as well as sites in certain territories of constituent entities of the Russian Federation

Second PDC start-up complex (MCC)

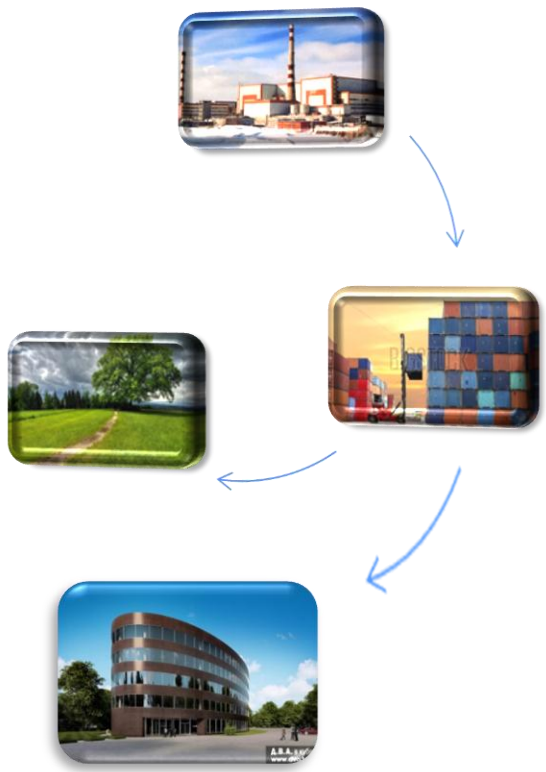
Staged shipment of RBMK-1000 SNF to centralized storage

Reprocessing RR and AMB SNF, damaged RBMK-1000 SNF and other

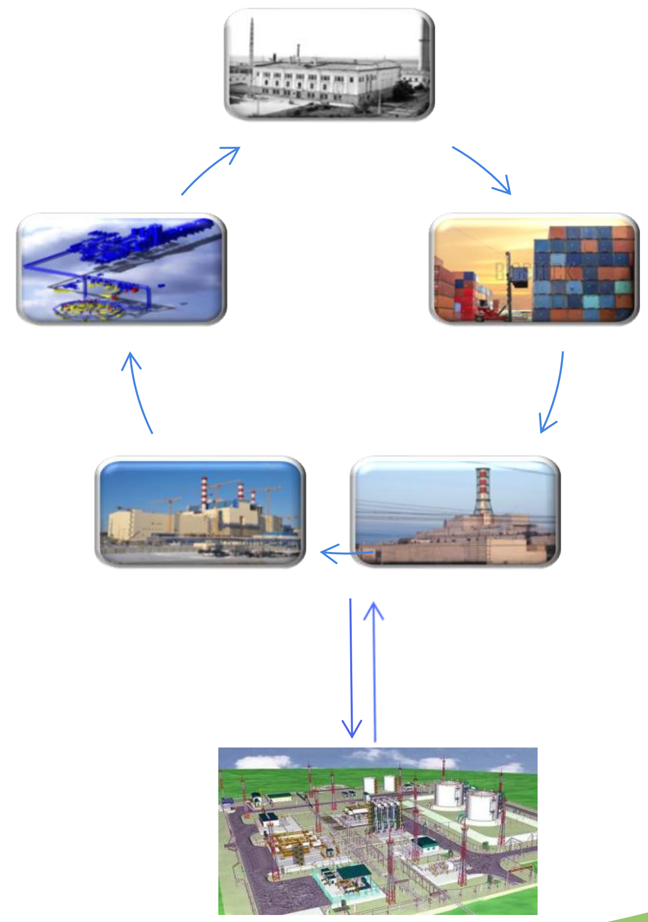
Life Cycle Options for an Industrial Site

1. Direct

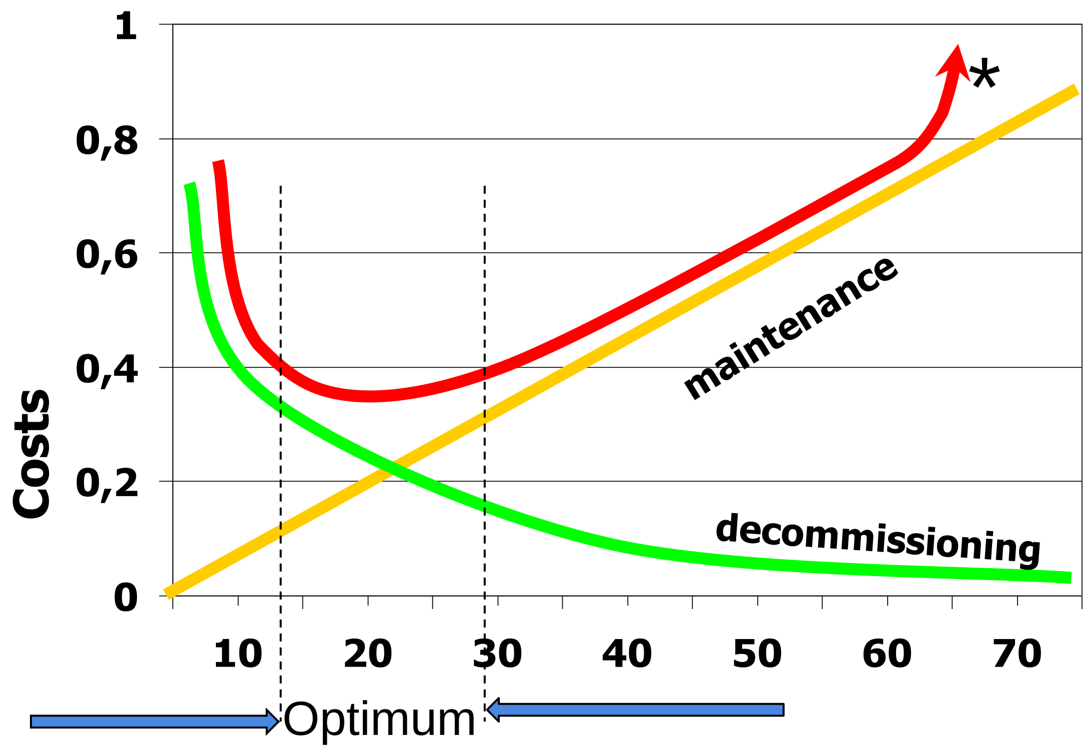
2. Hybrid



3. Continuous renovation



Optimal Strategy Selection: Nuclear and Radiation Hazardous Facilities (NRHF)

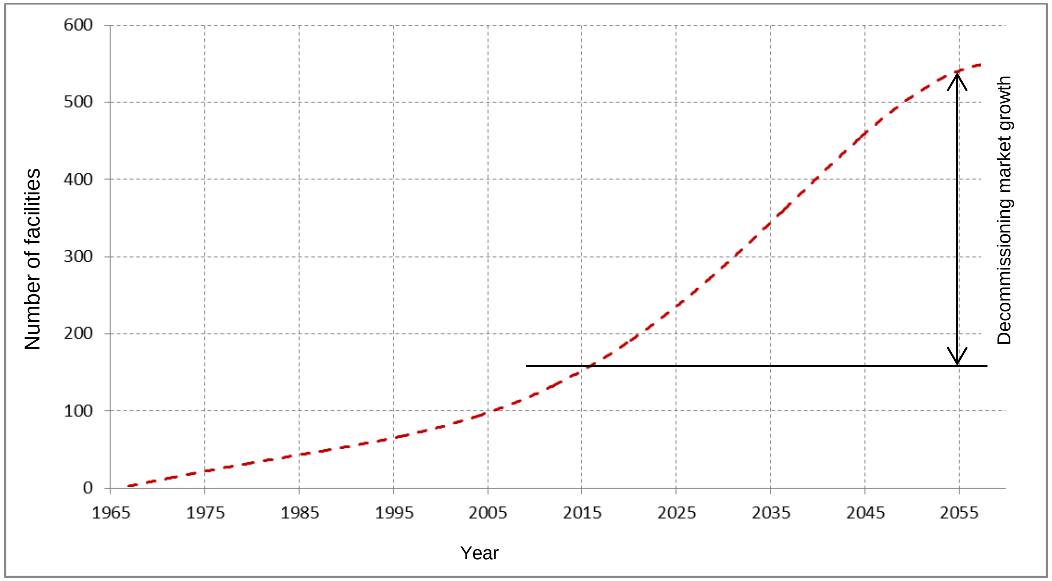


* - <u>Deferred dismantling</u>

- Degradation of structures and safety barriers
- Loss of information and personnel knowledge

Worldwide Trends in Decommissioning Schedules

Number of shutdown units

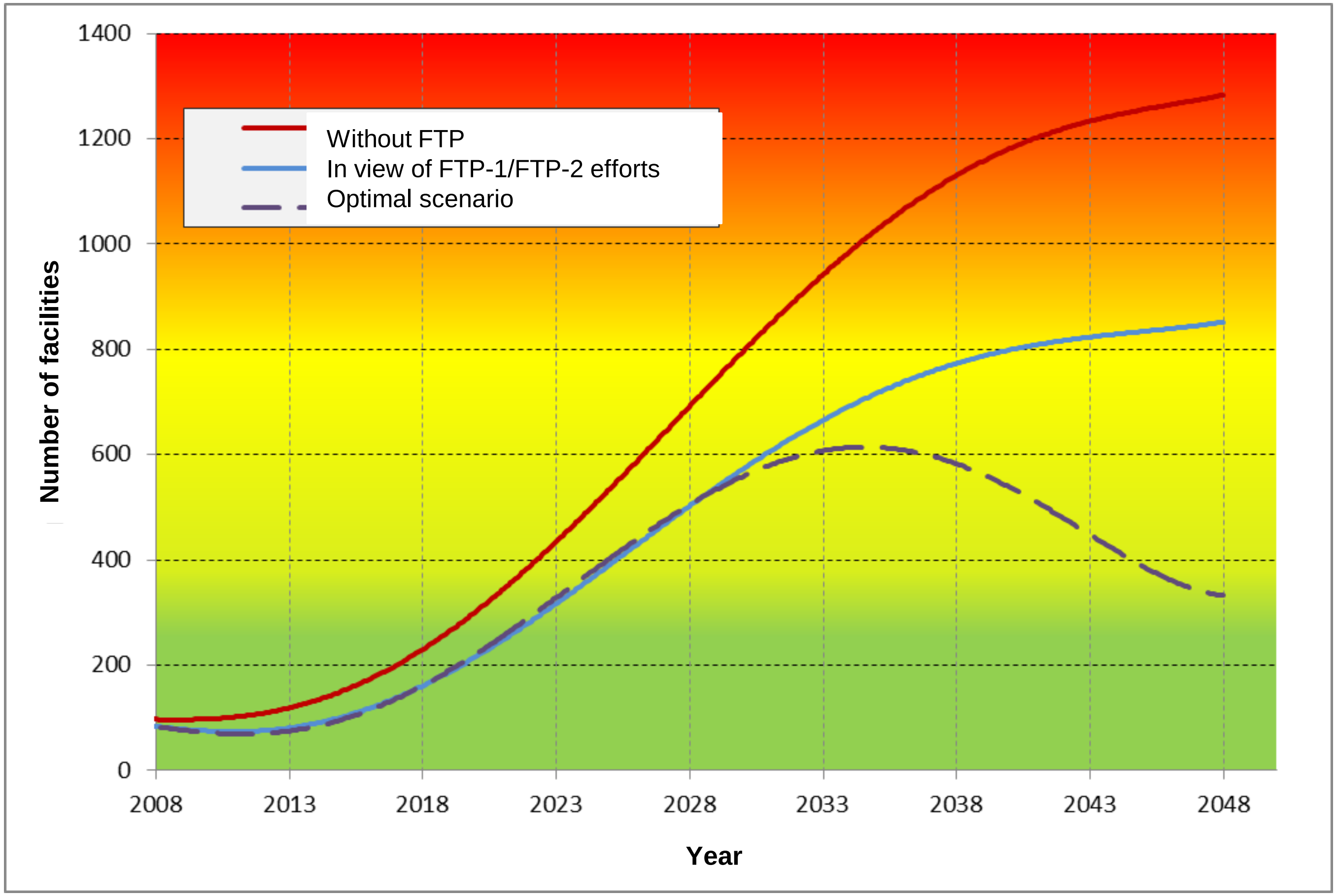


France:

- **The main strategy until 1999 – deferred dismantling.**
- **In1999, it was decided to proceed with decommissioning of heavy water reactor EL4 in Brennilis.**
- **In 2001, ASN adopted the strategy of immediate dismantling for all first generation nuclear power plants and the fast breeder reactor *Superphénix.* The program is scheduled for completion in 2036.**

Deferred Dismantling: Risks

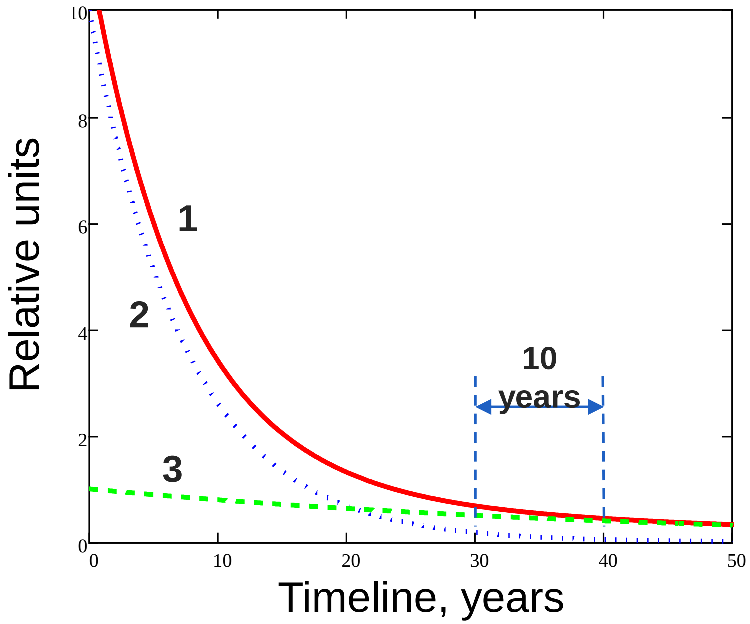
Decommissioning efforts shall be accelerated to avoid the build-up of problems:



Long-Term Storage: Short-Lived HLW

High-level waste at NPPs

A (Co-60)=10 A(Cs-137)

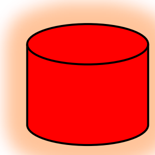


1 – total activity
2 – Co-60
3 – Cs-137

Building 178 at PA «Mayak»

Nuclear fuel element cladding
Short-lived radionuclides ($T_{1/2}$~5 years)

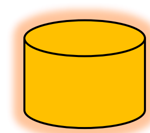
Without interim storage



HLW 0.2 man-mSv/m^3

	retrieval	disposal
	~550,000 RUB/m^3	567,000 RUB/m^3

Storage for 70 years



LLW 0.05 man-mSv/m^3

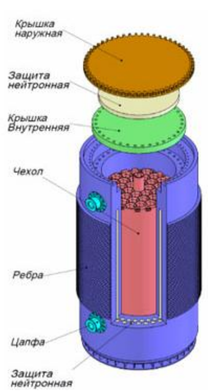
	retrieval	disposal
	~20,000 RUB/m^3	137,000 RUB/m^3

Long-Term Storage: SNF from Bilibino NPP

www.ibrae.ac.ru

Shipping options

~50 bln RUB

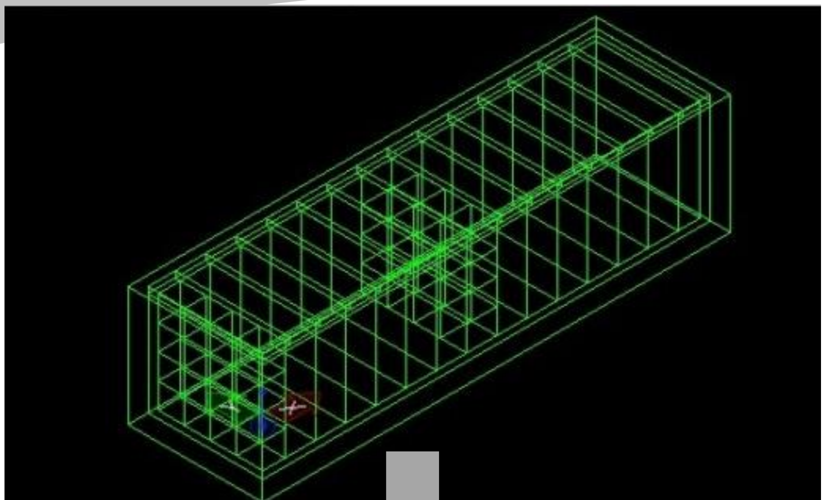


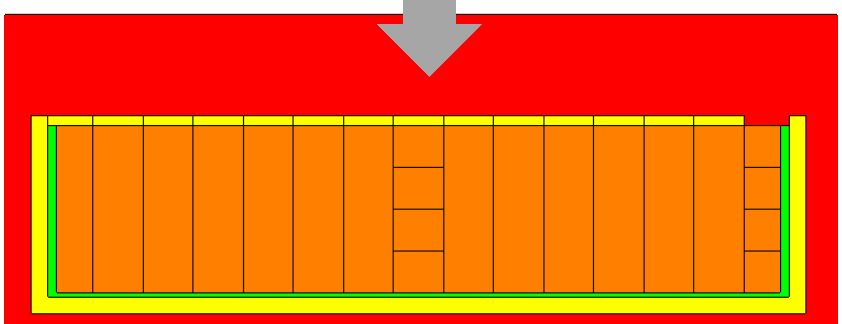
τ_{wall} ~ 24 cm
M_{empty} ~ 67 t
$S_{by\ air}$ ~ 4700 km

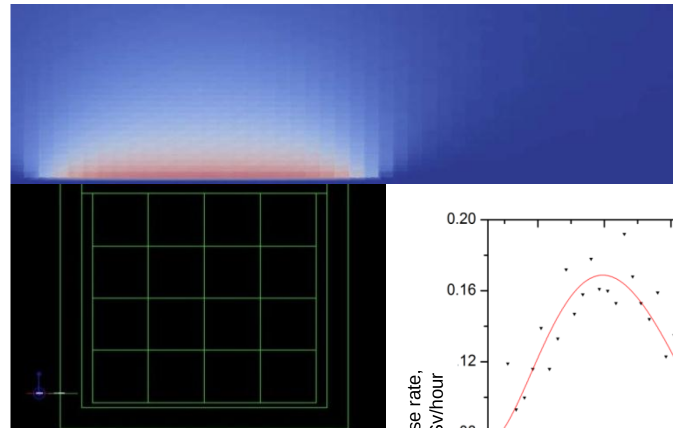
SNF storage

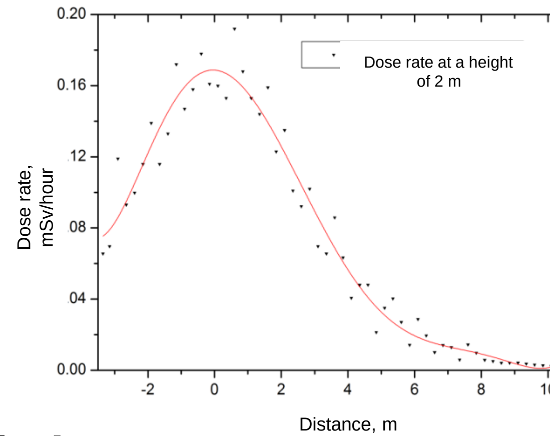
Major dose contributing RN	$T_{storage}$, years	TUK mass reduction, %	Economy t-km
Fission products, Co-60	5	-	-
Cs-137	30	13	**1,86E+07**
	60	16	**2,22E+07**
	90	18	**2,56E+07**
	150	25	**3,53E+07**

Decommissioning Safety: Calculation Methods to Optimize Radiation Exposure









Dose rate calculations

Retrieval of all RW will result in ~60 μSv of personnel exposure

Decommissioning Efficiency: Rational RW Management

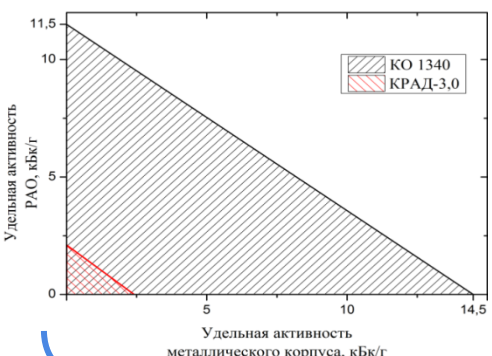
RSM – radioactive scrap metal

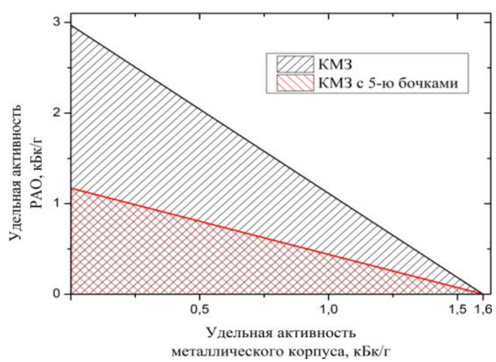
Processing → $ → Unconditional use

Disposal

Conditional use

Metal containers





Concrete slab reinforcement

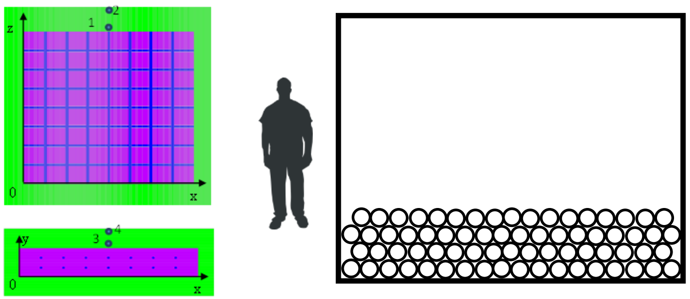


Рис. 3. Продольное (а) и поперечное (б) сечения армированной бетонной плиты:

Specific activity limit for reuse - 300 Bq/g

Summary

- **Meaningful progress has been made in planning and execution of NRHF decommissioning projects;**
- **Lessons learned from FTP NRS activities show that project costs can be reduced through thorough elaboration of decommissioning plans and the use of the best practices;**
- **Minimization of nuclear legacy burden will significantly increase the efficiency of nuclear power sector in all respects (finance, ecology, competiveness, public acceptance).**

- I would like to acknowledge the contribution of all experts involved in the RW initial registration campaign!

- Thank you for your attention!