Fond za financiranje razgradnje NEK
Fund for financing the decommissioning of the Krško NPP

Radnička cesta 47
HR-10000 Zagreb

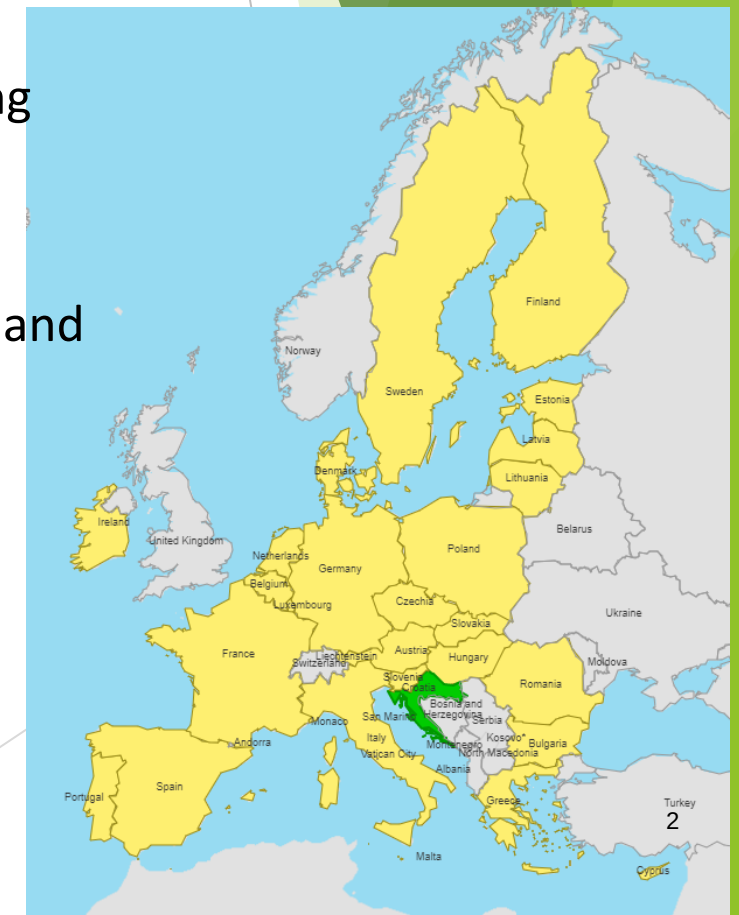
Small Inventory Program Needs in Decommissioning and Waste Management Croatia
For SNETP Forum, TS6, 4 February 2021

Andrea Rapić

Fund for financing the decommissioning of the Krško NPP, Zagreb, Croatia

Fund for Financing the Decommissioning of the Krško NPP

- The Fund for Financing the Decommissioning of the Krško NPP was founded in 2008 to fulfil obligations undertaken in the Bilateral Agreement
  - Acquisition, preserving and increasing the value of assets for financing the preparation, review and implementation of the Krško NPP Decommissioning and RW and SNF Disposal Programme
  - Preparation and drafting of the Krško NPP Decommissioning and RW and SNF Disposal Programme and its revisions (every 5 years, jointly with Slovenian ARAO Agency and Krško NPP)
  - Establishment of Radioactive Waste Management Centre in Croatia
  - Implementation of RW management in Croatia
- Headquarters: Heinzelova 70a, HR-10000 Zagreb, Croatia



The Krško Nuclear Power Plant

- Krško NPP, located in Krško, Slovenia
  - Operator: Nuklearna elektrarna Krško (NEK)
  - Built as a joint venture by Slovenia and Croatia
  - In operation: January 1983
  - 2-loop Westinghouse PWR
  - Thermal capacity: 1,994 MW_t
  - Net electrical output: 696 MW_e
- Nuclear fuel:
  - 5% enriched ^{235}U in form of UO_2
  - 121 FE in reactor; 18-month fuel cycle
- Reactor coolant: water with boric acid
- final shutdown: planned in 2023, prolonged till 2043
- Bilateral Agreement (2002)

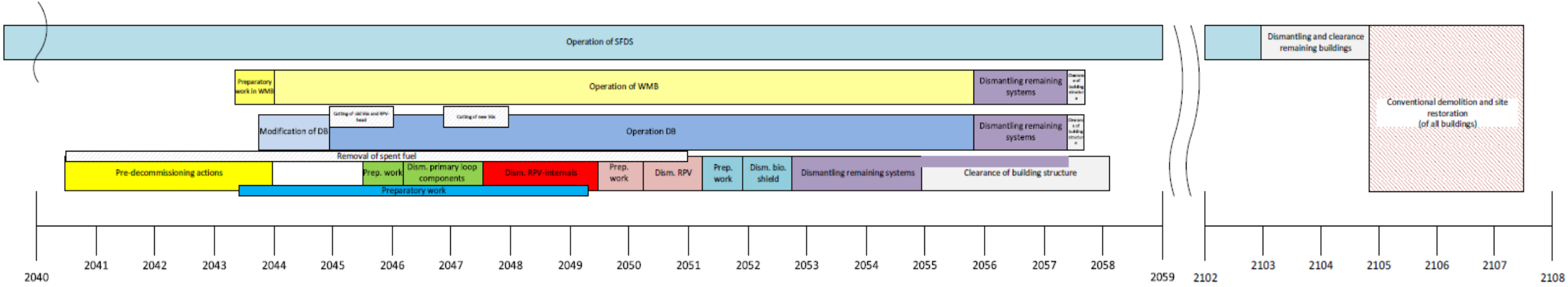
Krško NPP Decommissioning and RW & SF Disposal Program – Third revision

- Development of Site-Specific Decommissioning Plan for Krško NPP, 1996
- First Rev. of the Krško NPP Decommissioning and SF & LILW Disposal Program, 2004
  - Immediate dismantling strategy, generic solutions for RW and SF disposal
  - estimate decommissioning and RW and SF disposal costs for Krško NPP
- Second Revision – prepared 2009-2011, but never adopted
- **Third revision – prepared in 2018-2019 – approved in 2020**
  - **Safety upgrading, prolongation of lifetime**
  - **SF dry storage on site – changes to the "Decomm. end state"**
  - **Management of LILW – division and separate solutions (national programs)**
  - **Management of SF – joint solution**

Krško NPP Decommissioning

- **Immediate Dismantling Strategy**
  - wet storage (SF pool) will operate 5-7 years beyond NPP Krško operation for last discharges of reactor fuel
- **2 phases** of decommissioning - Spent Fuel Dry Storage (SFDS) on site
  - "Brown field" from 2058 - after dismantling all unnecessary buildings and decontamination & release of the remaining building structures (except for SFDS) and until end of SFDS operation
  - "Green field" status will be reached after dismantling of SFDS & related structures
- **2 scenarios**
  - Base case: SFDS in operation till 2103. "Green field" status in 2107
  - Sensitivity case: SFDS in operation till 2075. "Green field" status in 2080

Krško NPP Decommissioning

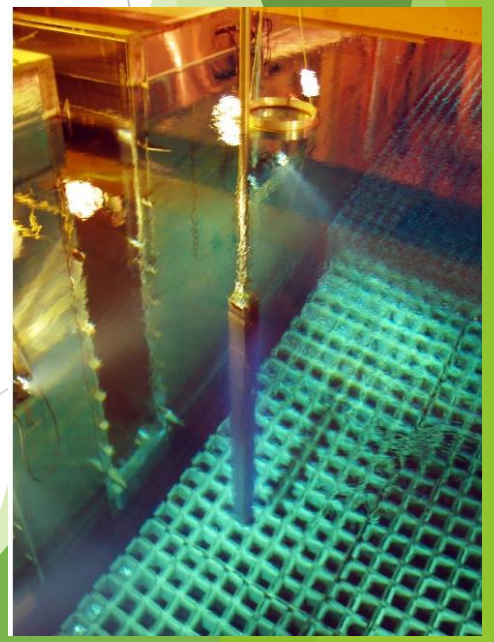


- Pre-decommissioning actions
- Preparation of the D&D works (shutdown/modification of systems, decontamination of primary circuit,…)
- Dismantling of primary loop components
- Dismantling of the RPV internals
- Dismantling of the RPV
- Dismantling of the biological shield
- Dismantling remaining systems
- Clearance of building structures
- Conventional demolition and site restoration

Krško NPP RW & SF Disposal - Inventory

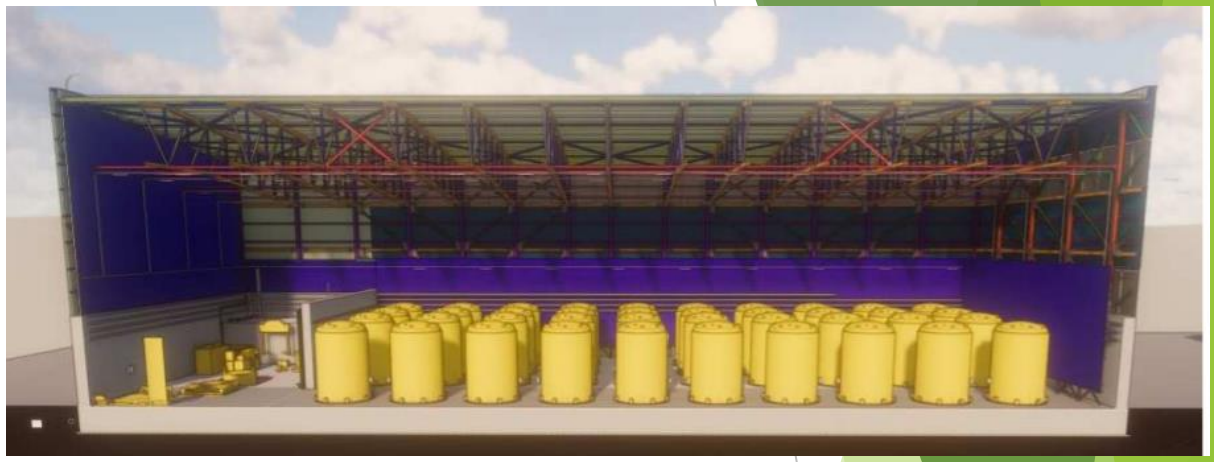
Period of generation	Type of LILW	Source of data	Mass (t)	Volume (m^3)	Activity (TBq)*
1983–2018	Operational	Interim storage Inventory	4,880	2,295	59.8
2019–2023		Assessment	265	160	14.4
2024–2043			885	550	43.3
2043–2058	Decommis-sioning		2,860	2,850	4.9
2103–2106			390	405	0.7
		Total	**9,280**	**6,260**	**123**

Year 2018	Year 2043			
No of SFE	No of SFE (Mass, t)	Activity (TBq)	Decomm. HLW (Mass, t)	Activity (TBq)
1,266 SFE	**2,282 SFE (926,5 t)**	$8,4 \times 10^8$	**82 t**	$1,6 \times 10^4$

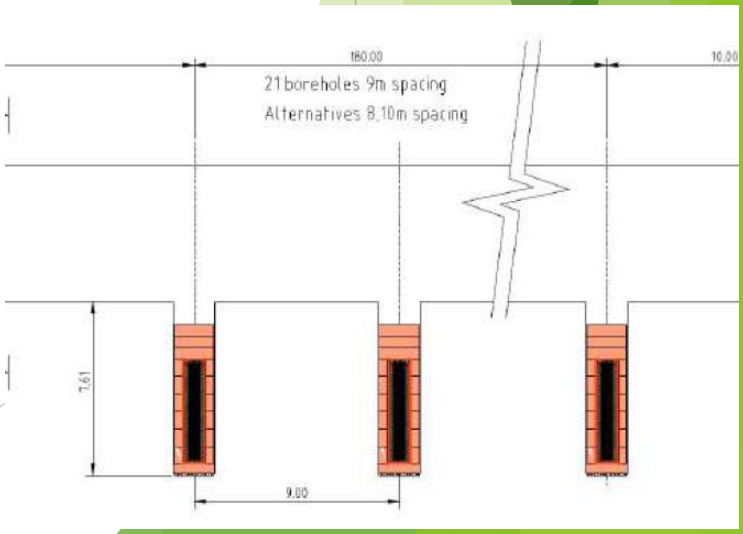


Krško NPP SF/HLW Predisposal and Disposal

Management of SF – joint solution



- **SF dry storage at Krško NPP site**
  - Construction 2020/21
  - Operation starts 2022/23
  - license for 60 or more years
  - 2 options of operation: 2075 or 2103
- **“Dual track policy” - Joint SF/HLW Disposal Project (Cro & Slo) or multinational solution**
  - Baseline scenario: deep geological repository at suitable location in Croatia or Slovenia
  - Reference disposal concept: SKB KBS-3V model
  - Planed operation: 2093-2103
  - Multinational Solutions - ERDO Association



LILW Division and Takeover Strategy

- LILW division & takeover (half in Slovenia, half in Croatia)
- Division according the waste stream, package type and total activity
  - technically feasible, not economically demanding
  - present circumstances in interim storage and knowledge of waste packages condition should improve
- two phases of takeover:
  1) stored operational LILW – 2023-2025 (last in – first out strategy)
  2) operational & decommissioning LILW – 2050-2058

LILW inventory until 2043

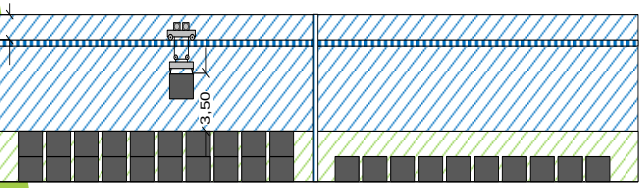
	WPs	Group 1 Mass (kg)	Group 1 Activity (Bq)	Group 1 No of WPs	Group 2 Mass (kg)	Group 2 Activity (Bq)	Group 2 No of WPs
Existing WPs	FWP in TTC	2,035,536	2.13E+13	1,086	2,036,332	2.13E+13	1,085
	FWP in D6	124,991	7.39E+10	308	125,424	7.39E+10	309
	I	24,799	1.11E+08	40	24,789	1.11E+08	40
	FWP in 200l drums	235,056	8.59E+12	451	235,032	8.58E+12	452
	Total	2,420,382	3.00E+13	1,885	2,421,576	3.00E+13	1,886
	Difference betw. G1 & G2	-1,194	1.06E+09	-1			
	Difference (%)	-0.0123%	0.0009%				
Projection	Estimation of TTC after treatment	16,637	2.05E+10	13	16,786	2.12E+10	14
	Projection for 2018-2023 (TTC)	132,024	7.22E+12	94	132,024	7.22E+12	94
	Projection for 2024-2043 (TTC)	442,667	1.44E+12	315	441,053	1.42E+12	314
	Total	591,328	8.69E+12	422	589,863	8.67E+12	422
	Difference betw. G1 & G2	1,464	1.95E+10	0			
	Difference (%)	0.0620%	0.0562%				
	Grand Total	3,012,519	3.8689E+13	2,307	3,012,384	3.8668E+13	2,308
	Difference betw. G1 & G2	135	2.06E+10	-1			
	Difference (%)	0.0011%	0.0133%				

RW Management Scenarios – National programs

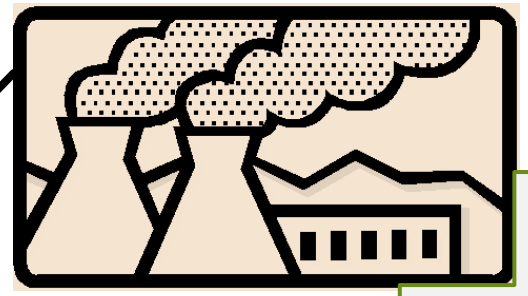
Management of LILW in Croatia

LILW treatment, conditioning & packaging

Long-term storage RWM Centre, Čerkezovac



Near surface, vault type repository, Trgovska gora

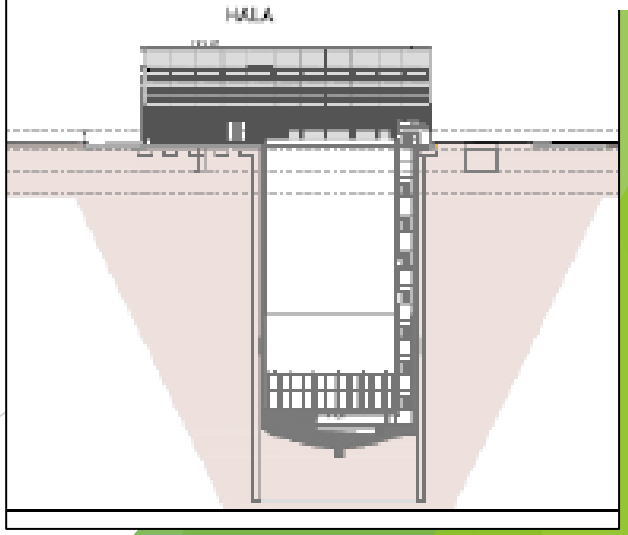


NPP Krško

Management of LILW in Slovenia

On site LILW conditioning & packaging

Silo Repository, Vrbina



National RW Management Program – Croatia

- RW & SF form the Krško NPP (Bilateral Agreement)
- IRW and DSRS from medicine, industry, science, education and past public use
- Temporary Interim Storage Facilities – closed and remediated
  - Ruđer Bošković Institute (RBI)
  - Institute for Medical Research and Occupation Health (IMROH)
  - At users/generators site

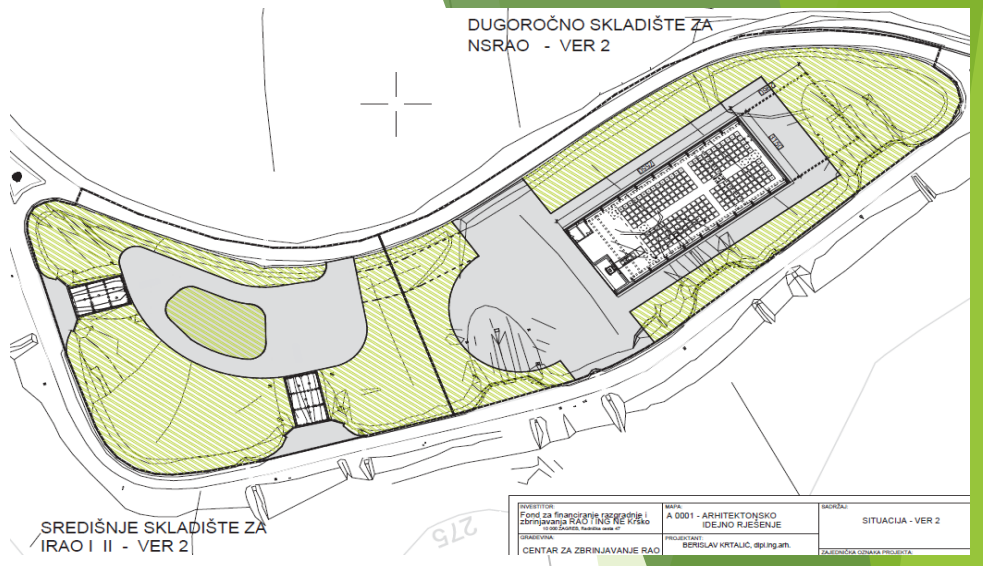
Institutional RW and DSRS Inventory

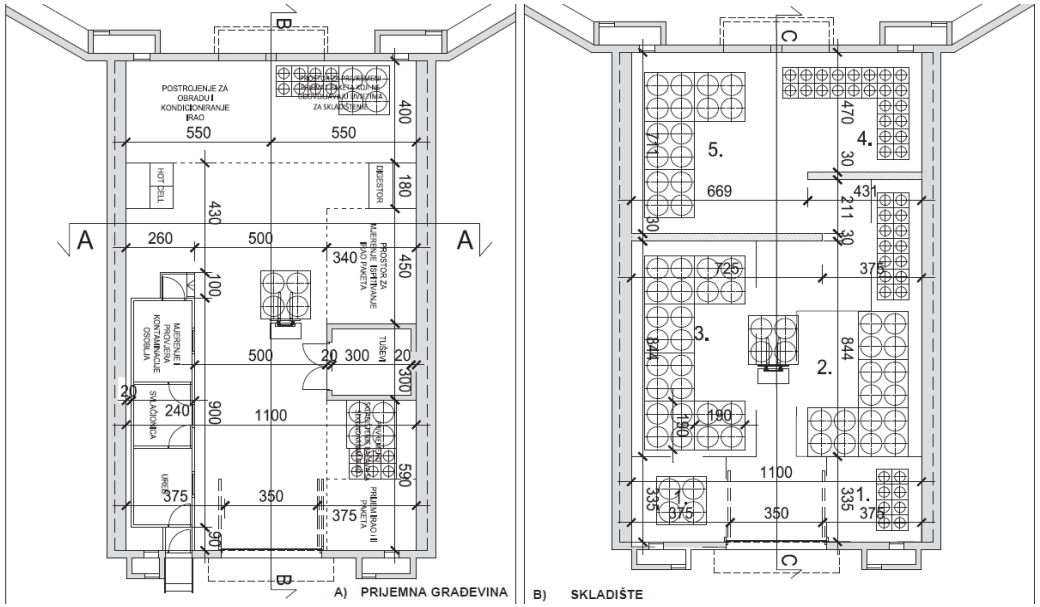
RW and DSRS type	Current volume and activity		Expected volume and activity in 2060	
Short lived	7,53 m^3	1,28 TBq	100,0 m^3	24,0 TBq
Long lived	3,81 m^3	2,05 TBq		3,0 TBq
Total	11,34 m^3	3,33 TBq	100,0 m^3	27,0 TBq

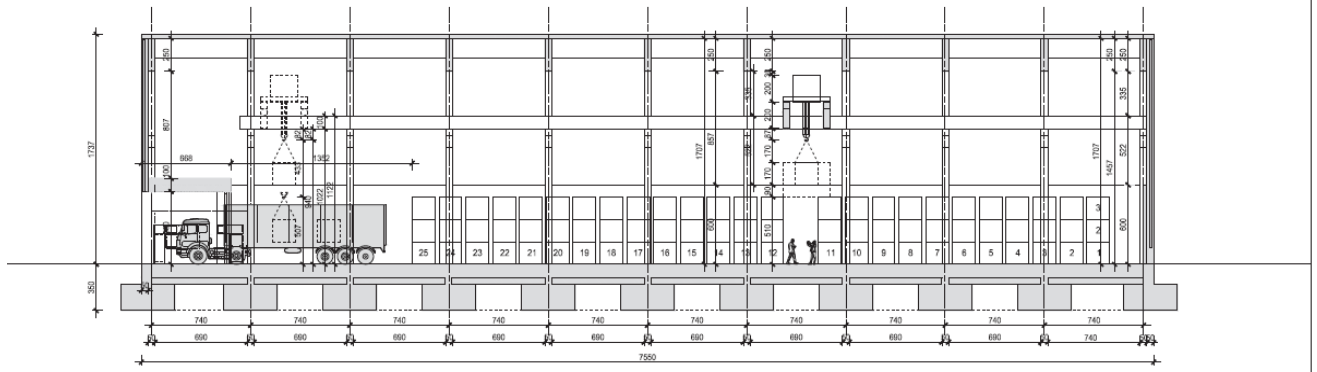
RW Management Centre in Croatia

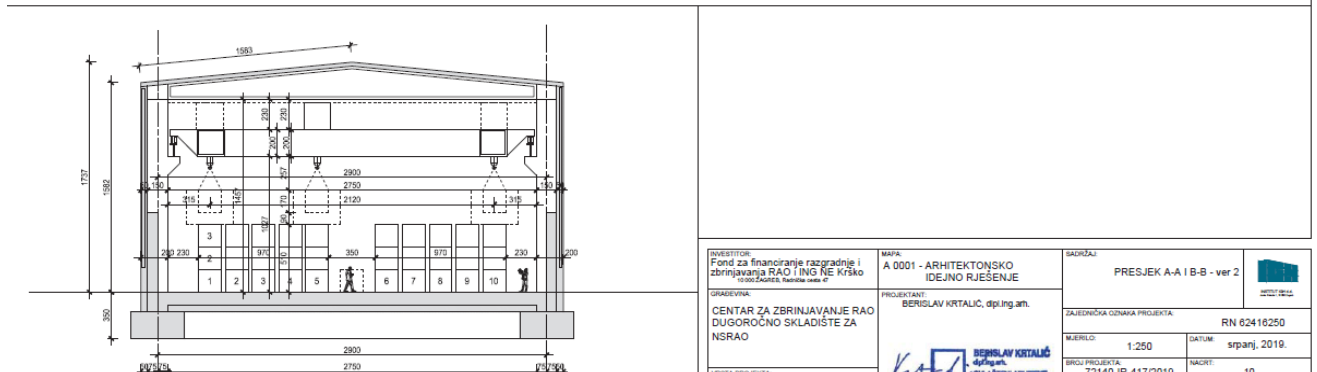
At Čerkezovac location

- Central storage for institutional RW and DSRS
- Long-term storage for Krško NPP operational LILW
- Administrative building
- Info-centre









Technology development requirements

- On site RW and RW packages characterisation
- Mobile predisposal options (characterisation, treatment, conditioning, packaging)
- Treatment and conditioning of relatively small amounts of specific RW streams
  - Evaporator concentrates and tank sludges (IDDS products) - corrosive (gas generation)
  - Compacted RW containing organics / corrosive (possible gas generation)
  - Spent primary and secondary iron resins (IDDS products/Vermiculite matrix) – hygroscopic (swelling)
  - Spent filters – in cement matrix but containing organics and gaps
- Storage/disposal container aging calculations

Thank you for your attention

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Zbrinjavanje radioaktivnog otpada