RD&D Programme on RWM
Institute for Nuclear Research, Romania

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Outline

- Nuclear program in Romania
- RWM strategy
- ICN competences and research in RWM
- Current national strategy for SF and LL-ILW management
  - Geological disposal concept
  - siting
- Conclusion

Main waste sources

- ***Nuclear Power Plant (NPP)***
  - Cernavoda U1, CANDU type, 720MWe, in operation from 1996
  - Cernavoda U2, CANDU type, 720MWe, in operation from 2007
  - **Cernavoda U3&4**, CANDU type – are foreseen to be constructed (2020)
- **Research reactors**
  - TRIGA 14 MW – in operation from 1979 (ICN Mioveni)
    - all HEU SF was sent back to USA
    - core conversion since 2004 - LEU SF management by Romanian authorities
  - VVER – shutdown in 1997, under decommissioning (IFIN-HH Bucharest)
    - all SF (enriched U) was sent back to the Russian Federation
- **Alfred demonstrator for LFR technology** is foreseen to be built on ICN site

Waste Management Strategy (1)

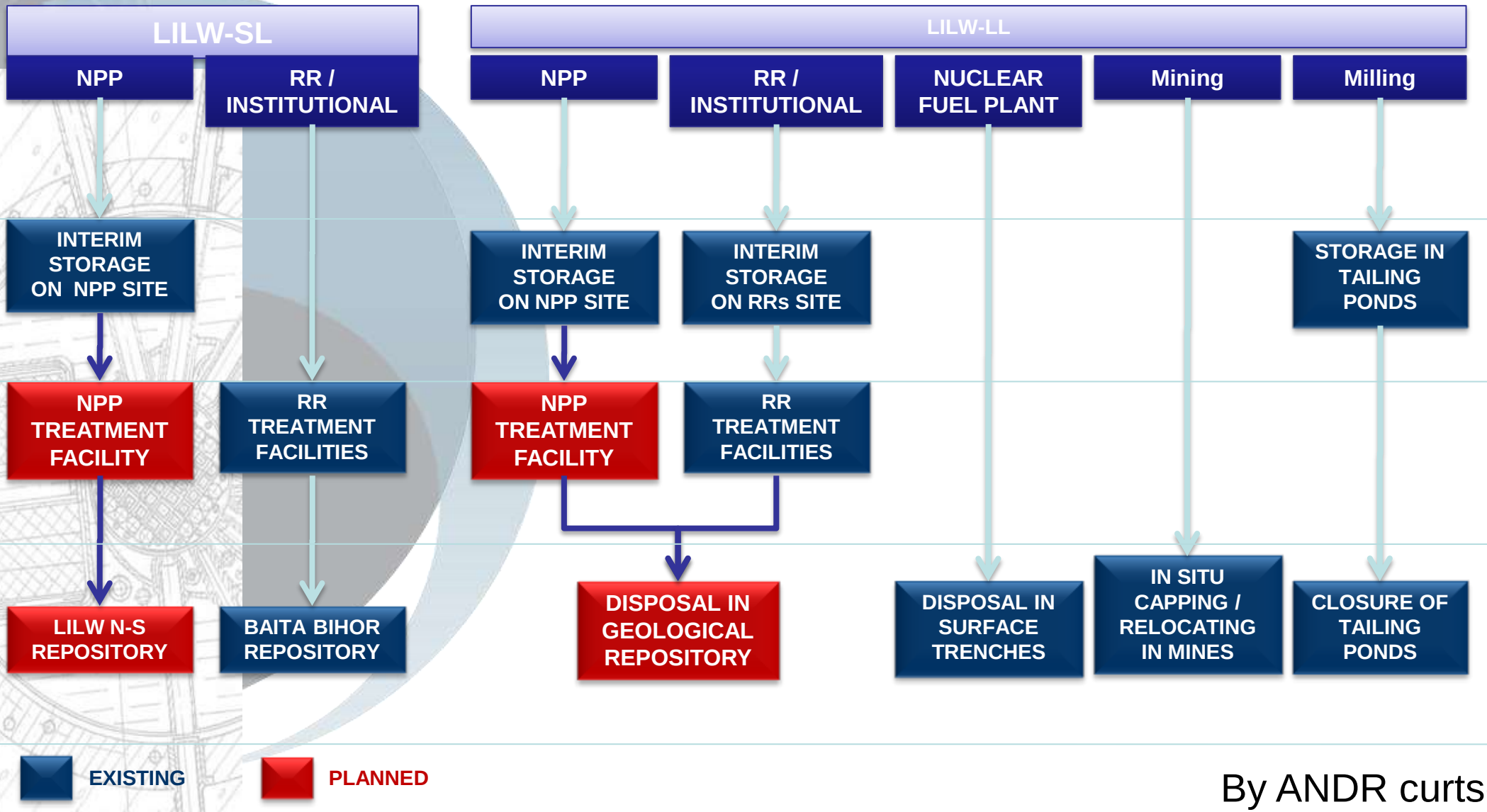
- **Responsible for waste management in Romania:** Nuclear Agency and for Radioactive Waste - **AN&DR**

- **SL-LIL waste** generated from Cernavoda NPP will be disposed of in a **near surface repository** located on **Saligny site**
- **LL-ILW** - to be disposed of in **deep geological disposal** foreseen to be commissioned **in 2055**
- **CANDU spent fuel**
  - SF is considered waste – direct disposal in **deep geological disposal**
  - stored for cooling in the reactor pools for min. 6 years
  - transferred in the dry storage facility built in 2003 on Cernavoda site
    - MACSTORE Type
    - the dry storage period was design for 50 years but the life time extension of the dry storage modules is expected to be needed until the deep geological disposal will be available

Waste Management Strategy (2)

- **Institutional radioactive waste** generated from research facilities (at IFIN-HH Bucharest and ICN Pitesti), and also from other industrial, medicine and research activities are disposed of in **National Repository Baita Bihor** (an old uranium mine).
- **Liquid and solid radioactive waste** generated from CANDU fuel fabrication (FCN) are processed at the Treatment and Conditioning Plant (STDR) of ICN Pitesti in order to **recover the natural uranium** (it is returned to the FCN)
- **Mining waste** – in situ capping/relocating in mines
- **Milling waste** – stored in tailing ponds

The Romanian Strategy for Safe Management of Radioactive Waste – LILW- LL



By ANDR curtsey

ICN competences and research in RWM

1. Radioactive waste characterization
2. Development of the treatment & conditioning technologies
3. Testing of different matrices for waste conditioning
4. Radioactive waste disposal

Radioactive waste characterization (1)

Competences:

- ⇨Gama scanning of conditioned waste drums before their transport to to be sent to National Repository Baita Bihor
- ⇨Measurement of **uranium** from liquid and solid waste from CANDU fuel fabrication
- ⇨Measurement of **^{14}C and ^{3}H** from aqueous, organic and solid waste
- ⇨Measurement of **^{90}Sr and actinides** in Cernavoda NPP effluent samples
- ⇨Characterization of **i-graphite** from TRIGA thermal column (activity and distribution of ^{3}H, ^{14}C, ^{152}Eu, ^{154}Eu, ^{60}Co, ^{137}Cs – under CARBOWASTE project)

Radioactive waste characterization (1)

Research:

Developing of high efficiency methods for waste dissolution and radionuclides separation for their subsequent measurement by:

- high resolution gamma spectrometry with anti-Compton system for γ-ray and X-ray emitters
- LSC for α-ray and β-ray emitters
- XRF, ICP-OES and ICP-MS – for qualitative and quantitative measurements

⇨Methods for ^{129}I, ^{99}Tc, ^{36}Cl, ^{90}Sr, ^{63}Ni separation from different waste streams

⇨Method for measurement of inorganic and organic species if C-14 in CANDU spent ion exchange resins and Zy-4 tubes (under CAST project)

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Treatment & conditioning technologies

Achievements:

- Technologies for treatment of the **liquid and solid waste** contaminated with **natural uranium**, with uranium recovery – applied to the waste generated from CANDU fuel fabrication
- Technologies for treatment & conditioning of **spent ion exchange resins, liquid and solid waste** – applied to the waste from TRIGA reactor and other research activities
- Technology for **decontamination of wastewaters** – applied to the liquid waste from Cernavoda NPP
- Methods for chemical removal of **gamma radionuclides** from **i-graphite**

Treatment & conditioning technologies

Research:

- Studies for alternative solution to the classical technologies in order to:
  - **reduce the volume** of the waste to be disposed
  - decrease the content of the **chemicals and hazardous substances** in the effluents
- Innovative techniques such as **semi-permeable membranes**, **micro-filtration**, **ultra-filtration**, **reverse osmosis**, **liquid membranes** are tested on different waste streams, both from TRIGA reactor and Cernavoda NPP
- Developing technologies for specific CANDU waste streams: **spent molecular sieves**, **radioactive sludge**

Testing of conditioning matrices

Achievements:

⇨**Approved matrices for conditioning of different waste in order to meet the WAC to the National Repository Baita Bihor**

⇨**Proprietary receipt for conditioning of organic liquid waste (spent solvents and oils) in quick setting mixed binder system**

Research:

- Concrete durability:
  - Investigations on hardness structure forming
  - Testing the mechanical strenght
  - Thermo-gravimetric analysis
- Glass – experimental tests using a high frequency induction equipment in order to get glass matrix for imobilization of ILW

Radioactive waste disposal - competences -

Site selection and characterization - for SL-LIL waste disposal

- Elaboration and implementation of:
  - ✓site characterization methodology
  - ✓pre-operational monitoring program
- Evaluation of structural, physical & chemical, hydro-geological properties of natural and engineered barriers of a disposal system: (loess, clays, limestone concrete, bentonite)
- Groundwater chemistry
- Radionuclide transport behavior through the disposal system
- Source term modeling
- Water flow and contaminant transport modeling
- Uncertainties analysis
- Performance and safety assessment for Saligny LILW repository

Research on Geological disposal

- No intensive research program on geologic disposal, but the competences gained from surface disposal program could be used and extended to the specific tasks for geological disposal

- Specific studies for geological disposal were related to:
  - **Inventory:** experimental methods development for radionuclide measurement
  - **Concept:** optimisation of the gallery in granite and clay
  - **Siting:** desk research bases on the existing geology data
  - **Near field:** laboratory tests on backfill materials (bentonite –under 7th FP project **FORGE** , crushed salt)
  - **Spent fuel behavior:** UO_2 dissolution in different pore water compositions
  - **Material behavior:** corrosion mechanisms of canister – Ti alloys
  - **Modeling:** radiological impact of a generic repository in granite and salt (SF only)
  - **Public involvement:** methodology for public participation (under 7th FP project **IPPA**)

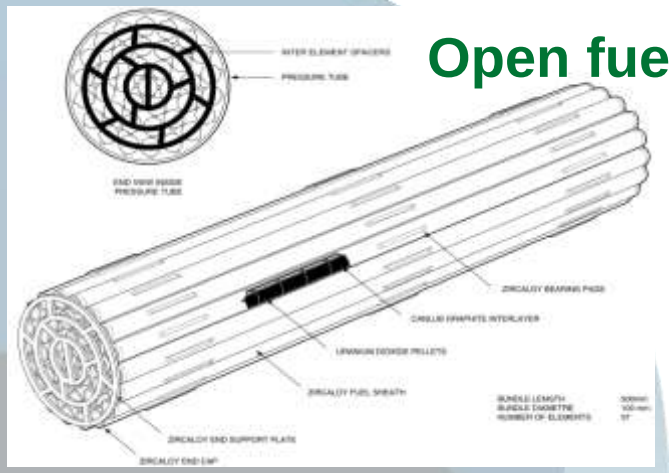
- Actual research activities:

⇨ pH influence of radionuclide sorption – under **NSRAWD 2 project** - IFA-CEA cooperation

⇨ C-14 release from CANDU Zy-4 tubes and spent ion exchange resins - under **CAST project** (Euratom FP 7)

⇨ C-14 and Ra-226 sorption and diffusion on concrete in different degradation stages – under **CEBAMA project** (Euratom Horizon 2020)

Current National Strategy for SF and LL-ILW

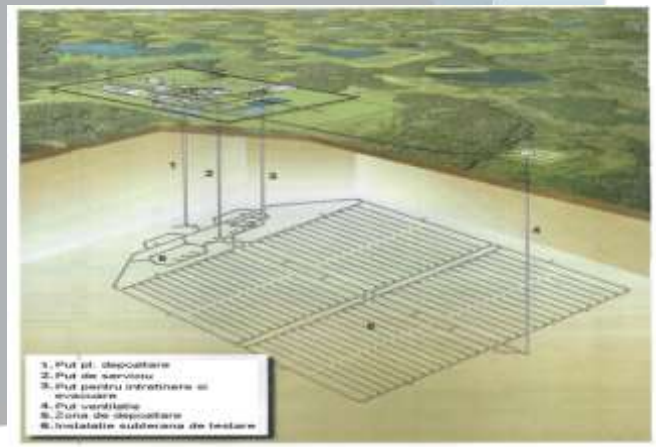


Open fuel cycle

Wet storage (6-7 years)

Dry storage (50 years)

2055



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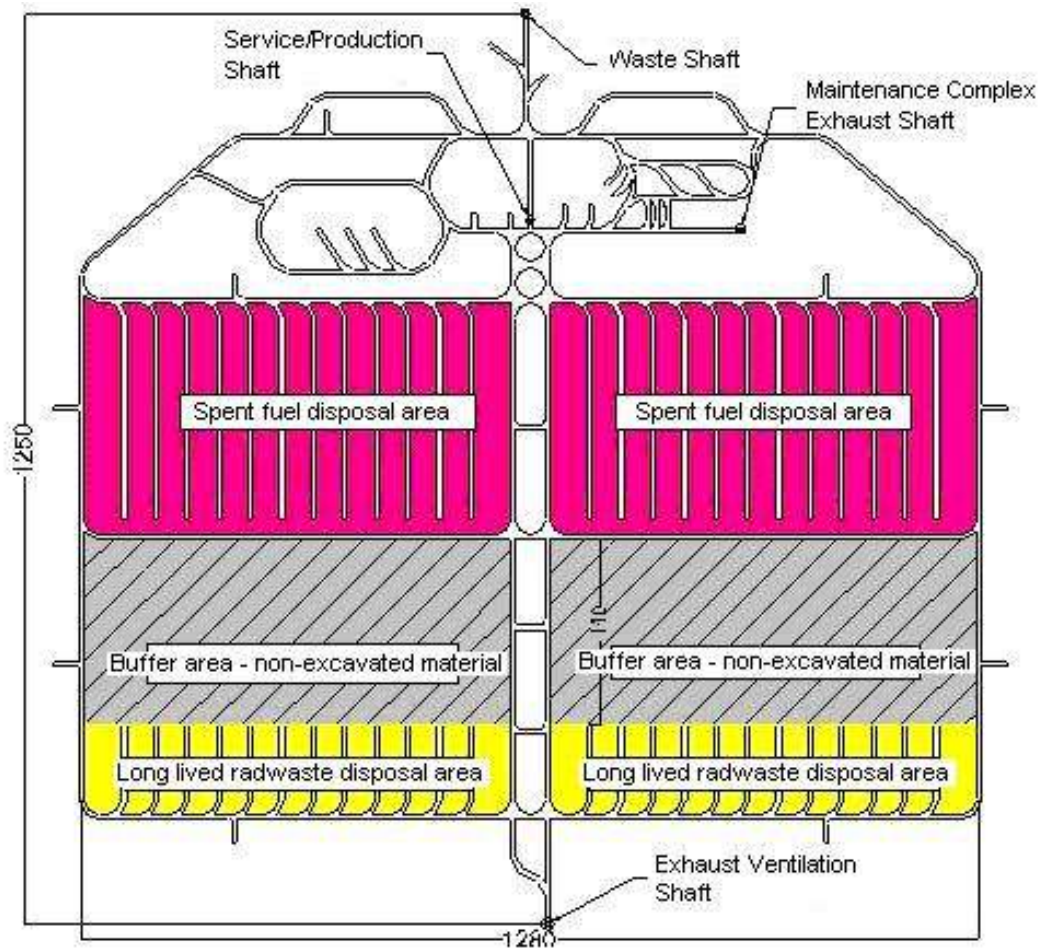
Geological disposal concept (1)

- GR facility will dispose **both SF and long lived wastes** from 4 Cernavoda Units in operation for 50 years and their decommissioning;
- **Non-retrievable** facility located at 500-1000m depth;
- Repository concept - **generic** (for costing purposes) based on **Canadian Concept** for a Deep Geological Repository for CANDU spent fuel;
- Construction, in advance, of an Underground Research Laboratory



GD general layout (by CITON)

Geological disposal concept (2)

- The spent fuel will be encapsulated in copper/steel double-shell containers with a capacity of 324 bundles, and will be horizontally emplaced inside the emplacement rooms
- The basic elements are:
  - copper/steel double-shell containers for spent fuel encapsulation (324 bundles capacity);
  - reinforced concrete containers for LL-ILW
  - buffer material surrounding the spent fuel/LL-ILW package (bentonite)
  - seals and plugs to isolate disposal galleries from the transport and access galleries (bentonite/concrete)
  - backfill material to fill the transport and access galleries (bentonite /sand mixture);
  - buffer area between SF and LL-ILW (non-excavated host rock)
  - host rock – assumed to be either granite or clay.

Sitting

- There is **no host rock** established and **no proposed site**. But:
  - 6 geological formations were identified, potentially favorable to host the geological repository:
    - green schist from Dobrogea
    - granite
    - basalt
    - clay
    - salt
    - volcanic stuff
- 2007-2008 – ANDR carried out the IAEA TC project - "Developing a geological disposal concept for spent nuclear fuel in Romania" (TC ROM 3/005)
  - Output – analysis of green schist properties from Central Dobrogea at NAGRA laboratories (Switzerland);
- In the last years, AN&DR investigated (using geophysical and existing borehole data) the anhydrides located in northeast of Romania

Next in DGR

- update the national inventory
- review the RW National Strategy according to the requirements of Council Directive 2011/70/EURATOM;
- other options are analyzed, such as recycling the spent nuclear fuel generated by CANDU Units of Cernavoda NPP, regional repository, deep geologic boreholes, etc.
- elaborate and implement a strategic programme for the initial stages of repository development, including:
  - safety case development
  - site selection
  - surface-based site characterisation,
  - development of a URL,

Ways of knowledge transfer

- Build missing national competence specific for GD:
  - safety case development
  - advanced techniques for site characterisation
  - thermo-hydro-mechanics analysis
  - interface processes
  - modeling
- Involvement of ICN personnel in common projects on geological disposal
- Access to URL experiments (mainly in clay and granite)

Conclusion

- Romania has a small size nuclear power programme, relatively younger, which shift the GD time-table;
- The legal frameworks ensure the safe management of SF and LL-ILW, according to best international practices;
- Currently direct disposal of SF and LL-ILW in geological repository is considered the end-point which guaranties sustainable, safe and secure long-term management;
- The programme for GD implementation is in the initial stages:
  - Generic disposal concepts have been proposed;
  - No siting procedure was yet initiated but some potential host rocks have been identified based on existing geological data
  - Dispersed R&D activities on GD have been developed
- Updated strategies and implementation plans are in progress
- Implementation of national strategies needs coherent R&D national programs in support to GD development able to integrate whole existing national expertise and to allow new competence building.