# Radioactive Waste Management at the NCSR “Demokritos”- Greece

Anastasia Savidou

Radioactive Materials Management Laboratory

Institute of Nuclear & Radiological Sciences & Technology, Energy & Safety,

National Centre for Scientific Research “Demokritos”

# National Frame for RadWaste & Spent Fuel (1)

*Radiation protection regulations* (Joint Ministerial Decision No. 1014 (FOR) 1994, Second Issue, Folio No. 216, March 6, 2001)

"Establishing a National framework for the nuclear safety of nuclear installations", Presidential Decree No. 60, Folio No. 111, First Issue, May 3, 2012, (transposition of the Council Directive 2009/71/ Euratom of 25 June 2009)

*"Establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste",* Presidential Decree No. 122, Folio No. 177, First Issue, August 12, 2013, (transposition of the Council Directive 2011/70/ Euratom of 19 July 2011)

*"Establishment of the National Policy for the management of spent fuel and radioactive waste",* Joint Ministerial Decision, No 131207/I3/ Folio 1858/27.08.2015 (NEW!)

# National Frame for RadWaste & Spent Fuel (2)

**JMD: national Policy** (NEW!)

- General principles
- Basic guidelines
- Organizations for implementation

**PD: National Frame** (NEW!)

- Basic principles
- Safety requirements for RW & SF management
- Safety requirements for RW disposal
- Responsibilities of organizations
- National Program
- System of licensing & inspections and audits
- Management procedures for RW & SF: import, transport, treatment, radiation protection, release, emergency, QA, clearance
- Notification and Public involvement
- Penalties
- Compensational benefits

**JMD: Licensing**
Facilities for RW management (not disposal facilities)

- Feasibility study
- License for establishment at a specific location
- Approval of the plan and license for construction
- Operation license
- Decommissioning License
- Release of site

**National Program**

- Targets
- Milestones & Schedules
- Inventory
- Management procedures/ technology

- Research and development
- Responsibility for implementation – performance
- Costing – funding
- Transparency & Notification

# National Policy – Main points


- Disposal will be allowed only for Radioactive waste produced in Greece
- Until the establishment of the disposal facility the waste shall be stored in authorized interim storage facilities
- RR SF is returned to the manufacturer or supplier country, according to applicable agreements.
- Sources are returned to manufacturer or producer according to applicable agreement submitted to GAEC before importing

# RW management in Greece – Main points


- Current practices: storage on site or in NCSR “D” interim storage, storage for decay and clearance, storage/ export
- No specific clearance only the general clearance (RPR, RP122 part I)
- Registry for all radioactive waste - sources – material by GAEC (independent regulatory authority)
- No official plan for radioactive waste disposal facility in the country.
- Appropriate disposal facility/ies types will be decided in the next years
- Integrated strategy for radioactive waste management will be determined in the next years

# National Centre for Scientific Research "Demokritos"

Located at Aghia Paraskevi, Athens

Total staff of about 1000

## INSTITUTES

- **Institute of Nuclear & Radiological Sciences & Technology, Energy & Safety (INRaSTES)**
- Nuclear and Particle Physics
- Institute for Advanced Materials, Physicochemical Processes, Nanotechnology & Microsystems
- Institute of Biosciences & Applications
- Informatics & Telecommunications

# The Greek Research Reactor (GRR-1) of INRaSTES

**GRR-1**

5 MW open pool type

MTR-type fuel elements

Be reflectors

Material of PCS is Al, Steel

First criticality 1961

Stop of operation in 2004

Extended shut down (6/6/2014)

# The RMML Facilities at INRaSTES

**(1) The Radioactive Waste Interim Storage Facility**

- Compartments for VLLW, LLW and radioactive sources

**(2) Three Storage facilities with historical waste**

**(3) Storage of ILW (not for near surface disposal) in the reactor building**

**(4) The station for segregation and cementation of radioactive waste**

- Clearance of VSLW
- Natural and radiological sorting/ clearance VLLW
- Cementation equipment (for sludge and powder)

**(5) Liquid waste retention tanks (15) and an old liquid waste evaporator**

# For planning predisposal and disposal technologies - integrated solution (1)

Inventory of waste and materials:

- Institutional/ Historical waste at the NCSR “D”
- Future wastes from decommissioning of NCSR “D” nuclear facilities
- Disused/ Spent/ Orphan sources (without back-end contract) collected in case of emergency and kept in the interim storage of RMML at the NCSR “D”
- Disused/ Spent sources kept on site (industries, universities, hospitals, foundries etc)
- NORM wastes

# For planning predisposal and disposal technologies - integrated solution (2)

Preliminary Assessment of the Inventory

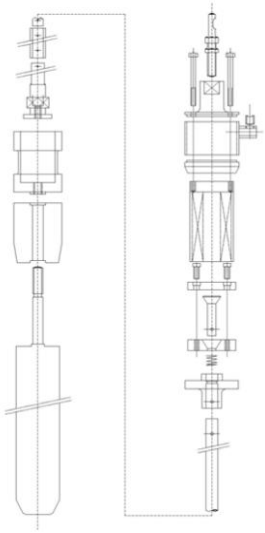
Estimation of the amount and kind of materials for the existing radioactive waste, systems, infrastructures and facilities which are contaminated or activated from the past activities in the NCSR “D”

- GRR-1 components and systems

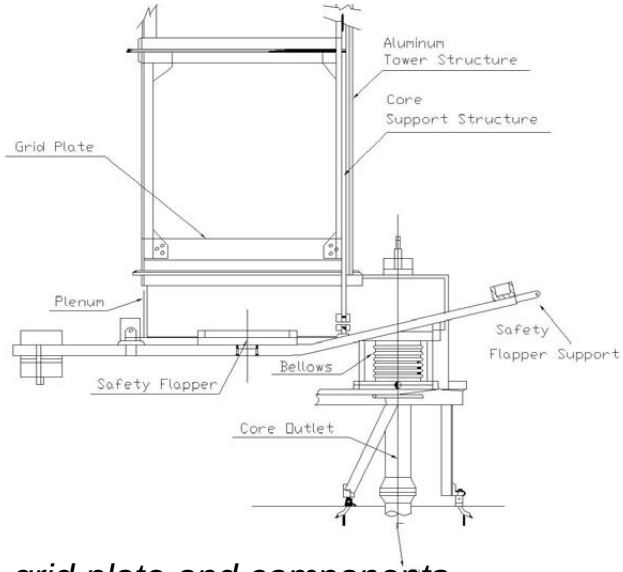
- GRR-1 resin waste

- Radioactive sources in the RMML interim storage facility

# Neutron calculations results for GRR-1 components of major radiological concern



*The control rod*




*The grid plate and components*

| Nuclide | $T_{1/2}$ (y) | Activity (GBq) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Al Grid (63 kg) | SS Pins | SS Bolts | Al Grid, SS Pins & Bolts (67 kg) | Control Rod (absorber, SS cladding & bottom tip) (3 kg) | Big Beryllium Block (40 kg) |
| Fe-55 | 2.74 | 282 ± 85 | 1550 ± 1180 | 339 ± 254 | 4580 | 3270 | 382 |
| **Ni-63** | **100.1** | **1.5 ± 0.8** | **50 ± 5** | **10 ± 8** | **135** | **105** | **12.6** |
| Co-60 | 5.27 | 0.46 ± 0.11 | 35 ± 3 | 144 ± 14 | 3.21 | 5.9 | 2.2 |
| Mn-54 | 0.85 | 0.36 ± 0.05 | 0.26 ± 0.03 | 0.17 ± 0.03 | 1.71 | | 0.8 |
| Zn-65 | 0.66 | 1.7 ± 0.3 | | | 1.64 | | |
| H-3 | 12.32 | | | | | | 1.6E5 |
| **Be-10** | **1.6E6** | | | | | | **0.8** |
| Ag-110m | 0.67 | | | | | 380 | |
| **Ag-108m** | **127** | | | | | **152** | |
| Cd-109 | 1.27 | | | | | 97 | |
| **Ni-59** | **7.6E4** | | | | | | **0.1** |

# The radiological characterization results for the PCS

- The activities at the larger part of the circuit was well below the general clearance level **(EW)**

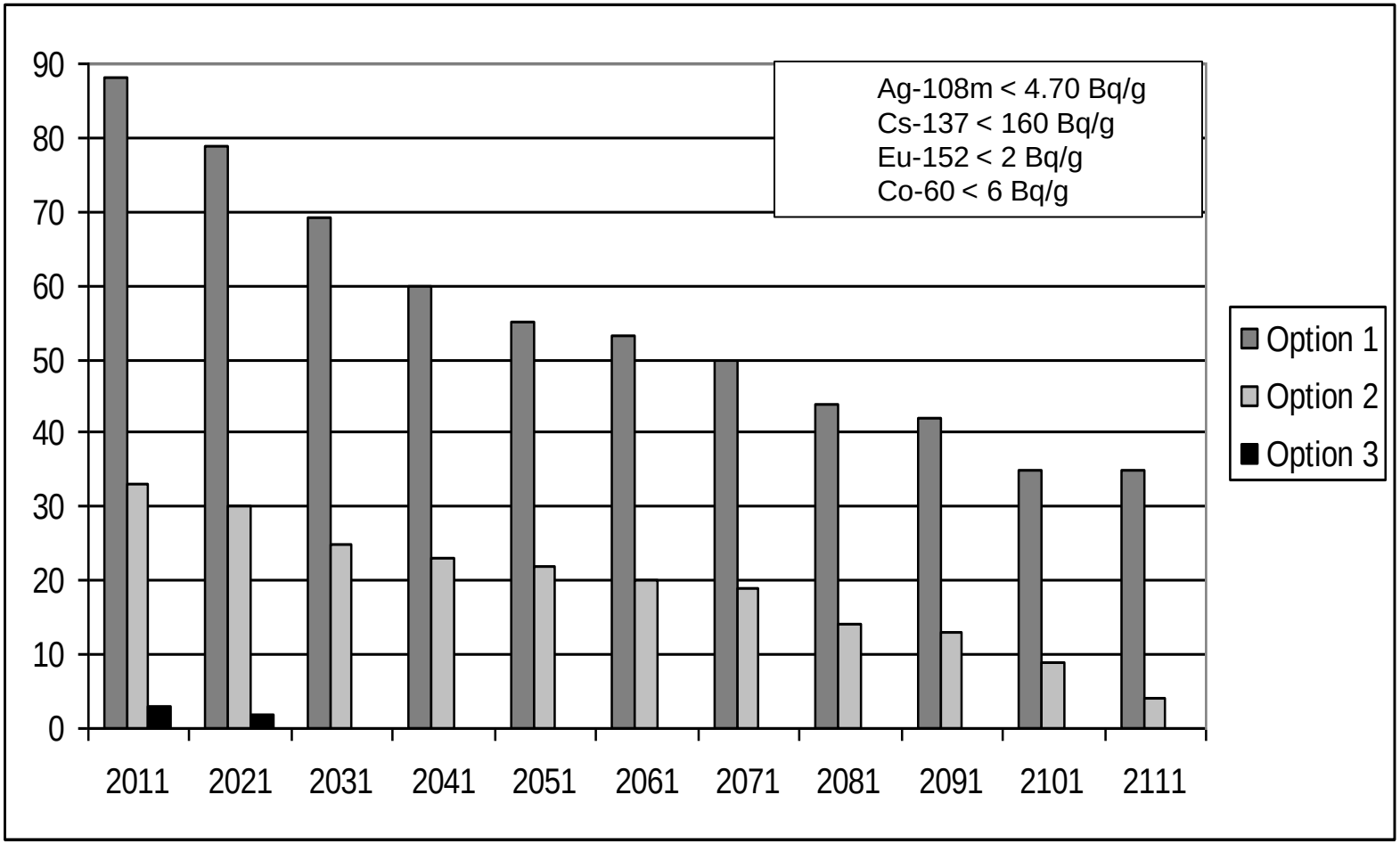
- The part of the piping from the heat exchangers back to the pool exhibited **Ag-108m** activity three times higher than the general clearance level of 100 Bq/kg **(VLLW)**

- The entire volume of the exchangers seemed to be contaminated by **Ag-108m** of the order of the general clearance level **(EW or VLLW)**


- The heat exchangers as well as the delay tanks presented spot contamination by **Co-60** at the bottom of the components **(LLW or ILW)**

- The presence of alpha or pure beta emitters was minor inside the primary circuit

# The number of drums of primary resin waste that will not satisfy the clearance criterion after a certain time of storage




Option 1: Solidification in cement and storage to reach general clearance
Option 2: Storage without solidification to reach the specific clearance for disposal at a landfill
Option 3: Solidification in cement and storage to reach the specific clearance for disposal at a landfill

# Inventory of the GRR-1 materials and raw resin waste

| METALS (tons) | | Graphite ( tons) | Resin waste (tons) |
|---|---|---|---|
| EW | 30 | 15 | 16 (EW, VLLW, LLW) |
| VLLW | 28 | | |
| VLLW (mixed) | 5 | | |
| LLW | 0.6 | | |
| LLW (mixed) | 1.8 | | |
| ILW | 0.3 | | |
| ILW (mixed) | 0.2 | | |

# Inventory of radioactive wastes at the RMML storages

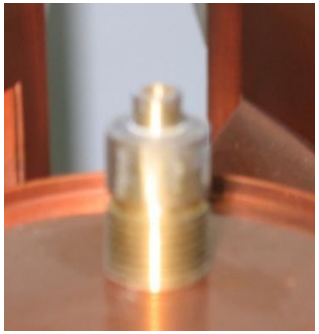
**Research Reactor and Research Laboratories of "Demokritos"**

- Radioactive wastes: Eu-152, Cs-137, Ag-108m, Co-60, I-131, I-125, Ga-67, Tl-201, In-111, Re-186, Sm-153, H-3, C-14, ….)
- Pu/Be and Am/Be neutron sources
- Other sealed sources

**Medical and Industrial Applications**

- Disused (without back-end contract) and orphan sealed sources (Co-60, Sr-90, Cs-137, Am-241, Ni-63 ….)
- Devices with Ra-226
- Lightning rods (Ra-226, Am-241) and smoke detectors (Am-241)





# Export of radioactive sources for recycling or disposal



Dismantling of the devices

Packaging for transport


# Topic 1 for discussion

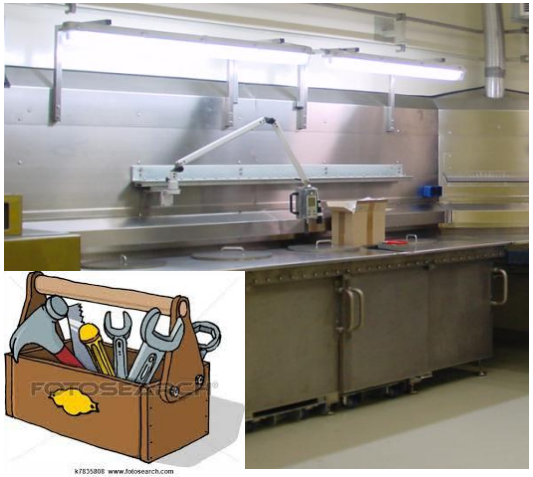

Is the export of all the sealed sources and radioactive devices a right policy for countries with small amounts of radioactive waste?

# Sources and other Radioactive Items

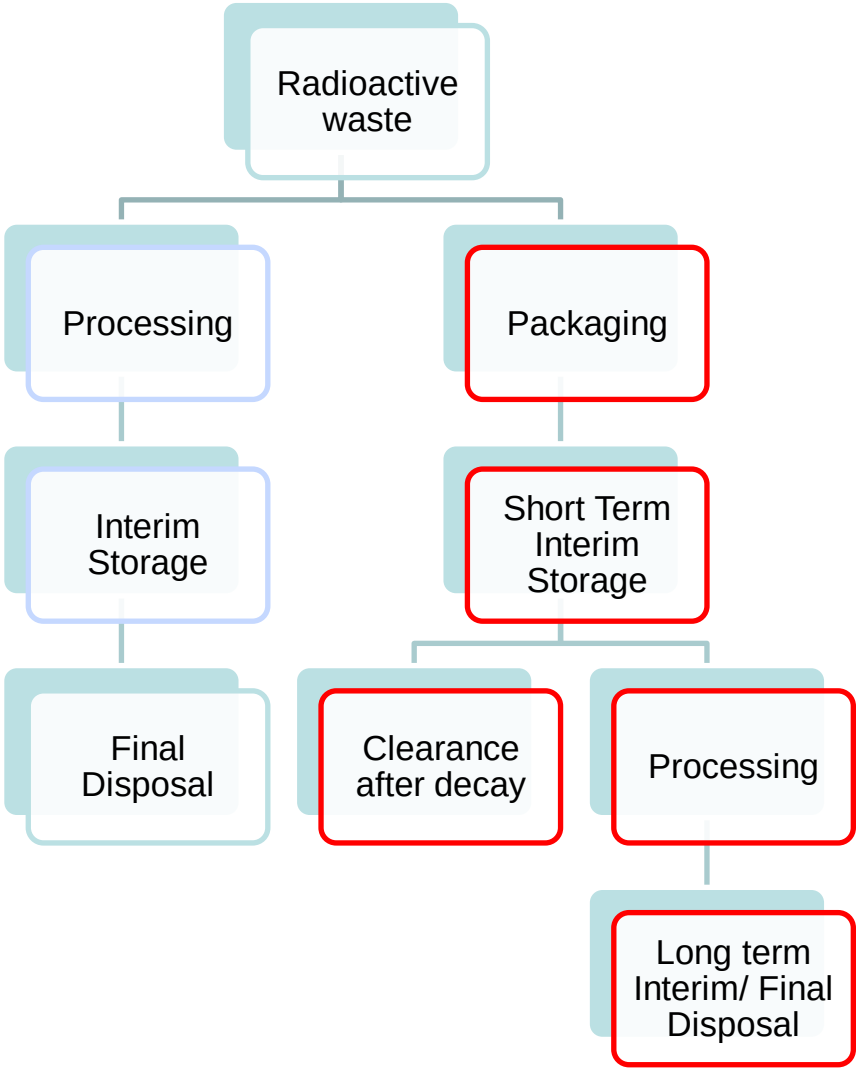
- RR Be blocks (possibly can be exported for reuse)
- Radioactive devices usually containing Cs-137, Kr-85, Co-60, Sr-90, Am-241, Ni-63, Am-Be (can be exported)
- Lightning rods of Am-241 (can be exported)
- Am-241 smoke detectors (can be exported)
- RR grid plate and components
- RR control rods
- RR graphite
- RR resin waste
- Contaminated with Cs-137 soil from foundries
- Institutional and historical waste
- Items with Ra-226 like dials of gauges and other sources of μCi activity. Also some lightning rods with Ra-226
- NORM
- Parts with Th-232 from airplanes engines
- Etc.

# Upgrade of the Radioactive waste management at INRaSTES

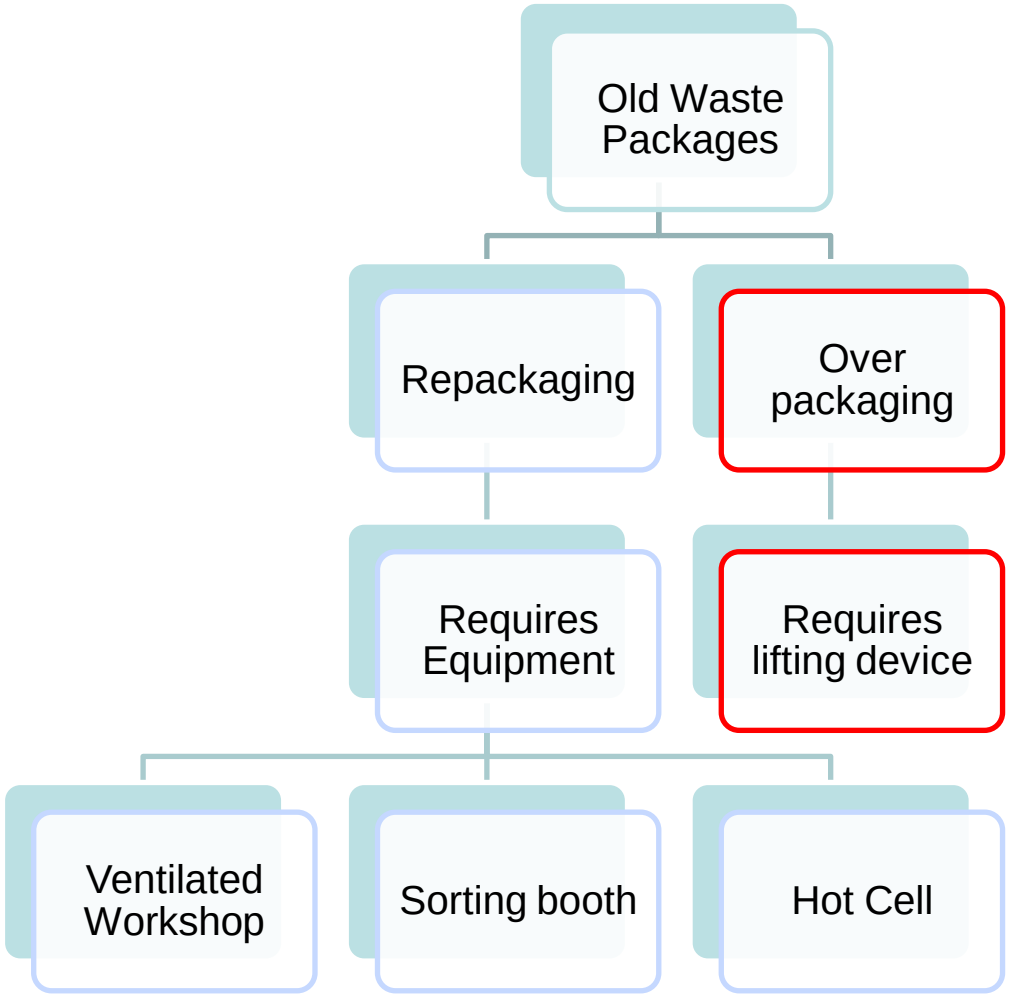
- Establishment of a security and controlled access system (now)
- Carry out safety studies
- Purchase of new drums for the waste
- Reconstruction of the buildings
- Establishment of local ventilation at workbench and workshops
- Repackaging of all the waste
- Packaging of the radioactive devices (as they are or after dismantling)



# Options for Radioactive waste (1)



# Options for waste (2)



# Over packing of RadWaste & improvement of the storage facilities

Remove of the drums to standard containers during reconstruction of the facilities

# A proposal for new drums containers

**Integrity:** isolate the waste from the environment

- IP2, Type A
- Carbon steel 2 mm
- anti corrosion coating inside/ outside

**Fire resistant:** isolate waste form in the event of a fire

- Fire resistant 1 h at 800 C

**Drop tested:** isolate waste form in the event of a drop event during handling

**Shielding:** optimization of the dose to operators and the public

- Concrete shielding
- Lead shielding
- Additionally activated carbon absorption layer to allow for Rn decay in case of Ra-226 sources
- Additionally welded gas tight drum and activated carbon absorption layer for items with radioactive gases

# Topic 2 for discussion


What type of drums we really need?

- Stainless steel drums?
- Carbon steel with anticorrosion coating?
- Regular drums or drums with specifications and certificates?

# Topic 3 for discussion


Do we need drums appropriate also for the future disposal?

Since a lot of scientific research is needed to develop double drums with cement barrier which meet the WAC for disposal, what is the best solution for a country with small amounts of radwaste?

- Start scientific research immediately?
- Buy drums for intermediate term storage and leave the issue of disposal for the future?
- Buy drums appropriate also for disposal from another country?

# An additional issue


A landfill or a near surface disposal facility is not appropriate for all the waste and also is difficult to be acceptable by the public.

Greece is a touristic country and the public is very sensitive about the environment. Also all the areas of the country are inhabited. The establishment of a small scale and cost affordable geological repository for the LLW and ILW seems to be the appropriate and most acceptable by the public disposal solution

A geological disposal repository can be the solution for any other category of radioactive waste in the country besides the waste that is kept in the NCSR “D” interim storages.

In case the country will decide some sources to be kept in the country for future disposal instead of export, this will make the construction of a national geological repository more cost effective.


# Thank you for your attention