Radioactive waste management and disposal : R&D issues in the European and national context

EPERC - aisbl
European Pressure Equipment Research Council

Pressure Equipment Innovation and Safety

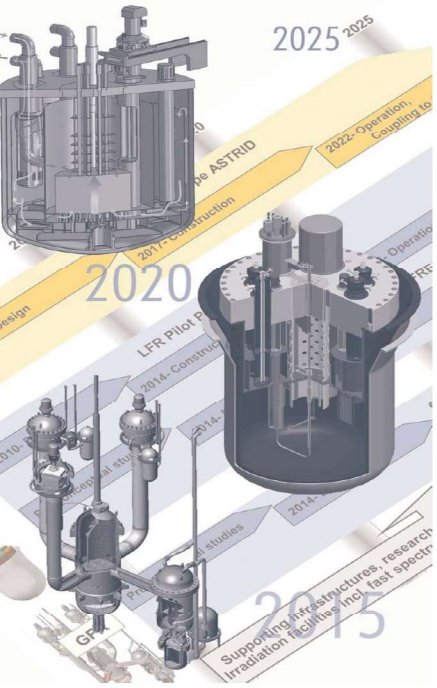
1-3 April, 2019
INAIL-Roma, Italy
www.eperc-aisbl.eu

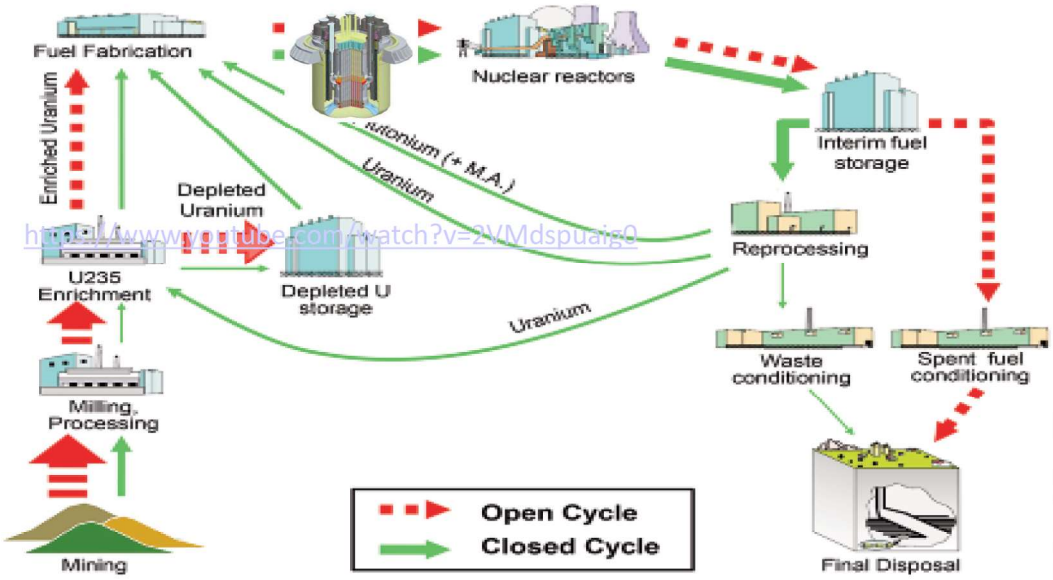
Ing. Massimo Sepielli
Department for Fusion and Nuclear Technologies for Safety and Security

European context

Fast reactors and closed loop fuel cycle

FROM SNE- TP



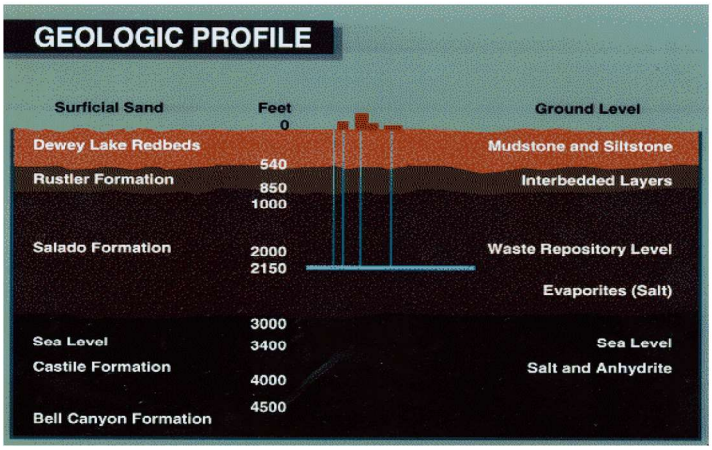


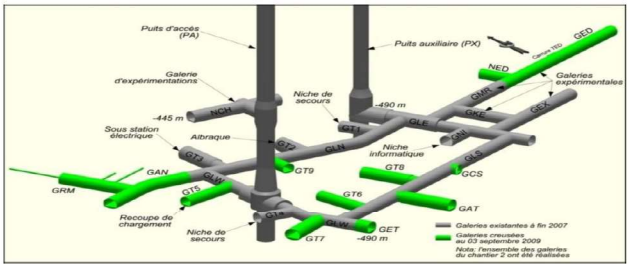
TO IGD-TP

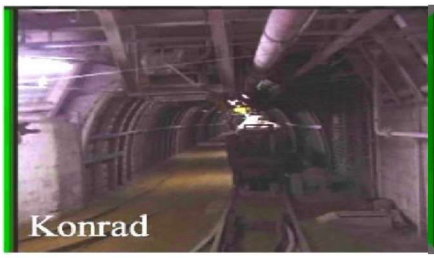

Research & Technology Organisations
Industry
Academia
Non-governmental Organisations
Technical Safety Organisations
Others

SNETP-IGDTP - IEP From new waste to geological disposal

- Burn most of TRU / Minor Actinides
- Reducing FP as much as possible
- Reducing of PuNon proliferation
- Improve stability of chemical and physical form
- Easy conditioning and storage
- Safe and economic geological disposal
- Average depth around m.500 and not m. 4000

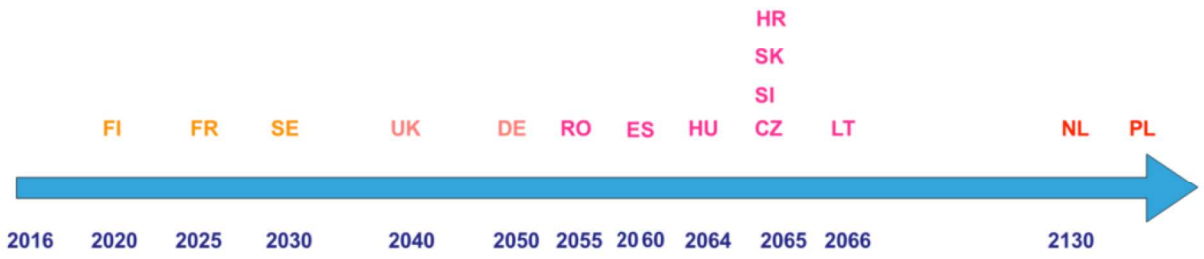


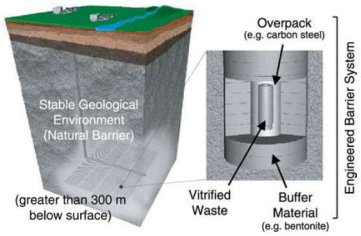


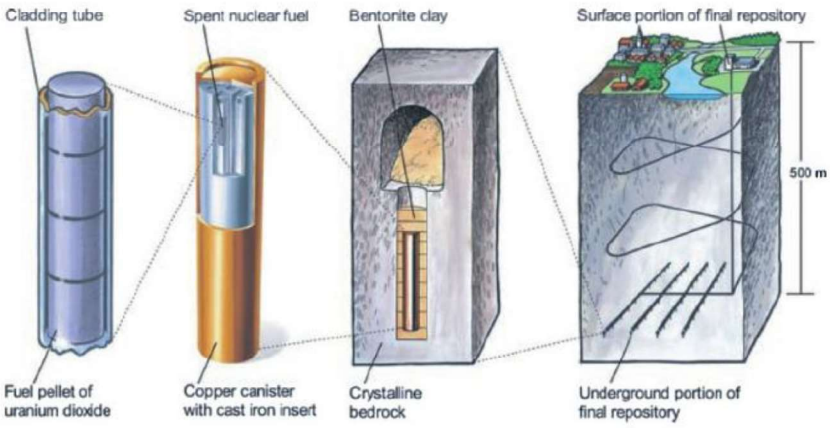


European status about L-ILW and HLW disposal

Geo disposal – Countries schedule

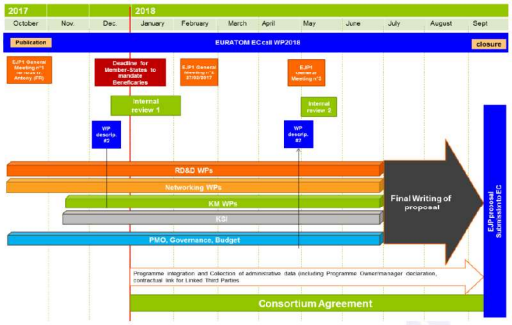






From JOPRAD Project to EURATOM WP 2018

JOPRAD



European Commission

EN

Euratom

Work Programme 2018

(European Commission Decision C(2018)6365 of 3 October 2018)

EJP Objectives from JOPRAD

The scientific and technical scope of the EJP on RWMD has been established in the JOPRAD Programme Document (JOPRAD Deliverable 4.4) :

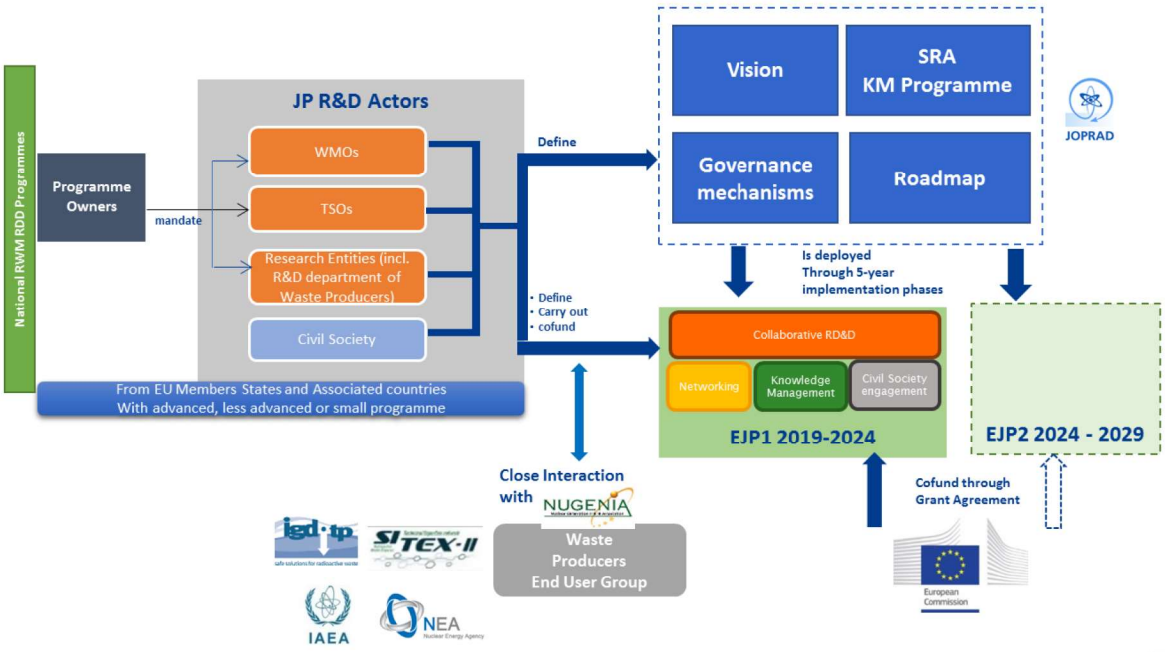
Cutting-edge scientific and technical activities on RWM from cradle to grave:

- Radioactive waste characterization & processing (incl. treatment, conditioning/ packaging);
- Interim storage of radioactive waste;
- Disposal solutions - Mainly geological disposal of spent fuel, high level waste (HLW) and intermediate level waste (ILW).

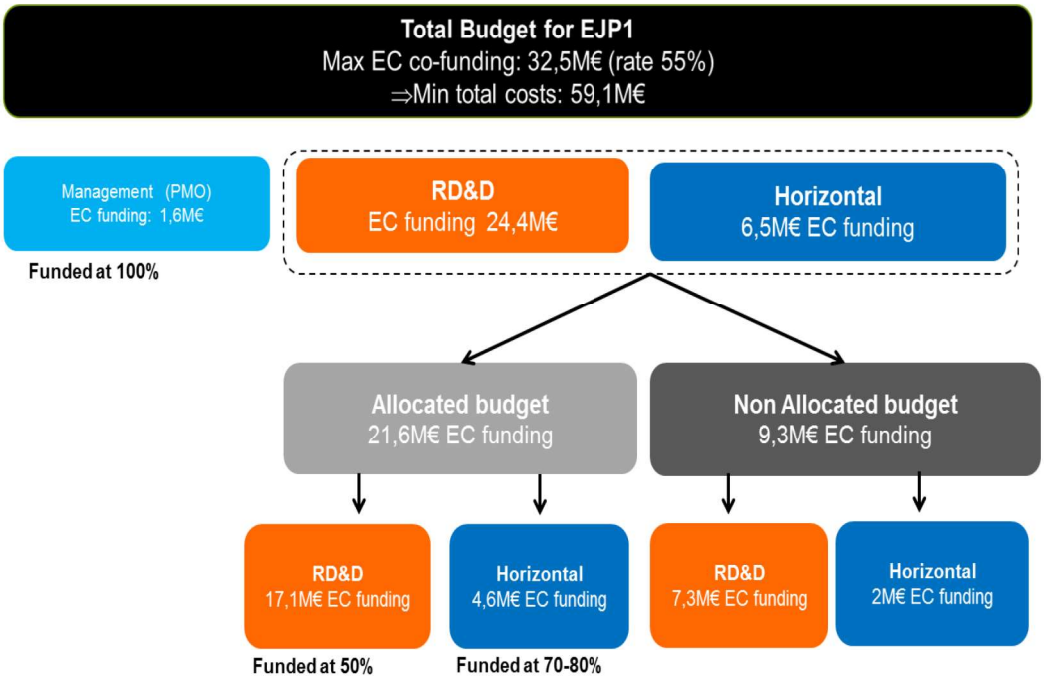
Surface disposal / low-level waste (LLW) are not excluded, it is however assumed that it does not require specific RD&D but RD&D studies may address both surface and deep geological disposal. It can also be addressed within horizontal activities (Networking / Knowledge Management).

The activities to be carried out within the Joint Programme should be a balance between topics in direct link with **operational RD&D** (in direct link with implementation of repository concepts) and **prospective RD&D** (long-term experiment and/or modelling works to demonstrate the robustness of the concepts or to maintain scientific excellence and competences throughout the stepwise long-term management of radioactive waste).

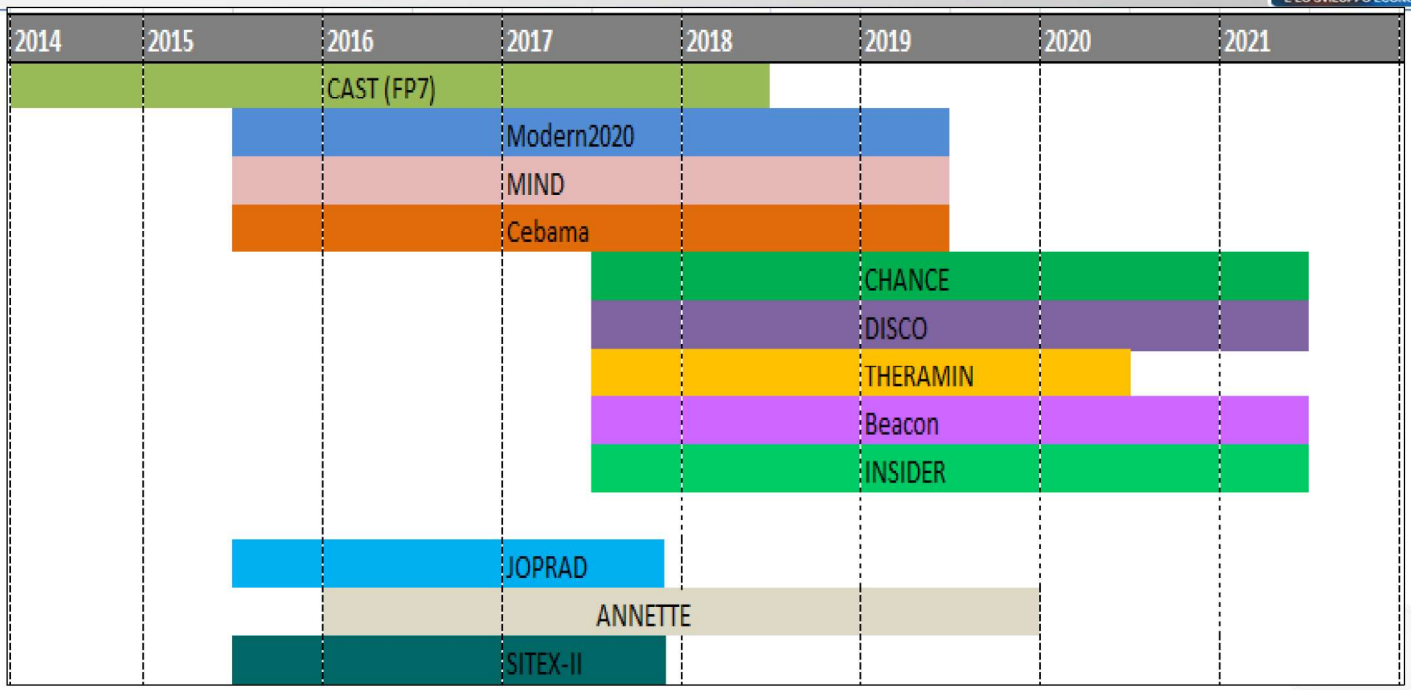
European Joint Programme 1 and 2



Total budget for EJP1

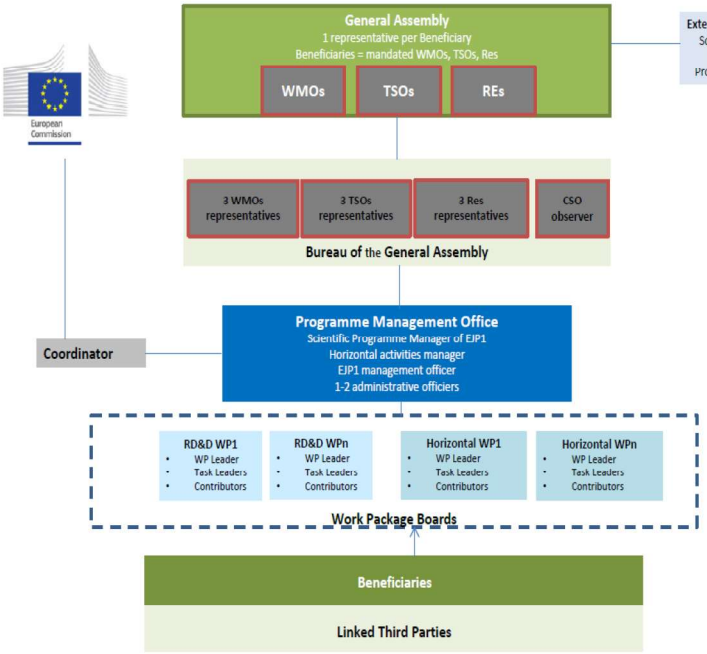


EJP connection with EC projects



EC projects are given on the following figure. The different topics addressed in ongoing EC projects are the following: monitoring (Modern2020), microorganisms (MIND), concrete alteration (Cebama), non-destructive assay methods (CHANCE), waste thermal treatment (THERAMIN), bentonite mechanical evolution (Beacon) and characterization of dismantling waste (INSIDER). The aim of this is to wait for feedback from these ongoing projects before launching any follow up WP within EJP1.

European Joint Programme 1
Countries, Actors and Organisation



	Programme Owners	Mandated Actors	WMO	TSO	RE
Belgium	Federal Agency for Nuclear Control (FANC)	Bel V		x	
Cyprus	Ministry of Labour, welfare and social insurance	University of Cyprus			x
Czech Republic	State Office for Nuclear Safety	SURO		x	
Denmark	Ministry of Higher Education and Science	Danish Decommissioning	x		
Finland	Ministry of economic affairs and employment	Posiva	x		
		VTT		x	
France	Ministère de la transition écologique et solidaire DGEC Ministère de l'Enseignement Supérieur et de la Recherche	Andra	x		
		IRSN		x	
		CNRS			x
		CEA			x
Germany	Federal Ministry for Economic Affairs and Energy (BMWi) Federal Ministry for Education and Research (BMBF) Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)	BGE	x		
		GRS		x	
		HGF			x
		PTKA-WTE			x
Greece	Greek Atomic Energy Commission	EEAE	x	x	
		NCSR Demokritos		x	x
Hungary	Hungarian Ministry of National Development	PURAM	x		
		TS Enercon		x	
		MTA			x
Lithuania	Ministry of Energy	RATA	X		
		CPST		x	
		LEI			x
Netherlands	Authority for Nuclear Safety and Radiation Protection (ANVS)	COVRA	x		
		NRG		x	
		TNO			x
Romania	Ministry of Energy	RATEN ICN			x
Slovenia	Slovenian Research Agency	JSI		x	
Spain	Ministry of Energy, Tourism and Digital Agenda	ENRESA	x		
	Ministry of Economy Industry and Competitiveness	CIEMAT		x	
Sweden	Nuclear Fuel and Waste Management Company, SKB	SKB	x		
		Uppsala			x
Switzerland	Federal Department of Economic Affairs, Education and Research EAER	NAGRA	x		
		PSI		x	x
Ukraine	State Agency of Ukraine on Exclusion Zone Management	Chornobyl R&D Institute	x		x
		SSTC NRS		x	

EJP1 – Main Research Activities

RD&D Work packages under development
Modelling of process couplings and numerical tools applied to PA
Assessment of chemical evolution of ILW and HLW disposal cell
Mechanistic understanding of gas migration (mainly in clay-based materials)
Influence of temperature on clay-based material behaviour
Cement-Organics-Radionuclide-Interactions
Fundamental understanding of radionuclide mobility
Spent Fuel characterization and evolution until disposal

Work packages under development	Coordination Teams				
Modelling of process couplings and numerical tools applied to PA	**F. Claret**	**BRGM**	**RE**	**FR**	f.claret@brgm.fr
	G. Bracke	GRS	TSO	DE	guido.bracke@grs.de
	G. Pépin	Andra	WMO	FR	Guillaume.Pepin@andra.fr
Assessment of chemical evolution of ILW and HLW disposal cell	**D. Jacques**	**SCK CEN**	**RE**	**BE**	diederik.jacques@sckcen.be
	E. Holt	VTT	TSO	FI	Erika.Holt@vtt.fi
	C. Martin	Andra	WMO	FR	Christelle.Martin@andra.fr
Mechanistic understanding of gas transport in clay materials	**X. Sillen**	**ONDRAF**	**WMO**	**BE**	x.sillen@nirond.be
	JD. Barnichon	IRSN	TSO	FR	jean-dominique.barnichon@irsn.fr
	E. Jacops	SCK-CEN	RE	BE	elke.jacops@sckcen.be
Influence of temperature on clay-based material behaviour	**M.Olin**	**VTT**	**TSO**	**FI**	markus.olin@vtt.fi
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	G. Armand	Andra	WMO	FR	gilles.armand@andra.fr
Cement-Organics-Radionuclide-Interactions	**M. Altmaier**	**KIT INE**	**RE**	**DE**	marcus.altmaier@kit.edu
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	T. Missana	CIEMAT	TSO	ES	tiziana.missana@ciemat.es
Fundamental understanding of radionuclide mobility	**D. Bosbach**	**FZJ**	**RE**	**DE**	d.bosbach@fz-juelich.de
	V. Havlova	UJV	RE	CZ	vaclava.havlova@ujv.cz
	S. Churakov	PSI	TSO/RE	CH	sergey.churakov@psi.ch
Spent Fuel characterization and evolution until disposal	**P. Jansson**	**Uppsala**	**RE**	**SE**	peter.jansson@physics.uu.se
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	J. Cobos	CIEMAT	TSO	ES	Joaquin.cobos@ciemat.es

EURATOM 2019-20 Call

C. RADIOACTIVE WASTE MANAGEMENT
NFRP-10: Developing pre-disposal activities identified in the scope of the European Joint Programme in Radioactive Waste Management

Specific Challenge: In Europe, the challenges in the field of radioactive waste management (RWM) include:
- To improve, innovate and develop science and technology for the pre-disposal management of radioactive waste streams and categories for which industrially mature processes currently do not exist or for existing processes which could benefit from improvement and innovation.
- To advance in the integration of research and development between Member States' national programmes for potential common use of radioactive waste pre-disposal solutions together with addressing the needs of all Member States, including those without nuclear energy, in line with requirements under Directive 2011/70/Euratom.
- To develop and transfer knowledge and competences across Member States' programmes.

Geological disposal oppotunity for Italy and Countries with minor amount of HLW: JOPRAD and ARIUS-ERDO

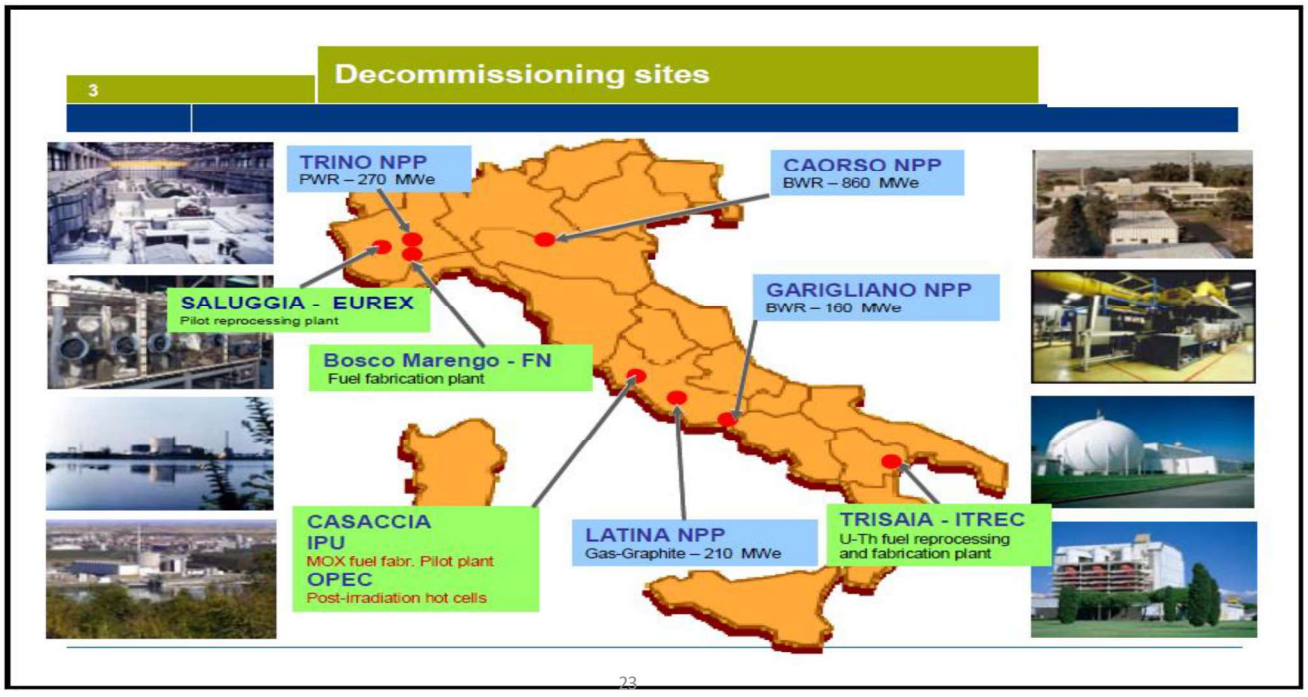
JOPRAD

ERDO working group

ERDO : Working on a shared solution for radioactive waste
A multinational working group, whose members are nominated by the appropriate Government level organisations, established to study the feasibility of setting up a Development Organisation (ERDO) that would implement one or more shared geological repositories in Europe.

National context

Decommissioning process in Italy



Waste Amount Projection (m^3)

SOGIN

STIMA DEL VOLUME DI RIFIUTI RADIOATTIVI CONDIZIONATI DA CONFERIRE AL DNPT

(Proiezione su un arco temporale di circa 40 anni)

BASSA E MEDIA ATTIVITA' (smaltimento a titolo definitivo)

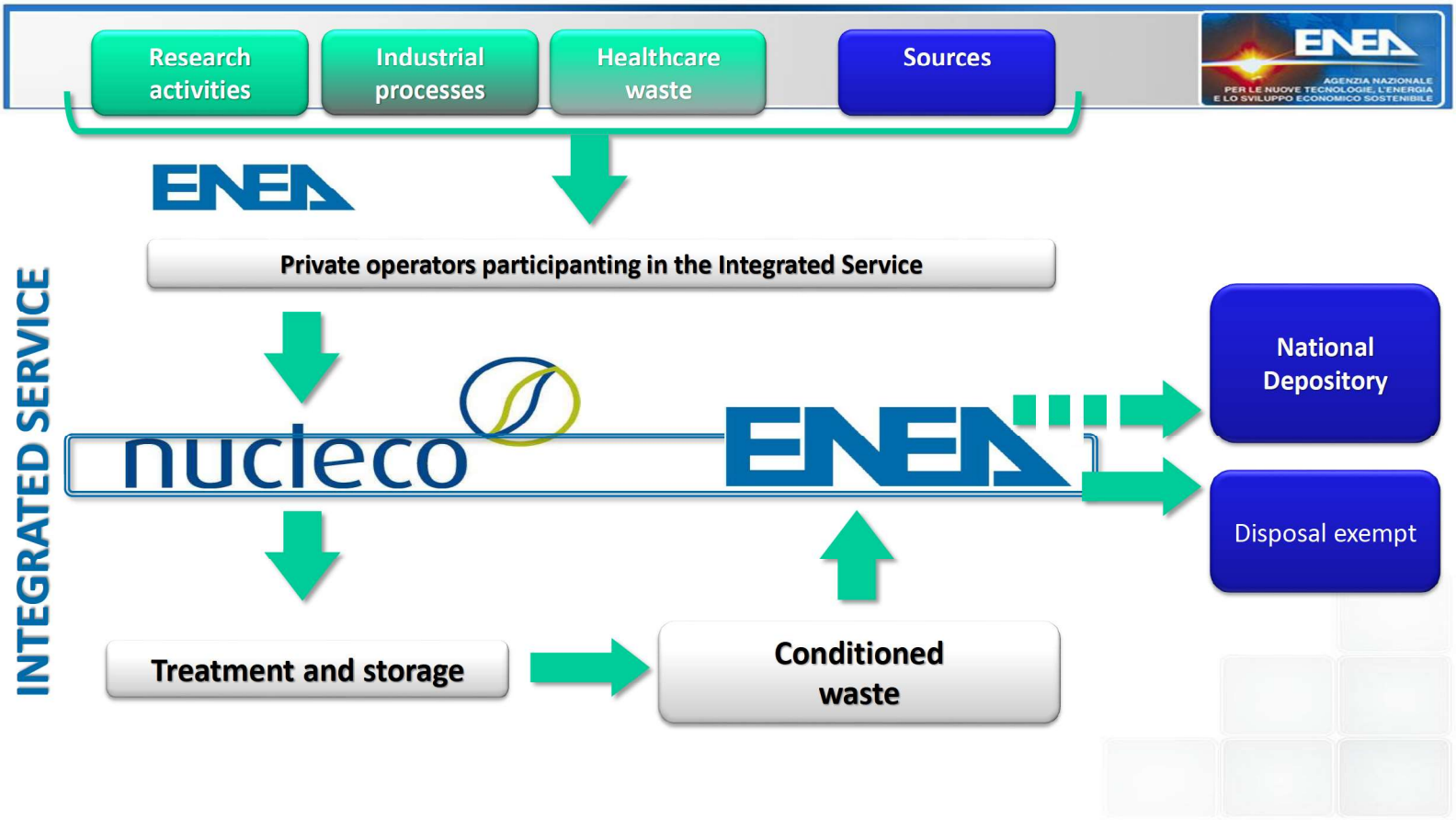
	ENERGETICI	NON ENERGETICI			
	SOGIN	Ricerca	Servizio Integrato**	Altri***	TOTALI
PREGRESSI (al 31.12.2012)					
Vol Manufatti (mc)	13.400	3.600	7.800	400	**25.200**
FUTURI					
Vol Manufatti (mc)	31.000	6.000	11.000	1.800	**49.800**
TOTALI					
Vol Manufatti (mc)	44.400	9.600	18.800	2.200	**75.000**
	44.400	30.600			

ALTA ATTIVITA' (immagazzinamento a titolo provvisorio di lunga durata)

	ENERGETICI	NON ENERGETICI			
	SOGIN*	Ricerca	Servizio Integrato**	Altri***	TOTALI
PREGRESSI (al 31.12.2012)					
Vol Manufatti (mc)	4.000	2.500	600	100	**7.200**
FUTURI					
Vol Manufatti (mc)	6.400	700	900		**8.000**
TOTALI					
Vol Manufatti (mc)	10.400	3.200	1.500	100	**15.200**
	10.400	4.800			

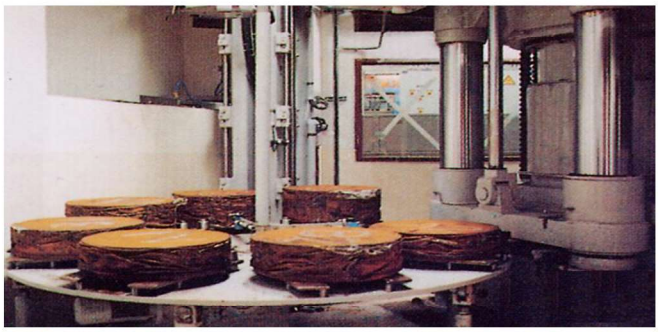
	mc	%
TOTALE RIFIUTI ENERGETICI	54.800	**60%**
TOTALE RIFIUTI NON ENERGETICI	35.400	**40%**
TOTALE COMPLESSIVO	**90.200**	

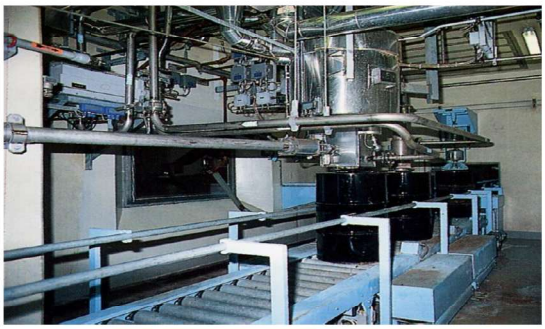
NOTE:
(*) A questi rifiuti vanno aggiunti circa 1000 mc di residui da riprocessamento e combustibile non riprocessabile in cask (nell'ipotesi di implementare lo 'swap' dei residui a bassa/media attività con un equivalente quantitativo di residui ad alta attività)
(**) La produzione futura di rifiuti da Servizio Integrato è assunta pari a 4 volte quella attuale (500 mc/anno) e quindi circa 2000 mc/anno che condizionati diventano circa 200 mc/anno
(***) Include i rifiuti di origine Ministero della Difesa


Research activities
Industrial processes
Healthcare waste
Sources
ENEA
AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE
ENEA
Private operators participanting in the Integrated Service
INTEGRATED SERVICE
nucleco
ENEA
National Depository
Disposal exempt
Treatment and storage
Conditioned waste

Radioactive Waste Management

Completion of the Integrated Service Activities, i.e. conclusion of the cycle.

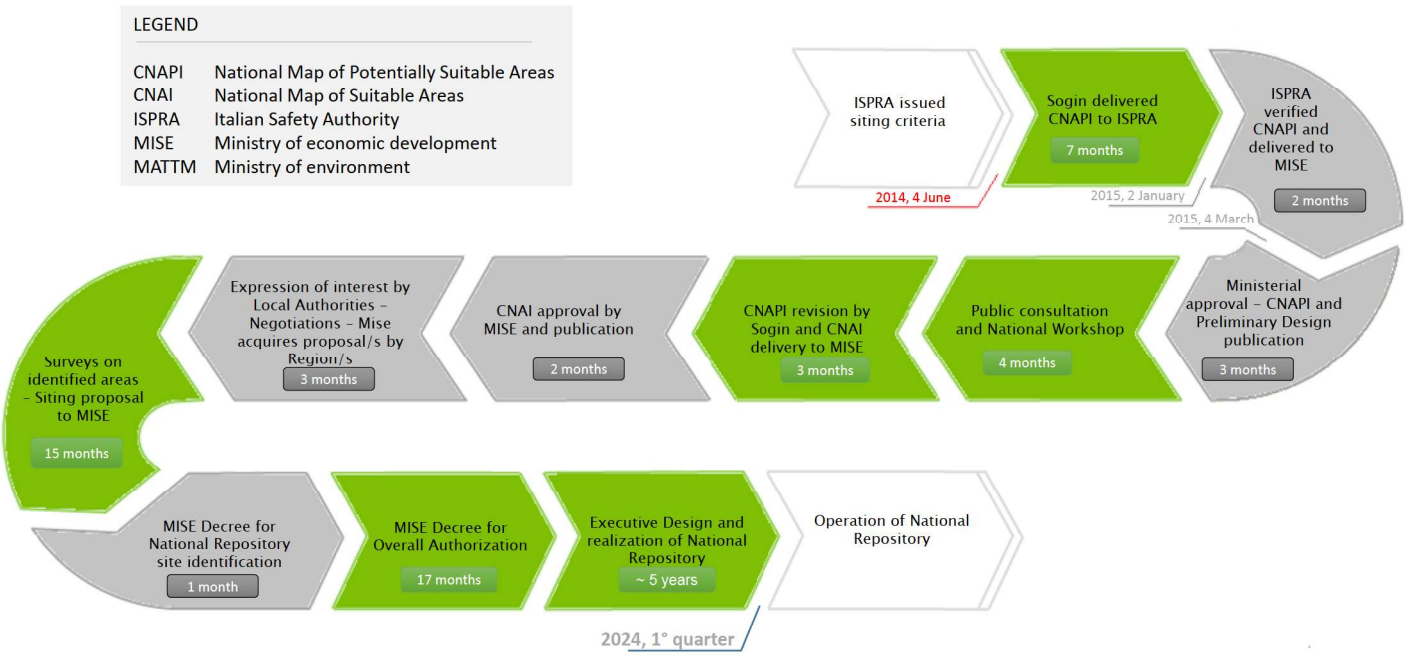




Compaction, drumming, cementation and temporary storage of low-activity non energy wastes

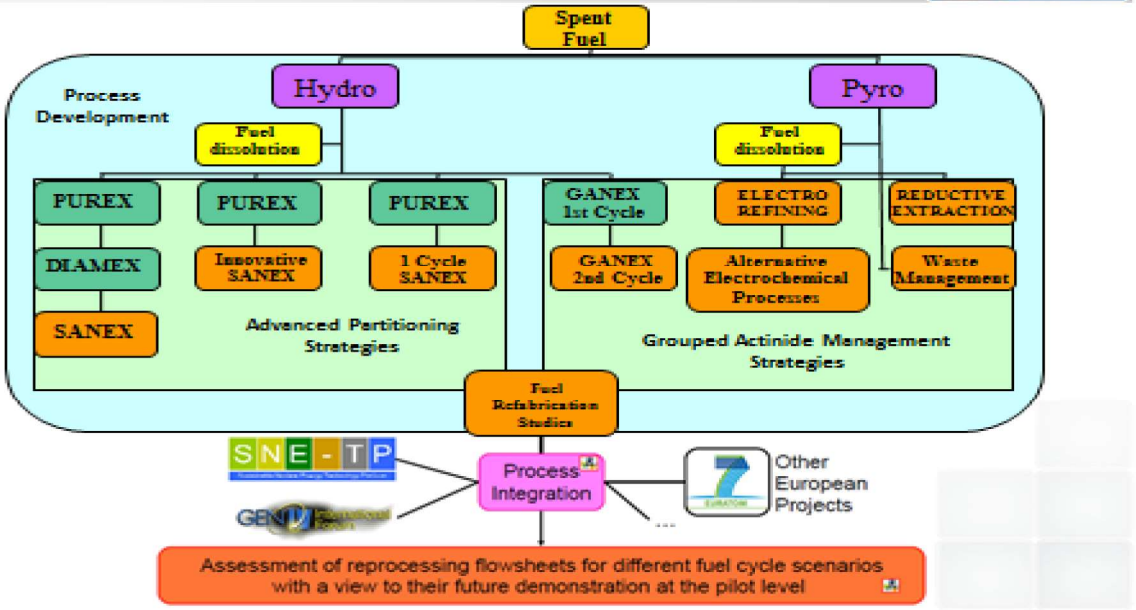
National Repository – Technology Park

SITING AND REALIZATION PROCESS*

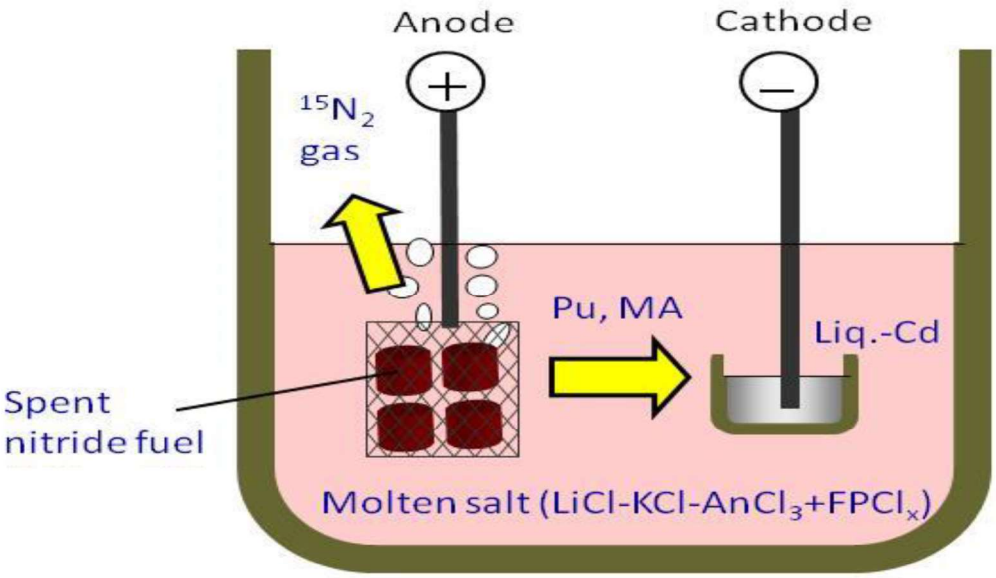


Example of
Research activities at ENEA
on
reprocessing and conditioning
up to the waste form

Treatment of spent fuel



Electrorefining of nitride fuel



Waste-form
Conditioning of chloride salt wastes from pyroprocesses with different matrices

- ❑ **SODALITE**
- ❑ **SAP**
- ❑ **MURATAITE-PYROCHLORE**

SAP matrix

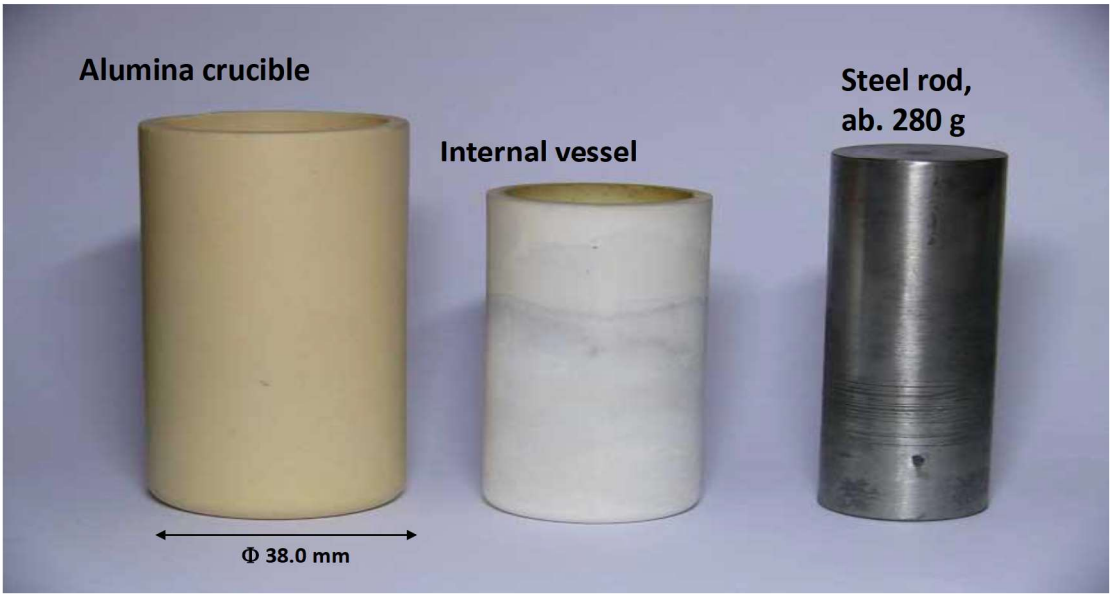
Transparent hydrogels

Products obtained after **Products obtained after each of the three main steps for preparation of SAP matrix**

RadWaste R&D for final disposal: New conditioning matrices

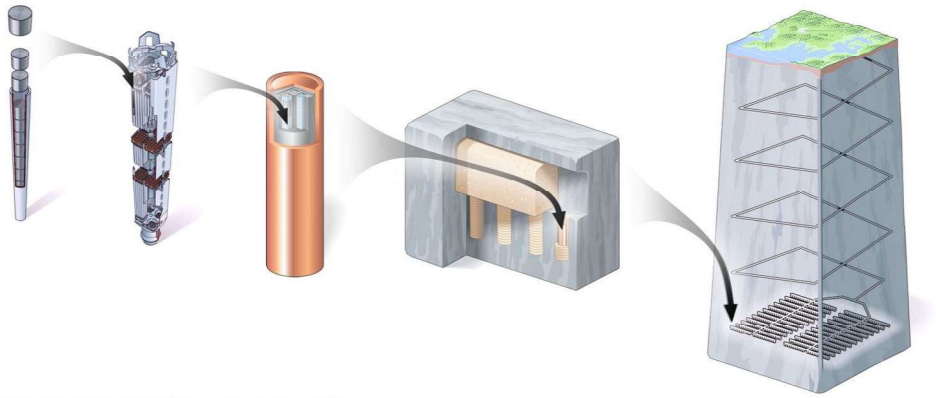
SODALITE matrix

Components used for labo. scale Pressureless Consolidation experiments



Mix of nepheline, salt waste and glass frit
between alumina crucible and internal vessel

Testing of containers
Drums, Casks, Canisters



INAIL test program for several design conditions

1) Normal operation, abnormal operaton, accident

During container filling, displacement, e interim storage sia both in the production and final disposal site, transportation, recovery inspection and maintenance

Prototype tests:

- Resilience to corrosion;
- Sealing;
- Stacking for interim storage;
- Resistance test to design pressure;
- Drain test.

https://www.youtube.com/watch?v=2VMdspuaig0

- ❑**Corrosion**
- ❑**Sealing / Leaching-Release**
- ❑**Free Drop**
- ❑**Resistence Penetration-Puncturation**
- ❑**Drainability**
- ❑**Resistance to design pressure**
- ❑**Fire test**
- ❑**Water immersion test**

- ***Stacking and Trasportation phase***

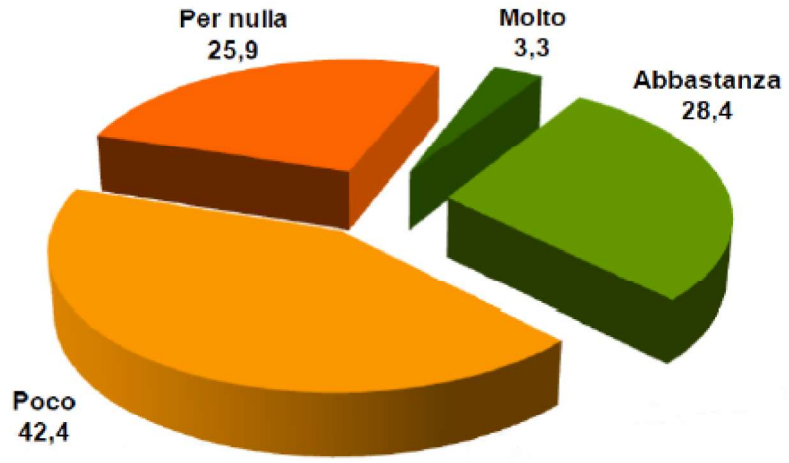
Potential synergy with EPERC on Radwaste management and disposal R&D

- ❖ Modelling
- ❖ RN Mobility
- ❖ Gas Migration
- ❖ Speciation
- ❖ Leaching
- ❖ Prz Gas release
- ❖ Cement-Bentonite
- ❖ Interaction
- ❖ Monitoring

Modelling of process couplings and numerical tools applied to PA
Assessment of chemical evolution of ILW and HLW disposal cell
Mechanistic understanding of gas migration (mainly in clay-based materials)
Influence of temperature on clay-based material behaviour
Cement-Organics-Radionuclide-Interactions
Fundamental understanding of radionuclide mobility
Spent Fuel characterization and evolution until disposal

Scientific dissemination, education, information

Comunication of R&D research on radioactive waste management



Knowledge in Italy about the subject is just around 30% the rest is nothing or poor (Fonte: Sogin)