IAEA activities on managing graphite

A high-level overview of a collective work

Presented by: Karina Lange, Radioactive waste disposal specialist, Waste Technology Section,

Outline

- IAEA Waste Technology Section
- Completed IAEA activities on managing graphite
- Disposal challenges and options

IAEA Waste Technology Section publications

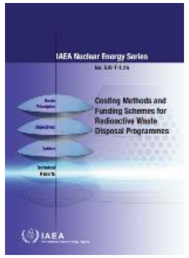
Structuring Knowledge, Guidance and Support → **Topical examples**

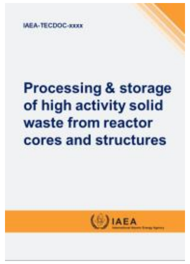
- **Radioactive waste**
  Inventory – Characterization – Waste Acceptance Criteria
  - Developing WAC
  - *Establishing a national Inventory**
  - *Waste minimization at NPP**
  - *Managing Irradiated Graphite*

- **Waste processing**
  Treatment – Conditioning - Storage
  - Treatment of liquid RW
  - Storage
  - *Processing of hazardous waste**
  - …

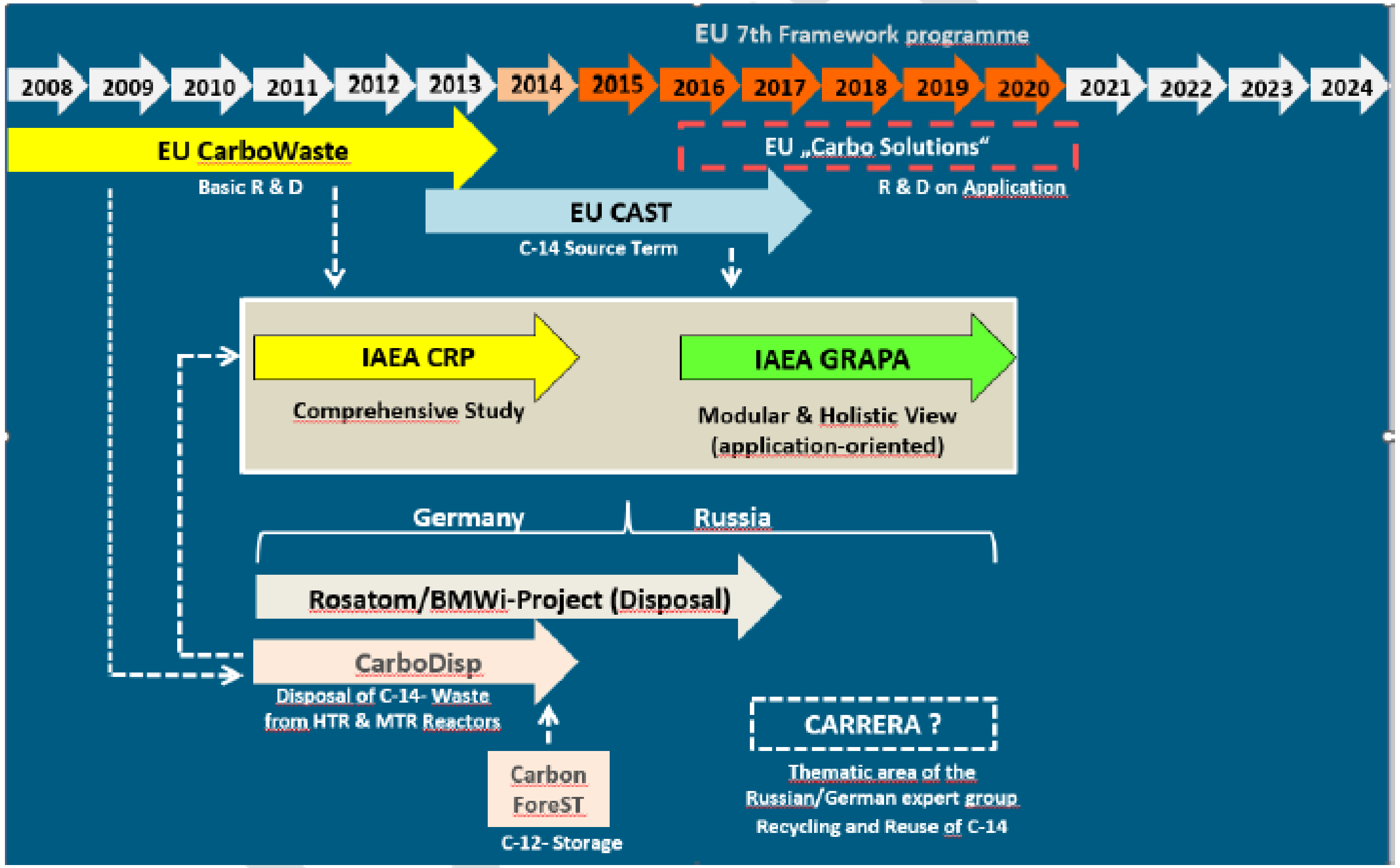
- **Disposal**
  Disposal options – Siting - Programme
  - Generic DGR Roadmap
  - *Planning the DGR RD&D programme**
  - *Going underground … DGRs*
  - …

- **National programme**
  From local inventories to national management solutions
  - Global Status & Trends
  - Policy & Strategy
  - *Establish national inventory**
  - …





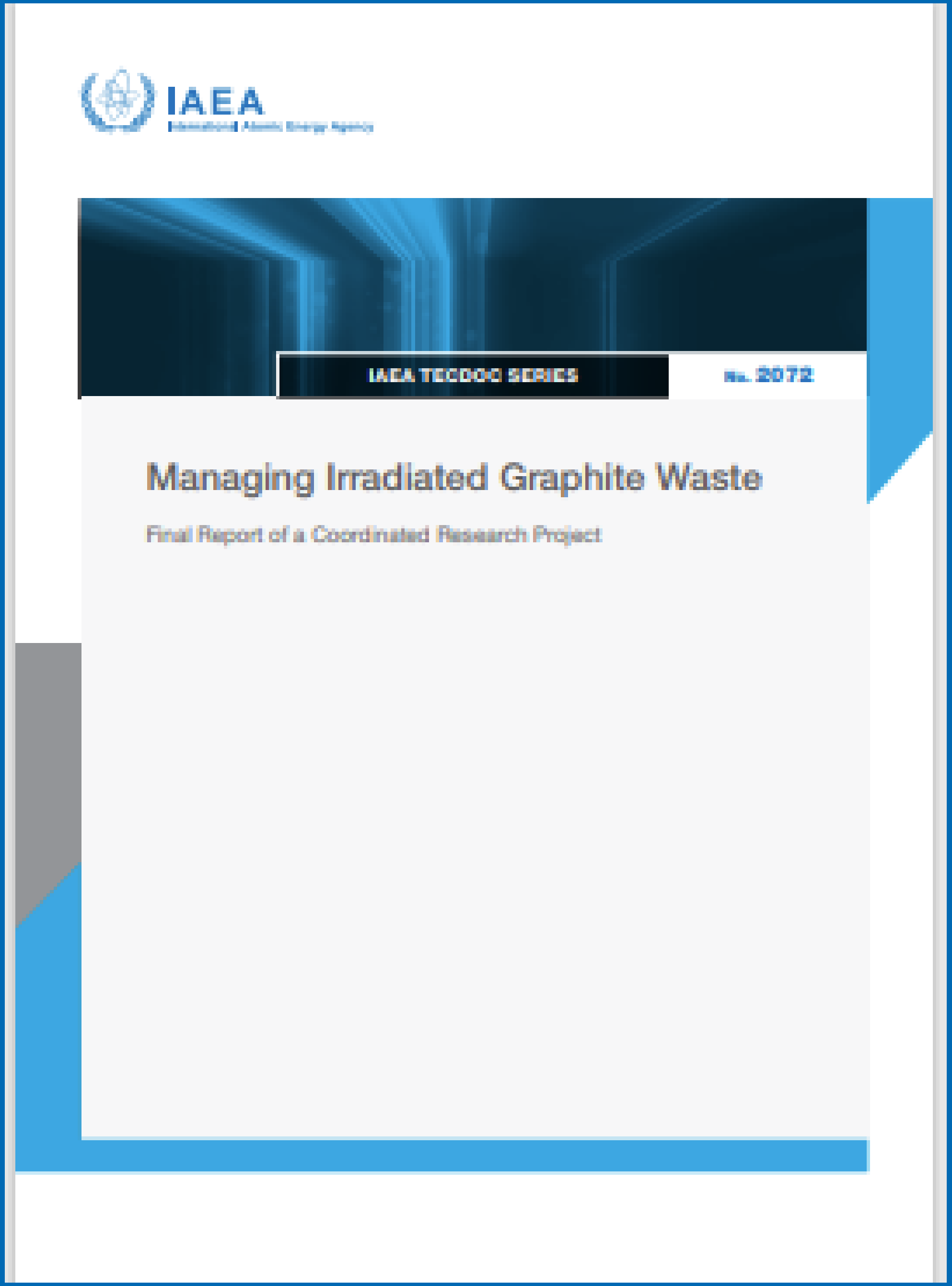
Building on past work



Completed IAEA work on graphite waste

IAEA Publication “Managing Irradiated Graphite Waste” (2024) – GRAPA group and IAEA scientific secretary Dr. W. Meyer

- Characterization
- Retrieval
- Treatment
- Packaging, Storage, Disposal


IAEA

IAEA TECDOC SERIES

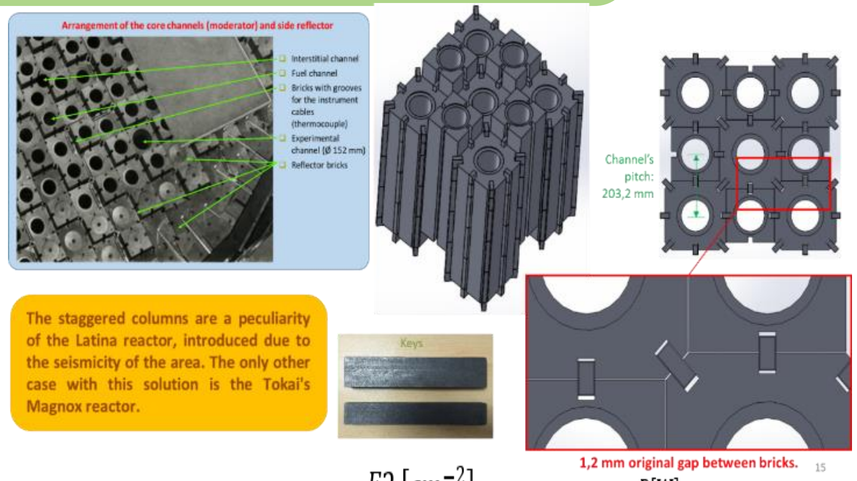
No. 2072

Managing Irradiated Graphite Waste

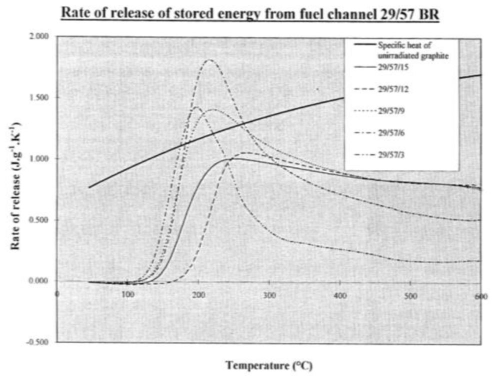
Final Report of a Coordinated Research Project

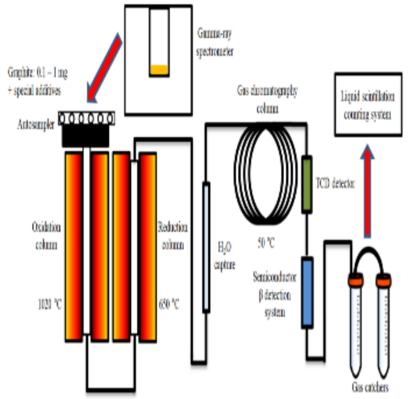
Properties of graphite:
WP 1- Characterization (GRAPA)

	Theme	Contributor
I-1	DOCUMENTATION REVIEW I-1 Reference guide on French graphite I-2 Reference guide from CAST project	Andra, CEA and EdF (France), and RWM (UK)
I-2	IMPURITY DISTRIBUTION I-2.1. UK nuclear graphite grades I-2.2. AGRS graphite I-2.3. Virgin graphite of L-54M reactor	University of Manchester (UK) and POLIMI (Italy)
I-3	MODELS OF REACTOR GRAPHITE ACTIVATION I-3.1. RBMK reactor I-3.2. L-54M reactor I-3.3. MAGNOX reactors I-3.4. C-14 inventory in RBMK	Center for Physical Sciences and Technology (CPTS) and POLIMI (Italy)
I-4	RADIOLOGICAL CHARACTERISATION I-4.1. Nuclide activity in RBMK-1500 I-4.2. C-14 inventory in AGR I-4.3. RNS inventory of L-54M reactor I-4.4. Developing a sequential radiochemical procedure	Ignalina NPP, Center for Physical Sciences and Technology (CPTS) and POLIMI (Italy)
I-5	LEACHING I-5.1 Carbon-14 from irradiated PGA graphite I-5.2. Results on leaching of i-graphite (CAST) I-5.3.From hot-pressed irradiated graphite of VANDELLÓS I NPP	National Nuclear Laboratory (NNL), UK and VANDELLÓS I NPP
I-6	WIGNER ENERGY I-6.1 L-54M I-graphite (POLIMI) I-6.2 Issues faced in reactor dismantling and graphite disposal	Tony Wickham and POLIMI (Italy)
I-7	MECHANICAL CHARACTERISATION I-7.1 MAGNOX reactor (LATINA) I-7.2 L-54M reactor (POLIMI)	SoGIN and POLIMI (Italy)
I-8	BULK CHARACTERIZATION I-8.1. Characterisation of AGR graphite fuel sleeves I-8.2. Rapid method for determination of 14-C	Sellafield Ltd (UK) and Center for Physical Sciences and Technology (CPTS)

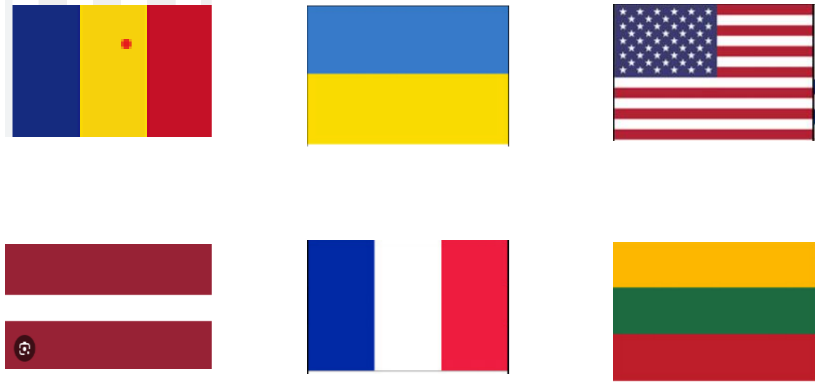


$$\Phi_{norm}[cm^{-2} \cdot J^{-1}] = \frac{F2\,[cm^{-2}]}{F7\,[MeV \cdot g^{-1}] \cdot F7_{mass} \cdot CF(MeV \rightarrow J)} \xrightarrow{\cdot P[W]} \Phi_{norm}[cm^{-2} \cdot s^{-1}]$$





New IAEA draft publication: Options and challenges for disposal of nuclear graphite wastes



Review of past work

Technical properties of graphite waste specific to disposal

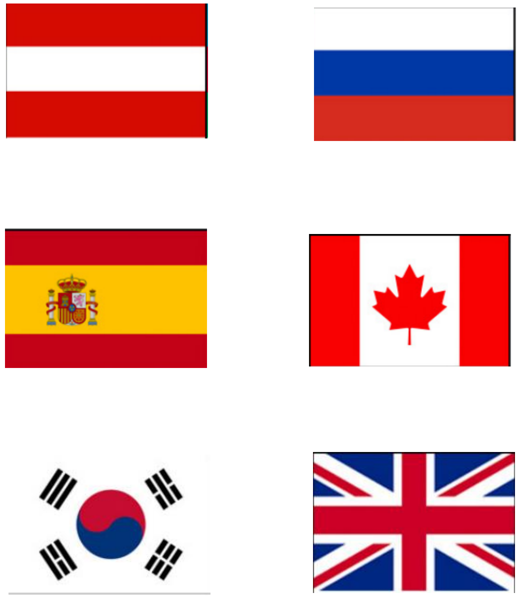
- Characterization, contaminants of concern, contaminant mobility, Wigner energy considerations, safety assessment

Other considerations for disposal

- Policy and strategy, costs

Current and planned disposal practices

- Near surface disposal, intermediate depth, geological disposal

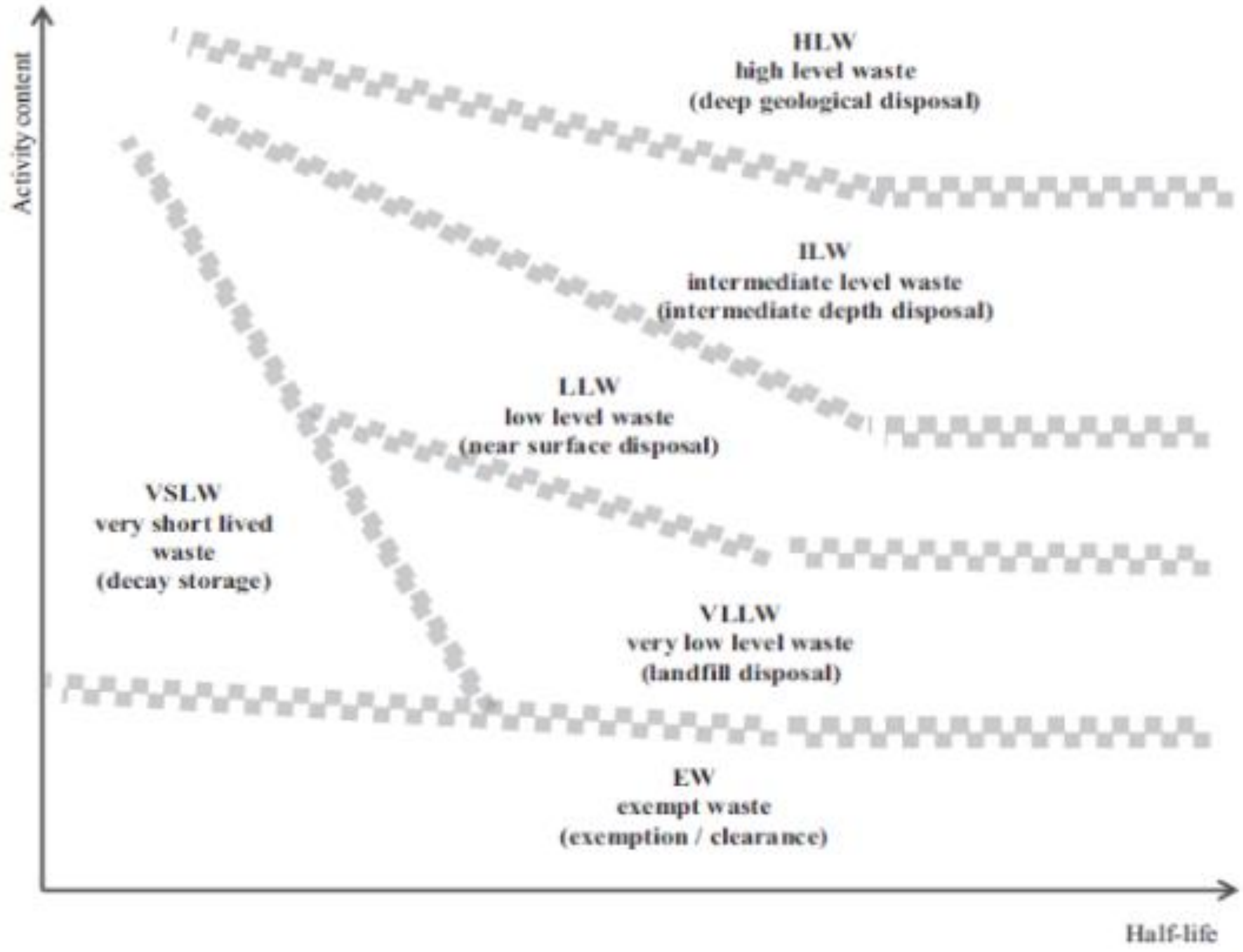


Main authors from 12 member states

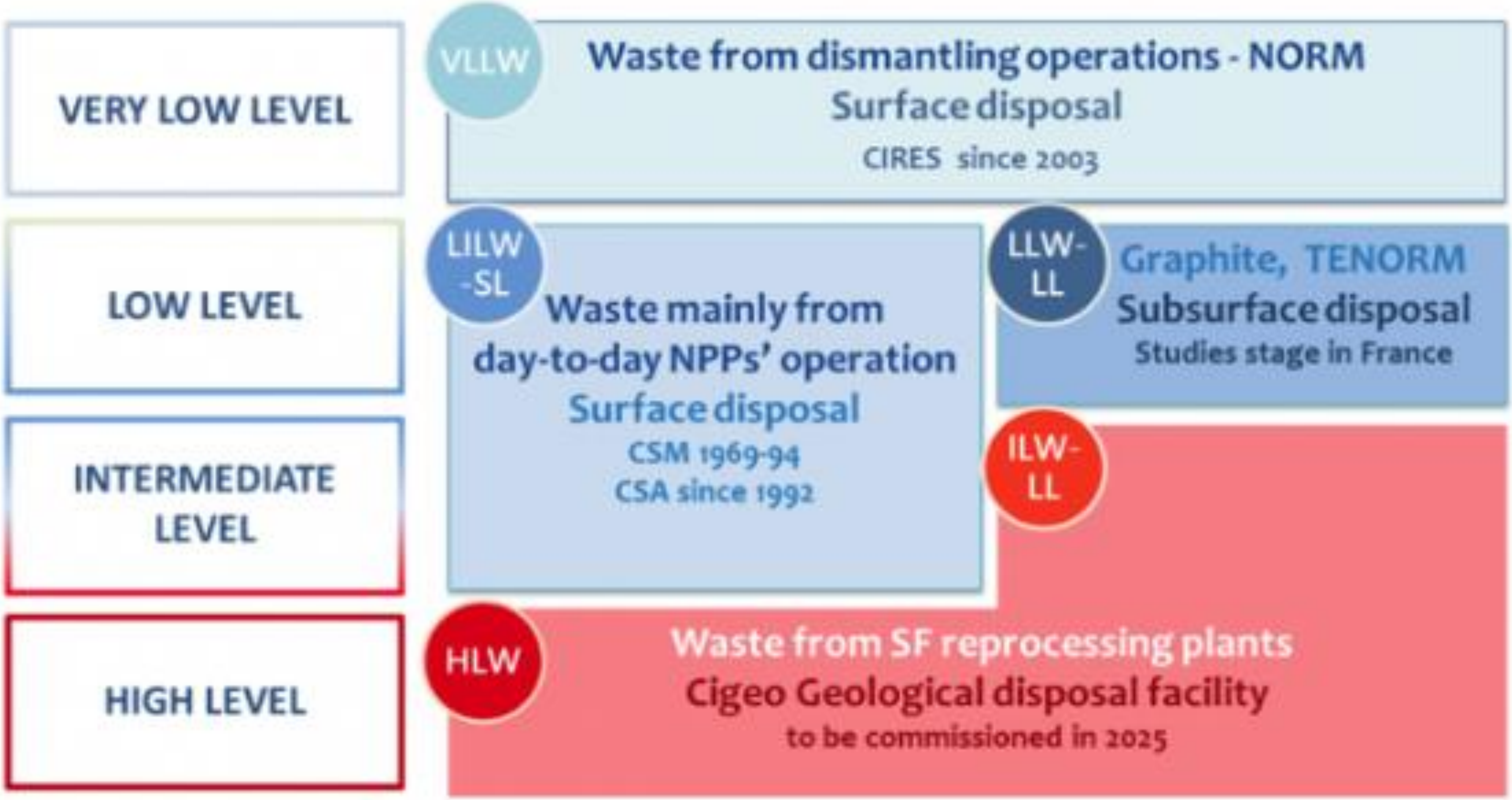
Some key factors that determine the disposal route for graphite..

- Policy, classification
- National waste disposal programmes
- Physical and chemical characteristics
- Decommissioning approach
- Availability of resources
- Stakeholder involvement
- Research and development
- Safety case

IAEA GSG 1 (2009)



Pathway might be predefined by policy, classification



ANDRA (2024)

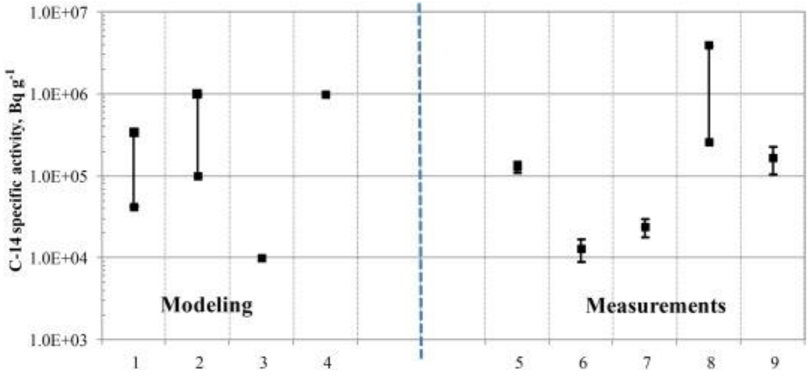
- Below 100-day period, management through in-situ radioactive decay.
- Only solid waste is to be disposed of.

Waste classes	Definition	Abbreviation	Surface dose rate mSv/h	Conditioning	Disposal method*
*Short lived low and intermediate level waste***					
A	Very low level waste	VLLW	≤0.2	Not required	Very low level waste repository
B	Low level waste	LLW-SL	0.5-2	Required	Near surface repository
C	Intermediate level waste	ILW-SL	>2	Required	Near surface repository
*Long lived low and intermediate level waste****					
D	Low level waste	LLW-LL	≤10	Required	Near surface repository (cavities at intermediate depth)
E	Intermediate level waste	LW-LL	>10	Required	Deep geological repository
High level waste					
G	High level waste	HLW		Required	Deep geological repository

LIT (JC, 2020)

IAEA publication on the disposal of reactor graphite waste

IAEA-GRAPA



Pokas et al., (2016) Graphite C-14 concentrations, estimate and actual, from Ignalina NPP (LIT)

Isotope	Content (%)	Mean Activity (Bq/g)
^{3}H	74.97	2.75E+05
^{14}C	15.32	5.62E+04
^{55}Fe	2.50	9.15E+03
^{60}Co	3.65	1.34E+04
^{63}Ni	2.39	8.77E+03
^{241}Pu	0.19	6.89E+02
Total	99.02	-

Isotopic composition and mean activity of graphite pile, Spain (provided by Enresa)

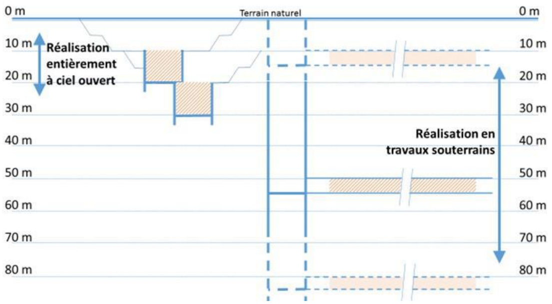
Disposal plans and options

Existing near surface LLW facilities, some waste able to meet WAC

LLWR site (UK) Courtesy of J. Shevelan (2022)

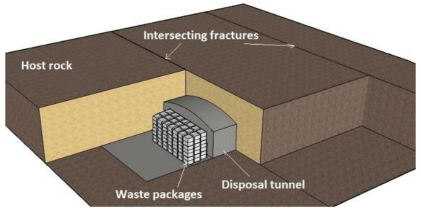
El Cabril facility

New designs: tens of m below surface



ANDRA (Investigations for potential tunnel at depth)

Deep geological repository



Grigaliūnienė et al. (2020) Plans for DGR in LIT

Proposed DRWSF in Russian Federation

Plans for disposal in Member States (e.g. Austria)

- Some graphite was able to be cleared reducing total inventory
- Graphite will be stored for the foreseeable future
- Austria committees starting talks on disposal possibilities in Austria

Technical notes:

- The maximum dose rate on contact of a graphite block was 3 mSv/h.
- Sampling was done systematically for the whole 2.5m length of the column. The activity of the graphite inventory can be seen in Table 2.
- Table 2: Activity of the graphite per 31.12.2021

Nuclide	Activity (Bq)
H-3	9,68E+09
C-14	5,67E+09
Cs-137	8,74E+08
Co-60	3,41E+08
Eu-152	2,80E+08
Eu-154	1,45E+08
Ba-133	3,98E+07

- No 36Cl was detected

Conclusion

- IAEA has completed a milestone of documenting the management of graphite wastes with the kind support of Member States with this inventory

- On disposal of graphite wastes: Member States have contributed a substantial amount of information to IAEA on planning and approaches, challenges, safety assessment development, WAC, and future work. This publication will be released in late 2025 as a preprint for review

- The IAEA graphite knowledge base and sharing practices for the safe decommissioning of graphite reactors stays current and continues

Thank you!