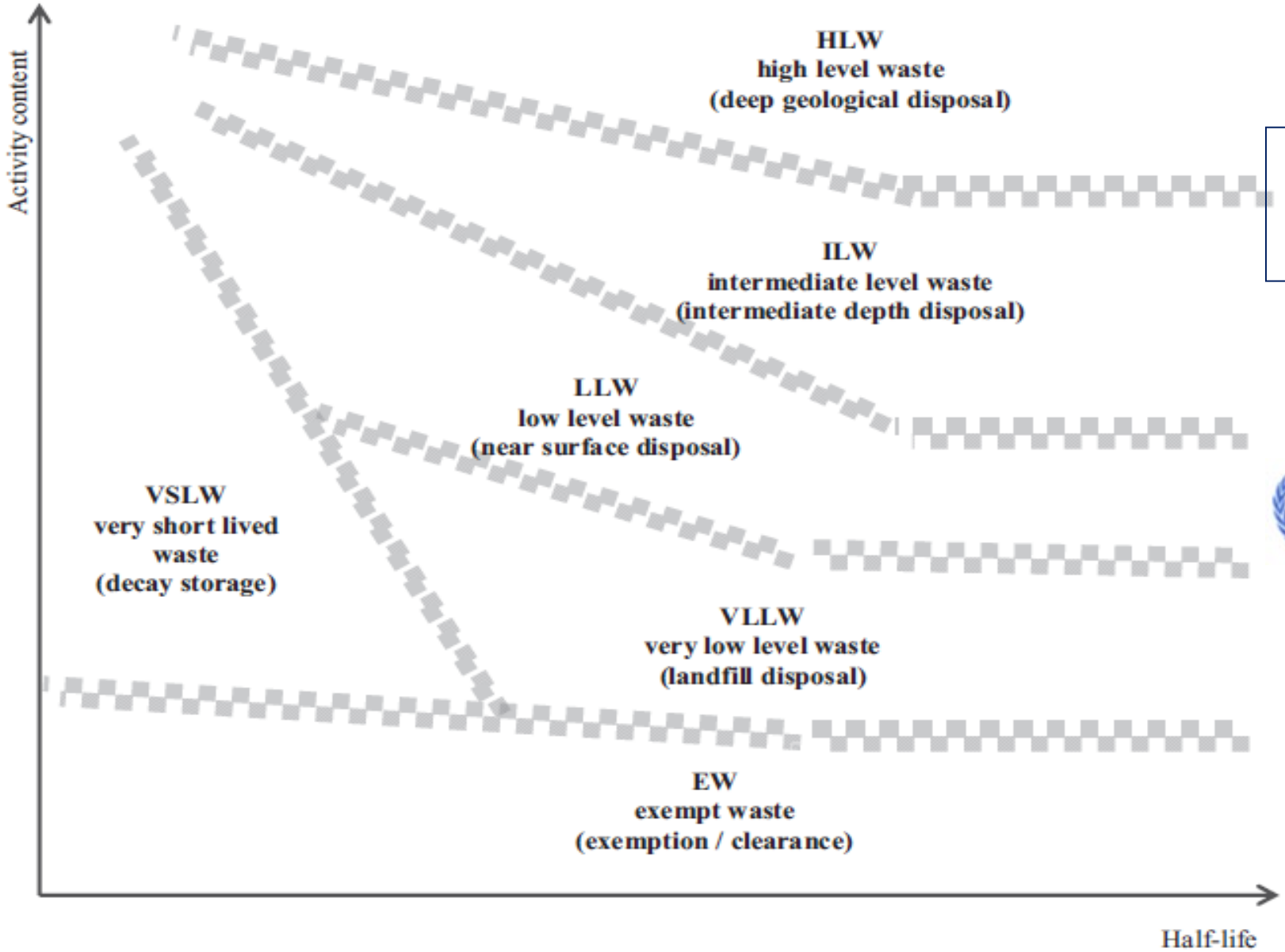
SOGIN

# Nuclear waste repository in Italy and annexed technology park

Annafrancesca MARIANI

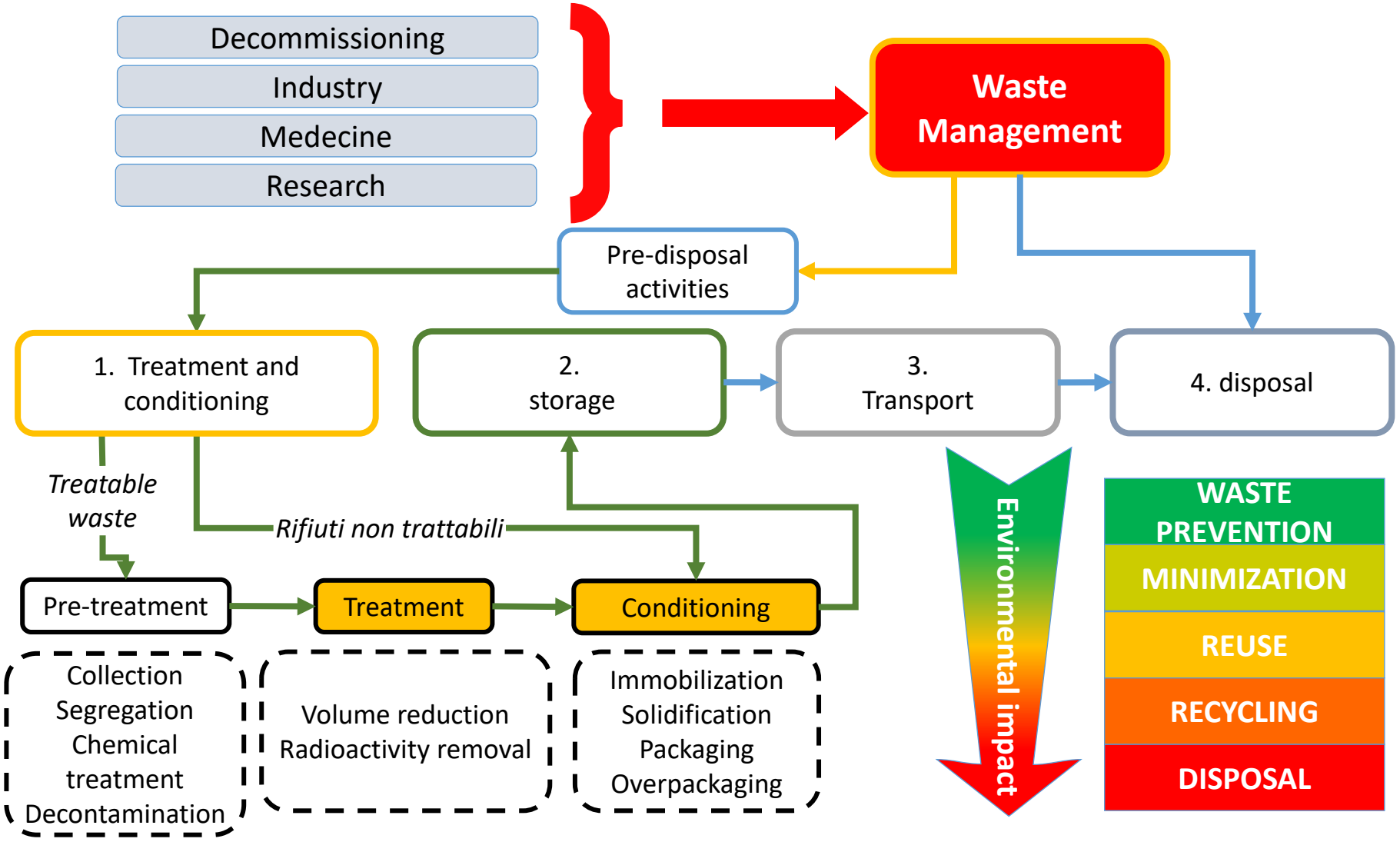
# Radioactive waste IAEA classification




IAEA Safety Guide No. GSG-1 "Classification of Radioactive Waste", 2009

IAEA International Atomic Energy Agency

# Management of radioacive waste and materials



# Material classification and Flow diagrams

Materials management is a key issue of the decommissioning process.
Based on their origin and radioactivity level, the materials resulting from decommissioning activities may be classified in:

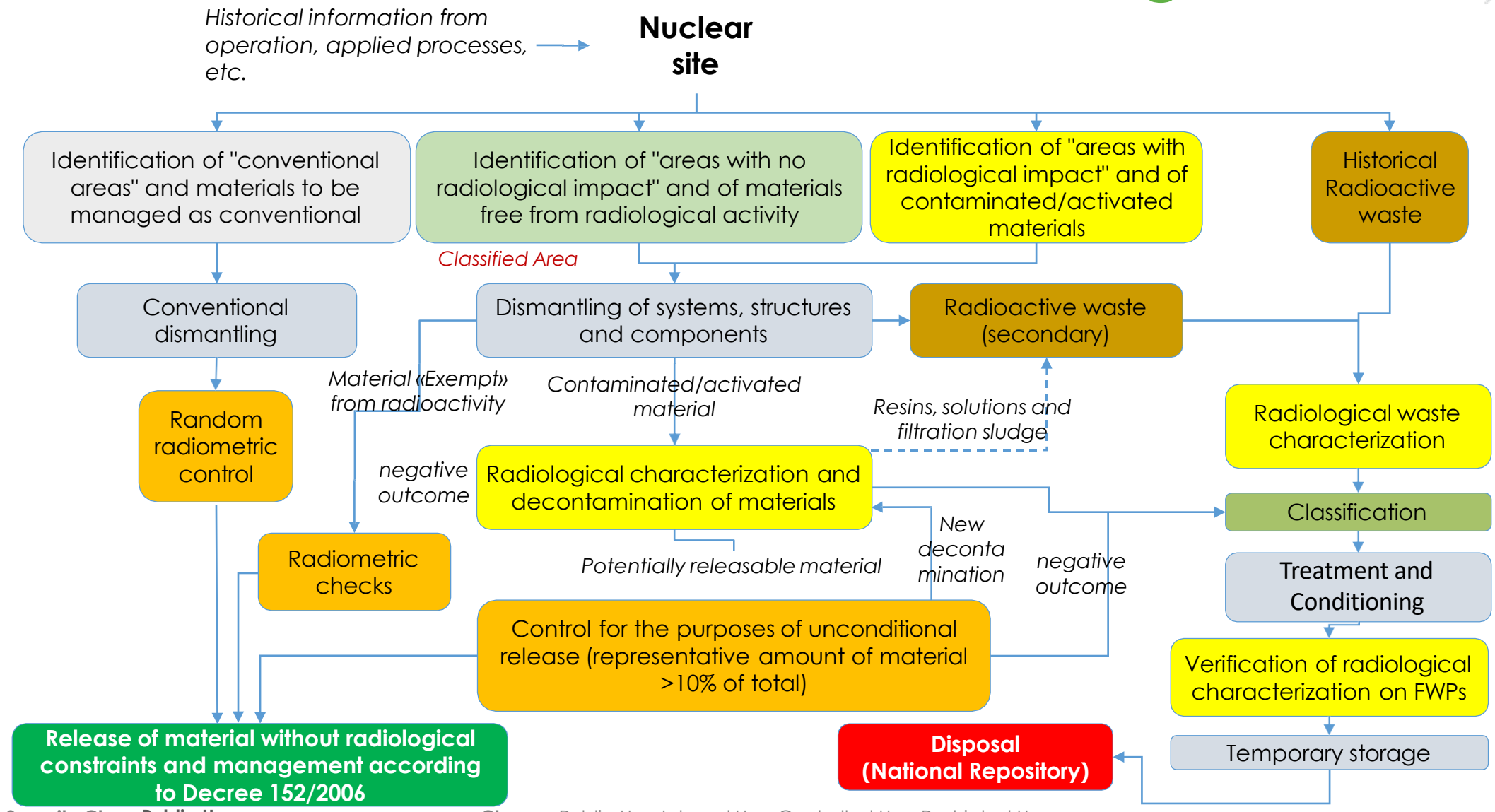
**CONVENTIONAL**
Materials from conventional areas of the plant.
Sample radiometric checks before leaving the site.

**EXEMPT**
Materials from exempt areas of the plant.
Radiometric checks in order to verify the absence of radioactive contamination.
The materials are removed from the site free of radiological risks.

**REMOVABLE/RELEASABLE**
Materials from areas with radiological impact.
Radiometric checks in order to verify that the radioactivity levels comply with the "clearance level".
Components or materials may be re-used, recycled or disposed of as conventional materials.

**NON-RELEASABLE MATERIALS**
Materials from areas with radiological impact.
Materials to be managed as radioactive waste.

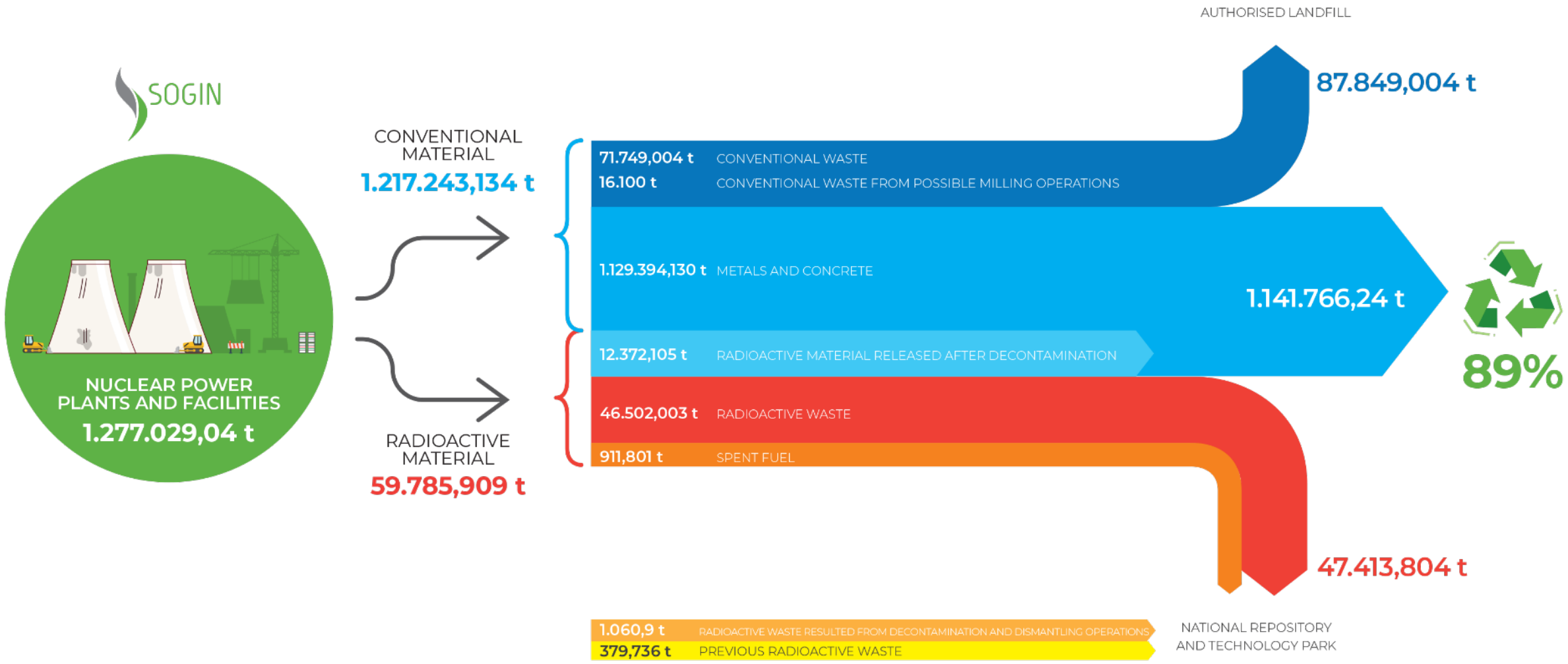
# Material classification and Flow diagrams




**Security Class**: **Public Use**

**Classes**: Public Use, Internal Use, Controlled Use, Restricted Use

# Decommissioning Waste inventory



# Specific Principles on RWM

The specific principles in Radioactive waste management can be grouped into the four following fundamental specific principles:

1. **Avoid generation of radioactive waste** in other word keep the generation of radioactive waste to the minimum possible or practicable;

2. **Minimize the spread of radioactivity** by containing it to the greatest extent possible. That means for example using a compartment strategy in line with the different contamination levels and prefer additional compartment for the most contaminated areas;

3. **Minimize the amount of radioactive waste** by applying adequate treatment technology, for example sorting or supercompaction;

4. **Optimize possibilities for recycle and reuse** of valuable components from existing and potential waste streams;

These specific principles are derived from IAEA TRS 401.

# Examples of waste treatment

## Waste reduction – SUPER-COMPACTION

A hydraulic press is used which works between 1000 and 2000 tons (order of hundreds of MPa) by vertically compressing the 220 liter metal drums containing radioactive waste.

The volume reduction factors achieved are typically in the range of 2-10 depending on the type of material

The compacted pellets are then placed in overpacks for subsequent conditioning

# Examples of waste treatment

**Section of a drumm containing supercompacted «pucks»**

# Examples of waste treatment

## Thermal treatment – FUSION

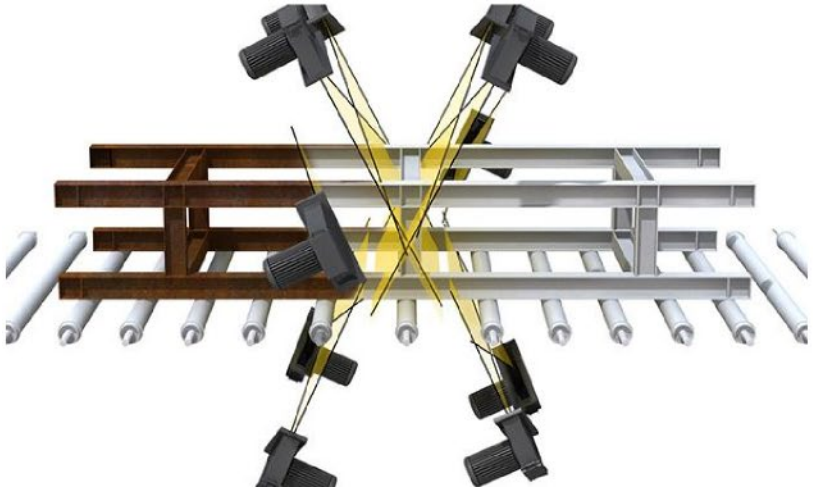
This is a technology widely used in the nuclear sector and allows for the recycling of more than 95% of the initial material

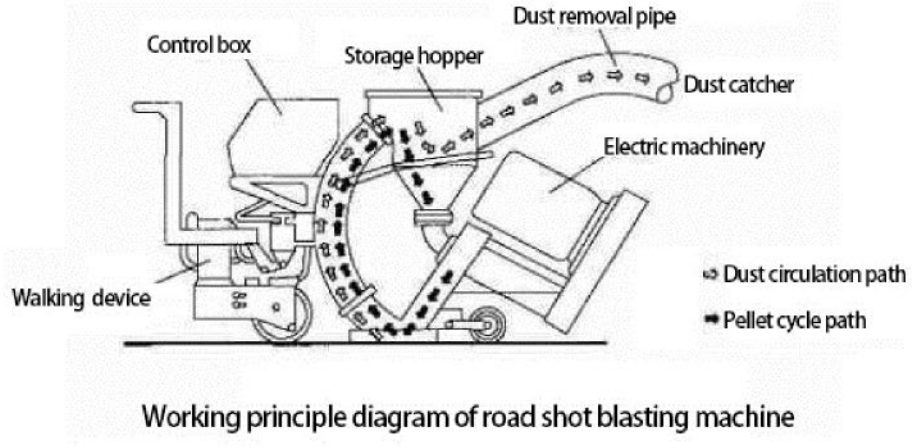
Radioactivity is concentrated in the melt slag (<5% of initial volume)

# Examples of waste treatment

## DECONTAMINATION AFTER DISMANTLING

Use of abrasive materials (metal balls or sand) to remove the surface contamination in order to reduce the final amount of waste.
The removed surface material and the abrasive are collected and managed as radioactive waste, the recirculation of the abrasives allows secondary waste to be minimized.
Applicable to most materials except those that may be crushed from the abrasive (e.g. glass or plexiglass)
It is most effective on flat surfaces and because the abrasive is sprayed, it is also applicable to areas difficult to reach



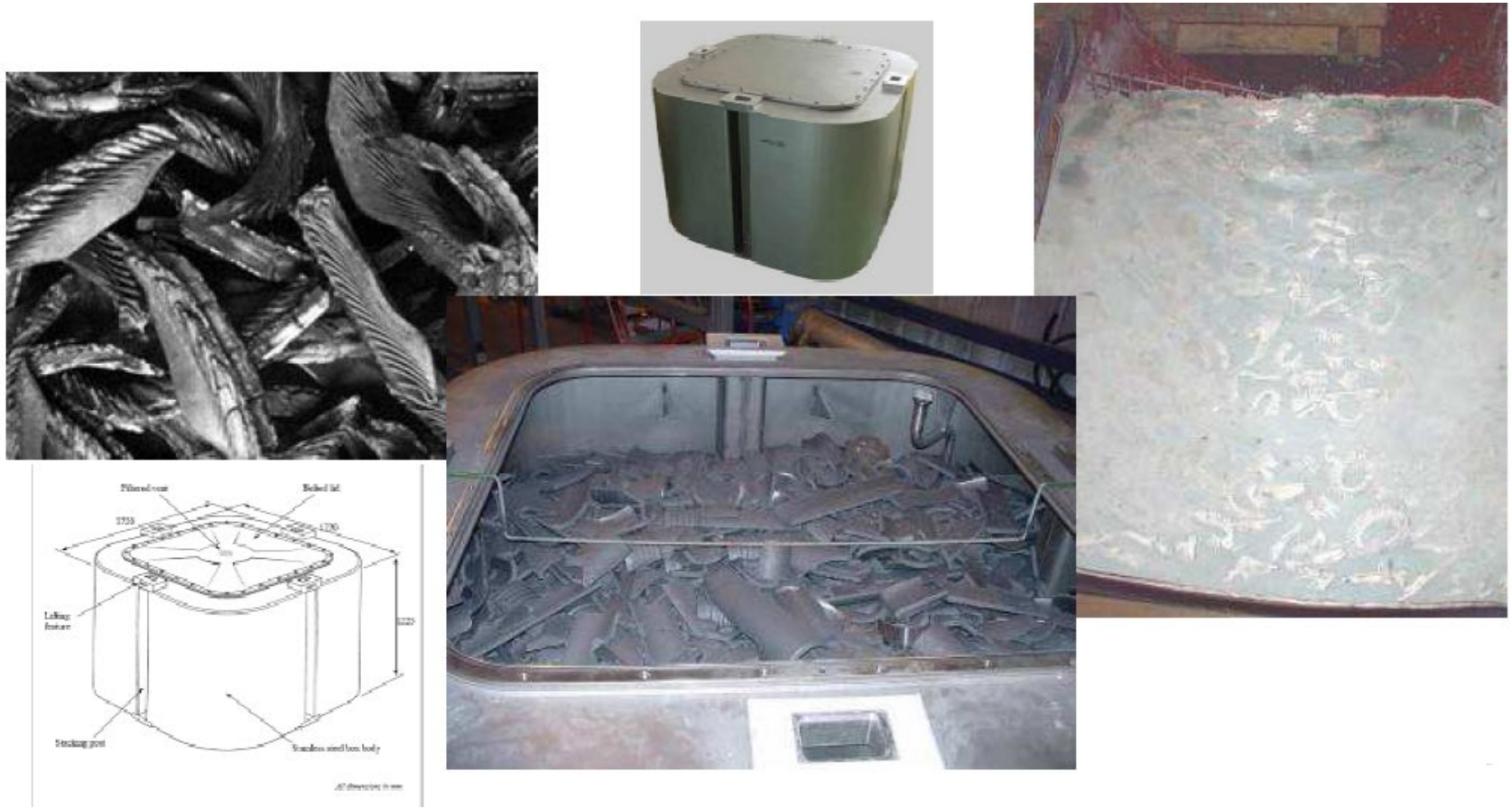


Working principle diagram of road shot blasting machine

# Radioactive waste conditioning

**"ENCAPSULATION"**

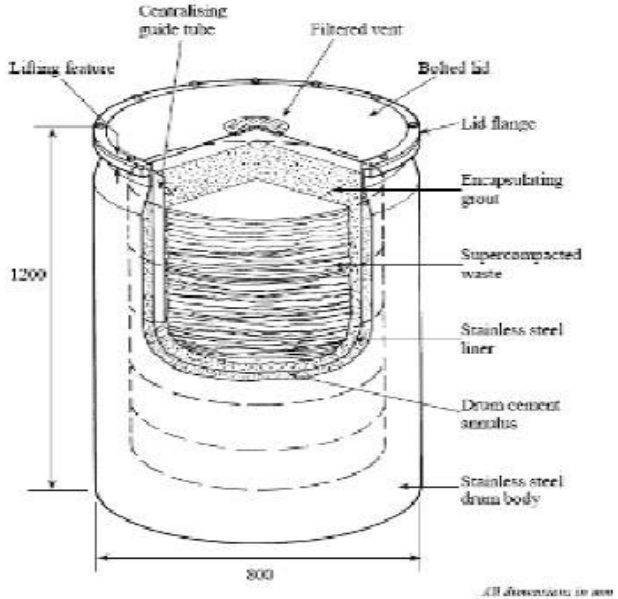
Encapsulation is the process of immobilizing solid waste by applying a fluid matrix (often cement-based) that completely penetrates the waste to form a solid monolith



# Radioactive waste conditioning

## "EMBEDDING"

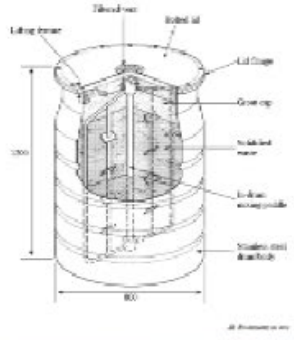
Embedding is a typical solid waste immobilization process, where the waste is incorporated into clay, mortar, sand, cement, etc. Generally, the elements (or additives) are inserted in the form of a fluid matrix together with the waste in a container, so that the voids can be filled and form a solid monolith. This process is generally used to immobilize waste in cylindrical containers and/or prismatic containers ("large containers").

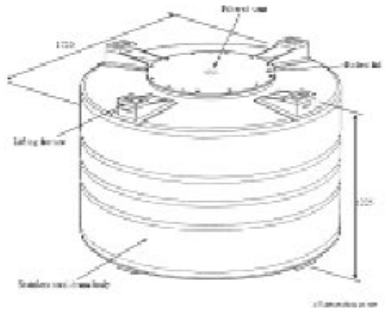




# Radioactive waste conditioning

## SOLIDIFICATION

"Solidification" is the immobilization process of non-solid phase waste (generally liquid or semi-liquid waste) which is generally applied by mixing the waste with cement, additives and water. A disposable stirrer is used to homogenize the mixture. The cement is then dried as for the "encapsulation process" to form a solid monolith.



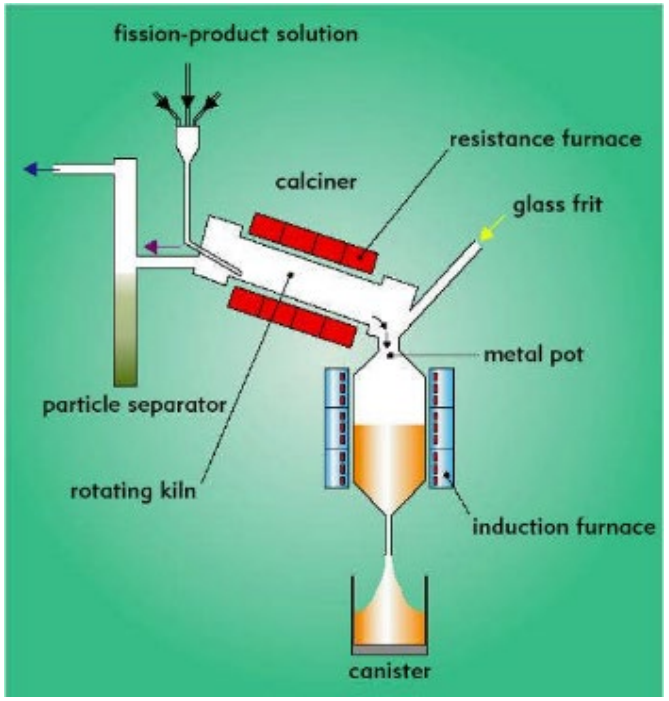


# Radioactive waste conditioning

## VETRIFICATION

High activity liquid radioactive waste (fission products obtained from the reprocessing phases of the irradiated fuel) is mixed with molten glass and poured into stainless steel containers (canisters) in order to obtain a solid matrix (vitrified waste).

Glass guarantees chemical/physical stability for long periods and is characterized by high resistance to leaching, radioactivity and heat; it therefore constitutes an excellent matrix for the containment of radioactive waste.



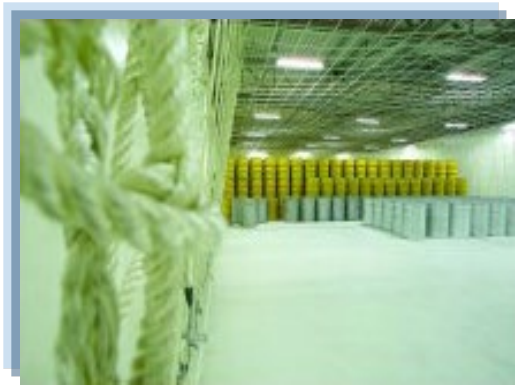

**H = 1.3 m**
**ø = 0.4 m**

# Italian waste management strategy

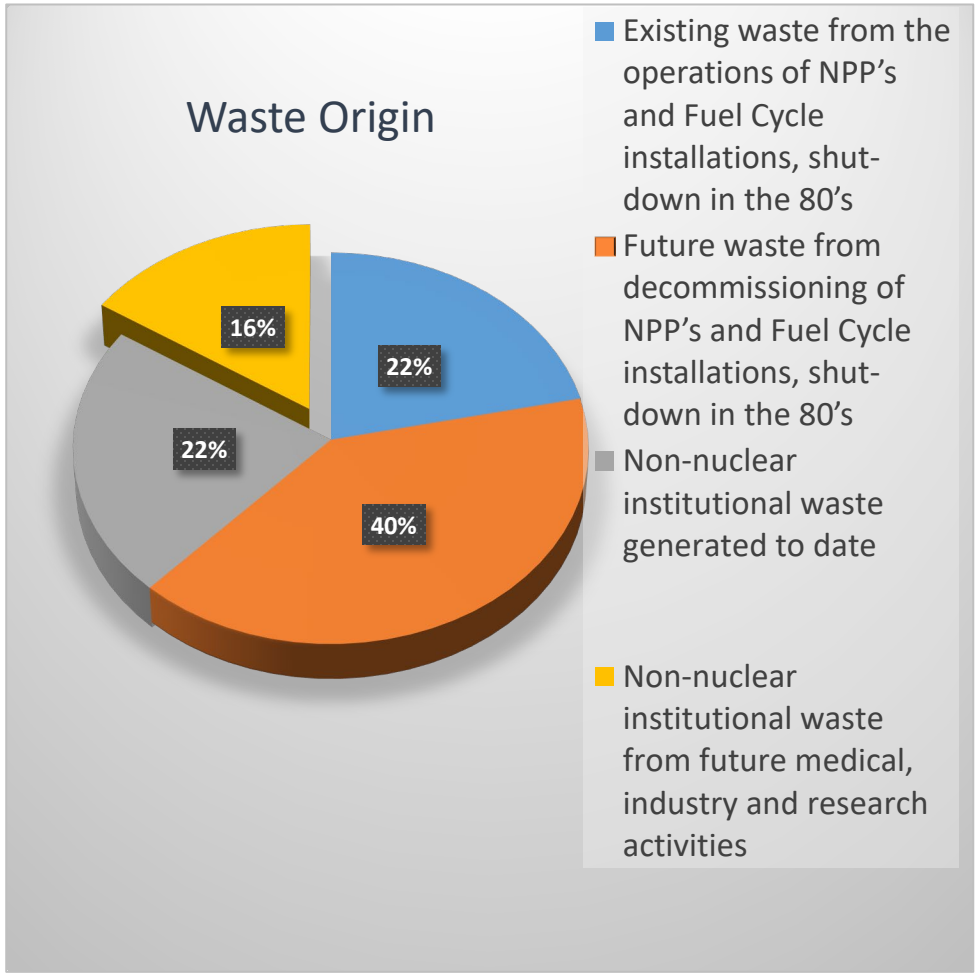
- **Treating and conditioning** all liquid and solid waste for delivery to the National Repository to be realised in Italy
- **Transport abroad** of the Spent Nuclear Fuel for reprocessing (except particular cases)
- **Receiving back** to Italy the residues foreseen by the reprocessing contracts
- **Interim storage** of waste at the production sites
- **Disposal** of Very Low and Low Level Waste in the National Repository
- **Long-term storage** of Medium and High Level Waste in the National Repository pending the availability of a geologic repository
- **Implementing R&D** aimed at the safe management of Spent Nuclear Fuel and Radioactive Waste
- **Transparency and actual participation** by the public in the decision process relevant to SNF and RW management

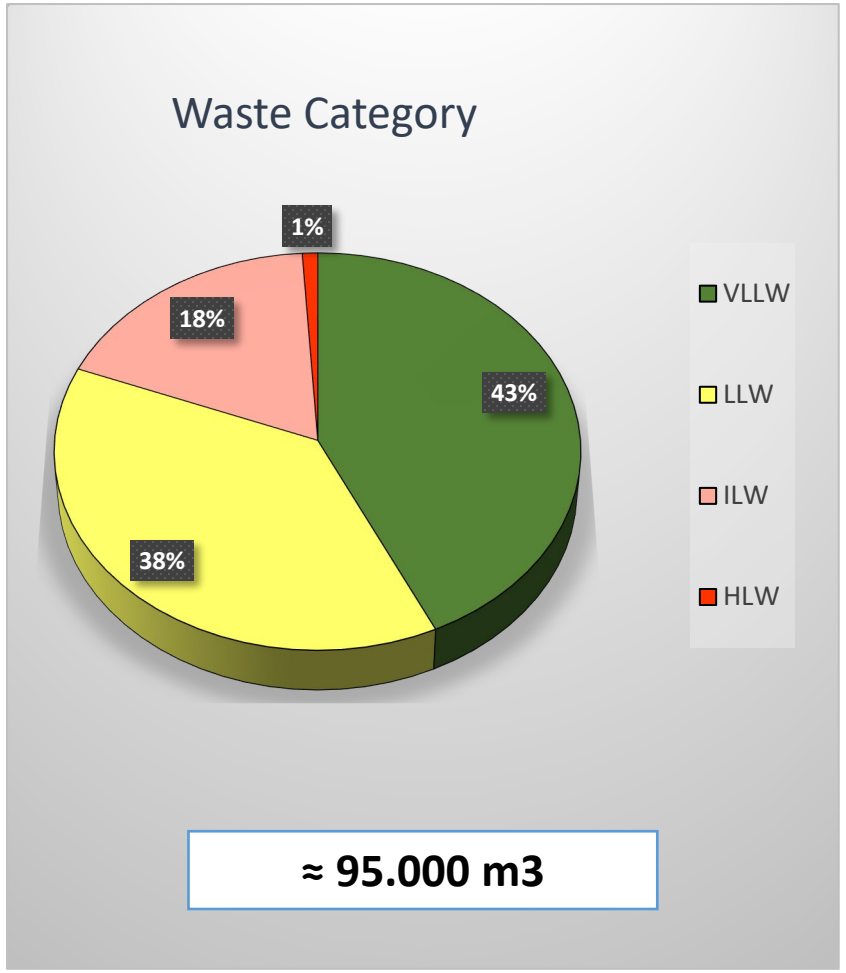
# Storage of operational waste

Currently the whole quantity of waste generated during the decommissining operation of the Sogin nuclear installations is safely stored at the same sites and partially at the Nucleco premises



# Radwaste inventory in Italy
## (Forecast of the overall volumes to be disposed of*)

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# DISPOSAL STRATEGY IN ITALY

**Very short-lived waste (VSLW)**

**Very low level waste (VLLW)**
**Low level waste (LLW)**

**Intermediate level waste (ILW)**
**High level waste (HLW)**
**Spent Fuel**

CONVENTIONAL DISPOSAL AFTER DECAY

TEMPORARY STORAGE ON SITE TILL AVAILABILITY OF NATIONAL REPOSITORY

NATIONAL REPOSITORY

NEAR SURFACE DISPOSAL

LONG-TERM STORAGE PENDING AVAILABILITY OF A GEOLOGICAL REPOSITORY

DISPOSAL IN A DEEP GEOLOGICAL REPOSITORY

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# CURRENT WASTE STORES IN ITALY

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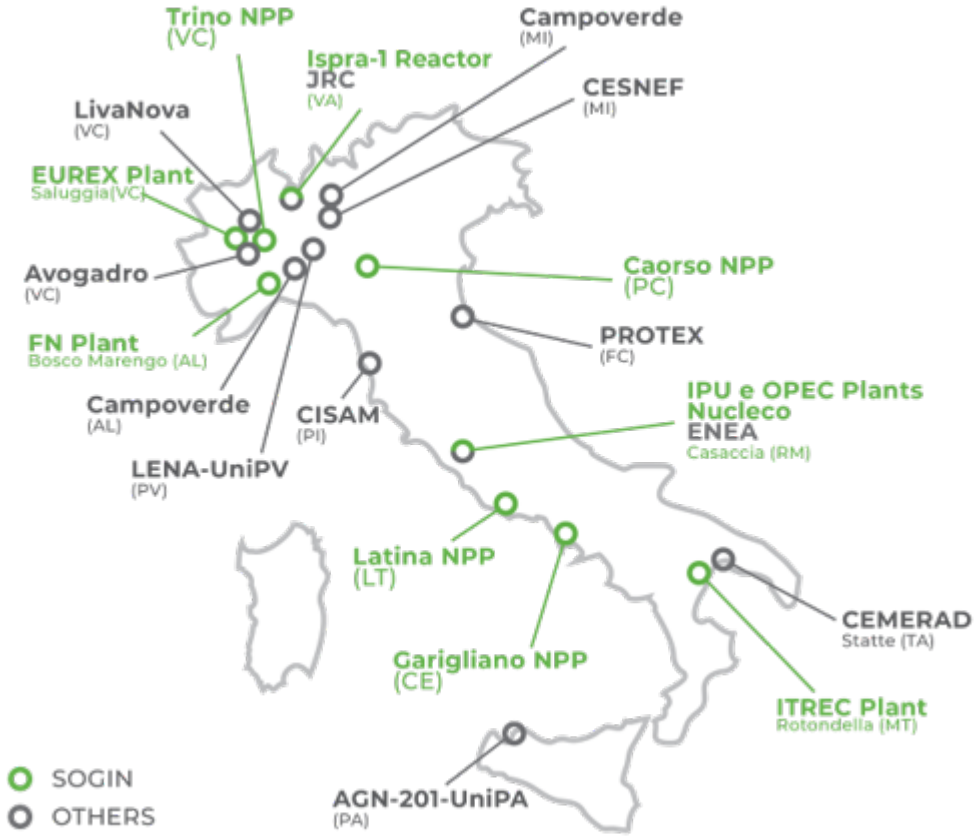
## Waste from medicine, research, industry

- VSLW managed by institutional producers, like hospitals, until natural decay allows their disposal as conventional (special) waste
- remaining LLW and ILW are collected by the operators of the so-called Integrated Service and stored in temporary storage facilities pending availability of the National Repository

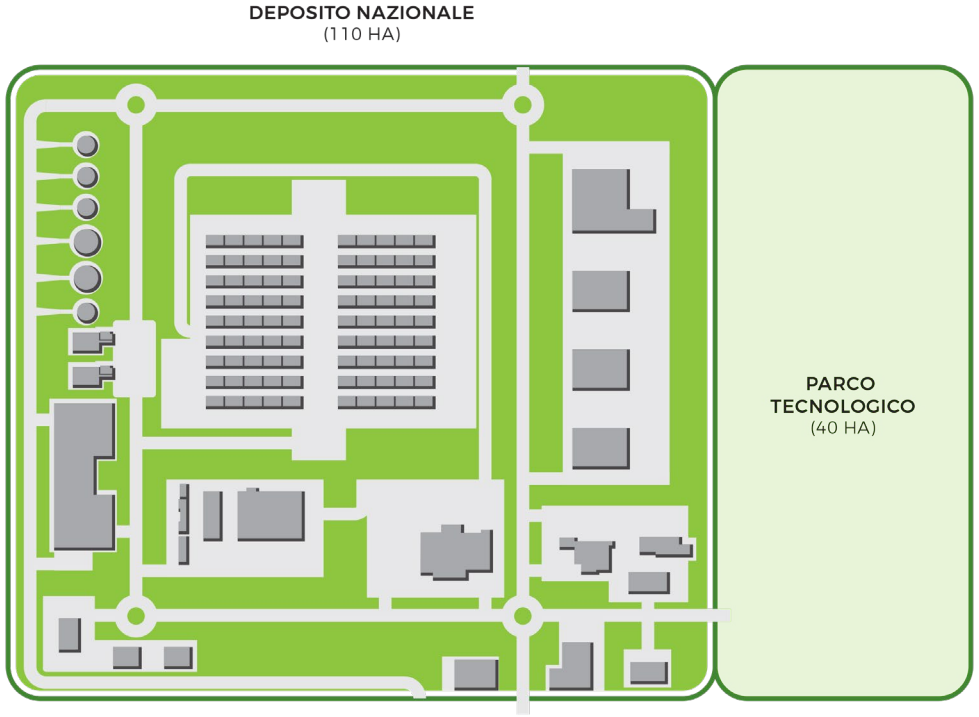
## Waste from nuclear power plants, fuel cycle facilities, research reactors and decommissioning

- stored by Sogin in temporary storage facilities at the sites of production pending availability of the National Repository



# NATIONAL REPOSITORY AND TECHNOLOGY PARK

- The National Repository is a surface infrastructure designed to place **all Italian radioactive waste**
- The project also envisages creating a Technology Park, a **research centre** in the fields of energy, waste management and sustainability
- **Law No. 31 of 2010** entrusted Sogin with the task of siting, designing, building and operating the National Repository and Technology Park
- For the localization of the site in which the infrastructure will be built, Sogin has managed a **public consultation**, lasted **about a year** (5th January 2021 - 14th January 2022), which included a **National Seminar**
- It represented an **efficient tool for civil society stakeholders' engagement** (institutions, associations, committees, companies, professionals and citizens): **over 600** questions, observations and proposals from 322 subjects





The National Repository will collect about **95.000 m³** of radioactive waste over time: **60%** of waste results from the nuclear decommissioning, while **40%** from scientific research, medical applications and industry.

# SITING CRITERIA

**Technical Guide n.29 published in June 2014 by ISPRA (Italian Regulator) with siting criteria for a near surface disposal facility**

Two categories of criteria are defined:


- ✓ **15 Exclusion Criteria** Applied by means of data on a national scale they led to the exclusion of areas whose characteristics do not comply with the main safety principles, resulting in the identification of potentially suitable areas
- ✓ **13 Investigation Criteria** Applied to the not excluded areas by means of available data on a local scale for further exclusion of unsuitable areas; they will be useful for elaborating a suitability order of potentially eligible areas and for the characterization of the sites of interest.

# EXCLUSION CRITERIA

| | |
|---|---|
| EC1 | with presence of active or quiescent volcanoes |
| EC2 | with high seismic activity |
| EC3 | interested by superficial faulting |
| EC4 | characterized by geomorphological and/or hydraulic risk and/or hazard of any grade as well as river belts |
| EC5 | with holocene alluvial deposits |
| EC6 | located above 700 m a.s.l. |
| EC7 | characterized by an average slope greater than 10% |
| EC8 | within 5 km from the current coast line or, if more distant, located under 20 m a.s.l. |
| EC9 | interested by morphogenetic karst processes or with presence of sinkholes |
| EC10 | with near surface piezometric levels or with piezometric levels which could anyhow interfere with the foundation of the disposal facility |
| EC11 | naturalistic, protected under the legislation in force |
| EC12 | at a unsuitable distance from residential zones |
| EC13 | within a distance of 1 km from highways, all principal suburban roads, and the main and complementary railway lines |
| EC14 | with known presence of underground resources |
| EC15 | with industrial activities involving major accident hazards, dams and artificial hydraulic barriers, airports or operating military shooting ranges |

# INVESTIGATION CRITERIA

| | |
|---|---|
| IC1 | presence of secondary volcanic activities |
| IC2 | presence of significant vertical movements as a result of subsidence and uplift phenomena (tectonic and/or isostatic) |
| IC3 | geological-morphostructural setting and presence of lithotypes with vertical and lateral variation |
| IC4 | presence of endorheic type river basins |
| IC5 | presence of accelerated erosion phenomena |
| IC6 | weather and climatic conditions |
| IC7 | physical and mechanical parameters of the soil |
| IC8 | hydrogeological parameters |
| IC9 | chemical parameters of soil and groundwater |
| IC10 | Habitats, animal and plant species of conservation importance, as well as geosites |
| IC11 | agricultural production of outstanding quality and places of archaeological and historical interest |
| IC12 | availability of primary transport infrastructures |
| IC13 | presence of relevant or strategic critical infrastructures |

# SITING PHASES

**Phase 1**: analysis of the national territory

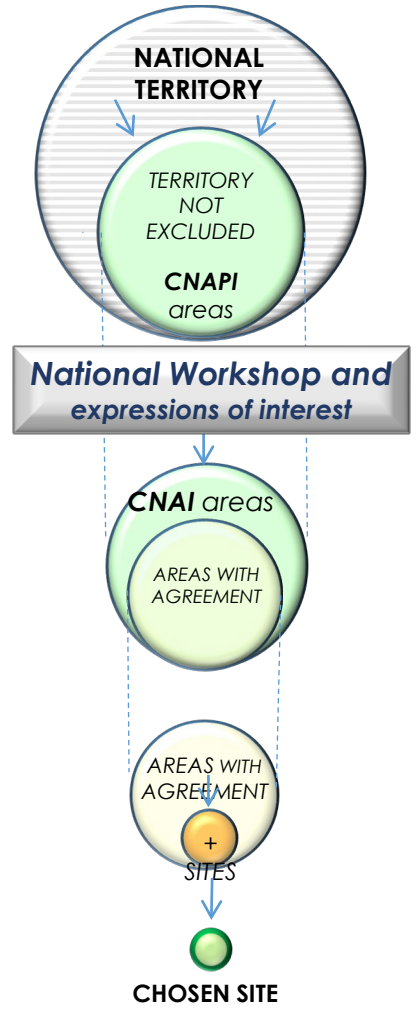
- The exclusion criteria are applied, in overlap, on a **national and regional level**. The result constitutes the **CNAPI** proposal (**National Map of Potentially Suitable Areas**)

**PHASE 2**: analysis at regional and local level

- After the expressions of interest collected from local authorities, the institutional agreements are framed. Then the **possible suitable sites** are identified within the areas selected in Phase 1

**PHASE 3**: detailed surveys and analyses at site level

- In areas with agreement, detailed technical surveys are carried out under the surveillance of ISIN (Regulator) to indicate the final site which will be subjected to safety analysis for the **Site qualification**

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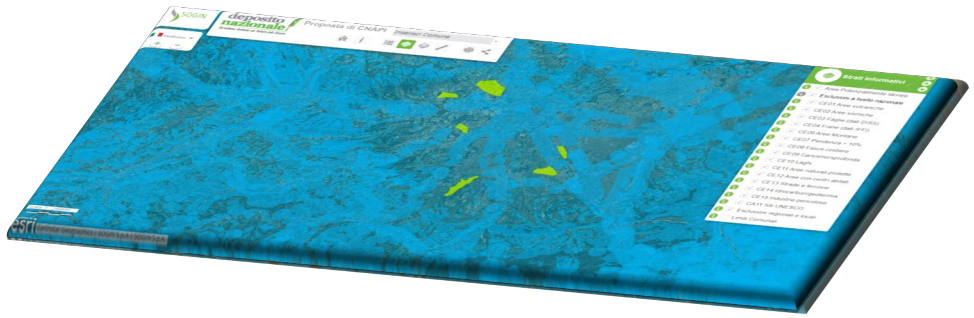
# APPLICATION OF THE CRITERIA

Sogin applied a procedure in two separate phases, as suggested by IAEA (SSG – 29):

- **Regional mapping phase:** areas are excluded if the analysis of the available data shows their non compliance with the Exclusion Criteria defined by ISPRA
- **Site screening phase:** areas are excluded or ranked according to more detailed data compared to the Investigation Criteria defined by ISPRA



The "potentially suitable areas" are areas, even vast, which have characteristics favorable to the identification of sites suitable for the localization of the repository

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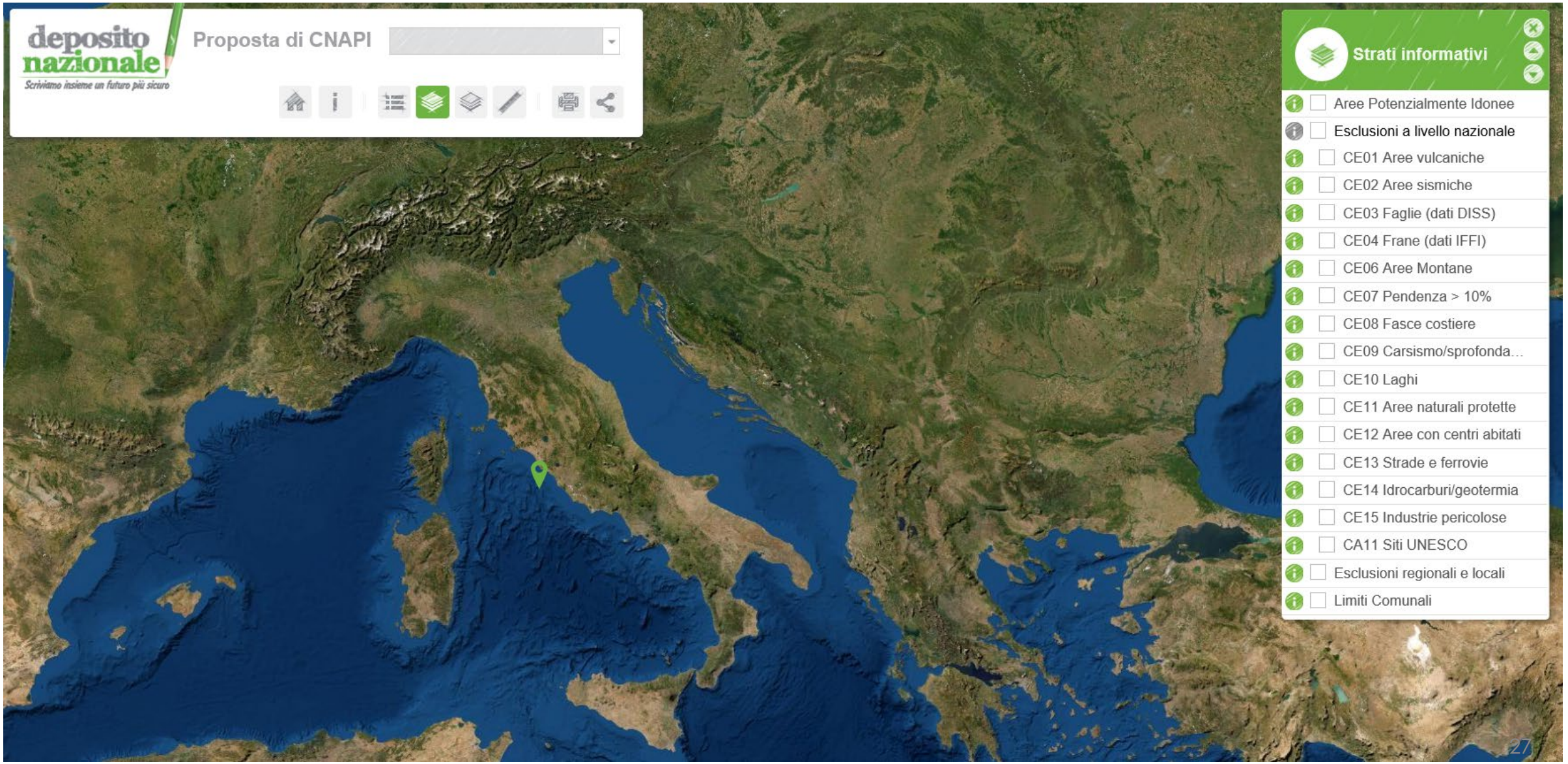
# APPLICATION OF THE CRITERIA



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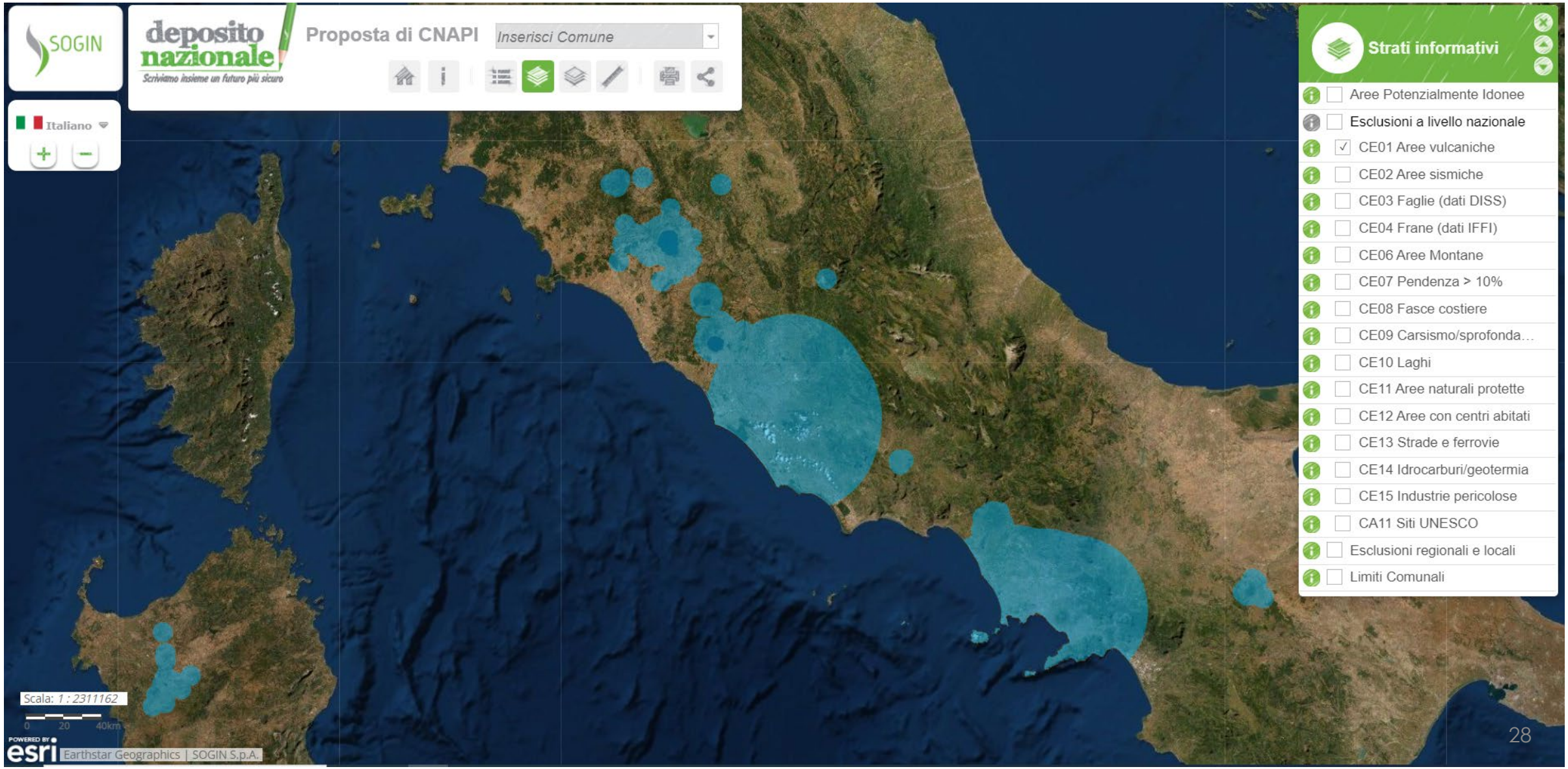

# APPLICATION OF THE CRITERIA


NATIONAL REPOSITORY

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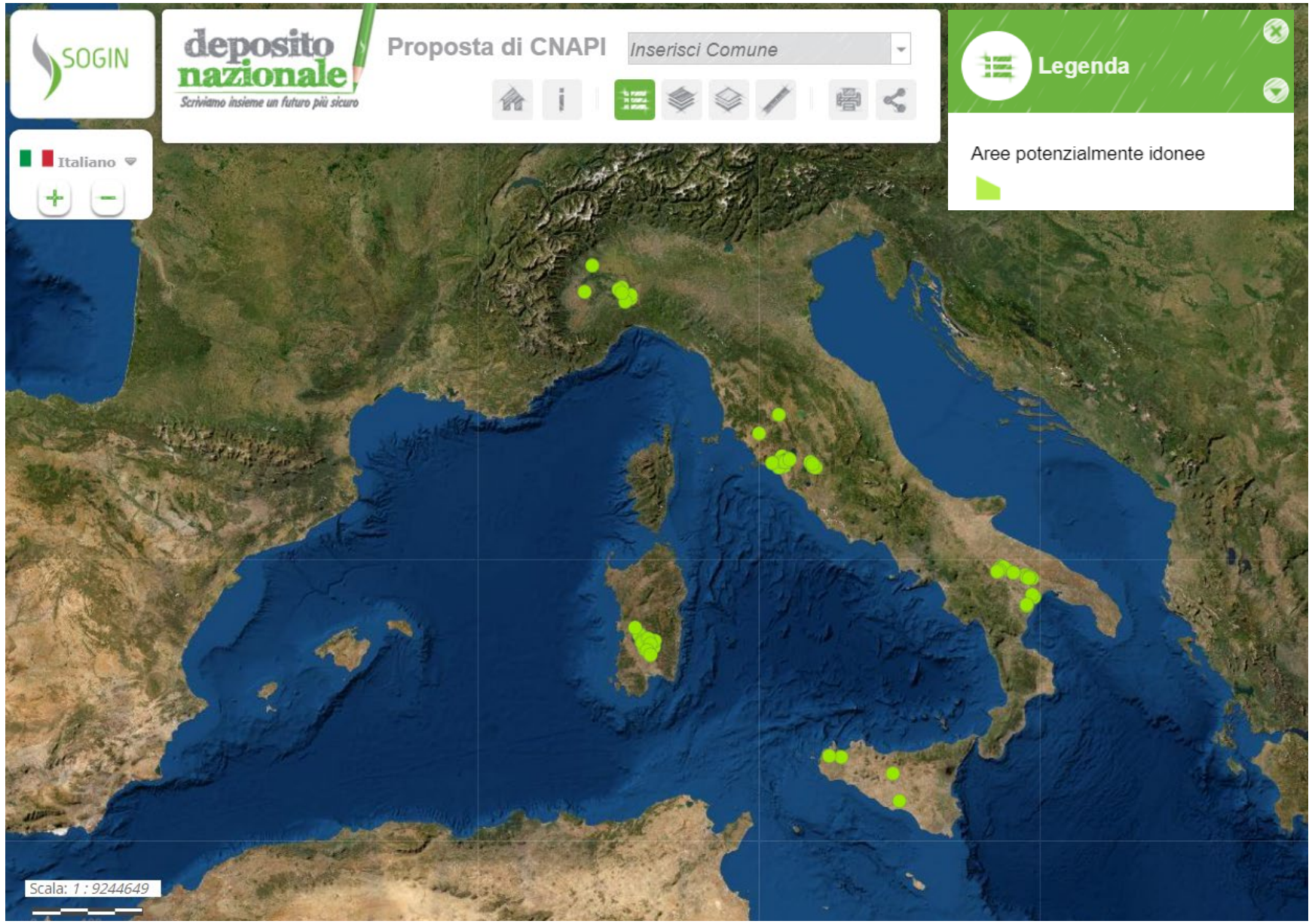


**National territory excluded**
**99,93%**

**29.978.212 ha**

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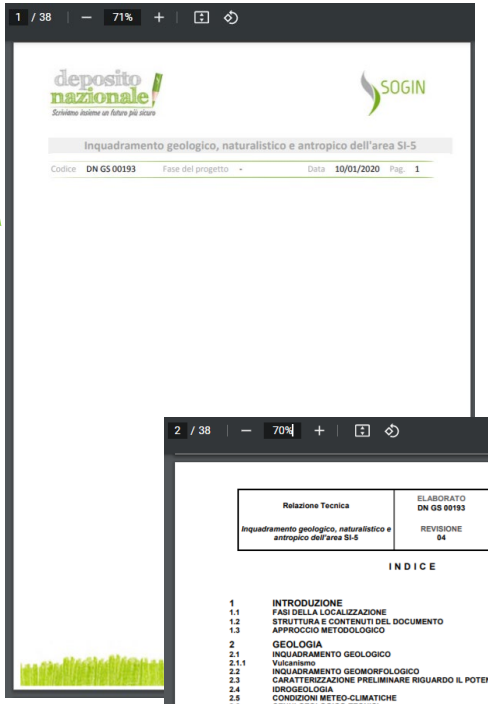
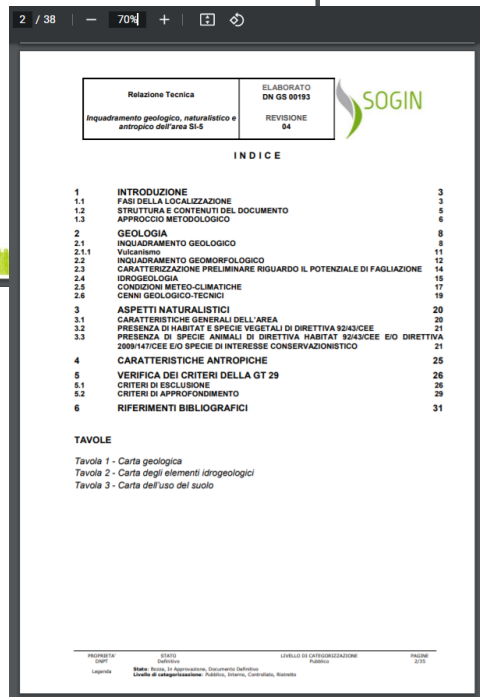
# APPLICATION OF THE CRITERIA

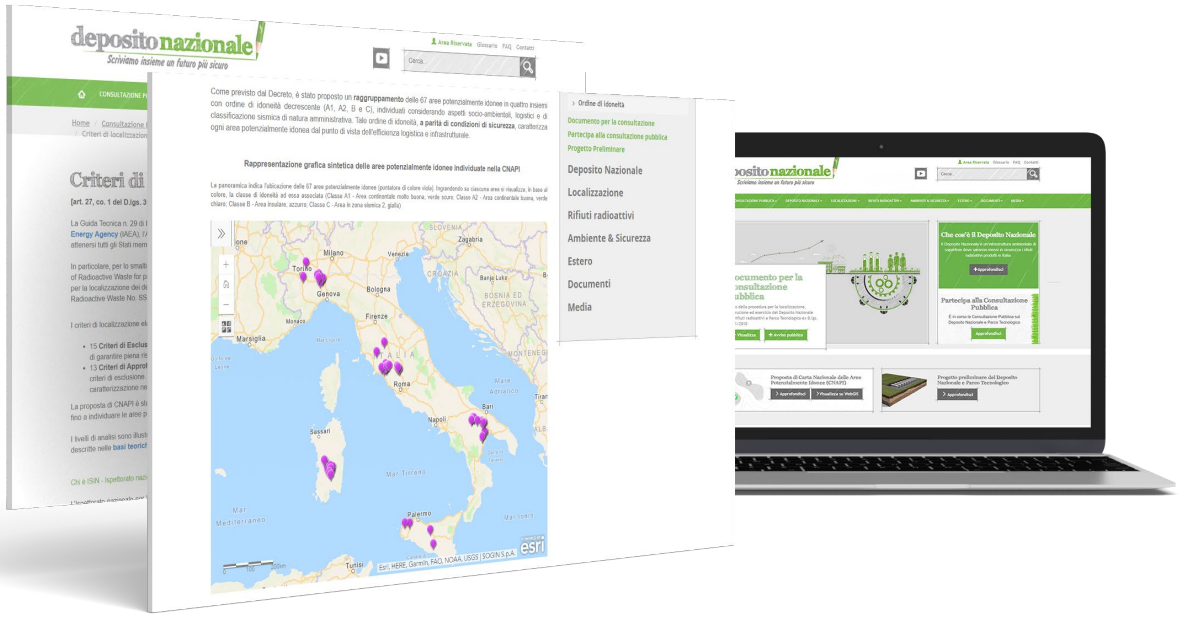

**Security Class**:

**Public use**

**Classes**: Public Use, Internal Use, Controlled Use, Restricted Use

# CNAPI

## 67 Potentially suitable areas, 7 Regions




- **Piedmont**: 8 areas
- **Lazio and Tuscany**: 24 areas
- **Basilicata and Apulia:** 17 areas
- **Sicily:** 4 areas
- **Sardinia:** 14 areas

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# PUBLIC CONSULTATION: MAIN STEPS

**elaborates** the proposal of CNAPI - National Map of Potentially Suitable Areas

**validates** the CNAPI and transmits it to the competent Ministries

**approve** the publication of the CNAPI (30/12/2020)

Competent Ministries

**CNAPI publication and start of the public consultation**
**5th January 2021**

**5th July 2021**
**Closing the first phase public consultation**

**National Seminar Promotion**
**3th August 2021**

**7th September 2021**
**Start of the National Seminar**

**Conclusion of the working sessions of National Seminar**
**24th November 2021**

**15th December 2021**
**Conclusion of the National Seminar and publication of the restitution of the working sessions**

**Closing the second phase public consultation**
**14th January 2022**

NATIONAL REPOSITORY

# NATIONAL SEMINAR: THE NUMBERS


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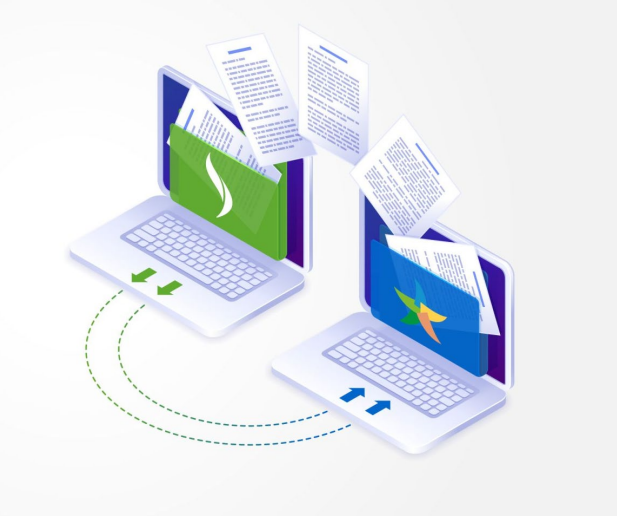
# SITING AND REALIZATION PROCESS


* Observations formally submitted to Sogin and MASE (former MiTE Ministry of Ecological Transition)

** CNAI will be published on the websites of Sogin, the competent Ministries and the ISIN

# WHERE WE ARE: TRASMISSION OF THE CNAI



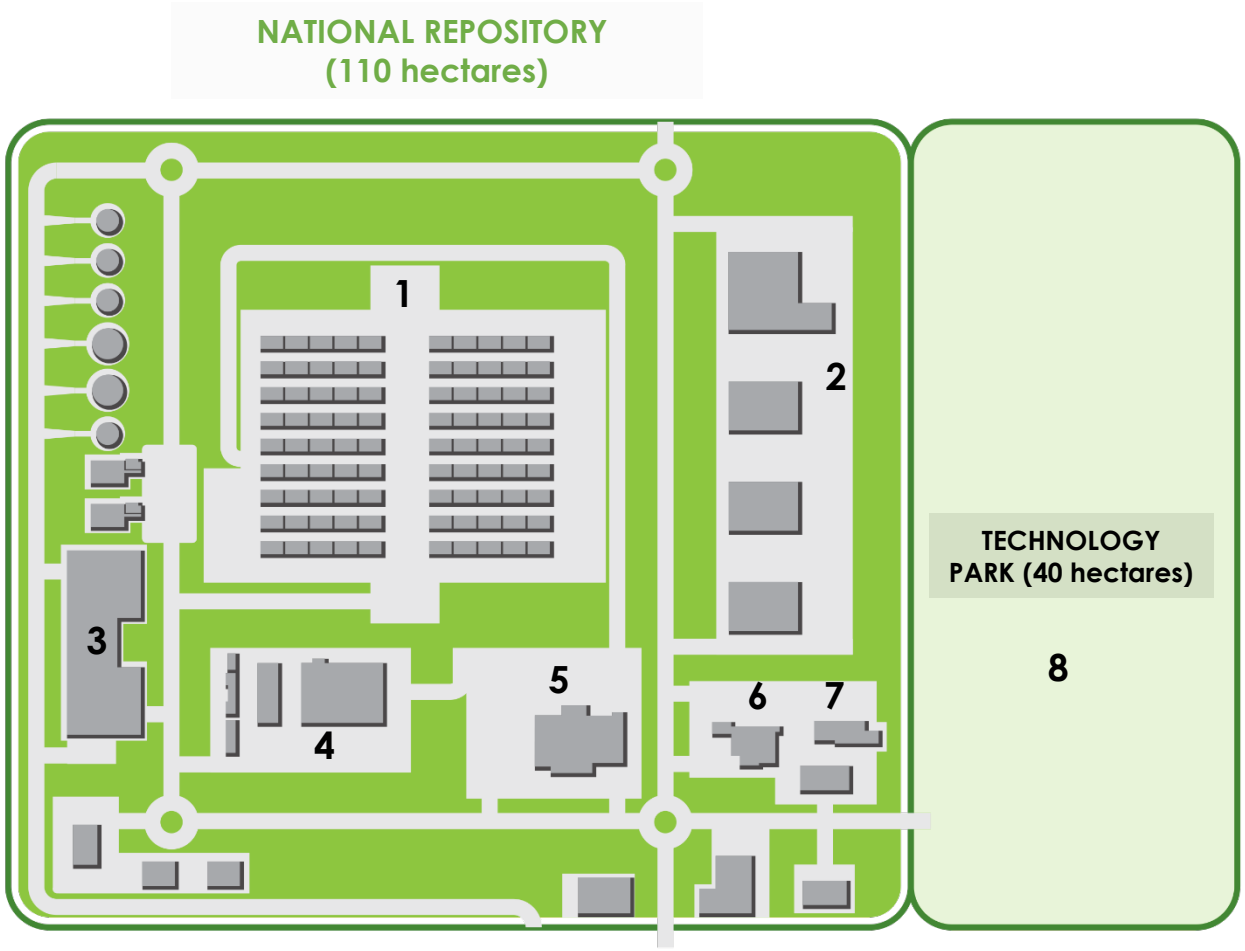


- Sogin drew up the proposal of CNAI, the National Map of Suitable Areas, based on the results of the most relevant **public consultation**, including a National Seminar
- **On Mars 15th, 2022** Sogin has sent the proposal of the **CNAI** to the Ministry of Ecological Transition
- Genuary 2th , 2023 the new Ministry of Environment and Energetic Safety has sent the ISIN technical opinion to Sogin with the request of some changes and addition

**NEXT STEP FOR THE LOCALIZATION**

- Approval of the CNAI by the Ministry of Environment and Energetic Safety in agreement with the Ministry of Infrastructures and Transports, subject to the technical opinion of the ISIN. The map shall then be published on the websites of Sogin, the two Ministries, and ISIN
- Expressions of interest of the Regions and Local Authorities having areas identified in the CNAI
- Technical investigations in the candidate sites
- Issue of the Localization Decree by the Ministry of Ecological Transition in agreement with the Ministry of Sustainable Infrastructures and Mobility

# NATIONAL REPOSITORY PRELIMINARY DESIGN




1. Disposal area for VLLW and LLW
2. Complex for storage of ILW/HLW (Casks and High integrity containers)
3. Area for cell production
4. Module Production Plant
5. Module Loading Plant
6. Solid Waste Treatment Plant
7. Quality Control, Radiochemical Analyses
8. Technology Park with common facilities and R&D labs devoted to D&WM as well as sustainable development activities to be agreed with the local communities

# Aims of Disposal

- Disposing of waste requires containing and isolating waste from the accessible biosphere until they represent a hazard for man and environment
- The amounts of radionuclides reaching the accessible biosphere due to any migration from the disposal facility are such that possible radiological consequences are acceptably low at all times
- During disposal the likelihood of inadvertent human intrusion into the waste is substantially reduced
- Disposal inhibits, reduces and delays the migration of radionuclides at any time from the waste to the accessible biosphere

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# Containment and isolation

- Containment and isolation of the waste are assured by a combination of engineered barriers in series and the natural geologic characteristics of the site
- The engineered barriers shall be designed and the host environment shall be selected so as to provide containment of the radionuclides until radioactive decay has significantly reduced the hazard posed by the waste
- Being water the main way of radionuclide transport, the barriers shall prevent water infiltration and/or leakage

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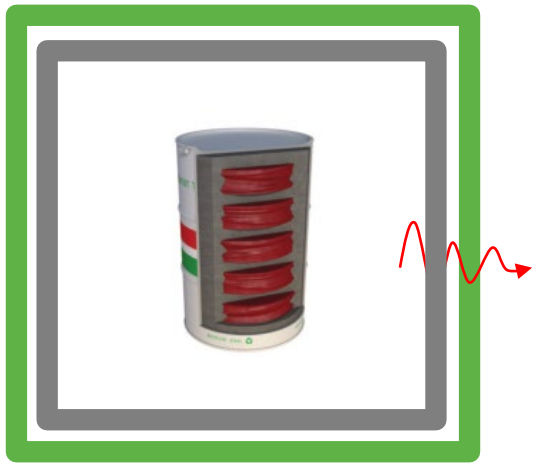
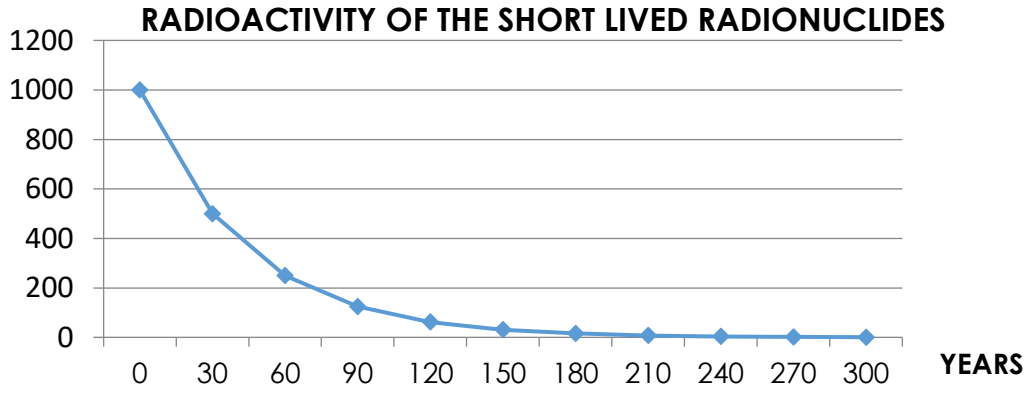
# Surface disposal – Basic concepts

- Limiting the inventory of the waste to be disposed of to 'short lived' waste (T/2 < 30 years; typically Cs-137 and Sr-90) and small quantities of 'long lived' RN (α emitters < 370 Bq/g)
- Engineered barriers qualified for > 300 years durability
- Institutional control period of 300 years for assuring isolation of waste
- 300 years = 10 half lives → $1/2^{10} \approx 1/1000$ of the initial activity of 'short lived' RN



# DISPOSAL OF VLLW AND LLW
## Multiple barrier system

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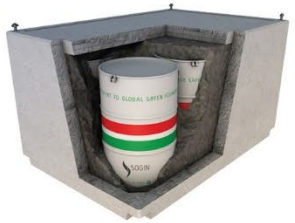
**1 WASTE PACKAGE**

Radioactive waste conditioned with a grouting matrix inside metallic containers, transported to the National Repository

**2 MODULE**

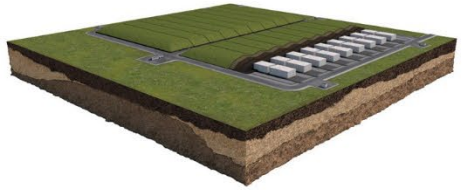


Waste packages inserted and grouted inside reinforced concrete modules (3m x 2m x 1,7m) qualified for 350 years duration

**3 VAULT**

240 modules placed in a reinforced concrete vault (27m x 15,5 m x 10 m) qualified for 350 years duration

**4 MULTI-LAYER COVER**

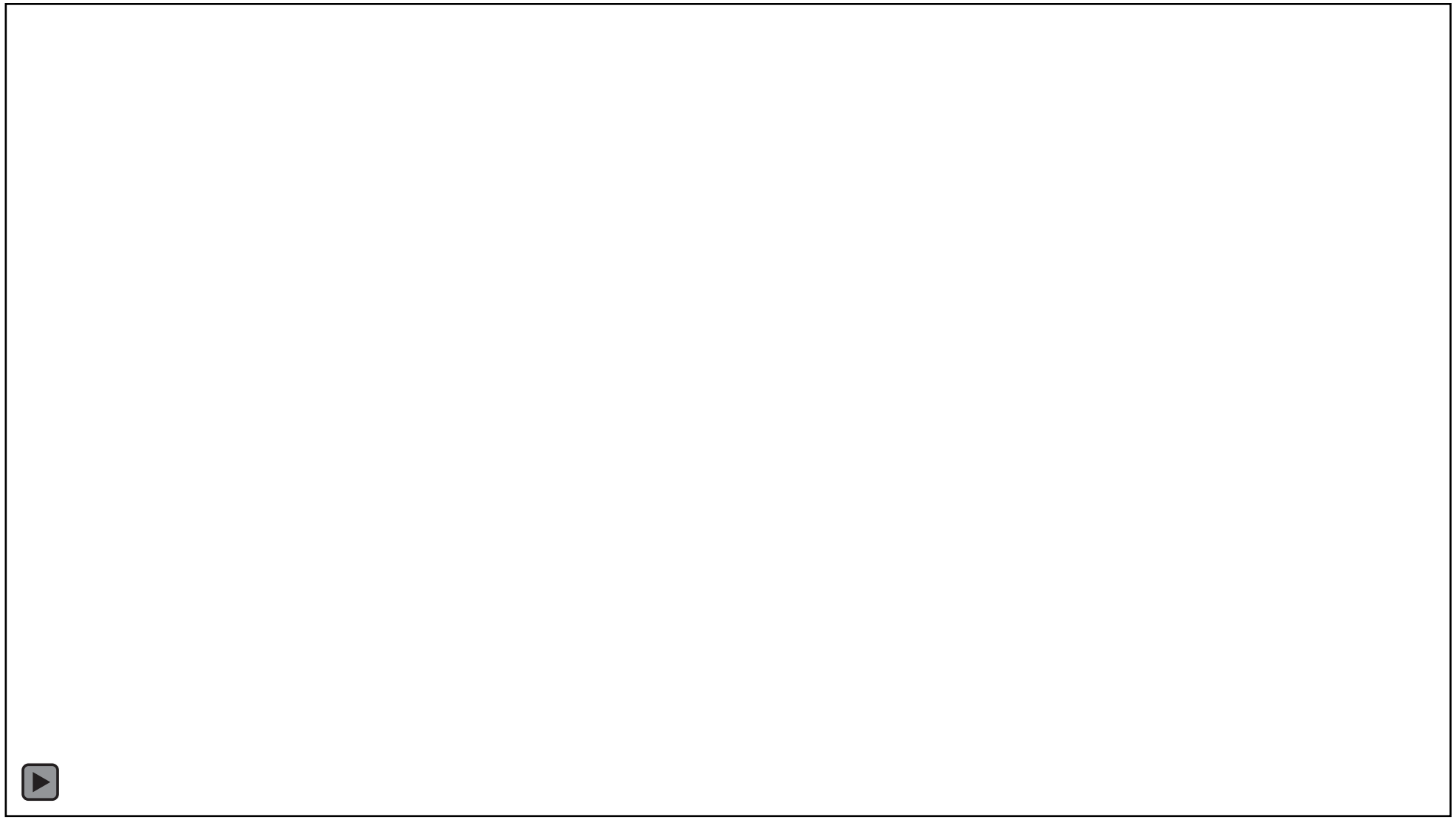


Once filled with modules and sealed, the vaults are capped with a final multi-layer cover for protection against rainfalls, isolation of waste from the environment and better visual impact

**Security Class:** **Public use**

**Classes:** Public Use, Internal Use, Controlled Use, Restricted Use

# Engineered Barriers System



# EXISTING DISPOSAL SITES - FRANCE

La Manche
(Normandie)
**Closed**

NATIONAL REPOSITORY

# EXISTING DISPOSAL SITES - FRANCE

L'Aube
(Champagne-Ardenne)
**Operating**

NATIONAL REPOSITORY

# EXISTING DISPOSAL SITES - FRANCE

El Cabril
(Provincia di Córdoba)
**Operating**

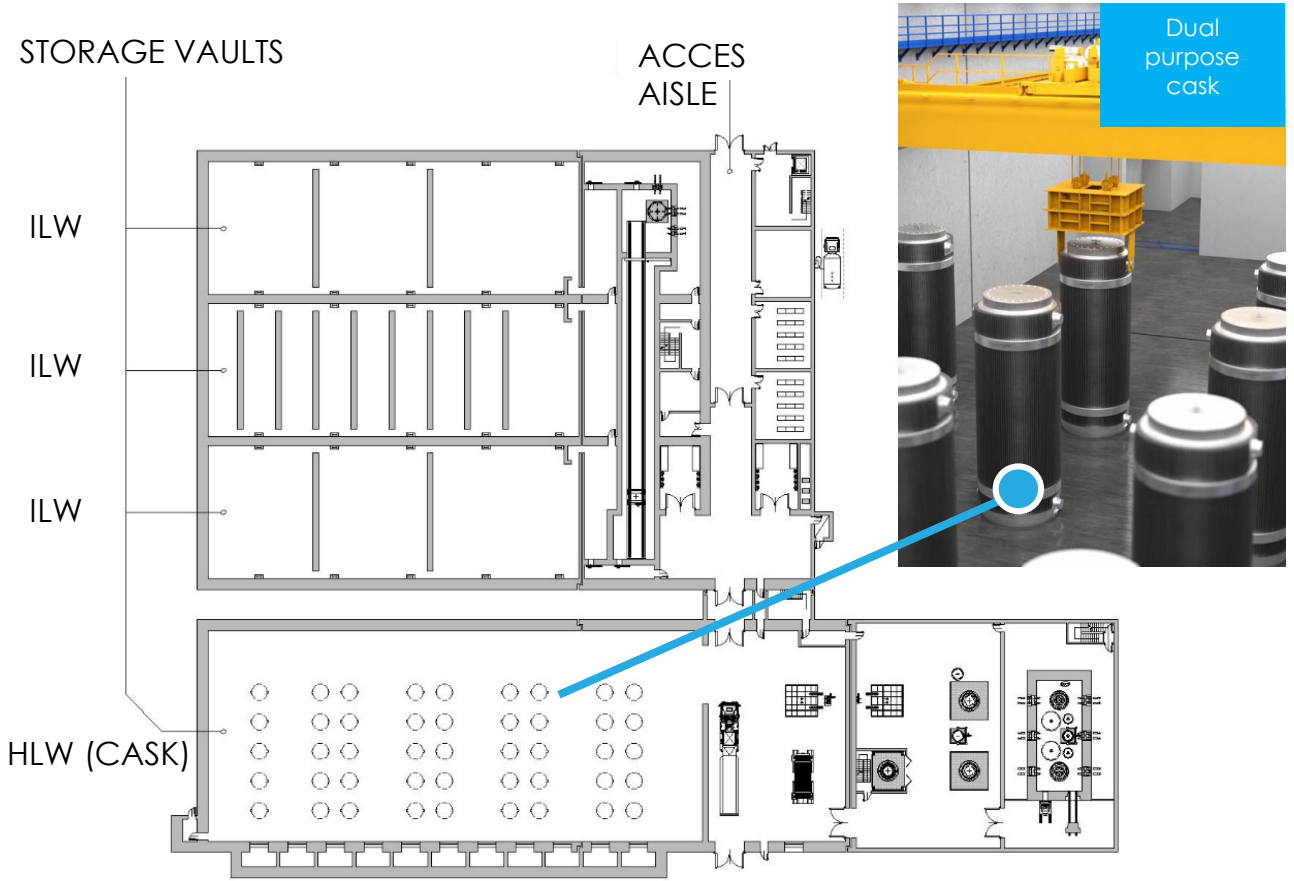
NATIONAL REPOSITORY

# STORAGE OF ILW/HLW
## Long-term storage Complex for ILW-HLW

NATIONAL REPOSITORY

- The **Complex for the long-term storage** of ILW-HLW includes **4 similar buildings**, each one with separated halls for storing different kinds of ILW. The halls are connected through an access aisle for the transfer of the ILW waste packages

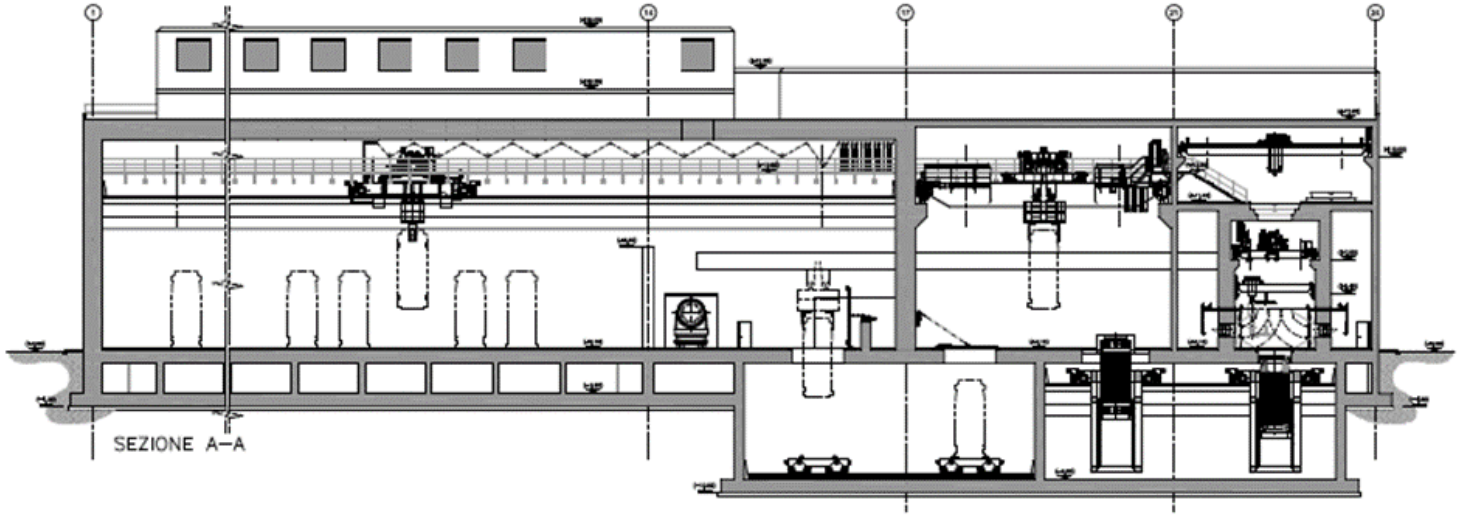
- One of the buildings will host the hall dedicated to HLW (vitrified and compacted residues from fuel reprocessing) and non reprocessable irradiated fuel that will be stored in **'dual purpose' casks** (high integrity and shielded containers qualified for safe transport and storage)

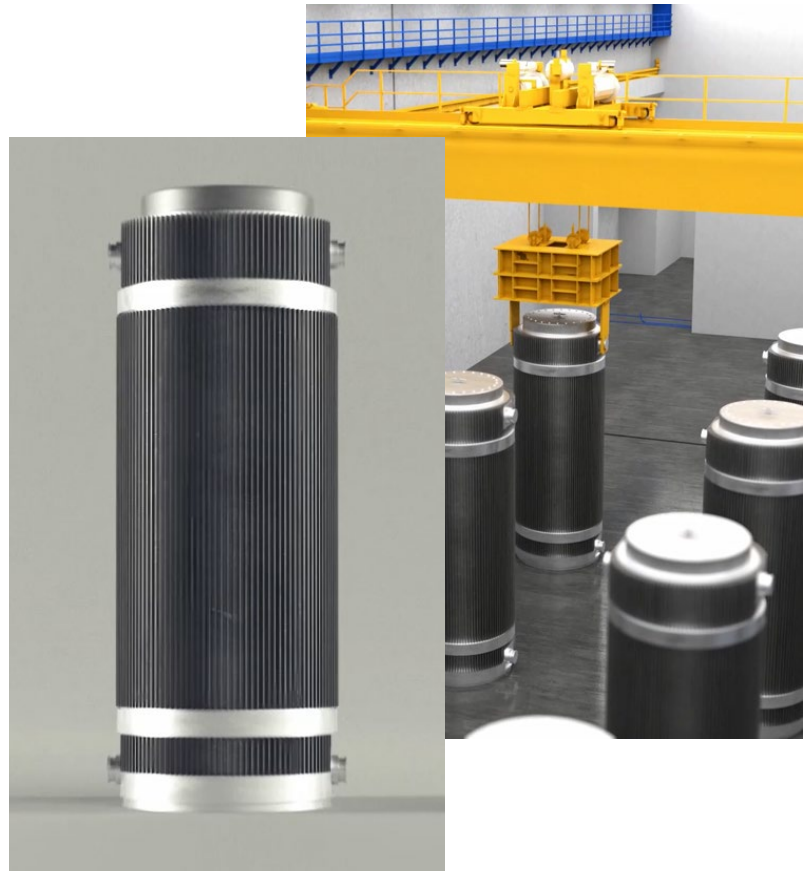



**Storage building with 3 ILW halls and 1 HLW hall**

# HLW (CASK) STORAGE HALL

HLW (vitrified and compacted residues from fuel reprocessing) and non reprocessable irradiated fuel will be stored in a dedicated hall in 'dual purpose' casks (high integrity and shielded containers qualified for safe transport and storage). A hot cell will host the equipment for possible maintenance of the cask lids.



Dual purpose cask

# GORLEBEN

Spent fuel and vetrified residues cask storage building (TBL)

420 cask

Start operation 1995

ILW storage building (AVL)

15.000 mc

Start operation 1984

NATIONAL REPOSITORY

# Zwilag

Spent fuel and vetrified residues storage building

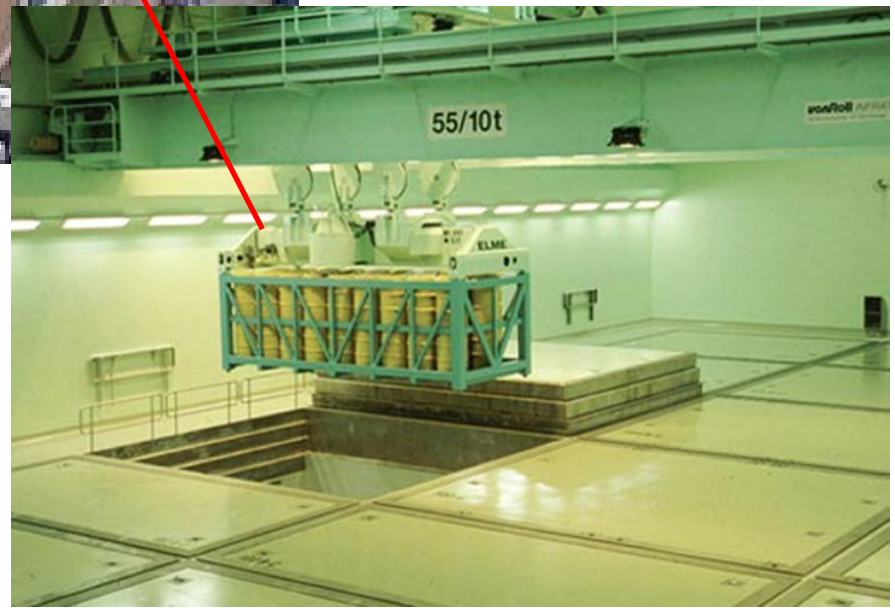
200 cask

Start operation 2000

ILW storage building

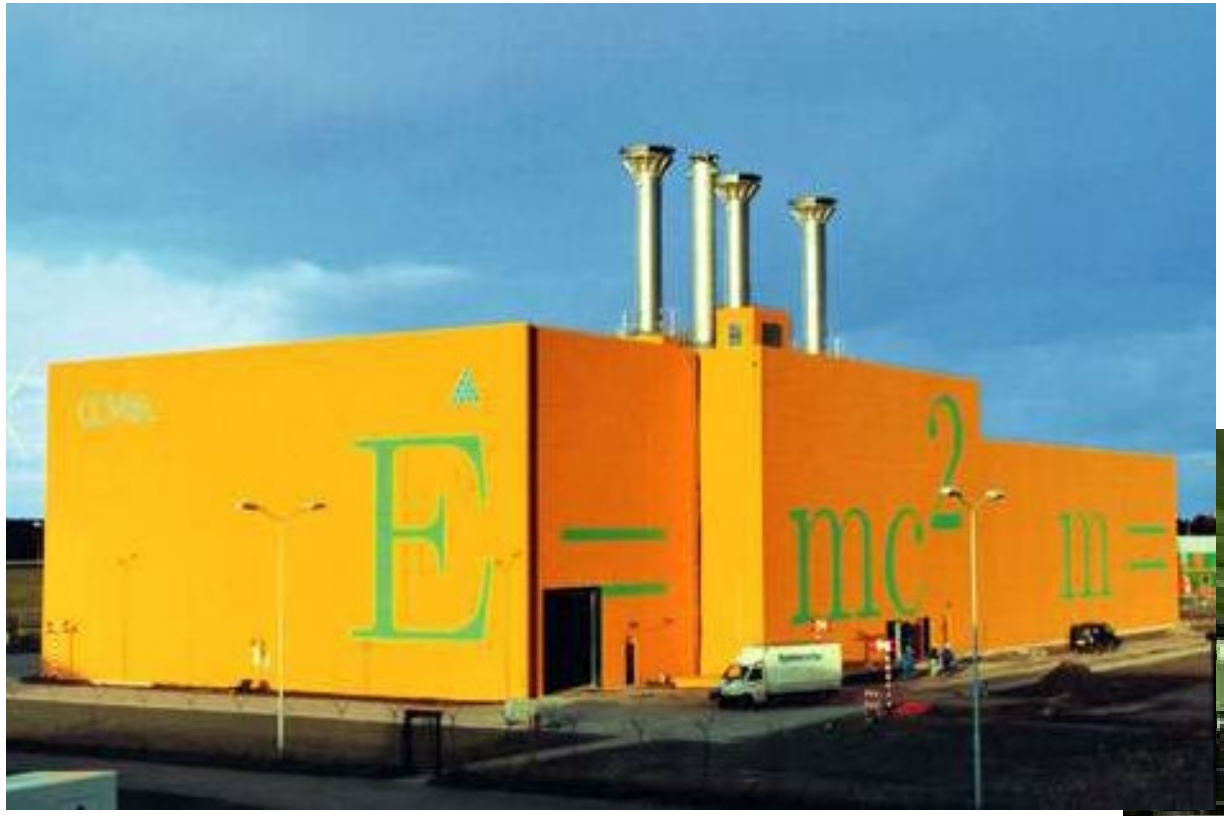
10.000 mc

Start operating 2000




NATIONAL REPOSITORY

# HABOG

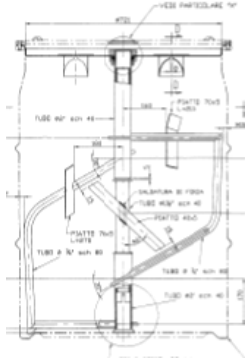



The HABOG repository, designed for a life of 100 years, houses irradiated fuel, reprocessing residues and other high-activity wastes.

NATIONAL REPOSITORY

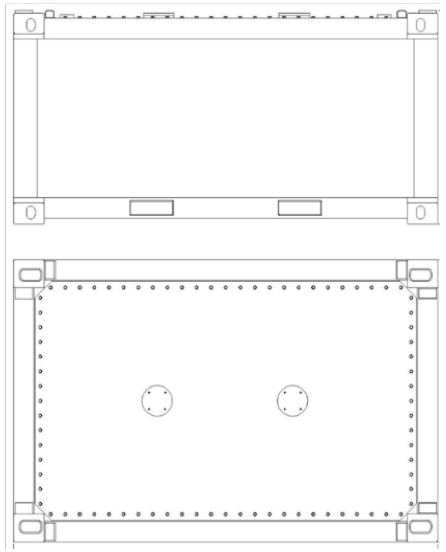
# Packaging of LLW

**Drum 380 l - 440 l**

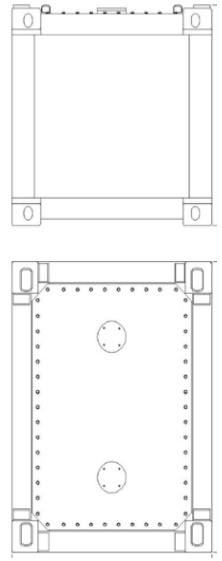



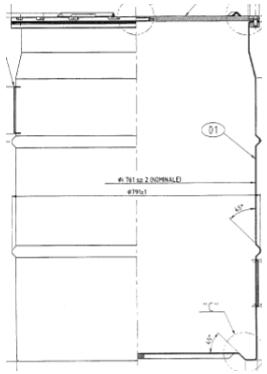
Model with lost paddle for liquid waste

**Box – 5,2 m3**
**Solid waste**

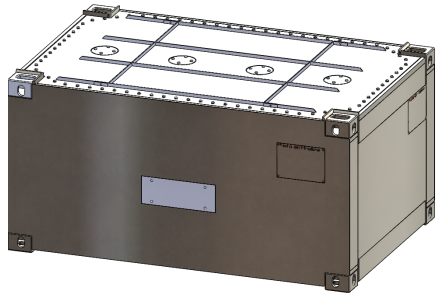


**Box – 2,6 m3**
**Solid waste**



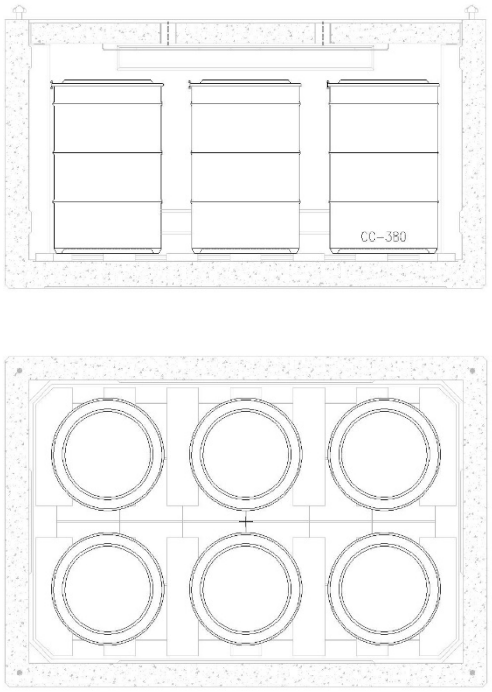


Model for solid waste

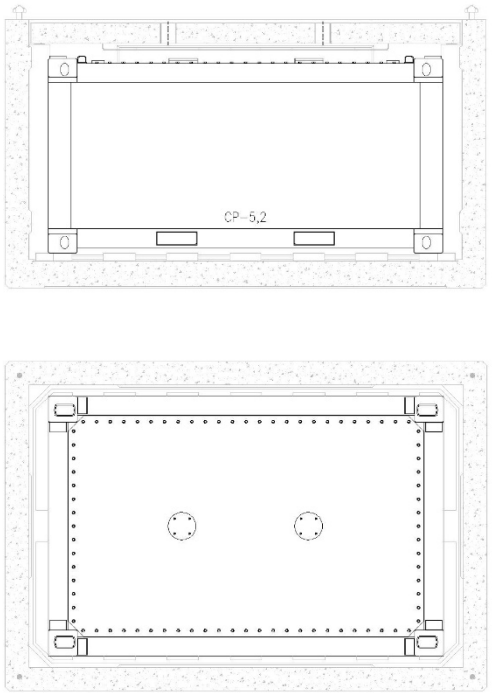


# LLW packages loading into the Module

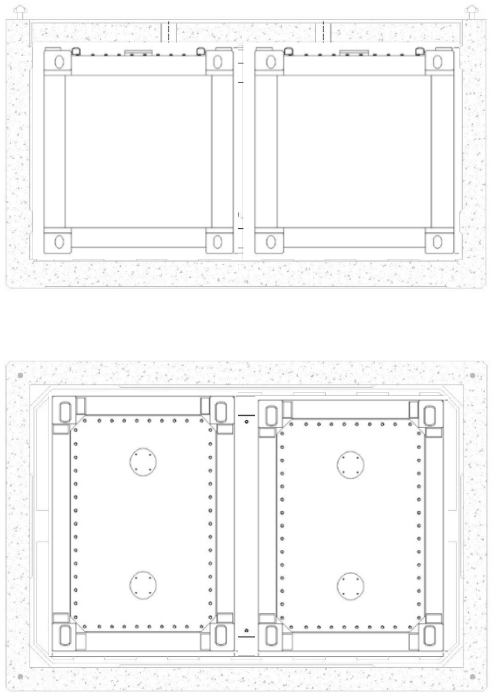
N.6 drums 380 l - 440 l




N.1 box 5,2 m3




N.2 boxes 2,6 m3



NATIONAL REPOSITORY

# ILW packaging

**LIQUID WASTE, SLUDGES**

- NPP's
- Reprocessing facilities
- Research centers

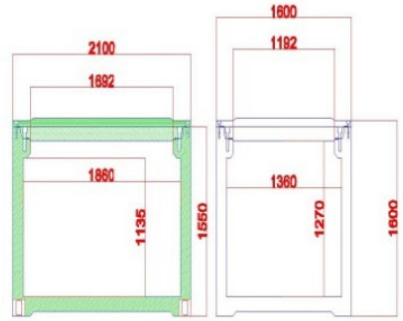
Conditioning with solidification matrix for increasing short term safety

**SOLID WASTE**

**Activated**

- NPP

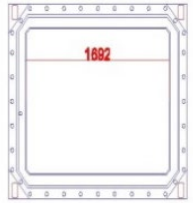
Packaging without matrix in shielded 'Special Containers'




**a contaminated**

- Reprocessing facilities
- Research centers

Feasibility study for packaging without matrix in 'Special Containers'




NATIONAL REPOSITORY

# TECHNOLOGY PARK

NATIONAL REPOSITORY

The National Repository will be realized within a **Technology Park**, i.e. a centre of excellence for advanced R&D on nuclear matters and sustainable development with structures dedicated to information and training.
**It will support the local communities bringing added value to the territory**

## Foreseen research laboratories and infrastructures

- Laboratories on new technologies for decommissioning and waste management activities
- Laboratories for environmental analyses
- Visitors centre
- Research laboratories for sustainable development to be agreed with hosting communities during the site selection phase

# TECHNOLOGY PARK

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**National and International scientific communities will be engaged in the development of the research laboratories together with the local communities**

**It will support the local communities bringing added value to the territory**

# TECHNOLOGY PARK

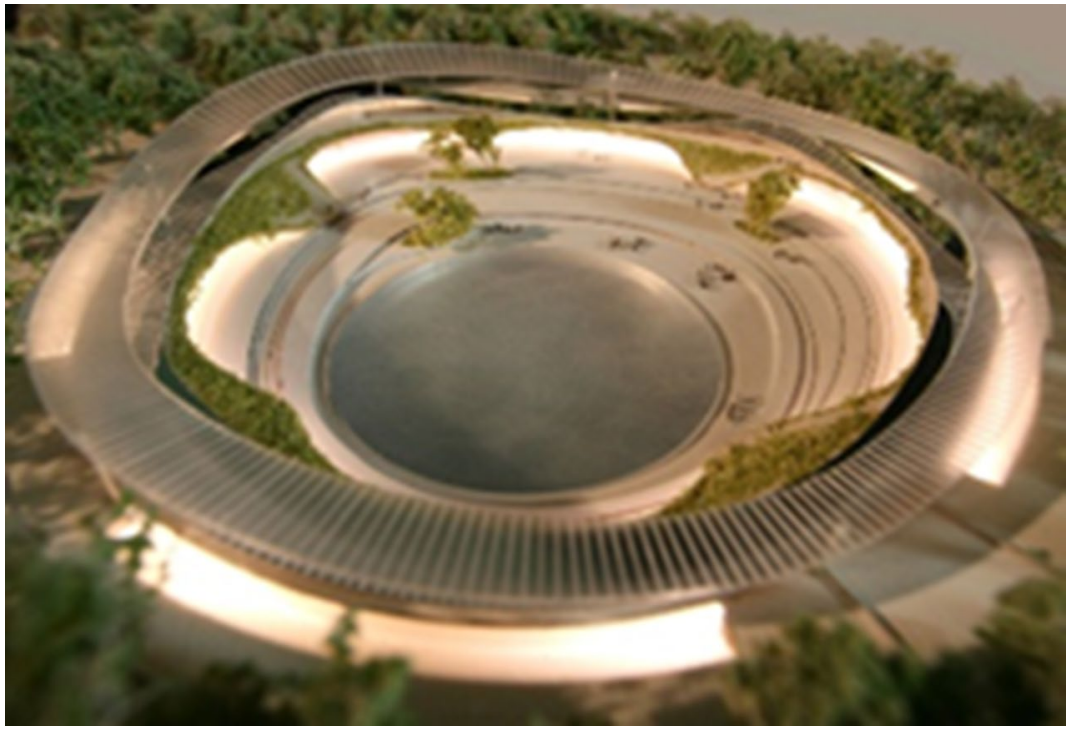
## Foreseen research laboratories and infrastructures

- Laboratories on new technologies for decommissioning and waste management activities
- Laboratories for environmental analyses
- Research laboratories for sustainable development to be agreed with hosting communities during the site selection phase
- Visitors center
- Education and training structures

# TECHNOLOGY PARK

## Possible research fields to be explored

- New characterization systems for radioactive waste;
- New treatment and conditioning solutions for special waste (e.g. graphite);
- New monitoring systems for environment and workers
- Research activities on the Italian geological disposal



# TECHNOLOGY PARK

## Possible research fields to be explored

- Use of nuclear science to solve problems on the conventional field
- Modification of conventional solution to be applied in nuclear field
- New solutions for renewable energy production
- New solution on the medical field
- New technologies (artificial intelligence, robotics, …)

# MAIN CHALLENGES FOR THE NATIONAL REPOSITORY REALIZATION

- The National Repository realization is a **national challenge** with a **strong local/regional dimension**. Public information, consultation and participation in environmental or technological decision-making are today's best practice
- Its implementation is an essential element to achieve the **'greenfield' status** in the Italian nuclear installations, eliminating all constraints related to radiation, and to manage all radioactive waste, including that produced by industrial, research and nuclear medicine activities
- Designing and, when agreed, implementing the National Repository and Technology Park in ways that reflect the **values** and **interests** of local communities and surrounding region

**National commitment and local and regional involvement are two essential dimensions of the complex task of securing continued societal agreement for the disposal of radioactive wastes**

# GEOLOGICAL REPOSITORY

NATIONAL REPOSITORY

## Italian National Program

- Italy, through its research and development bodies (ENEA, CIRTEN), is participating in EU and international programs aimed at identifying an international shared geological repository (so-called "regional").

- With the start of operation of the National surface Repository, scheduled on 2029, while maintaining the primary interest in the construction, shared internationally, of a regional repository for disposal in geological formation Italy will start also studies for the identification of a national solution, to be implemented through a regulatory system aimed to provide an active involvement of the population as to that already carried out in the case of the national surface repository. The studies will be carried out also in the laboratories of the Technology Park in the National Repository

- The aim of the studies will be to define the geological repository within a further 40 years (2070), at the time of the closure of the national repository, and to allow the construction in the following 50 years (possibly also adopting an extension of the operational life of the CSA).

SOGIN

**We protect the present**
**We guarantee the future**