NERS 2015 Conference
AREVA Nuclear Experience for Advanced Solutions:
Radioactive Waste Management in France

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AREVA Director Central Eastern Europe
Prague, November 11, 2015

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Radioactive Waste Management in France
Content

- [x] *The legal and regulatory framework*
- [ ] *The Players and their industrial tools*
- [ ] *The radioactive waste classification and inventory*
- [ ] *The management routes*
- [ ] *The solutions*

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Used Nuclear Fuel and Radioactive Waste Management: a comprehensive regulatory framework

63 GWe

60 GWe

50 GWe

20 GWe

1 GWe

1993 First Inventory

ANDRA

Dec.1991 Act*

2006 Acts**

Aug. 2015 Act***

1970 1980 1990 2000 2010 2020

* *Act N° 91-1381 of 30 December 1991 on research on radioactive waste management*

** *Act N° 2006-739 of 28 June 2006 on the Sustainable Management of Radioactive Materials and Wastes*
Act N° 2006-686 of 13 June 2006 on Transparency and Security in the Nuclear Field

*** *Act N° 2015-992 of 17 August 2015 Energy Transition for the Green Growth*

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Radioactive Waste Management in France: The main Players

LEGAL & REGULATORY BODIES

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

ASSEMBLÉE NATIONALE

SÉNAT

AUTORITÉ DE SÛRETÉ NUCLÉAIRE
asn

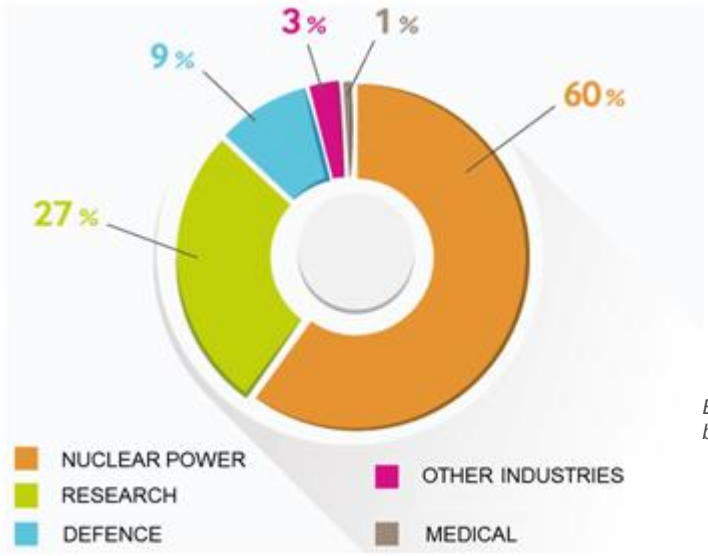
MAJOR WASTE PRODUCERS

EDF

AREVA
l'avenir pour énergie

cea

''SMALL'' WASTE PRODUCERS



Breakdown of radioactive waste by economic sector (end 2013) – Source ANDRA

THE WASTE AGENCY

ANDRA

REVIEW BODIES

OPECST

cne²

- Parliamentary Office for the Evaluation of Scientific and Technological Choices
- National Assessment Board

STAKEHOLDERS inc.CIVIL SOCIETY

HCTISN Haut Comité pour la transparence et l'information sur la sécurité nucléaire

PUBLIC DEBATE COMMISSIONS

NGOS

- High Committee for Transparency and Information on Nuclear Safety

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The French Nuclear Industrial Tool at a glance

Low and intermediate level Waste repository closed – under surveillance

Areva - La Hague facilities

Low and intermediate level Waste repository (CSA Soulaine)

Very Low Level Waste Repository (CIRES Morvilliers)

AREVA– Melox

Gravelines
Penly
Paluel
Flamanville
Chooz
Cattenom
Brennilis
Nogent
Fessenheim
St-Laurent
Dampierre
Chinon
Belleville
Civaux
Bugey
Creys-Malville
St-Alban
Le Blayais
Cruas
Tricastin
Golfech

NPP in operation (58)

- **34 PWR 900 MW**
- **20 PWR 1300 MW**
- **4 PWR 1500 MW**

- **EPR in construction (1)**
- **In decommissioning (9)**

- Andra repositories
- CENTRACO facilities
- AREVA facilities

CENTRACO Incinération & melting

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The French Radioactive Waste Classification and final disposal solutions

In operation

Under project

	Very short lived waste *containing radionuclides with a halflife of < 100 days*	Short lived waste *in which the radioactivity comes mainly from radionuclides with a half-life ≤ 31 years*	Long lived waste *containing mainly radionuclides with a half-life > 31 ans*
Very low level (VLL)	Management by radioactive decay on the production site *then disposal through routes dedicated to conventional waste*	*Recycling or dedicated surface disposal* (Industrial centre for collection, storage and disposal (Cires) disposal facility in the Aube département) "CIRES"	
Low level (LL)		*Surface disposal* (Aube waste disposal facility) "CSA"	**> 2025** *Shallow depth disposal* (being studied pursuant to the Act of 28 June 2006) (subject to authorization)
Intermediate level (IL)			"CIGÉO"
High level (HL)	Not applicable[1]	**2025** *Deep geological disposal* (being planned pursuant to the 28th June 2006 Act) (subject to authorization)	

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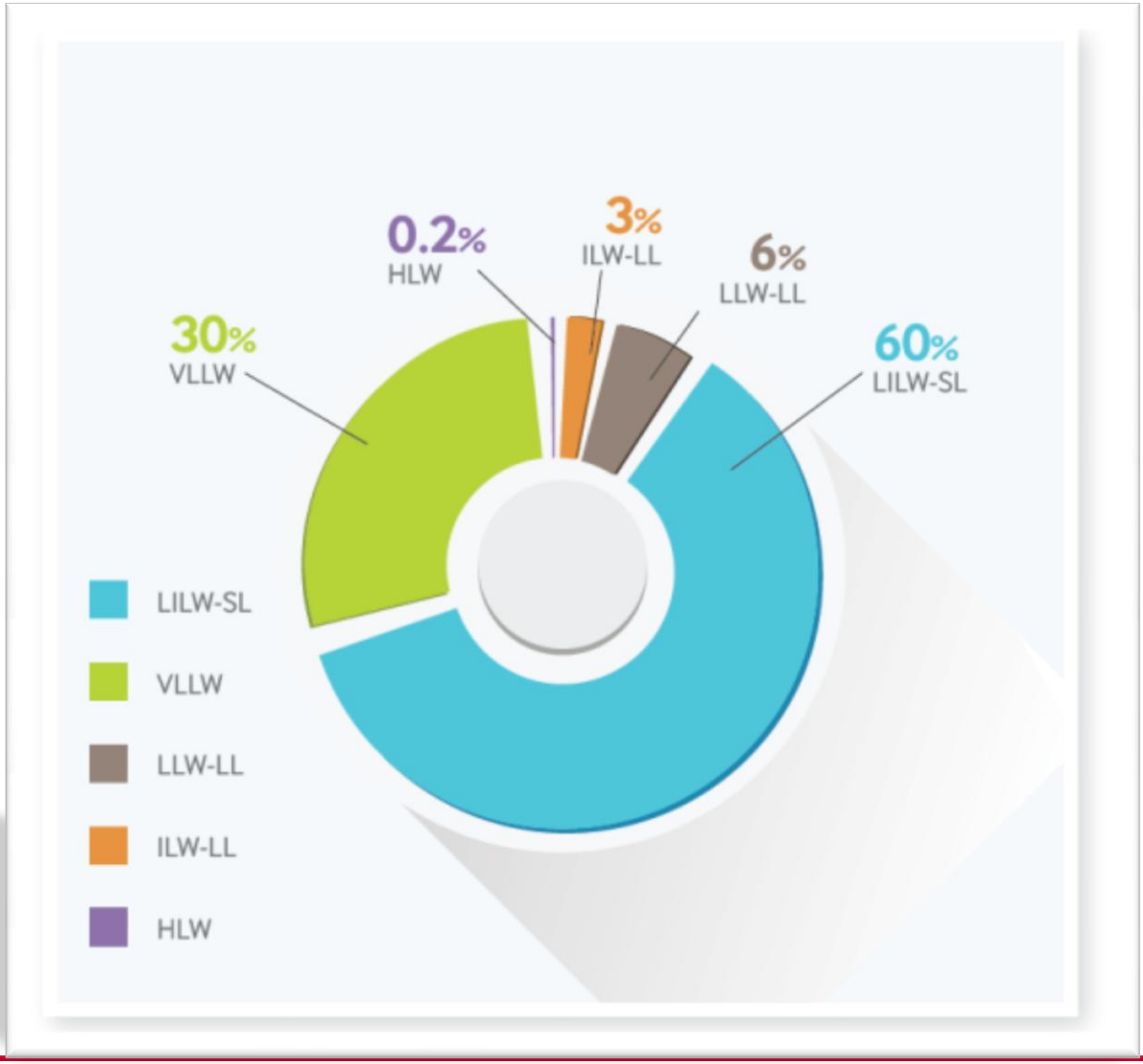
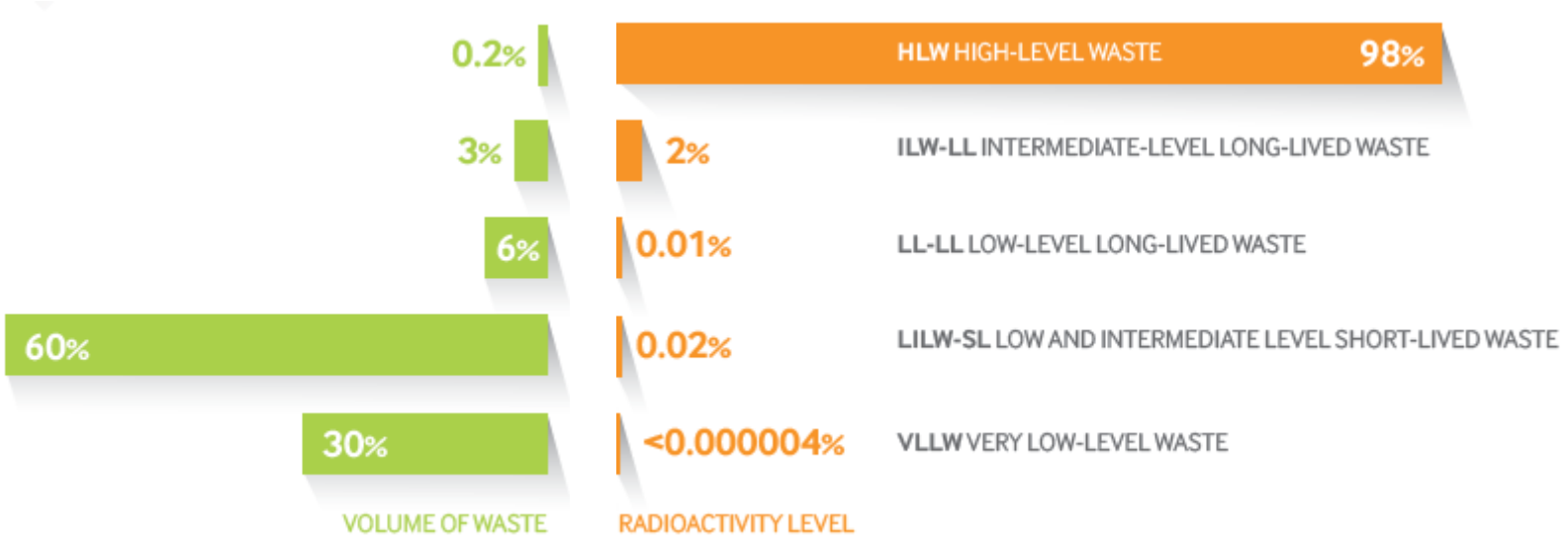
Breakdown of radioactive waste volumes by category, end of 2013



Source Andra : Essentials 2015

Breakdown of volume and radioactivity level of radioactive waste present at the end of 2013



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Radioactive Waste Management in France
Interfaces for management routes implementation

ASN : Nuclear Safety Authority

Compliance with safety standards: operation, interim storage and disposal

New packaging specification for production approval

Approval for new packaging and interim storage

Periodic Inspections

Producer ***Conditioning facility***

Disposal specifications

Acceptance package application

Periodic Inspections

Compliance with disposal requirements => individual package acceptance

Andra **Final Disposal Facility**

Provide an optimized conditioning for a safe disposal taking into account various, sometimes differing requirements from regulators, producers, “disposers’ and other stakeholders

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Radioactive Waste Disposal facilities currently in operation, in France

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Main streams stemming from Nuclear Power Generation

electricity

USED FUEL

1050 tons/year

Nuclear Power Plants

Fuel Cycle Facilities

1200 tons/year

FRESH FUEL

Technological, maintenance and process radioactive waste

(10 to 15 000 m^3 / year)

Radioactive waste
From decomissionning
180 000 tons / 30 years

HLW

(150 m^3/year)

ILW

(200 m^3/year)

STORAGE AND DISPOSAL FACILITIES

Volume ÷ 5
Radiotoxicity ÷ 10
Standardization
Enhanced Proliferation Resistance

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Main Operational Waste Streams at NPPs

(SHORT LIVED WASTE)

electricity

Nuclear Power Plants

Resins Primary circuit, concentrates, water filters

Sludges, air filters

Technological

Resins Secondary circuit

Oils Solvents, Liquors

Scrap Metal

Rubble

Conditionning

Incineration

Solidification of ashes and clinker

Melting

Recycling

CSA

(LLW & SL-ILW repository)

CIRES

(VLLW repository)

Reference main streams at La Hague Plant

100% HM of used fuel

Recycling

- **Uranium 95%** → **ERU**
  - Used in 4 reactors in France
  - RepU kept as strategic inventory
- **Plutonium 1%** → **MOX**
  - Loaded in 22 reactors in France

Ultimate waste from UNF treatment

- **Fission products, fines 4%**
  - Different FPs solutions

- **Metallic structures**
  - Hulls
  - End caps
  - Cladding

Operational waste + legacy waste

- **Technological waste**
  - Metallic
  - Material based on polymer

- **Effluents or derivatives**
  - Rinsing solutions
  - Sludges
  - Resins

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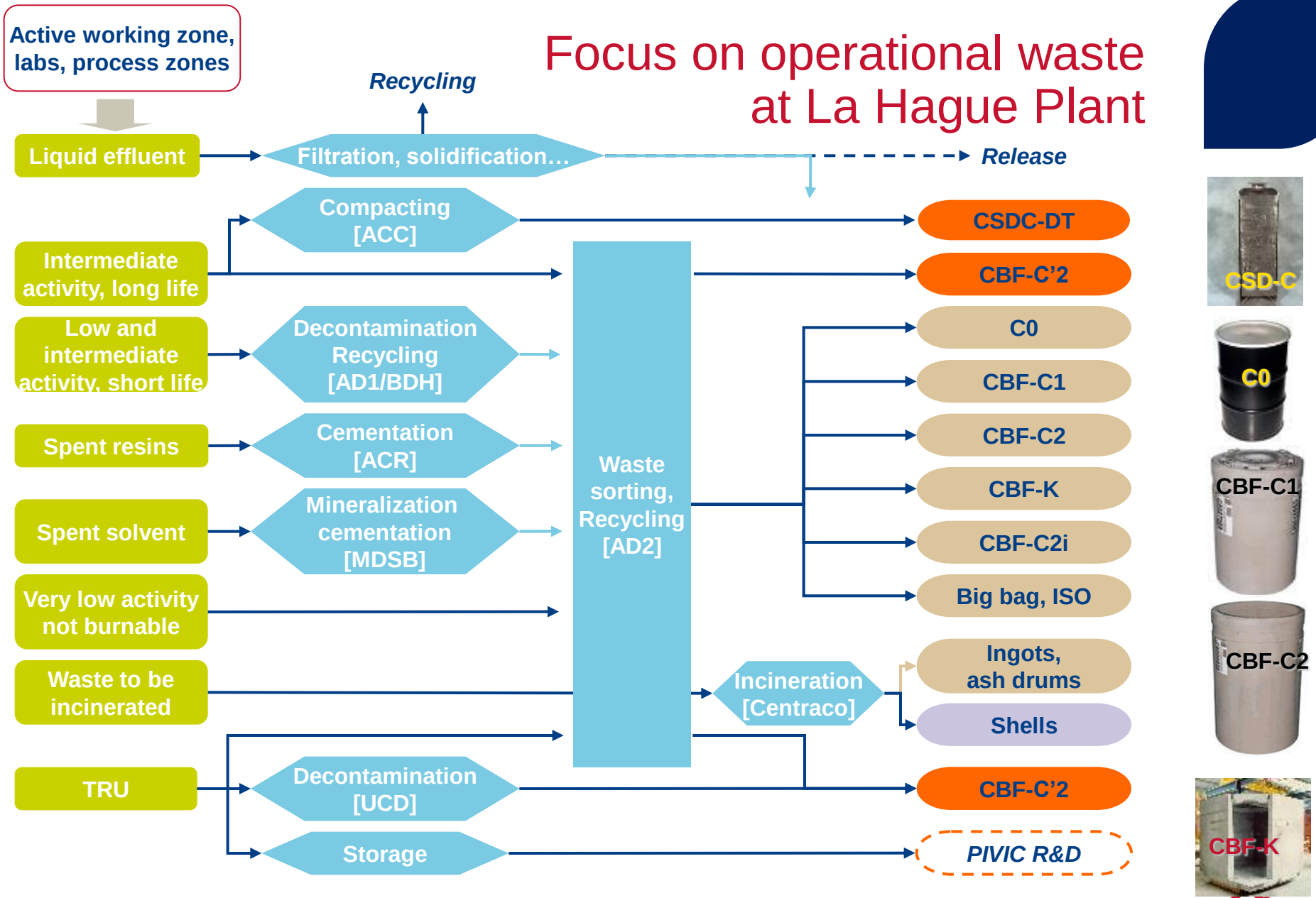
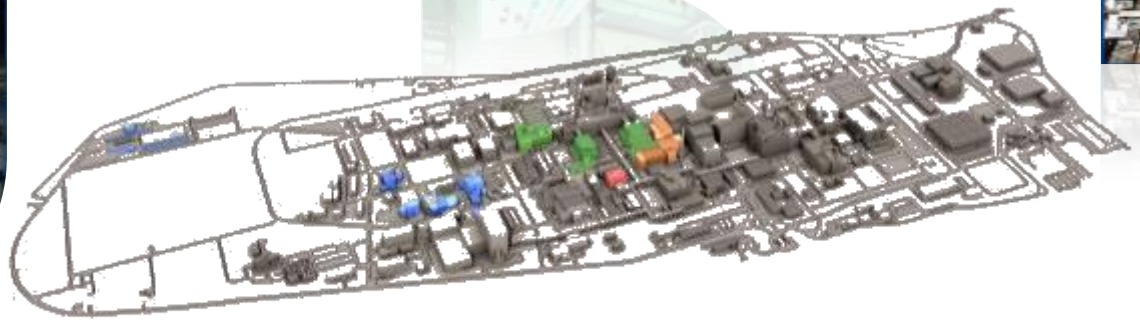
Focus on operational waste at La Hague Plant



A Broad Range of Processes for Waste Conditioning

Examples from the La Hague Plant



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Waste package conditioning: a continuous improvement approach

FIVE MAIN PRINCIPLES

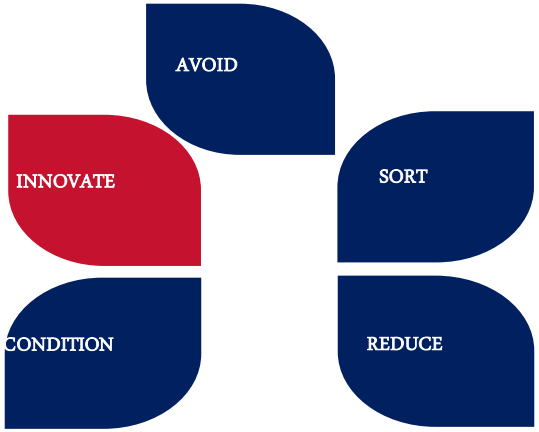
❶ Develop a continuous approach for increasing waste incorporation and volume reduction

❷ Use the feedback and the proven technology (tool kit) for conditioning new type of waste

❸ Develop suitable matrix or filling materials to ensure the best chemical compatibility

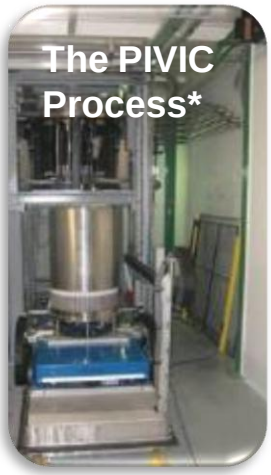
❹ Perfom a comprehensive approach to understand the physico-chemical interactions and long term disposal

❺ When necessary, develop new technological block



Radioactive Waste Management:
how to take-up present and future challenges

- Innovate for legacy waste and already planned inventory
  - by adapting existing routes with the aim at increasing performance
    - Safety (containment, resistance, durability …)
    - Compactness,
    - Matrix improvement
    - Standardization
    - Economics : leveraging on Capex / Opex
  - by creating new routes only when necessary, notably for waste categories currently without a management solution route



* Developed by AREVA, CEA, ANDRA for waste with an a prevailing spectrum

* Developed by AREVA, as an alternative to sludge bitumization

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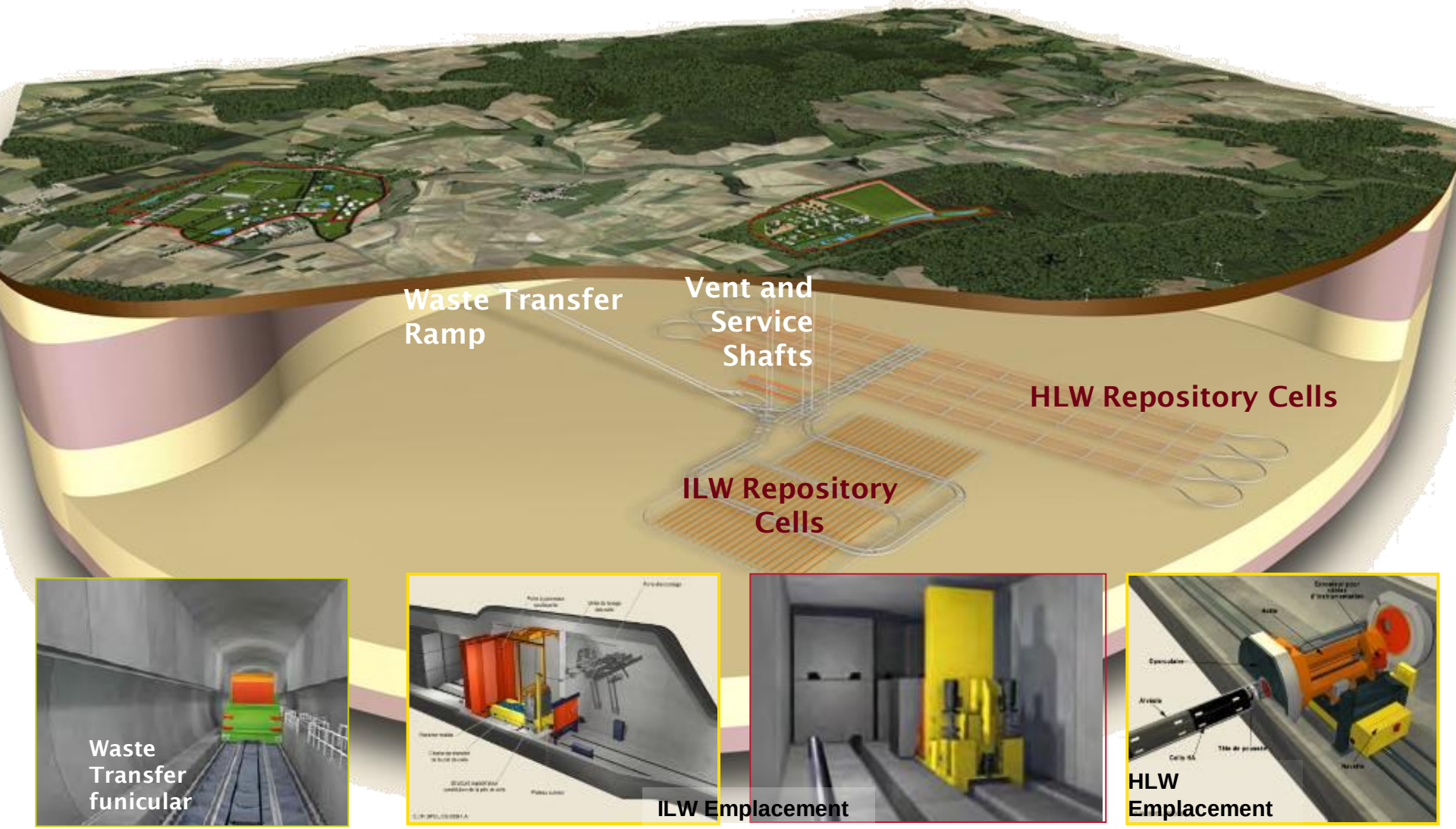
Source ANDRA

The Cigeo deep geological Repository for HLW and ILLLW



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HLW and ILW-LL storage at La Hague Plant

Stored before their return
to countries of Origins

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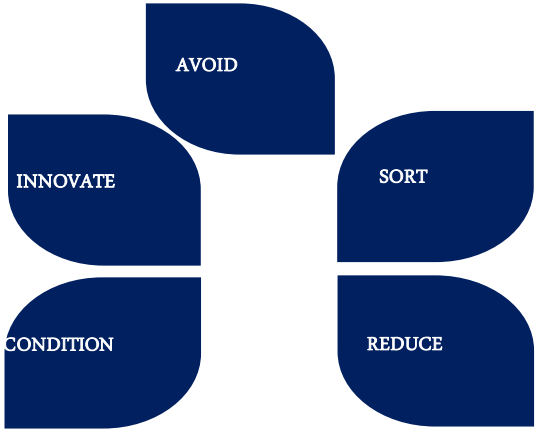
Conclusion (1/2)

- The efficiency of the management of radioactive waste shall be assessed considering the overall route from generation to disposal
  - A route = Management during nuclear facilities operations
  - Management “post” operation
    - → packaging optimization taking into account “downstream” stages
  - Storage
  - Transport
  - Disposal with targeted encapsulation avoidance

Eco - design target for all stages

- Adhere to “golden rules”



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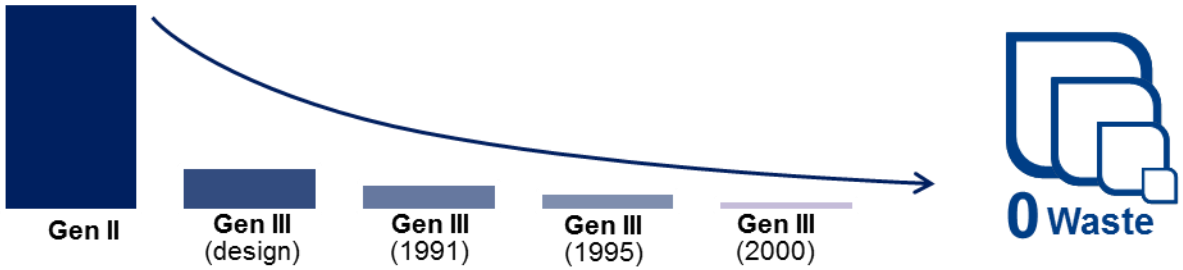
Conclusion (2/2)

- Solutions based on safe, proven and continuously improved technologies and industrial tools do exist
- They allow already the implementation of responsible and comprehensive routes
- Their implementation for legacy and current waste should not be differed on the pretext of “more promising” technologies
  - Avoid burdens to future generation



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