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forward-looking energy

Progress in Dealing with the World's Stockpile of Used Nuclear Fuel – How Can Consolidated Interim Storage and Reprocessing Help?

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Agenda

- France Recycling Program
- Recycling Benefits
- 2030 Outlook
- Sustainable Cycle Solutions

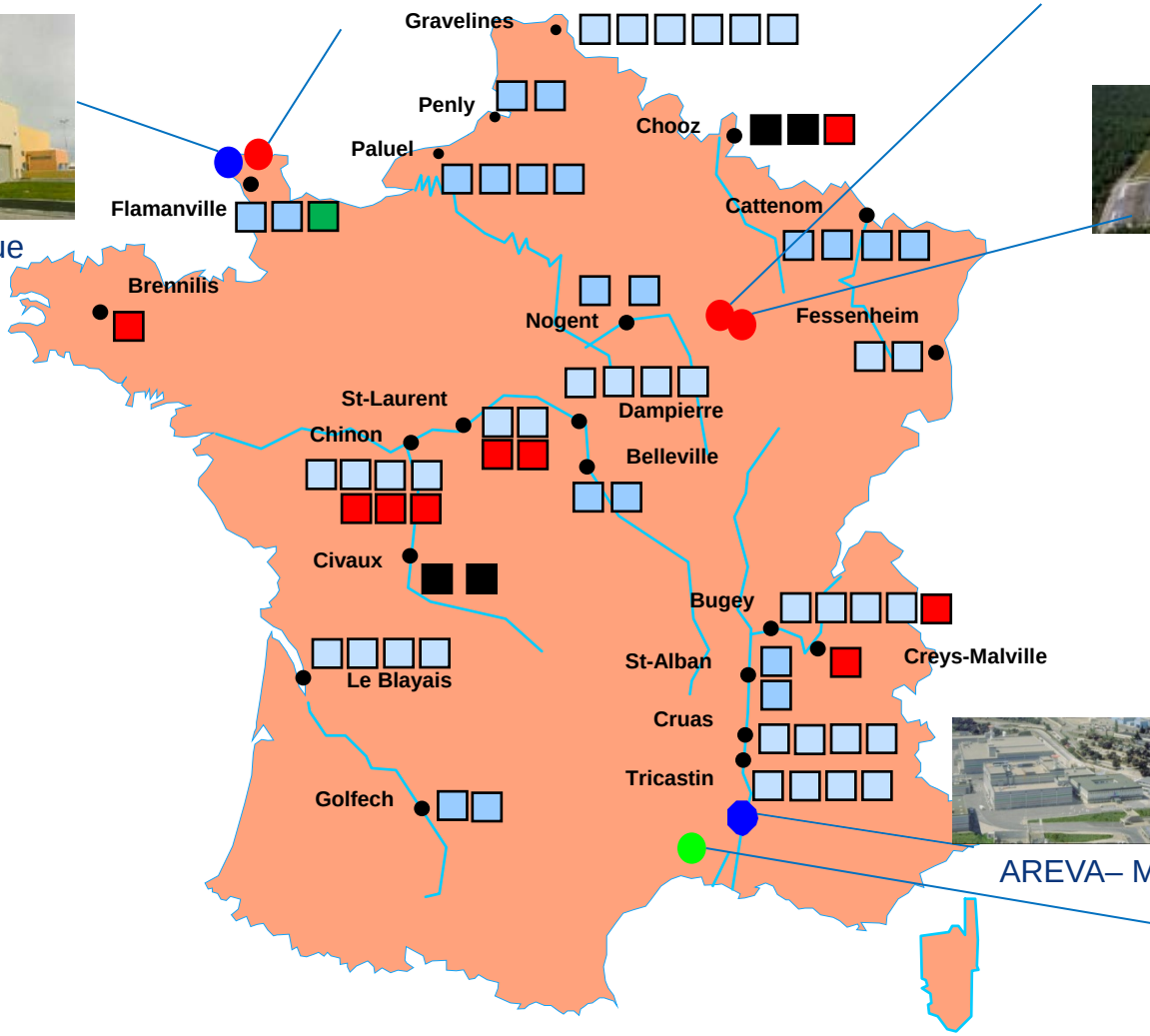
EDF, AREVA and Andra

Low and intermediate level Waste repository closed – under control

Low and intermediate level Waste repository **(CSA Soulaine)**

Areva - La Hague facilities

Centre de stockage TFA (CIRES Morvilliers)



NPP in operation (58)

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

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

AREVA– Melox

- Andra repositories
- CENTRACO facilities
- AREVA facilities

CENTRACO Incinération & melting

Radioactive Waste Overview

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 m3 / year)

Radioactive waste
From decomissionning
180 000 tons / 30 years

HLW

(150 m³/year)

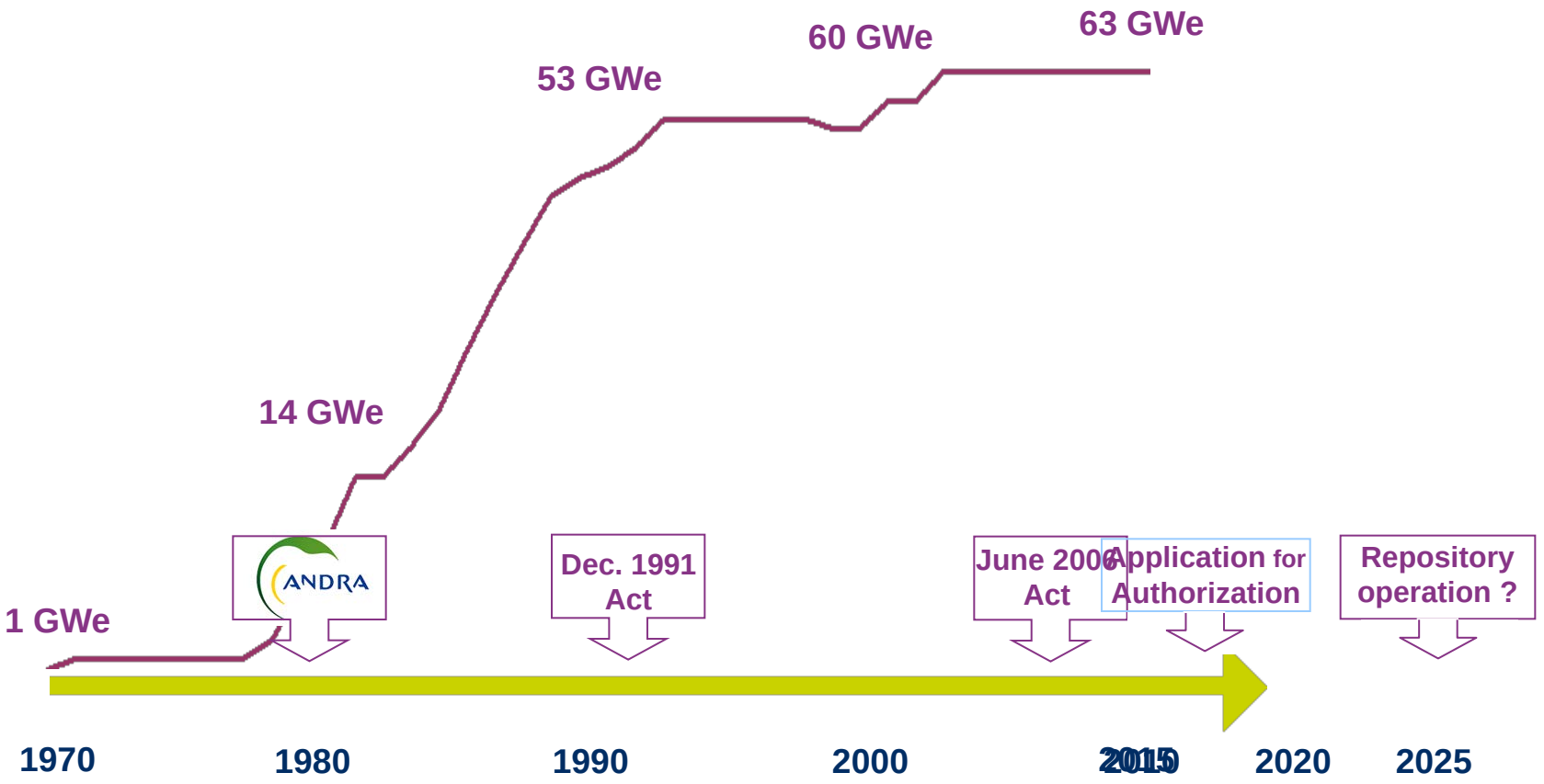
ILW

(200 m³/year)

STORAGE AND DISPOSAL FACILITIES

Volume ÷ 5
Radiotoxicity ÷ 10
Standardization
Enhanced Proliferation Resistance

Used Nuclear Fuel and Waste Management: evolution of the French regulatory framework



Over 28,000 tons* of Used Fuel Recycled through La Hague and MELOX

	Tons processed
EDF *France*	***18 940***
German utilities	***5 483***
Japanese utilities	***2 944***
Swiss utilities	***771***
Synatom *(Belgium)*	***671***
EPZ *(The Netherlands)*	***360***
SOGIN *(Italy)*	***190***

* UOX or MOX type fuel

Recycling Benefits in France

- **Manages Risks Now**
  - Safely Buys Time to Develop a Repository
  - Reduces Interim Storage Needs / No Safeguards
- **Optimizes the Use of a Disposal Site**
  - Volume and Source Term Reduction
  - Waste Form designed for Disposal
  - Heat Load Management
- **Saves Resources**
  - Example of France: saved over 20 000 tons of natural Uranium so far

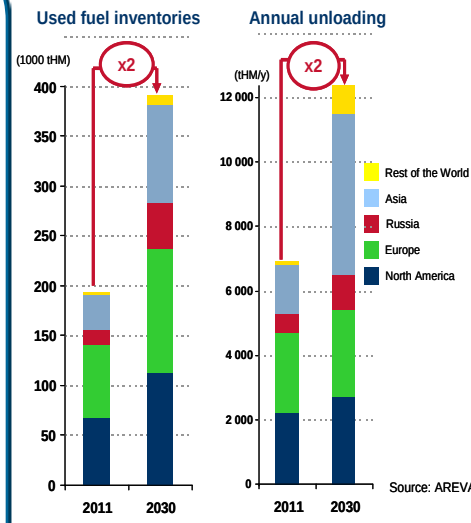
AREVA - La Hague facilities

- **Allows for Flexible and Sustainable Industrial Scenarios**
  - Recycle Once in LWRs
  - Multi-Recycle Scenarios in LWRs
  - Smooth Transition to GenIV Reactors
    - Limited Number of Fast Reactors

    AND / OR
    - Transition to Fast Reactors

2030 Outlook

- **Inventories** of Used Fuel will have **Doubled**
- **Annual Unloading** of Used Fuel will have **Doubled**
- **Geological Disposal** will be a **Scarce & Valuable Resource**
- **Recycle Helps**
  - Time, Interim Storage Needs
  - Optimization of Deep Disposal Use
  - Saves Resources, Flexible Options Open
- **Worldwide Recycling Capacity will address 50% of Annual Unloading at best**
  - All Options are Needed ! Interim Storage & Recycling
  - Reactor Fleet Situations / Transition Strategies



Sustainable Cycle Solutions

Sustainable Solutions for an optimized, long-term and responsible management of used fuel

RECYCLING & HLW STORAGE



RECYCLING

INTERIM OPTIONS FOR USED FUEL

DRY STORAGE


WET STORAGE

TRANSPORTATION SYSTEMS


Sustainable Cycle Solutions

A smart mix of proven and evolving technologies tailored to stakeholders' needs and constraints

Backup

Reference main streams at La Hague

100% HM of used fuel

Recycling

- Uranium 95% → ERU
  - Loaded in 4 reactors in France
  - Kept as strategic inventory
- Plutonium 1% → MOX
  - Loaded in 22 reactors in France

Ultimate waste from UNF treatment

- Fission products, fines 4% → Vitrification → UC-V
- Hulls and end pieces → Compaction → UC-C

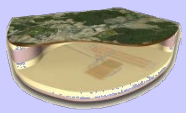
Waste from Operations

- Techno waste → Compaction → UC-C
- Techno waste → Cementation → CBFC'2
- Effluents → Vitrification → UC-B
- Low level waste → Cementation → C0, C1, C2…

CIGEO

HLW-LL-ILW

Repository

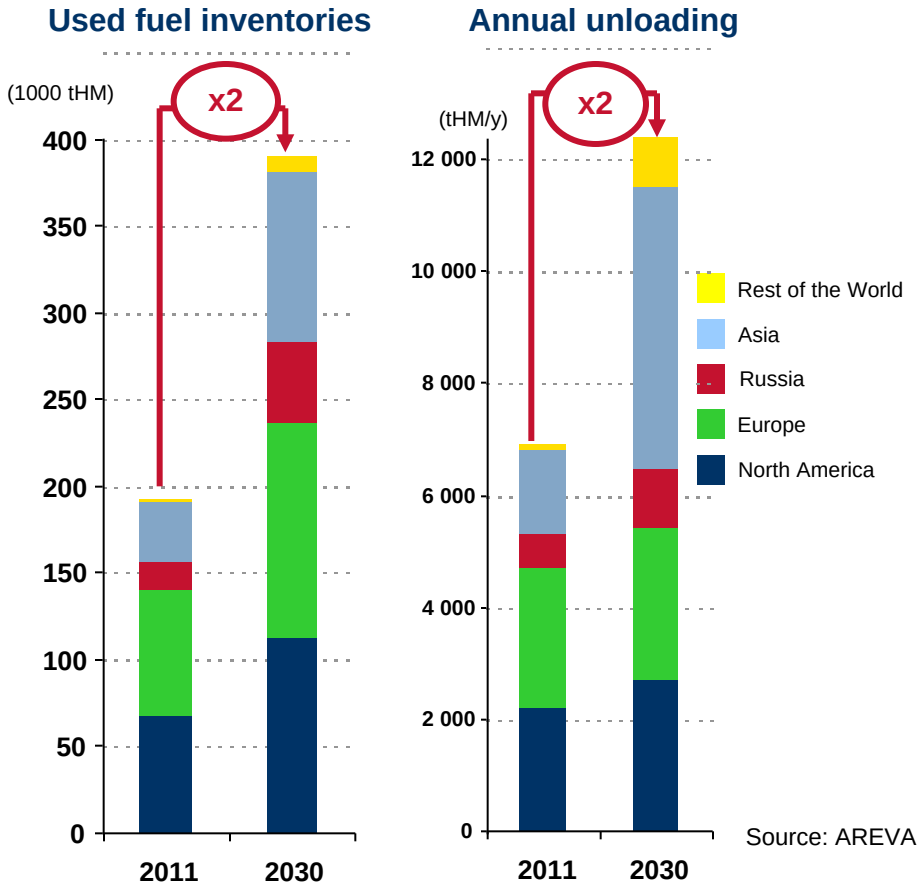


CSA

LLW & SL-ILW repository

Used Fuel Inventories

Global nuclear capacity is expected to increase by~+50% over 2012-30



Main drivers of used fuel management

Risk Reduction

- Non-proliferation & security
- Nuclear safety
- Environmental impact & footprint
- Public acceptance

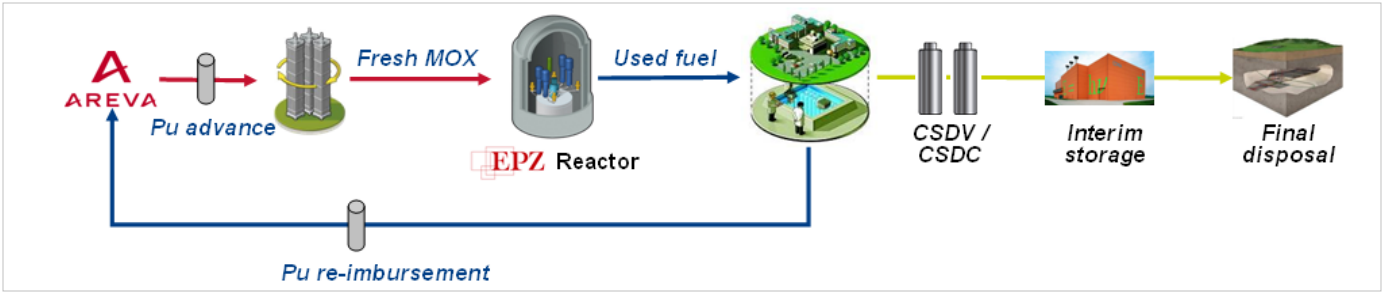
Nuclear System Performance

- Increase energy independence
- Optimize cost of nuclear electricity
- Preserve natural resources
- Minimize waste generated

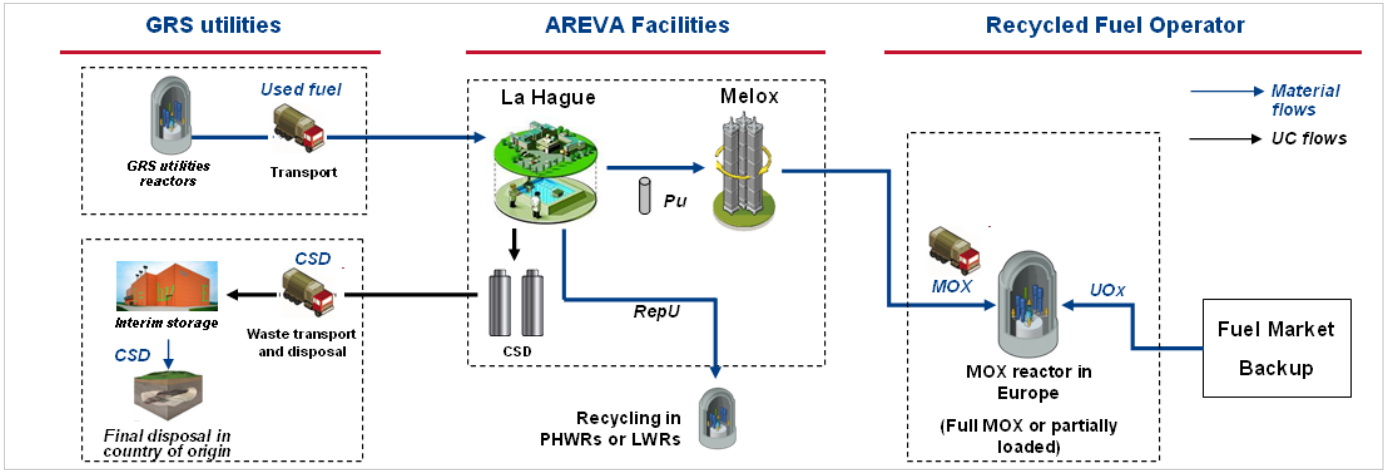
Optimizing the fuel cycle will become even more crucial to ensure the sustainable growth of nuclear energy

Developing New Offers for Used Fuel Management

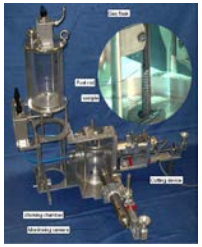
- **Precycling**

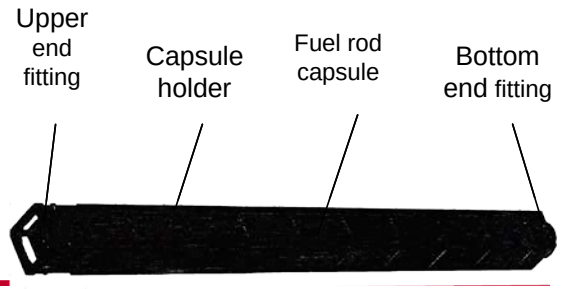


- **Global Recycling Services**



- **Damaged fuel treatment**





French Policy is Consistent with the Conclusions of the 2010 ORNL Study

- **ORNL Analysis Concludes:**
  - **The cost of implementing full recycle will be an insignificant change to the cost of nuclear electricity**
  - **Engineered safeguards can be used to provide adequate proliferation resistance**
  - **Continuing delay will likely occur in locating and operating a geologic repository**
  - **Continued storage of used fuels is not a permanent solution**

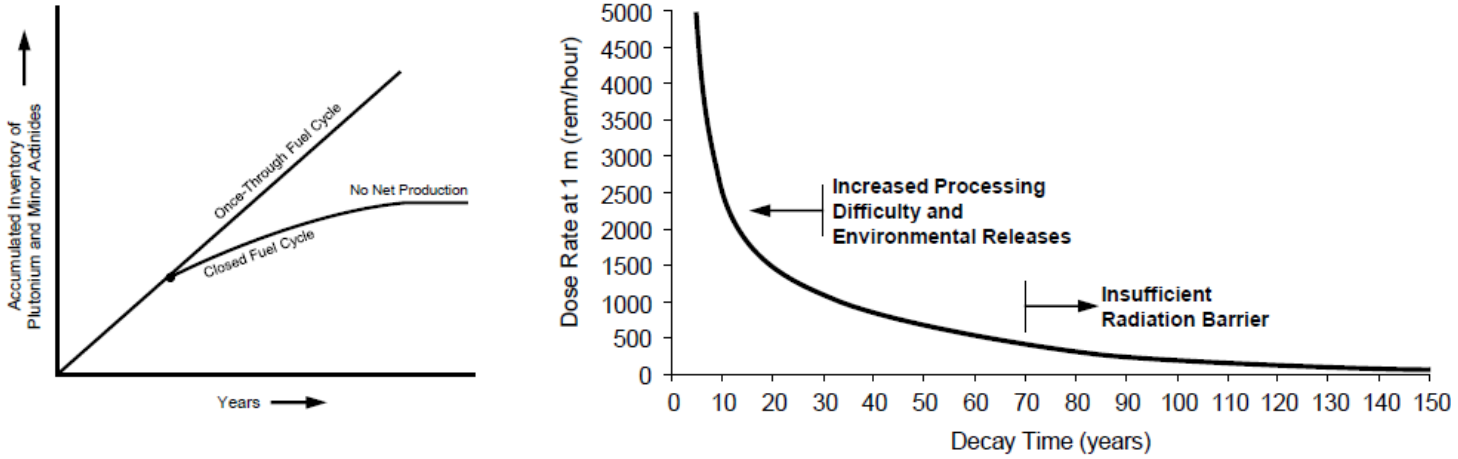
- **With no decision, the path forward for used fuel disposal will remain uncertain, with many diverse technologies being considered and no possible focus on a practical solution to the problem**

- **However, a decision to move forward with used fuel recycling and to take advantage of processing aged fuels and incorporation of near-complete recycling can provide the focus needed for a practical solution to the problem of nuclear waste disposal**

Source: Oak Ridge National Laboratory, "Compelling Reasons for Near-Term Deployment of Plutonium Recycle from Used Nuclear Fuels—A Systems Analysis Study"

ORNL: The Risks of Waiting

Continued Storage Concerns — increasing inventory and decreasing radiation barrier



- Current inventory contains ~500 MT of plutonium and annual production is ~20 MT/year
- Radiation barrier decreasing exponentially with time
- At least 50 years required to build recycle capacity needed to match annual production
- With equal recycle capacity and production rates, inventory will continue to increase because of incomplete burnup in each partitioning-transmutation cycle
- Implementation of plutonium recycle is needed

Source: Oak Ridge National Laboratory, "Compelling Reasons for Near-Term Deployment of Plutonium Recycle from Used Nuclear Fuels—A Systems Analysis Study"

No health impact

- **From a radiological standpoint, the site's impact* is 100 times lower than natural radioactivity levels**

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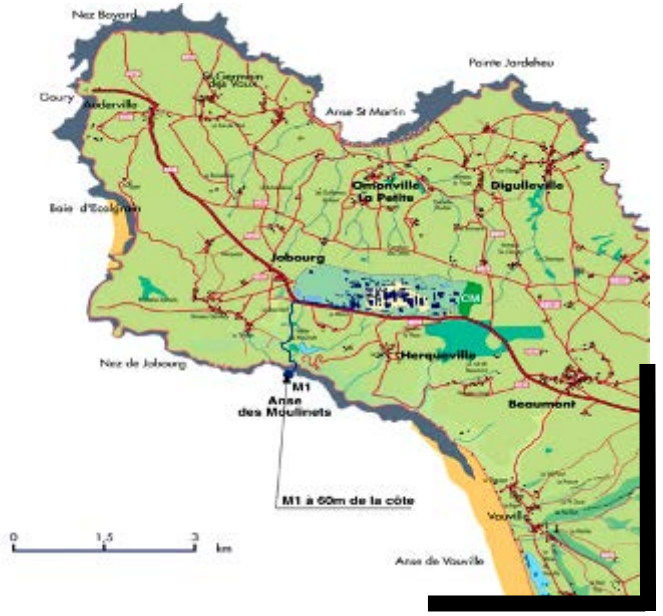
La Hague
< 0,02 mSv / year

Natural exposure
2,4 mSv / year



*Impact calculated since 2004 using a model produced by the GRNC (Groupe Radio-écologie Nord-Cotentin), making allowance for the results of the AREVA public enquiry (1998), for a reference group : population likely to be the most highly exposed due to its position and lifestyle.

A few comparisons

A scan	**10 mSv**
Natural exposure in the Limousin area	**6 mSv per person per year**
Average Natural Exposure in France	**2,4 mSv per person per year**
An abdominal **X-ray**	**1 mSv**
A chest **X-ray**	**0.1 mSv**
Consuming 1 ½ liters of **mineral water** every day for a year	**0.03 mSv**
A transatlantic flight	**0.02 mSv**
A 400-meter **change in altitude**	**0.02 mSv per person per year**
Consuming **200 g** of mussels	**0.02 mSv**
Annual impact of the emissions from AREVA-La Hague	**< 0.02 mSv per person per year**