Reprocessing and Recycling of Used Nuclear Fuels : The French Feedback Experience and International Aspects

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CONTENT

- ***The back-end of the fuel cycle***
  - ***The French strategy to sustain nuclear energy***
  - **Recycling the spent fuel : WHY ?**
  - **A unique industrial tool in France**
  - **Option for the future**
- **Multilateral approaches for the back-end of the fuel cycle**
  - **General trends and issues**
  - **Reprocessing of spent fuels**
  - **Recycling of fissile materials : MOX and ERU**
  - **Transport of fuels and waste**
- **Conclusion**

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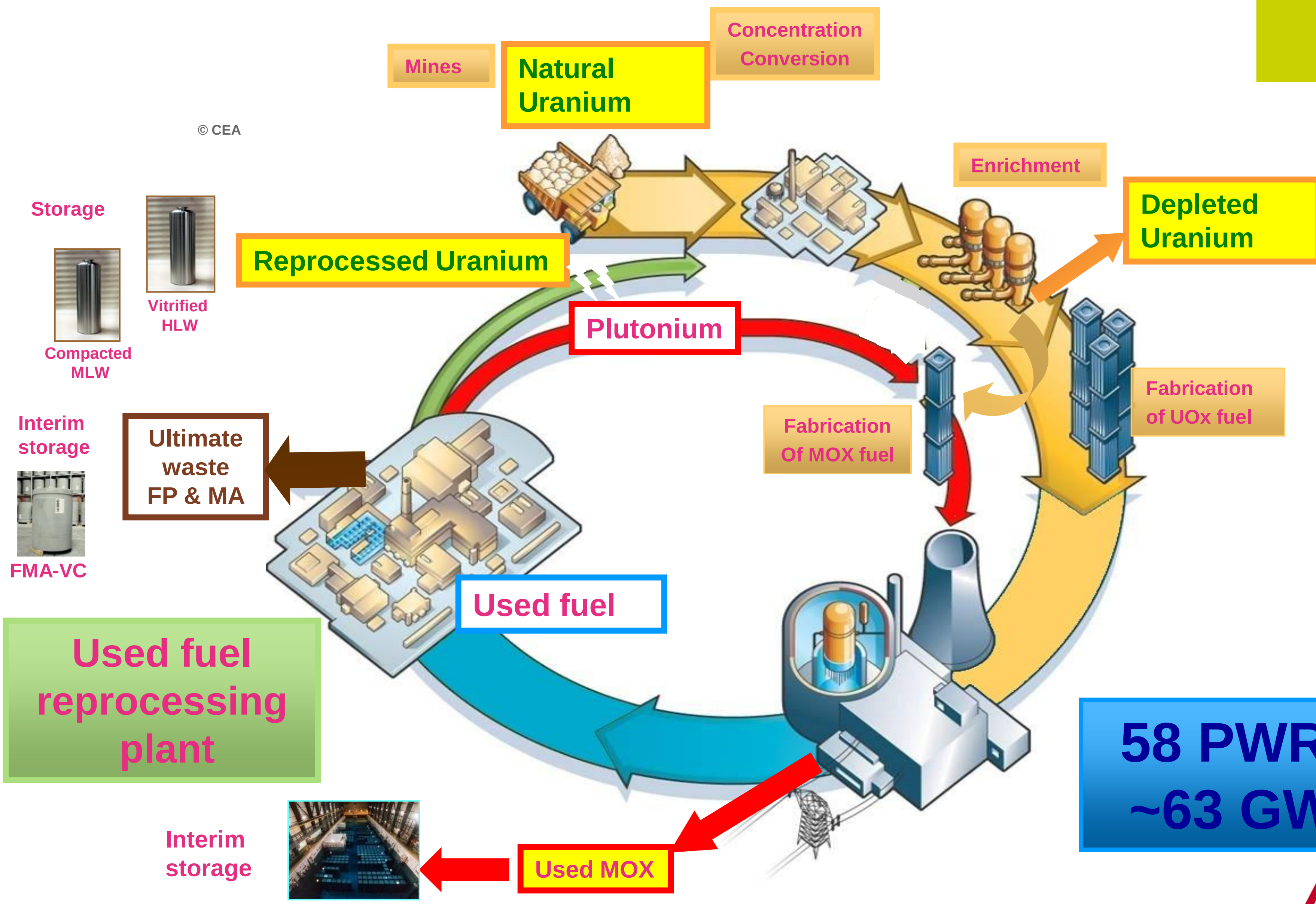
PWR fleet & Nuclear fuel cycle in France



58 PWRs
~63 GWe

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A sustainable Management of Nuclear Fuel & Waste : The Act of June 28, 2006

- National Plan for managing ***nuclear materials and radioactive waste (RW)***
- Guarantees for ***long term funding*** of radioactive waste management
- Stepwise program for ***Long-Lived Waste (High and Medium Activity)*** management along various approaches:

Atalante & Phenix

→ **Minimize RW : Partitioning & Transmutation:**
- ✓ 2012: Assessment of Fast Reactors / ADS
- ✓ 2020: Fast reactor Prototype

→ **Investigate and assess Retrievable Geological Repository:**
- ✓ 2015: Authorization decree
- ✓ 2025: Beginning of operation

→ **Consider long term Interim storage:**
- ✓ Creation of new facilities in 2015

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Framework for Recycling Foreign Spent Fuel (art. 8)

- **Reinforcing the control of SF importation and waste shipping:**

  "*[Spent fuel]* **introduction for treatment can be authorized only as part of intergovernmental agreements and provided the radioactive wastes, resulting after the treatment of these substances are not stored in France beyond a date set by said agreements. The agreement states the estimated periods for the reception and treatment of these substances and, where applicable, the prospects for the subsequent use of radioactive materials separated during treatment.**"

- **Practical consequences:**
  - **New accounting system for RW**
  - **International agreements**
  - **Public reporting with detail description of :**
    - Spent fuel and waste packages stockpiles and flows (including reprocessing and shipping schedule)
    - Radioactive materials (U, Pu)
      - + **Follow up of inter-governmental agreements**

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Objectives of spent fuel reprocessing

Composition of the LWR spent fuel assembly (FA) after irradiation

➔ **1 LWR fuel assembly: 500 kg uranium before irradiation in the reactor**

Recyclable materials | Waste

U 475 to 480 kg
(94 to 96 %)
→ RECYCLING

Pu 5 kg
(1 %)
→ RECYCLING

FP 15 to 20 kg
(3 to 5 %)
→ FINAL RESIDUES

**NOTE :* percentage can vary slightly with burnup

Why reprocess and recycle ?

1 - Reprocessing makes waste management easier :

- ➔ Reduces volume of ultimate HLW conditioned waste (factor 5 to 10)
- ➔ Can reduce thermal load in final repositories (➔ lower size and cost)
- ➔ Strongly reduces overall radiotoxic inventory (up to a factor 10)
- ➔ Produces well characterized and qualified waste packages
- ➔ Provides a reliable option for an interim long term storage period

2 - Reprocessing provides flexible solutions for the long term : deployment of breeders, MA recycling, …

3 - Saves natural resources : 25 % of natural uranium to day and avoid the use of it in the long term (with Breeders)

… while protecting human beings and the environment

And for a cost less than 6 % of the cost of the KWh

This contributes to make nuclear energy MORE ACCEPTABLE to the public

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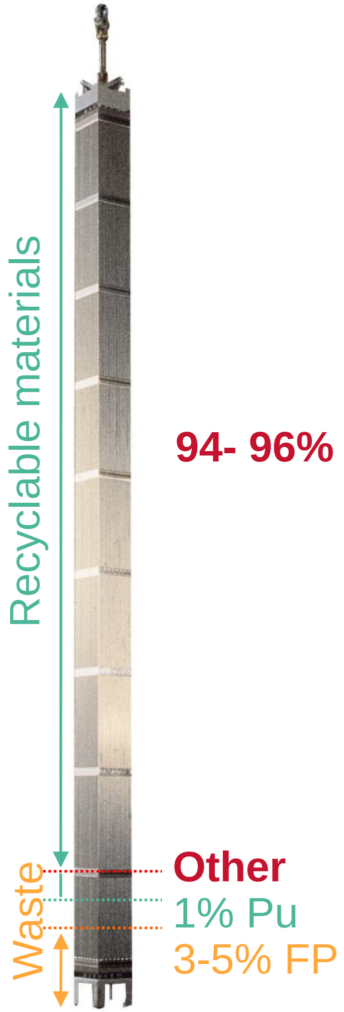
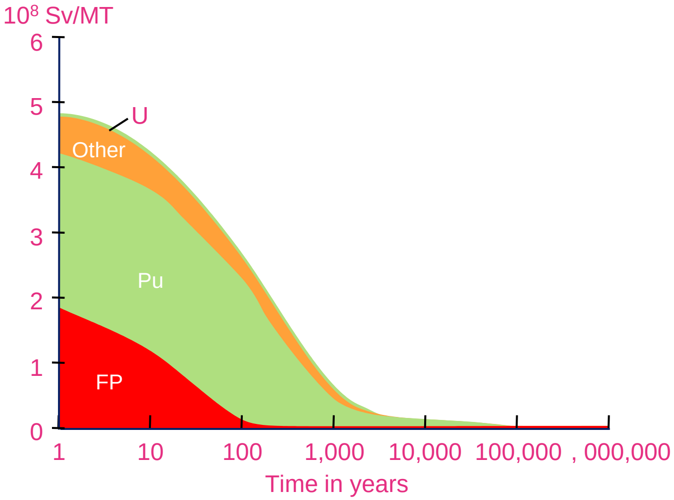
Spent fuel radiotoxic inventory versus time : 80 % comes from Pu between few centuries and several hundred thousands years

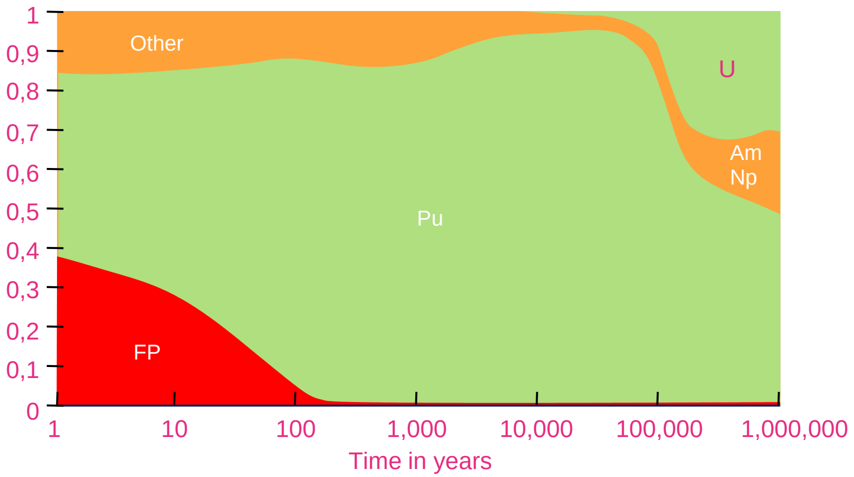
Spent fuel assembly



Spent fuel radiotoxicity over time

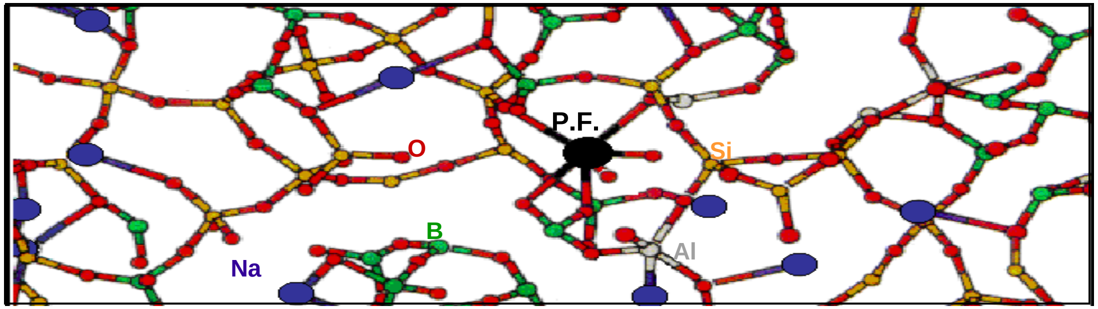


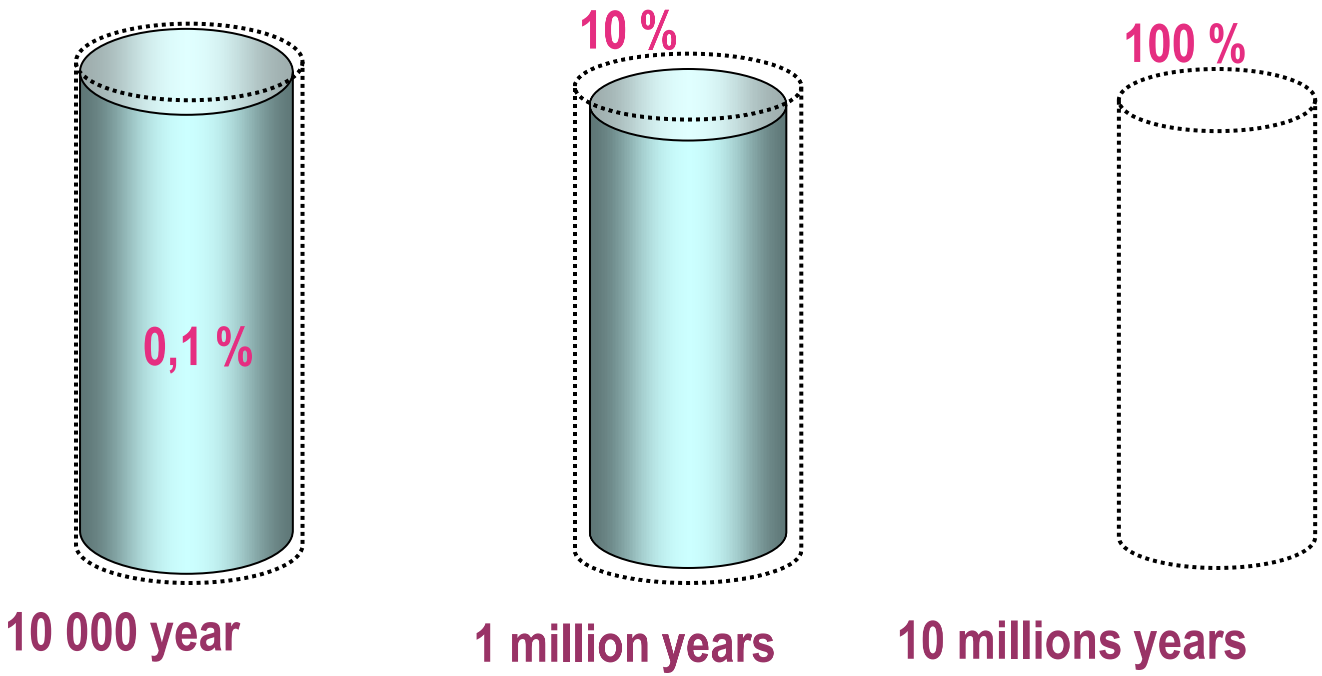
Spent fuel radiotoxicity by component



U : Uranium
Pu : Plutonium
FP : Fission products
Sv : Sievert
Am : Americium
Np : Neptunium

Glass has proven scientifically as a very robust matrix against alteration by water





<u>Important phenomena are :</u>

- **Dissolved silica** in the water of the geological media slows down alteration
- **Protective gel** formed around the glass : increases the longevity of the glass

RECYCLING SAVES NATURAL RESOURCES

- Reprocessed uranium (RepU)
  - Represents about 95 % of the mass of LWRs spent fuel (enrichement 0.8 % to 0.9 %) but mixed with U236
  - Its recycling (after re-enrichment) is already experienced by several utilities throughout the world (in 2 PWRs in France, all RepU in the near future)
  - Recycling RepU allows to **save between 11 % to 13 % of natural U**

- Plutonium
  - 1 gram of Pu = 1 or 2 tons of oil
  - In France, all plutonium is recycled in MOX fuel :

    roughly 10 tons/year = **12 % natural U saving** (equivalence : 10 million tons of oil, that is 10 % of imported oil)

A gain of a factor 50 or more could be reached in the future with Gen-IV reactors

To sum up …

Reprocessing / recycling option :

◆Recycles	96%	of the content of spent nuclear fuel
◆Conserves	25%	of our natural resources
◆Represents less than	6%	of the cost of the kWh
◆Divides waste volumes by	5 - 10	(may be more in the future)
◆Divides waste toxicity by	10	(but if recycled in LWR ➔ produces MAs)

◆Produces waste packages that remain stable for tens of thousands of years : that's ease SAFETY DEMONSTRATION of the final disposal of ultimate waste and make the public more confident to this solution.

Reprocessing gives time and expands choices for the best possible management of nuclear waste: FLEXIBILITY

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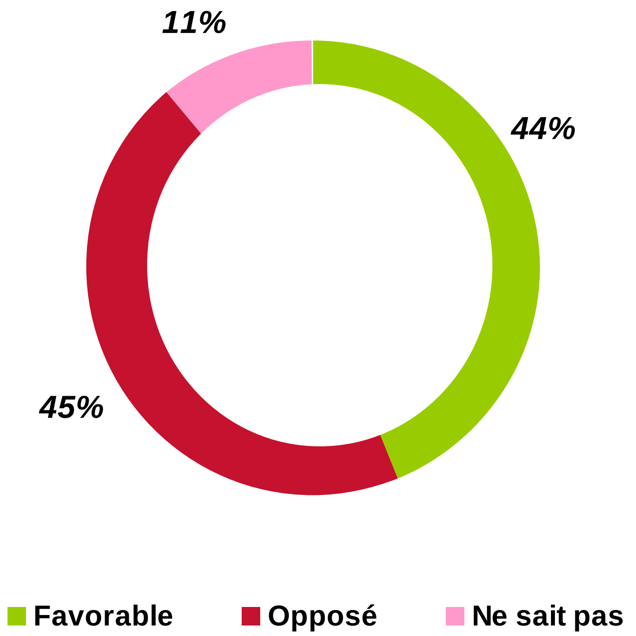
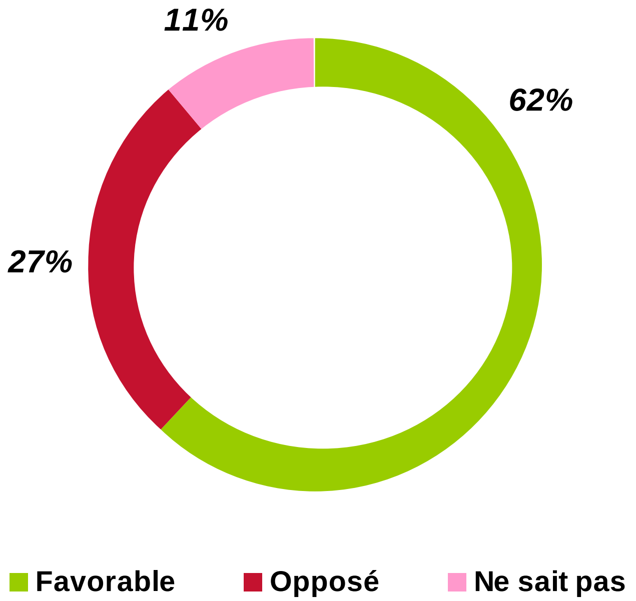
Public acceptance of nuclear energy : the role of the back-end of the fuel cycle

Support of EU citizens to Nuclear Energy (Eurobarometer, 2008)



*« **Without** a solution to waste issue »*



*« **With** a solution to waste issue »*

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The Reprocessing-Recycling Option in France : Industrial tools features and achievements

Reprocessing : The LA HAGUE Plant (startup in end of 70's for LWR fuels)

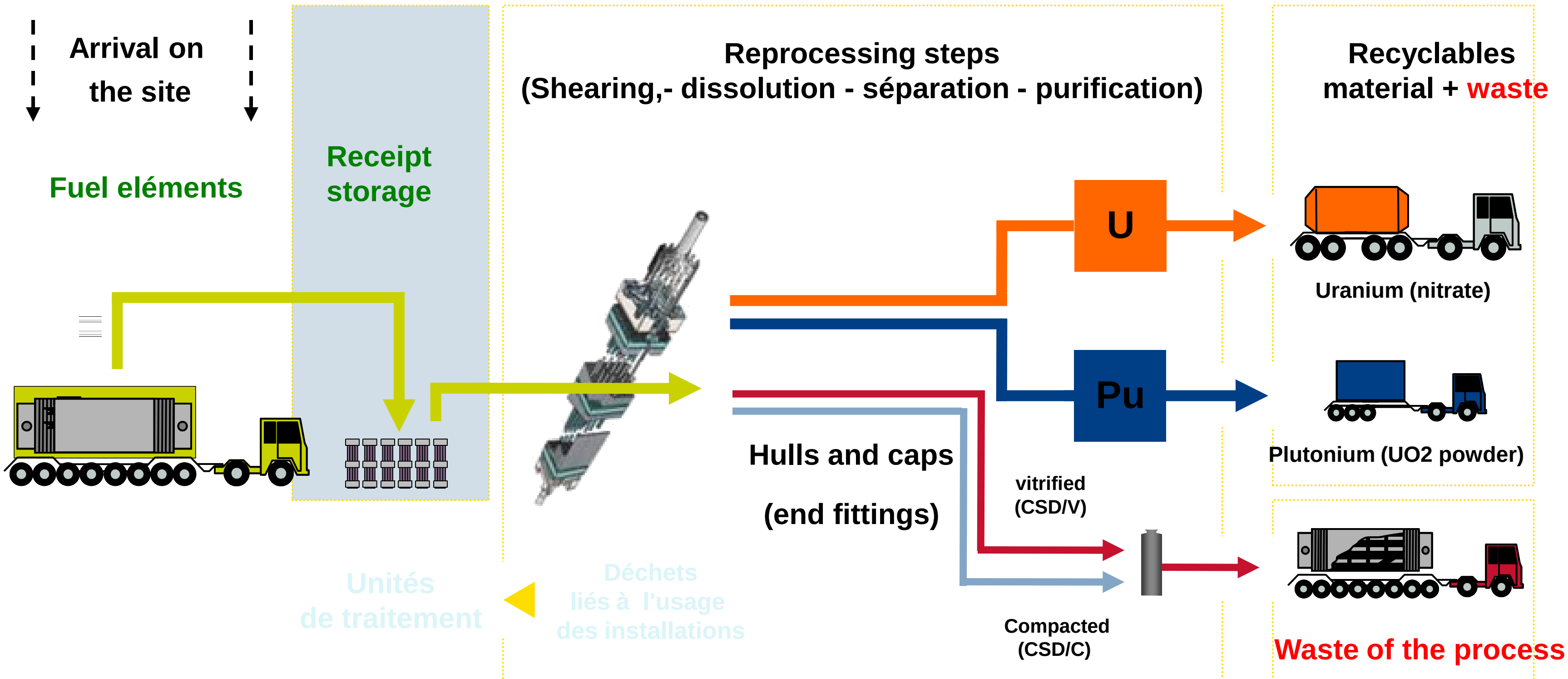
- Commissioned in 1966 and constantly modernized since then
- Uses full proven industrial process : Liquid-Liquid extraction process (more than 99.8 % of Pu and U recovered)
- Total annual capacity : 1700 THM (UP2 + UP3) – Equivalent to 100 PWRs
- Allows reprocessing of all types of fuels (including MOX and FNRs fuels)
- More than 25 000 THM reprocessed today
- On-line conditioning of ultimate waste
- Very low occupational exposure of workers (100 times below current regulation limits) and environmental impact.

Recycling : the MELOX Plant (startup : 1995)

- Total annual capacity : 195 THM (U + Pu in MOX fuels)
- Adapted to both PWR and BWR fuels (all kinds)
- Cumulative production of MOX fuels : more than 1400 THM (end of 2008)

The AREVA La Hague plant

Main steps of reprocessing



- Each step has its own process
- There is a « nuclear material control an accounting » system (MC&A) at each step, under the control of EURATOM and IAEA
- Customers (utilities) keep the ownership of their nuclear materials and waste are sent back to the customers

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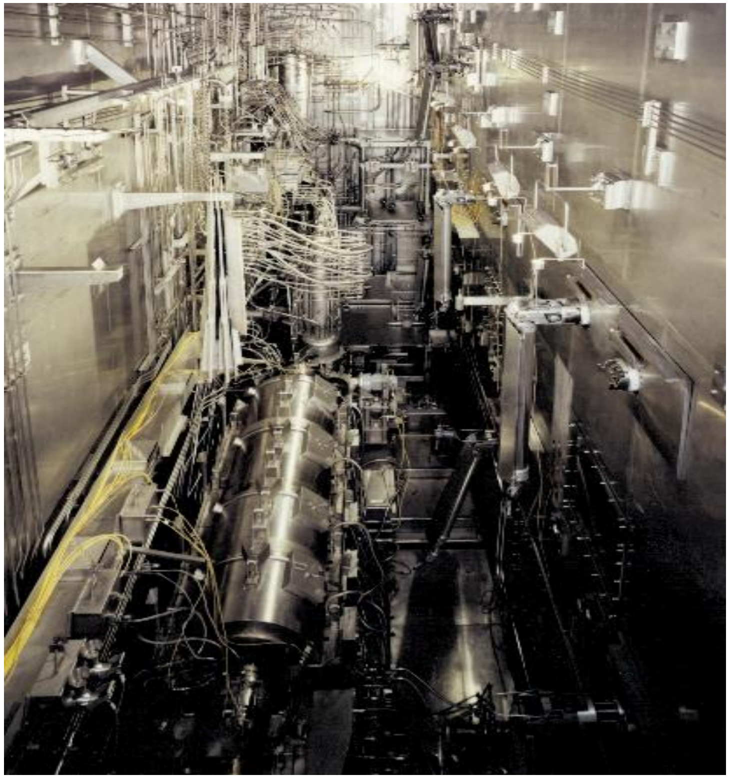
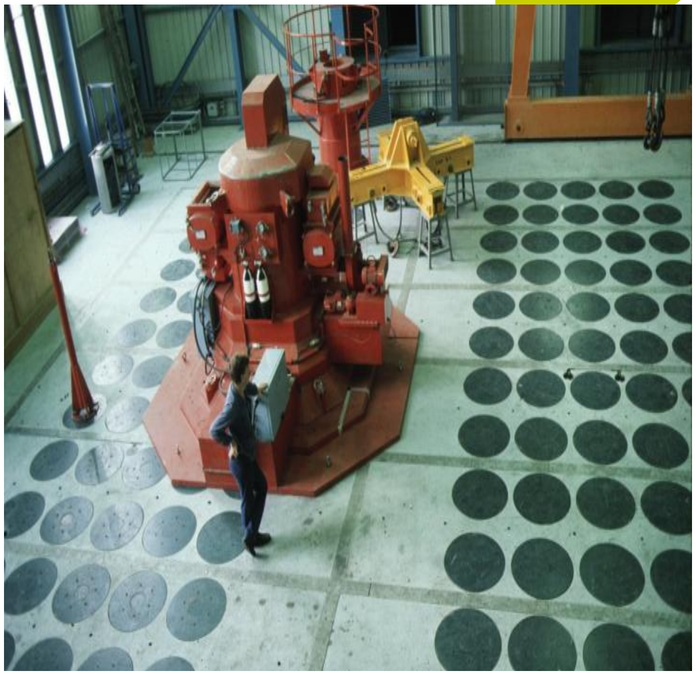
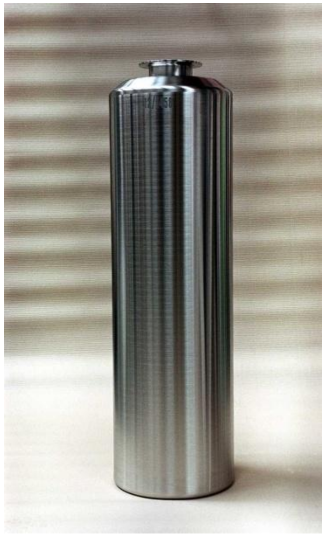
The spent fuel storage pools before reprocessing at the La Hague plant (18 000 THM capacity)

Vitrified waste (FP + MA) at La Hague







A robust solution proven with french experience feedback at the former reprocessing plant of Marcoule : 40 years of storage without any safety problem).

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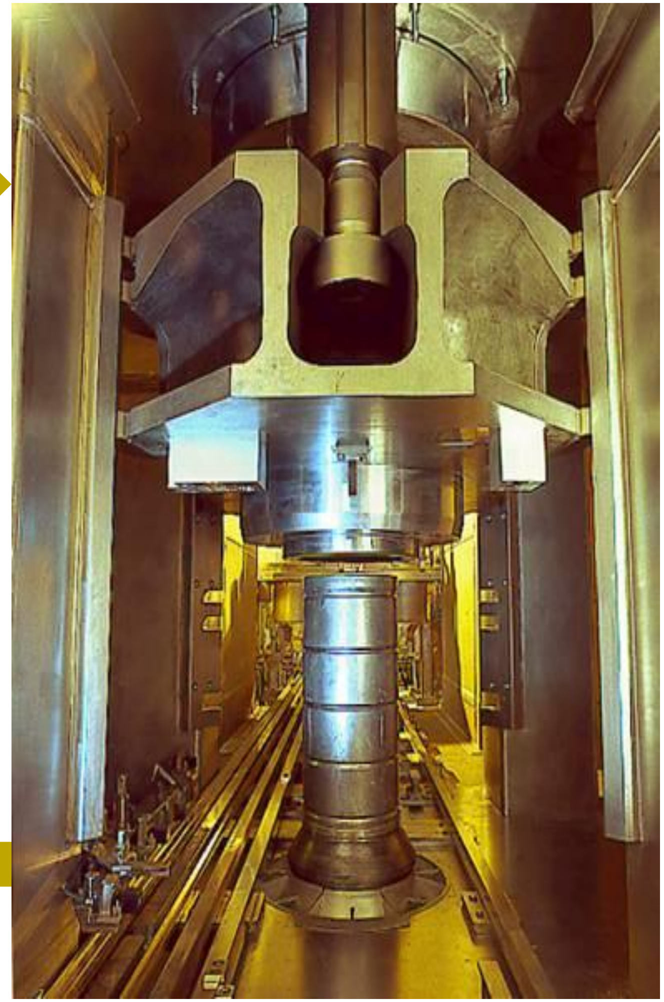
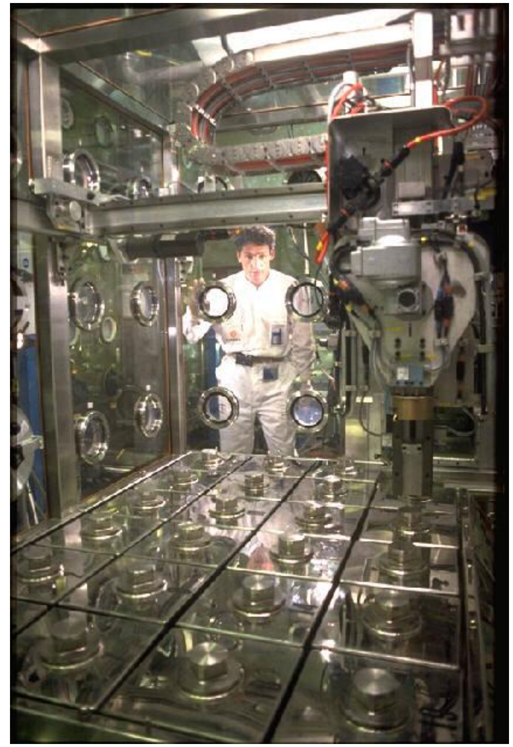
The compacting process (hulls, end-pieces, tecnological waste, …)



THE MELOX PLANT

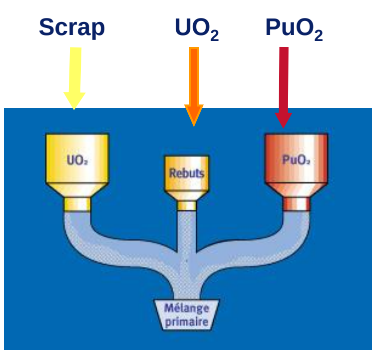
PuO2 Boxes

+ depleted U

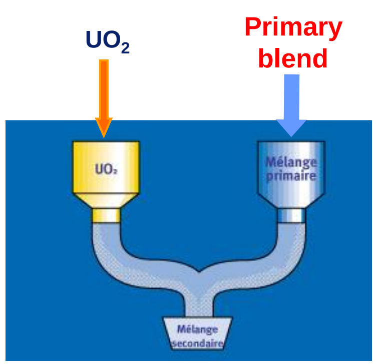


Powder blending is the key to the MELOX process

(with on line recycling of scraps)



1 Preparation of primary blend



2 Preparation of secondary blend

- Pressing
- Sintering
- Grinding
- Cladding

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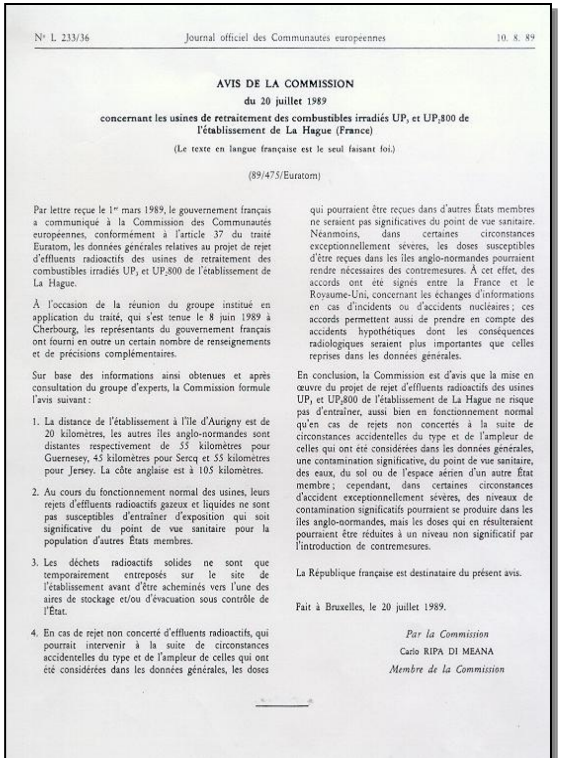
The recycling plant's activities comply with international law and standards



N° L 233/36 Journal officiel des Communautés européennes 10. 8. 89

AVIS DE LA COMMISSION

du 20 juillet 1989

concernant les usines de retraitement des combustibles irradiés UP_3 et UP_2800 de l'établissement de La Hague (France)

(Le texte en langue française est le seul faisant foi.)

(89/475/Euratom)

Par lettre reçue le 1er mars 1989, le gouvernement français a communiqué à la Commission des Communautés européennes, conformément à l'article 37 du traité Euratom, les données générales relatives au projet de rejet d'effluents radioactifs des usines de retraitement des combustibles irradiés UP_3 et UP_2800 de l'établissement de La Hague.

À l'occasion de la réunion du groupe institué en application du traité, qui s'est tenue le 8 juin 1989 à Cherbourg, les représentants du gouvernement français ont fourni en outre un certain nombre de renseignements et de précisions complémentaires.

Sur base des informations ainsi obtenues et après consultation du groupe d'experts, la Commission formule l'avis suivant :

1. La distance de l'établissement à l'île d'Aurigny est de 20 kilomètres, les autres îles anglo-normandes sont distantes respectivement de 55 kilomètres pour Guernesey, 45 kilomètres pour Sercq et 55 kilomètres pour Jersey. La côte anglaise est à 105 kilomètres.
2. Au cours du fonctionnement normal des usines, leurs rejets d'effluents radioactifs gazeux et liquides ne sont pas susceptibles d'entraîner d'exposition qui soit significative du point de vue sanitaire pour la population d'autres États membres.
3. Les déchets radioactifs solides ne sont que temporairement entreposés sur le site de l'établissement avant d'être acheminés vers l'une des aires de stockage et/ou d'évacuation sous contrôle de l'État.
4. En cas de rejet non concerté d'effluents radioactifs, qui pourrait intervenir à la suite de circonstances accidentelles du type et de l'ampleur de celles qui ont été considérées dans les données générales, les doses qui pourraient être reçues dans d'autres États membres ne seraient pas significatives du point de vue sanitaire. Néanmoins, dans certaines circonstances exceptionnellement sévères, les doses susceptibles d'être reçues dans les îles anglo-normandes pourraient rendre nécessaires des contremesures. À cet effet, des accords ont été signés entre la France et le Royaume-Uni, concernant les échanges d'informations en cas d'incidents ou d'accidents nucléaires ; ces accords permettent aussi de prendre en compte des accidents hypothétiques dont les conséquences radiologiques seraient plus importantes que celles reprises dans les données générales.

En conclusion, la Commission est d'avis que la mise en œuvre du projet de rejet d'effluents radioactifs des usines UP_3 et UP_2800 de l'établissement de La Hague ne risque pas d'entraîner, aussi bien en fonctionnement normal qu'en cas de rejets non concertés à la suite de circonstances accidentelles du type et de l'ampleur de celles qui ont été considérées dans les données générales, une contamination significative, du point de vue sanitaire, des eaux, du sol ou de l'espace aérien d'un autre État membre ; cependant, dans certaines circonstances d'accident exceptionnellement sévères, des niveaux de contamination significatifs pourraient se produire dans les îles anglo-normandes, mais les doses qui en résulteraient pourraient être réduites à un niveau non significatif par l'introduction de contremesures.

La République française est destinataire du présent avis.

Fait à Bruxelles, le 20 juillet 1989.

Par la Commission

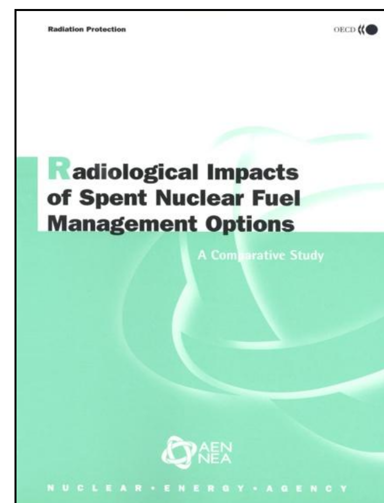
Carlo RIPA DI MEANA

Membre de la Commission

- **EURATOM treaty:** ***the discharges levels for La Hague and Melox were approved by the European Commission pursuant to Article 37***

- ***All recycling activities comply with the 2001Joint Convention on Spent Fuel and Waste (AIEA)***

- **OSPAR Convention:** ***towards zero discharge by 2020 and application of the Best Available Technology (BAT)***



NEA report of 2000 : "The radiological impacts of both the reprocessing and the non-reprocessing fuel cycles studies are small, well below any regulatory dose limits for the public and for workers, and insignificantly low as compared with exposures caused by natural radiation".

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Advanced recycling : objectives

- **Further reduce the recycling cost : more integration of workshops, reprocessing and recycling facilities in the same plant, process simplifications ("simplified Purex", advanced MOX fabrication process), increase of its operating performances (burnup credit, maintenance, environmental impact, waste generation, …), process simulation and control,**

- **Increase reprocessing plant flexibility : high burnup fuels, RTR fuels, MOX, FNR, partitioning of MAs, Cold crucible melter for vitrification, high alpha content glass,….**

- **Further reduce the ultimate waste, in particular through Partitioning and transmutation (P&T) : volume, heat, radiotoxicity, …**

While enhancing proliferation resistance

(no Pu separation (Coex™) , safeguard by design, …)

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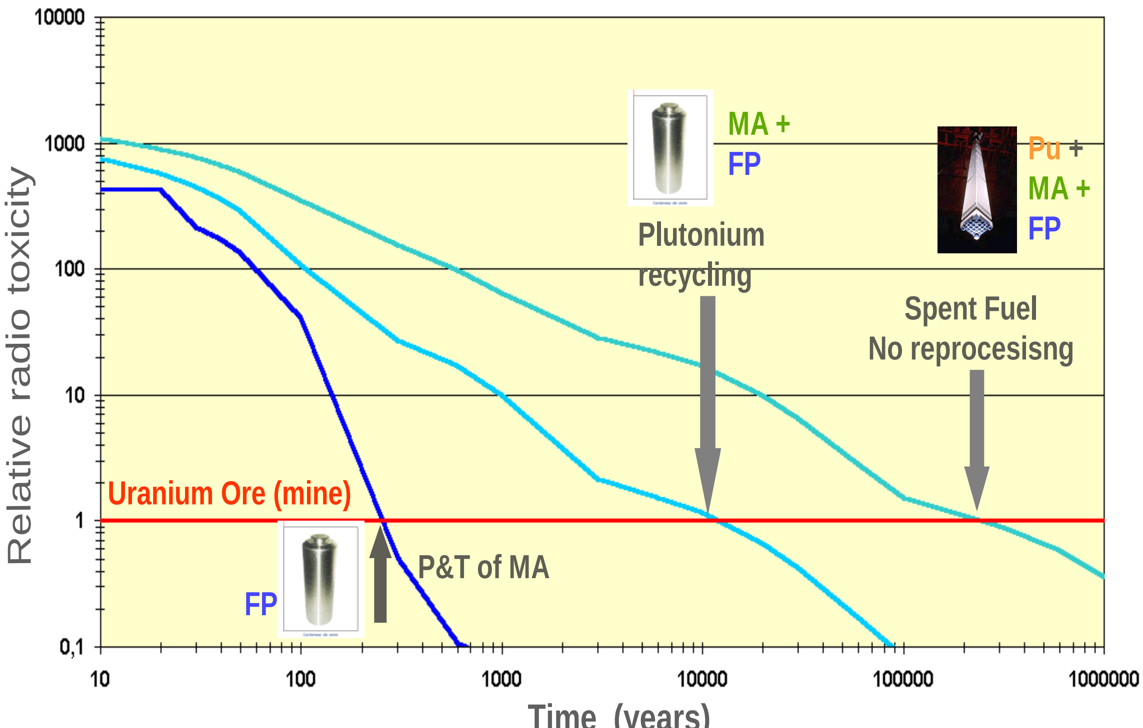
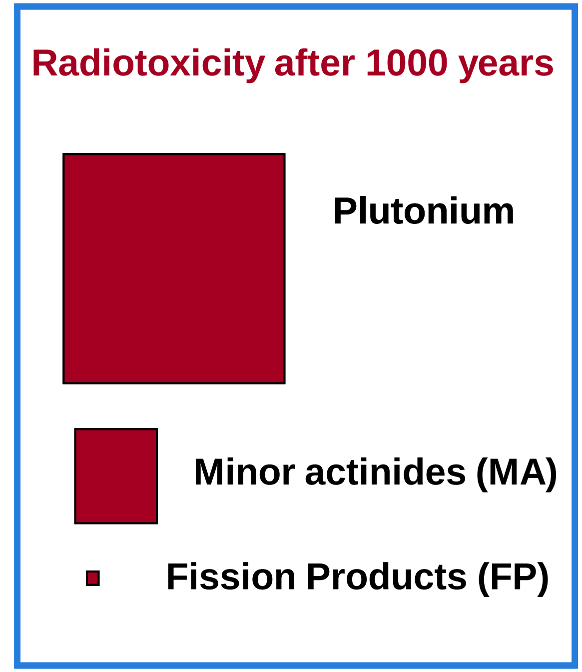
Global Actinide Management in LWRs & Fast Reactors

Minimizing waste with advanced actinide recycling

- Plutonium is the major contributor to the long term radiotoxicity of spent fuel
- Plutonium has a high energetic potential

→ **Plutonium recycling**





- After plutonium, MA have the major impact to the long term radiotoxicity

→ **MA transmutation**

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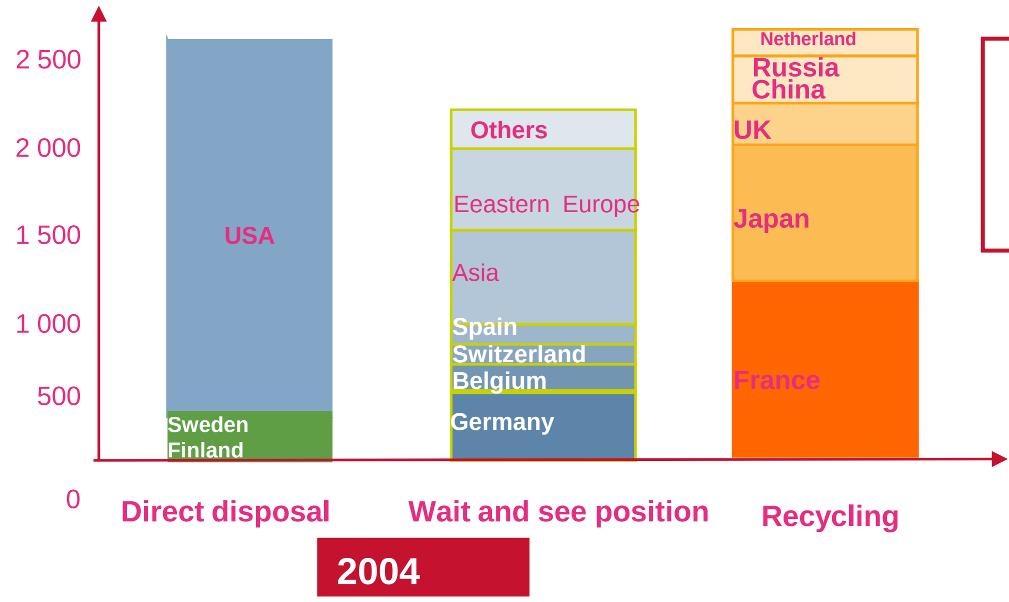
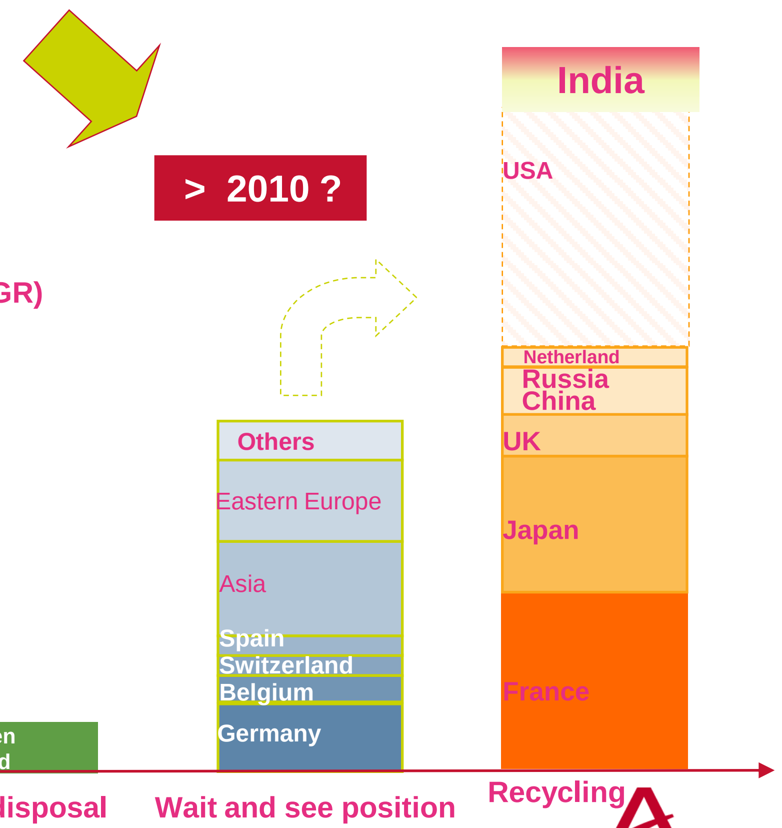
Recycling : international status



Recycling comes with a sustainable nuclear energy



USA : ***"Federal loan guarantees are not the most important incentive needed to support construction of new nuclear units. The most important issue to address, to gain public support, is disposition of spent fuel, and the answer is reprocessing and recycling that fuel. Technology to do that could be developed and implemented more rapidly than could coal combustion technology using carbon capture and storage"*** ***JAMES ROGERS, CEO DUKE ENERGY***

(1) Tons of used fuels per year for Light Water reactors and for «*Advanced Gas Reactor »*

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Multinational Approaches to the fuel cycle :
an industrial point of view

Radiation Protection basic principles can be applied to multinational approaches for the back-end of the fuel cycle

- ***Limitation*** **principle and security / guarantees of supply**
  - **Long term contracts (but with suspension clauses)**
  - **Existence of competitors**
  - **Large size profitable facilities**
  - **Matched with governmental or international export agreements**

- ***Justification*** **principle to allow evolution of capacities**
  - **No a priori prohibition of new capacities in new countries IF there is an economic evidence of the need and IF non proliferation status of the country is undisputable**

- ***Optimization*** **concept**
  - **Existing capacities should be better used and preserved**
  - **Competition should be kept but financial incentives could be justified**

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Control Approach for nuclear materials

Legal Basis

- **EURATOM : In implementation of the article 77 of the EURATOM treaty, the Commission insure that :**
  - The nuclear materials are not diverted from the declare use,
  - The respect of provisions about supplies and obligation towards states or international organizations.
- **IAEA : Agreement between France, the European Union and the I.A.E.A. (INFCIRC/290) .**
  - I.A.E.A. designation of Melox shipment area for regular inspection of Mox assemblies to be transferred to NNWS as of August 1^{st}, 2001.
  - Definition of a new nuclear Material Balance Area (MBA)

Control Approach

- **B.T.C. (Basic Technical Characteristics) verification of physical characteristics and access of the MOX send off area periodically re-verified by inspectors**
- **Continuous inventory of the in-process nuclear materials**
- **Accountancy verification**
- **Physical inventory verification**

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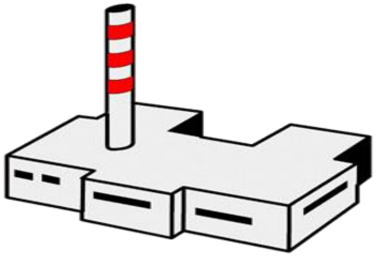
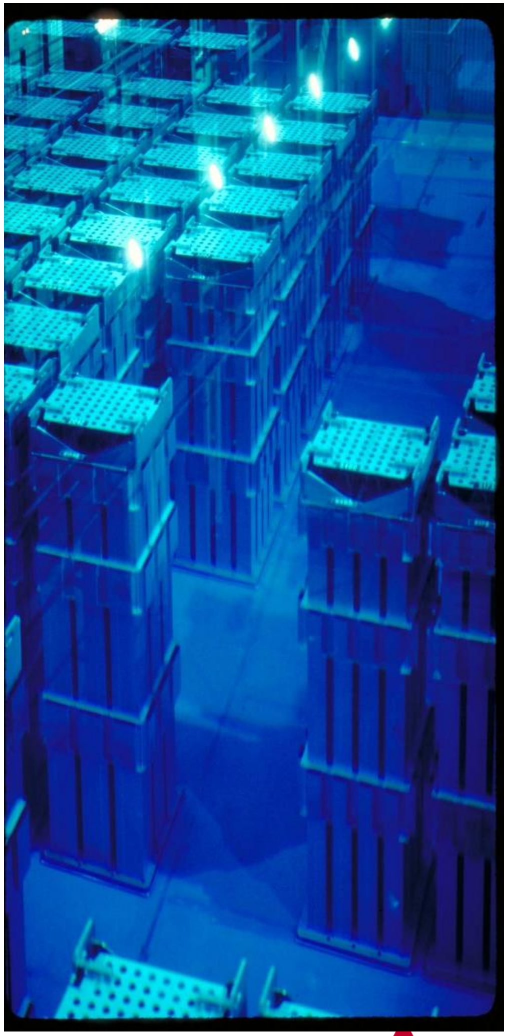
Statistics of reprocessed spent fuels at La Hague for foreign customers (end of 2009)



	With NO send back of waste		With send back of waste	
	Quanities (THM)	Period	Quanities (THM)	Ended in
The Netherland	**79**	1979 - 1995	247	2006
Belgium	**40**	1980 - 1981	631	2001
Switzerland	**70**	1976 - 1984	701	2011
Japan	**151**	1982 - 1986	2793	1999
Germany	**172**	1977 - 1995	5311	2008

TOTAL 512 + 9683 =
> 10 000 THM

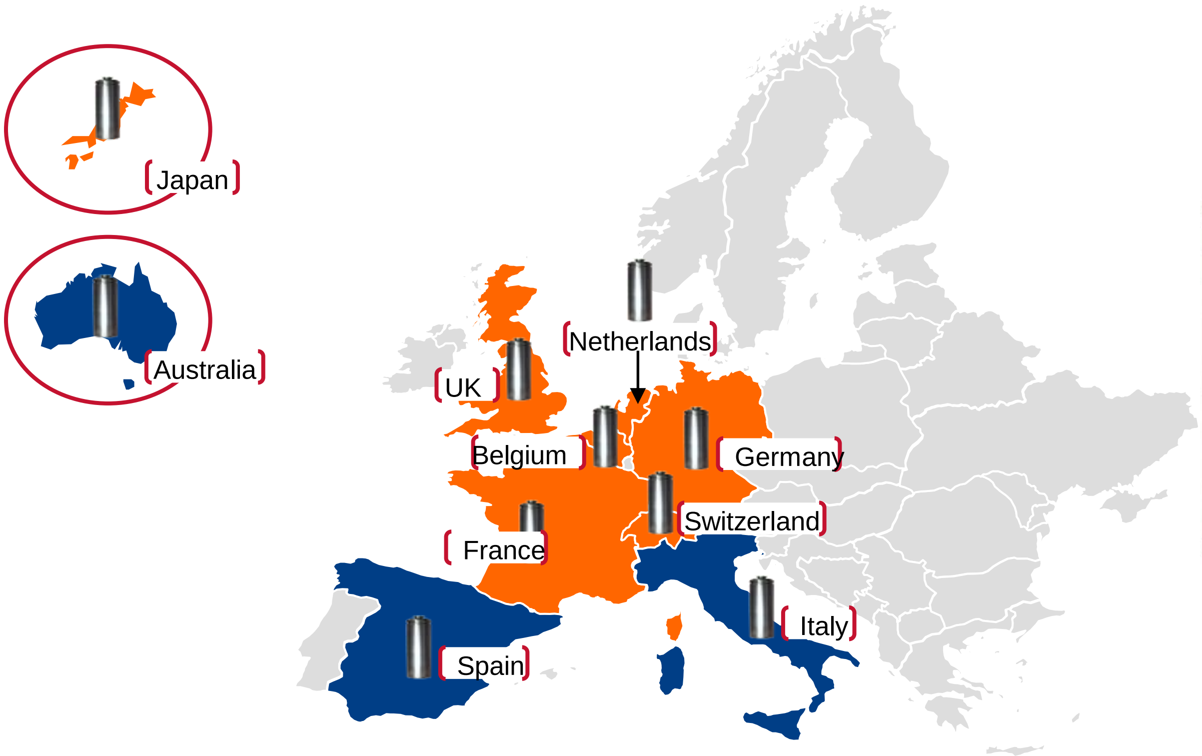


Other reprocessing services are on going or prepared : Australia, Italy, Belgium, Switzerland, …

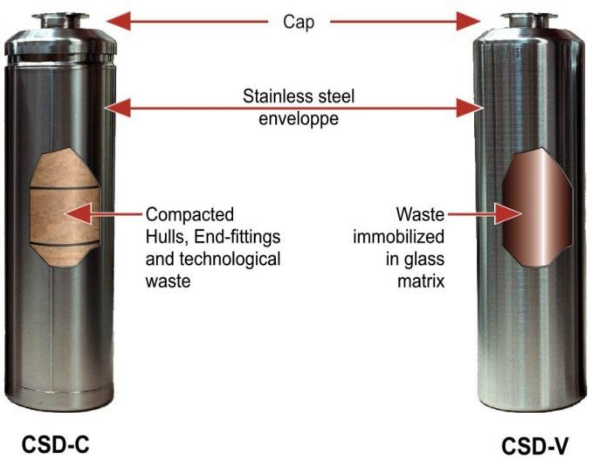
The waste from reprocessing

Internationally Accepted and Qualified Waste Specifications:

- **France, Japan, Germany, Belgium, Switzerland & Netherlands**
- **In progress: SPAIN, AUSTRALIA, ITALY**



"Universal Canister" (UC)



Designed for long-term safety, Universal Canisters simplify handling and leave room for shared storage solutions

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MOX[1] and ERU[2] fuel market and customers

- **ERU : Over 30 reactors totalizing more than 5000 ERU FAs[3] in 2010**

- **MOX : Over 36 reactors totalizing more than 6000 MOX FAs[3] in 2010**

(first MOX fuel loaded in a NPP in germany in 1972)

- **This represents about :**
  - **About 2500 t of re-enriched uranium, or 20000 t of natural uranium**
  - **170 tons of plutonium, that is an equivalent of 35000 t of natural uranium[4].**

That is a saving equivalent to almost ONE YEAR of the worldwide nat U consumption

(1) : MOX : Mixed Oxide

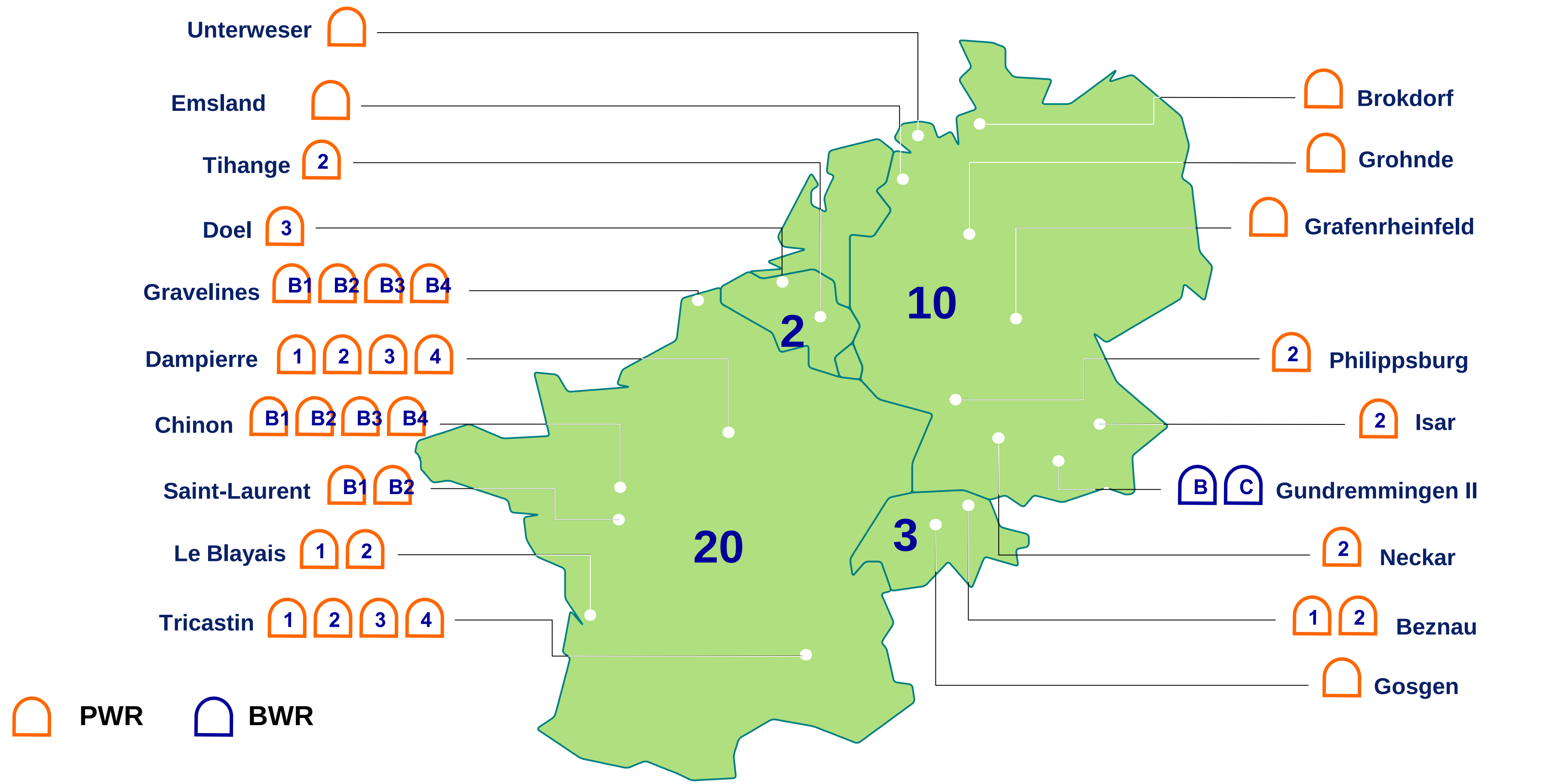
(2) : ERU : re-Enriched Reprocessed Uranium

(3) : FAs : Fuel Assemblies

(4) : According to WNA web site, about 2000 tons of MOX loaded in March 2009. This corresponds to 2400 tons or so at the end of 2010 that is 170 tons of plutonium assuming an average content of 7 % Pu in MOX

MOX MARKET & CUSTOMERS Recycling in Europe and Japan

Reactors cores loaded with MOX fuel : 35 (Light WaterReactor)



JAPAN : **11 utilities committed to loading MOX fuels (1 reactor started operation with MOX in 2009)**

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Reprocessed Uranium (RepU) separated at La Hague and recycled (status in 2009)

Owners	Uranium separated (or to come)	Recycled Uranium or send back
France incl AREVA NC	13 550	3 230 (24%)
Japan	2 690	450 (17%)
Germany	5480	3140 (57%)
Belgium	640	640 (100%)
Switzerland	740	670 (91%)
The netherland	310	270 (87%)
Spain	0*	0
Italy	220	0
Total (rounded)	23 630	8 400 (36%)

Orange arrow: *Recycling through dilution* (Germany, Switzerland, The netherland)

Green arrow: *Recycling through reenrichissement* (France, Japan, Belgium)

Green square: **Uranium separated (or to come)**

Blue square: **Recycled Uranium or send back**

* 0,1 et/ou UNGG non inclus

CONTENT

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  - The French strategy to sustain nuclear energy
  - Recycling the spent fuel : WHY ?
  - A unique industrial tool in France
  - Option for the future
- Multilateral approaches for the back-end of the fuel cycle
  - General trends and issues
  - Reprocessing of spent fuels
  - Recycling of fissile materials : MOX and ERU
  - ***Transport of fuels and waste***
- Conclusion

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Transport of ultimate waste ("residues") from reprocessing

- **Vitrified and compacted waste are conditioned in the same universal and multi purpose canister, named the Universal Canister (UC) : easy handling operations either by a crane or by a loading/ unloading machine.**

- **The resulting residue is named:**
  - **CSD-V or UC-V for vitrified waste,**
  - **CSD-C or UC-C for compacted waste.**

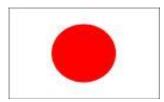
- **For the transport of the vitrified residues, an IAEA type "B" packaging is required.**

Transport organization from La Hague

- **Vitrified waste / Europe**

  - **Road transport from La Hague plant to Valognes rail-road transfer terminal**
  - **Railway transport from Valognes to either the customer storage site, or to a rail-road transfer terminal and then by road to the storage site.**

- **Vitrified waste / Japan**



  - **Road transport from La Hague plant to Cherbourg port**
  - **Sea transport from Cherbourg port to the Japanese port (PNTL ships)**

- **Compacted waste**
  - **Same conditions will apply.**
  - **Specific assessments were necessary to obtain suitable classification from AIEA and from French security authority (HFDS), in terms of physical protection (“Category II – Irradiated fuel” like vitrified waste)**

Statistics of waste transports for foreign customers (end of 2009)

	COMPACTED WASTE			VITRIFIED WASTE	
	Number of transport per year	Number of casks per transport	Period	Started in	Number of transport
The Netherland	2	1 or 2	2004 - 2013	2004	5
Belgium	Up to 3	2	2010 - 2013	2000	14
Switzerland	2	Up to 3	2009 - 2015	2003	8
Japan	1	Up to 7	2013 - 2021	1995	12
Germany	Under discussions		2012 - 2024	1996	10

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General aspects – 1 : a stringent regulatory framework

- The transport of radioactive material worldwide is governed by a very stringent and demanding regulatory regime, which includes standards, codes and regulations that have been continuously revised and updated over the past four decades.

- In addition to the safety regulations, the regulatory regime addresses other related issues such as physical protection and liability.

- IAEA regulations (first publication in 1961) is a common regulatory basis for more 60 nations and most of international organizations dealing with transportation

- International Maritime Organization (IMO) has also introduced its own international code and security rules, in particulars for ships and containers

General aspects – 2 : an international consensus

- **In September 1998 the General Conference of IAEA, which brings together all the Member States of the Agency, recognised that**

"compliance with regulations which take account of the Agency's Transport Regulations

is providing a high level of safety during the transport of radioactive material" (Resolution GC(42)/RES/13).

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General aspects – 3 : technical aspects

- All transported nuclear materials are in a solid form and are locked in special casks
- These casks are submitted to extreme accidental conditions tests (drop, fire, immersion, …)
- Sophisticate tracking systems are in force as well are emergency plans and response teams
- Transports are submitted to high safety and security standards
- There has never been accident leading to significant radioactive release in the past 50 years

General aspects – 4 : social aspects

- Transportation of nuclear materials (TNM) can be adversely affected by oppositions from some resident countries (populations, media, or governments) along shipping routes, in spite of the UNCLOS convention[1].

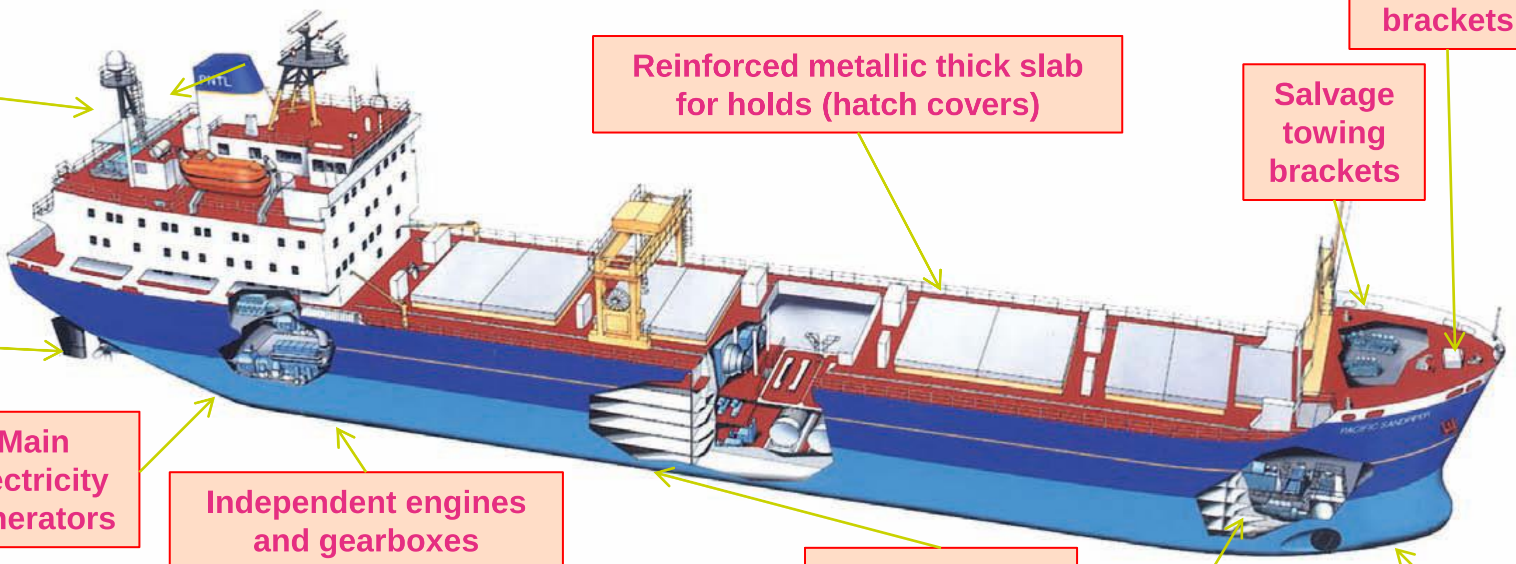
- Industry stakeholders concerned (suppliers of recycling services, utilities, carriers,…) are conscious of fears and concerns raised by TNM in these countries. Therefore, they consider that it is their responsibility to inform them on this issue

- As part of this effort, industry stakeholders have send representatives in these countries to understand their preoccupations and to explain them safety and security provisions of TNM, and to tackle further specialized issues

- They have also undertake a program of visits of PNTL facilities and French recycling plants (example : journalists and environmental association peoples were on board of the "Pacific Swan" for the crossing of the panama canal in 1998). Number of information means are also widely used (brochures, video, interviews,…)

(1) : The United Nations Convention on the Law of the Sea (UNCLOS) establishes rules governing all uses of the world's oceans, seas, and their resources. It clearly establish that costal states have no right to deny passage to ships transporting nuclear materials

Ship for international nuclear material transportation (PNTL : Pacific Nuclear Transport Ltd[1])



(1) Dedicated subsidiary of International Nuclear Services Ltd (GB), TN International and Japanese companies. It owns 3 ships and has already carried out more than 170 transports (2000 casks)

It complies with ISO 9001 and 14001 requirements.

The ships have safely covered more than 5 million miles and there has never been a single incident resulting in the release of radioactivity

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International transports : some denials and delays[(1)]

- Some shipping companies, air carriers and port terminals have policies refusing to transport radioactive material ("Class 7")
- Impediment to transport only due to radioactive properties of the material for transport
- Possible reasons are
  - worries about insurance implications
  - perception of other customers whose goods they want to carry, personal feelings
  - special handling procedures or reporting requirements too complicated and too onerous
  - problem with ports and terminals which do not accept Class 7 cargoes
- IAEA has put in place an International Steering Committee on Denials of Shipments (DoS) with 6 regional coordinators
- IAEA and IMO have created a joint data base on DoS to collect the records occurring anywhere in the world and has identified National Focal Points to which industry could address in case of DoD

(1) – "Denials and delays of radioactive shipments - Bernard Monot – IAEA - Conference PIME 2010

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Conclusion on back-end of fuel cycle (1/2)

- Many nuclear countries (and most of countries having a significant nuclear program) consider that RECYCLING is the best strategy for achieving a SUSTAINABLE nuclear energy (while avoiding spent fuel accumulation and buildup of "plutonium mines")
- Quite extensive industrial worldwide experience already exist on reprocessing and recycling : it is in particular a mature industry in France
- Reprocessing makes waste management easier and safer, while keeping high standards of safety and quality as well as having very low environmental impact : this provides a steady back-end solution in France
- The PUREX process used in France will dominate the world industrial reprocessing for next decades (including its variants such as COEX™)

Conclusion on back-end of fuel cycle (2/2)

- R&D priorities should focus on new improvements of this process :
  - Further reduce its cost
  - Increase its flexibility (adaptation to new fuels, adaptation to innovative management of radionuclides, …)
  - Enhance its operating performances (maintenance, environmental impact, waste generation, …)
- New requirements may appear in the near future :
  - Partitioning of MA (or even LLFP)
  - Intrinsic proliferation resistance constraints (no pure Pu separation)

R and D should also address these issues

- R and D on future reactors (GEN IV) must be backed up with R and D on their associated fuel cycle

Industrial recycling facilities in France have already been used by foreign customers and could meet additional needs along the lines of Multi-National Approaches concepts.

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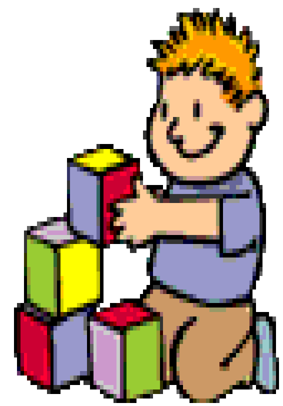
To sump up, CLOSING the fuel cycle ….

- …has been always viewed in France as a national interest driven issue by policy makers and industrial actors
- …is an industrial reality with more than 25000 tons of LWR fuel reprocessed more than 100 tons of plutonium recycled in France
- …meets highest safety and environmental standards and features outstanding records in this area
- …has clearly been proven a cost effective solution for spent fuel management while being a flexible way to cope with future challenges
- … has been largely and successfully implemented on a multinational basis, proving the feasibility of this approach for the back-end of the fuel cycle, as promoted by IAEA

CLOSING THE FUEL CYCLE ENABLES TO EXPLOIT ALL ENVIRONEMENTAL ASSETS OF NUCLEAR ENERGY AND HELPS MAKING THE CONCEPT OF SUSTAINABLE ENERGY A REALITY

Atoms for peace !



Thank you

COMPLEMENTARY SLIDES

The role of recycling in assets and challenges of nuclear energy

- **Assets of Nuclear Energy**
  - Competitiveness
  - Security of supplies (mainly national industry)
  - Minimal impact on environment
  - NO GREENHOUSE GAS EMISSIONS

- **Challenges (sustainability criteria for Nuclear Energy)**
  - Long term availability of uranium ➔ Breeder reactors + recycling
  - Waste management ➔ recycling (+ P&T ?)
  - Non proliferation ➔ Multinational approach for fuel cycle services (IAEA, GNEP, International fuel cycle centers, …) + efficient institutional and international control regimes (safeguards, NSG, …) + plutonium control (no "plutonium mines") and degradation (Pu in spent MOX fuel = non weapon usable)

FUEL CYCLE back-end plays a fundamental role to cope with these challenges

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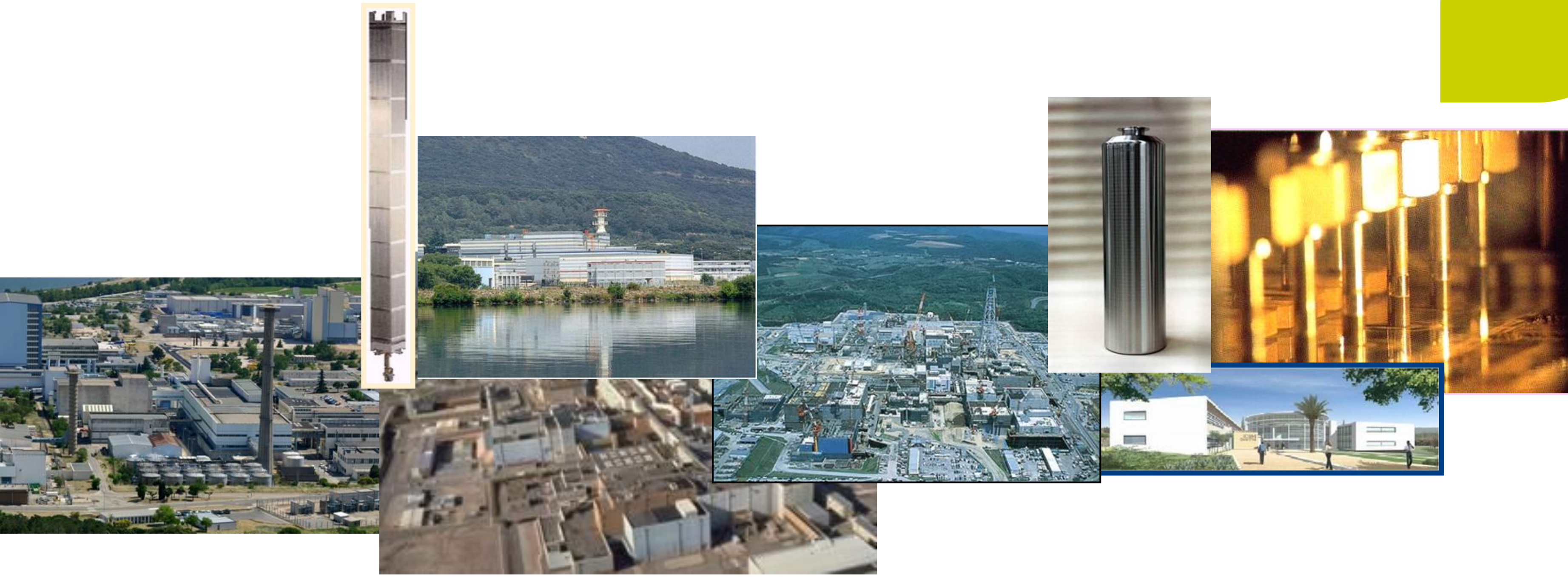
Future trends of the fuel cycle objectives



1950	1970	1990	2010	2030	2050	2070	2090

1st Generation — 2nd Generation — 3rd Generation — 4th Generation

PUREX

Marcoule UP1

Hanford, Savannah (US)

PUREX + MOX

La Hague, Melox

Rokkasho-Mura (Japan)

COEX™

Integrated U-Pu recycling plant

Multirecycling of Pu and of all minor actinides or of a part of them


SPECIAL ADDRESS
Anne Lauvergeon
Chairman of the Executive Board
"let me remind you of the fact that light water reactors, such as AREVA's EPR, present absolutely no risk in themselves as far as proliferation is concerned. As for the nuclear material needed to operate such reactors, it may become sensitive only when associated with the mastering of highly sophisticated dual-use technologies, namely uranium enrichment and spent-fuel treatment. But most countries do enjoy the benefits of nuclear energy without having to master those technologies : thanks to a well-functioning fuel-cycle market, with suppliers like AREVA that provide enrichment and spent fuel management services at competitive prices, they simply do not need it"
WORLD
ENERGY
CONGRESS
ROME 07
WORLD ENERGY COUNCIL

Multinational Approaches to the fuel cycle
assessing the proliferation threat

- **4 Challenges**
  1. **No diversion of nuclear material under safeguards to undeclared illicit uses**
  2. **Absence of undeclared (ie clandestine) facilities, through the use of imported technology or equipments or through purely national developments**
  3. **No theft of weapons grade material or weapons from the military stockpiles**
  4. **No use of civil facilities, equipments and materials for weapons fabrication in case of withdrawal from NPT**

- **Fuel cycle concerns**
  - **Sensitive facilities and material can be properly safeguarded (up to now, there is no case of diversion and misuse of safeguarded material)**

  BUT

  - **No guarantee upon use of sensitive facilities after withdrawal from NPT**

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IAEA Safeguards control approach

- **Measurements before shipment**
  - **Assembly measurements :**
    - Neutron
    - Gamma
    - Active length*
  - **Assembly sealing**
    - Fuel Holder
    - Container

- **Accountancy verification**
  - **An Inventory Change Report (ICR) sent on a monthly basis to EURATOM Luxembourg accountancy service. Lists, each month, all the occured accountancy transactions.**
  - **Physical inventory at the end of the shipment operations check assembly left.**
    - It is sent by EURATOM to I.A.E.A.

Conclusion on non proliferation concerns (industrial approach) - 1/2

Nuclear industry is an important stakeholder in the non proliferation debate

- **Proliferation issue serves as argument against the use of nuclear power and development of industry**
- **Support or acceptance of public opinion is needed**
- **Non proliferation is part of ethical rules and sustainable development**
- **Industry has a major role as a designer of nuclear facilities, a sensitive material holder, a supplier of surveillance and safeguards equipment, an exporter of material, equipment and technology**
- **Industry can contribute to counter proliferation efforts by securing material from the military sector**

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Conclusion on non proliferation concerns (industrial approach) - 2/2

A strong institutional non proliferation framework is already in place in France through :

➔ **International safeguards**

France, as a signatory of NPT is under IAEA and EURATOM safeguards + additional protocol regime (ratified by France)

➔ **Export control procedures**

- **As a member of Nuclear Supplier Group, France follows closely its guidelines (i.e; very stringent conditions for the export of sensitive technologies or nuclear materials)**
- **Bi lateral agreements are also implemented (ex. with Japan)**

➔ **IAEA conventions**

Physical Protection, safety, waste management.

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