Overview of AREVA's Nuclear Fuel Recycling Activities

Presentation to The Blue Ribbon Commission on America's Nuclear Future

La Hague Facility Visit
20-21 February 2011

AREVA

Presentation Summary

1. *AREVA Overview*
2. *AREVA's Back-End Business Group*
3. *What is Recycling?*
4. *Why Recycle?*
5. *AREVA's La Hague Facility*
6. *MELOX & MOX Fuel*
7. *Summary & Conclusions*

AREVA

1

AREVA Overview

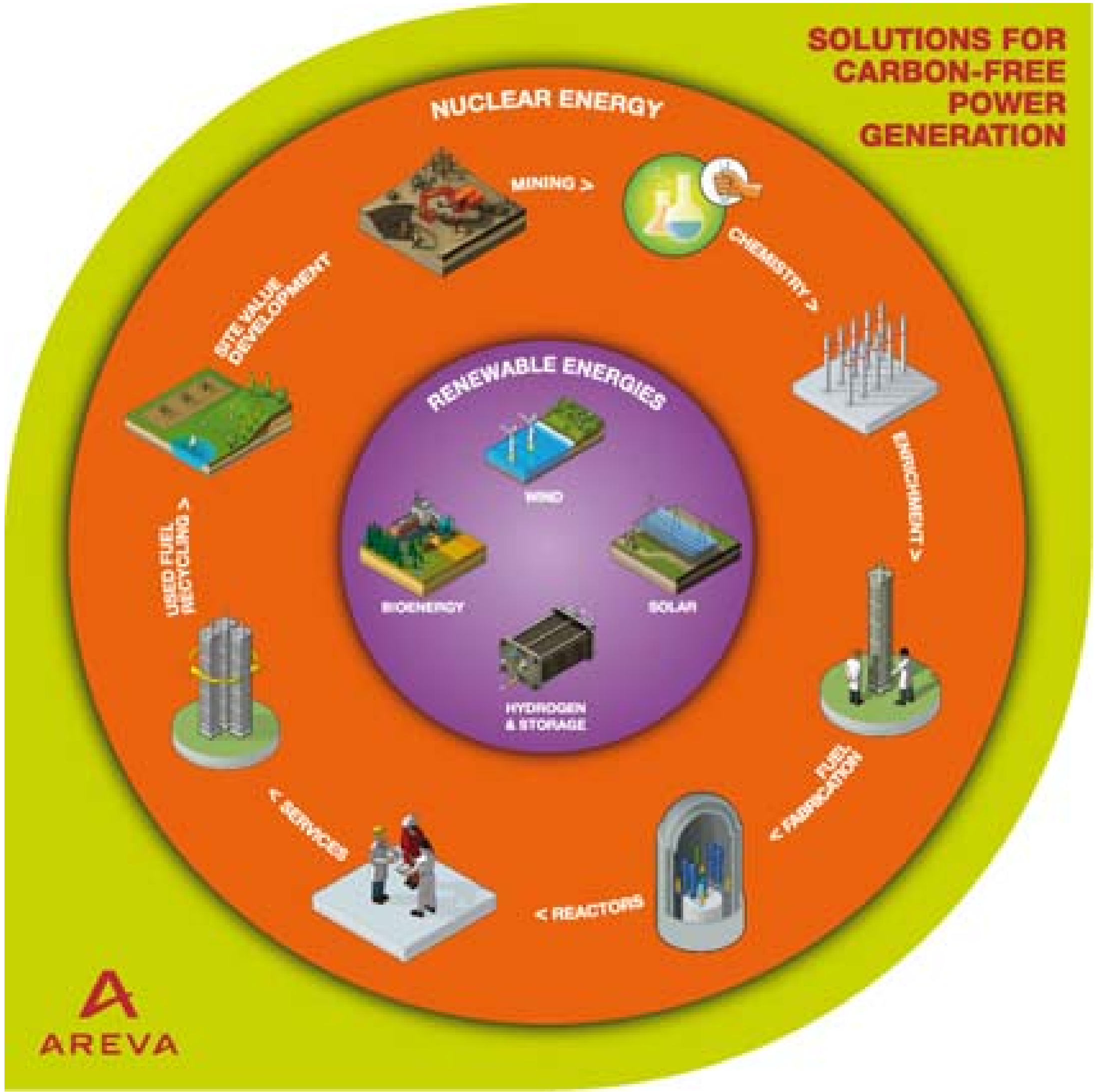
AREVA offers solutions for carbon-free power generation

- **World leader in nuclear power**
  - **A unique integrated model, from uranium mining to reactor design and related services to used nuclear fuel recycling**

- **A major player in renewable energies**
  - **A portfolio of diversified operations: offshore wind, biomass, concentrated solar power, hydrogen and energy storage**

Nuclear and renewables: contributing synergistically to a reliable, economical, carbon-free energy mix

An energy mix that meets our customers' requirements



AREVA across the globe

48 000 employees

2009 Sales: €8.5 bn

FRANCE
38% of revenue
63% of workforce

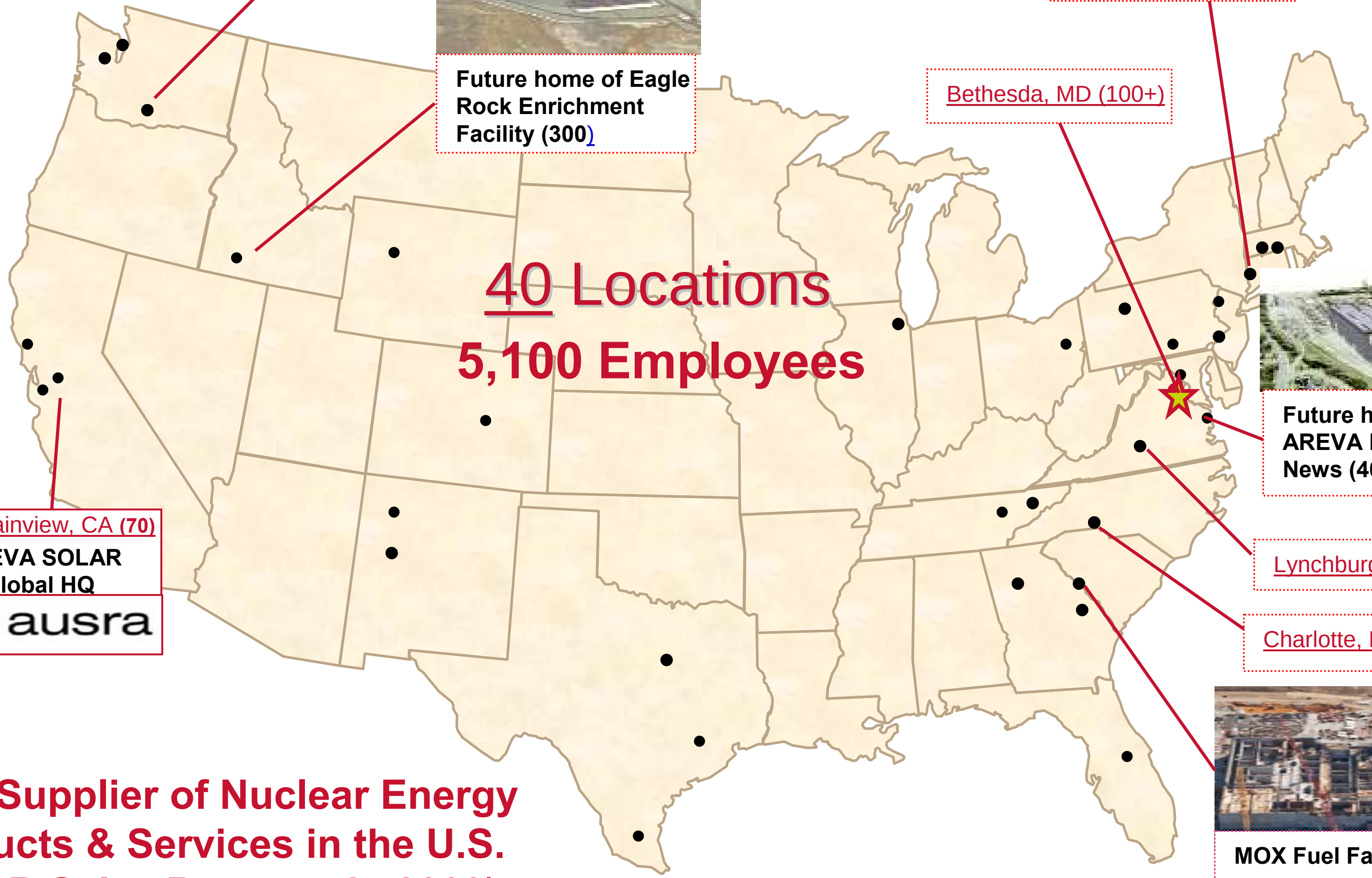
EUROPE AND CIS (outside France)
25 % of revenue
17 % of workforce
MANUFACTURING OPERATIONS
Belgium, Germany, Kazakhstan, Spain, Sweden, United Kingdom

NORTH AND SOUTH AMERICA
20% of revenue
13% of workforce
MANUFACTURING OPERATIONS
Brazil, Canada, Chile, United States

AFRICA AND MIDDLE EAST
2% of revenue
6% of workforce
MANUFACTURING OPERATIONS
Côte d'Ivoire, Namibia, Niger, South Africa, Sudan

ASIA-PACIFIC
15% of revenue
1% of workforce
MANUFACTURING OPERATIONS
Australia, China, India, Japan, Thailand

AREVA US Locations
HQ – Bethesda, Maryland



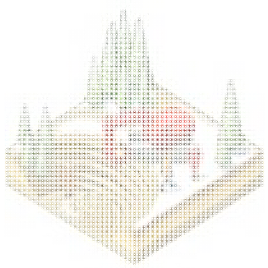
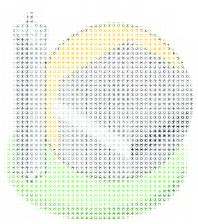
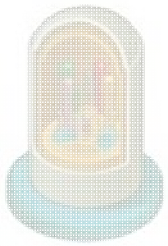
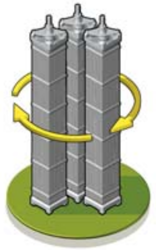
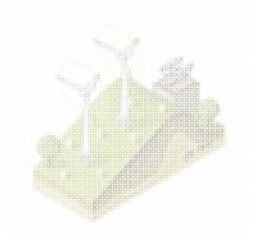
No. 1 Supplier of Nuclear Energy Products & Services in the U.S. ($2.5 B Sales Revenue in 2009)

AREVA

2

AREVA's Back-End Business Group

Position in AREVA Group

Mines	Conversion, Enrichment & Fuel	Reactors & Services	Back End	Renewable Energies
				

Back End

- Recycling
- Logistics
- Nuclear Site Value Development
- Clean-up

€1.596bn (2009)
19% of AREVA group revenue

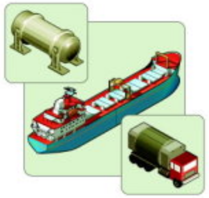
9,000 people (2009)
20% of AREVA group workforce

Back-End Business Units

RECYCLING

- A full scope of fuel recycling services, including mixed oxide fuel and reprocessed uranium fuel fabrication
- Recycling technology and operational expertise

LOGISTICS



- A global offering including:
  - Design and supply of radioactive materials shipping and storage casks
  - Safe and secure transportation and logistics services

NUCLEAR SITE VALUE DEVELOPMENT

- Performance-based project management for dismantling and decommissioning (D&D) programs
- Development of innovative integrated solutions for AREVA and its external customers

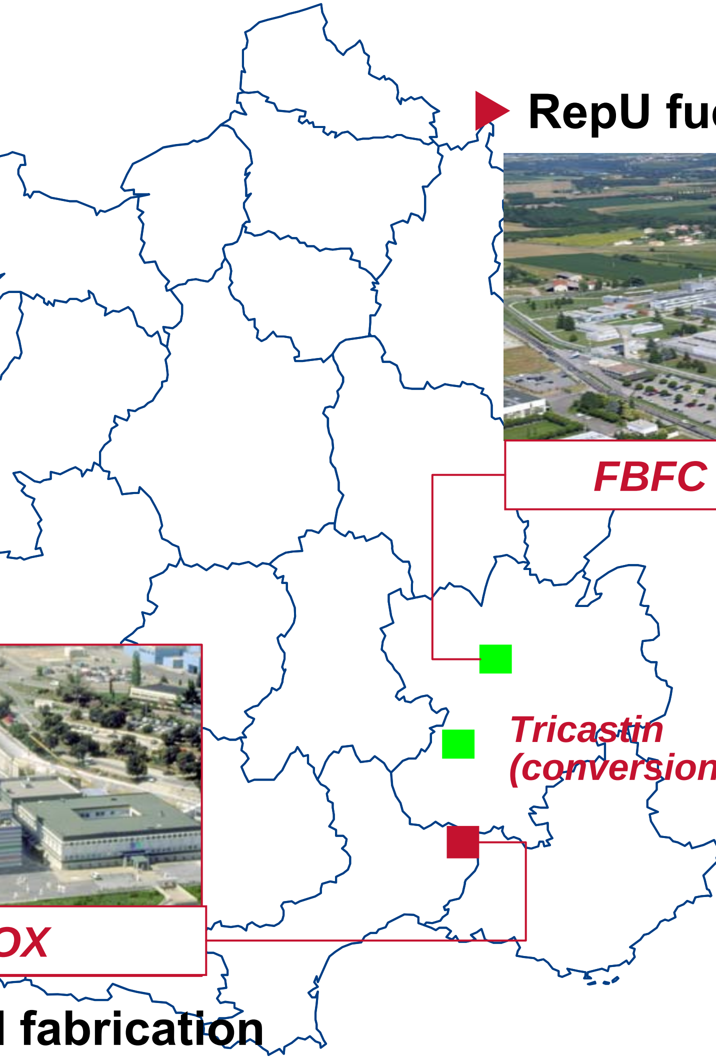
CLEAN-UP

- Dismantling and waste processing facility operations
- Specialized nuclear maintenance
- Logistics support for NPPs during operations and schedule outages
- Radiation protection and monitoring services

AREVA Recycling Platforms in France

La Hague

- **Used fuel treatment**
  - **Extraction of valuable materials**
  - **Ultimate waste conditioning**



- **RepU fuel fabrication**

FBFC Romans

MELOX

- **MOX fuel fabrication**

Note : ■ **Reprocessed uranium activities (conversion, enrichment & fuel fabrication) are included in AREVA's Front-End Business Group**

AREVA Global Back-End Activities

USA

Savannah River Site:

- Design and construction of the MOX Fuel Fabrication Facility (MFFF) through a Shaw & AREVA consortium
- Contract for liquid waste remediation project (including vitrification) through a consortium

Hanford Reservation:

- Contracts for waste disposal and site remediation projects through URS & AREVA and CH2MHILL & AREVA consortia

UK

Sellafield Sites:

- M&O contract for the Sellafield sites through a URS, AREVA & AMEC consortium
- AREVA focus on technical assistance and operational performance improvement
- Commissioning of a new cladding line for the Sellafield MOX Plant

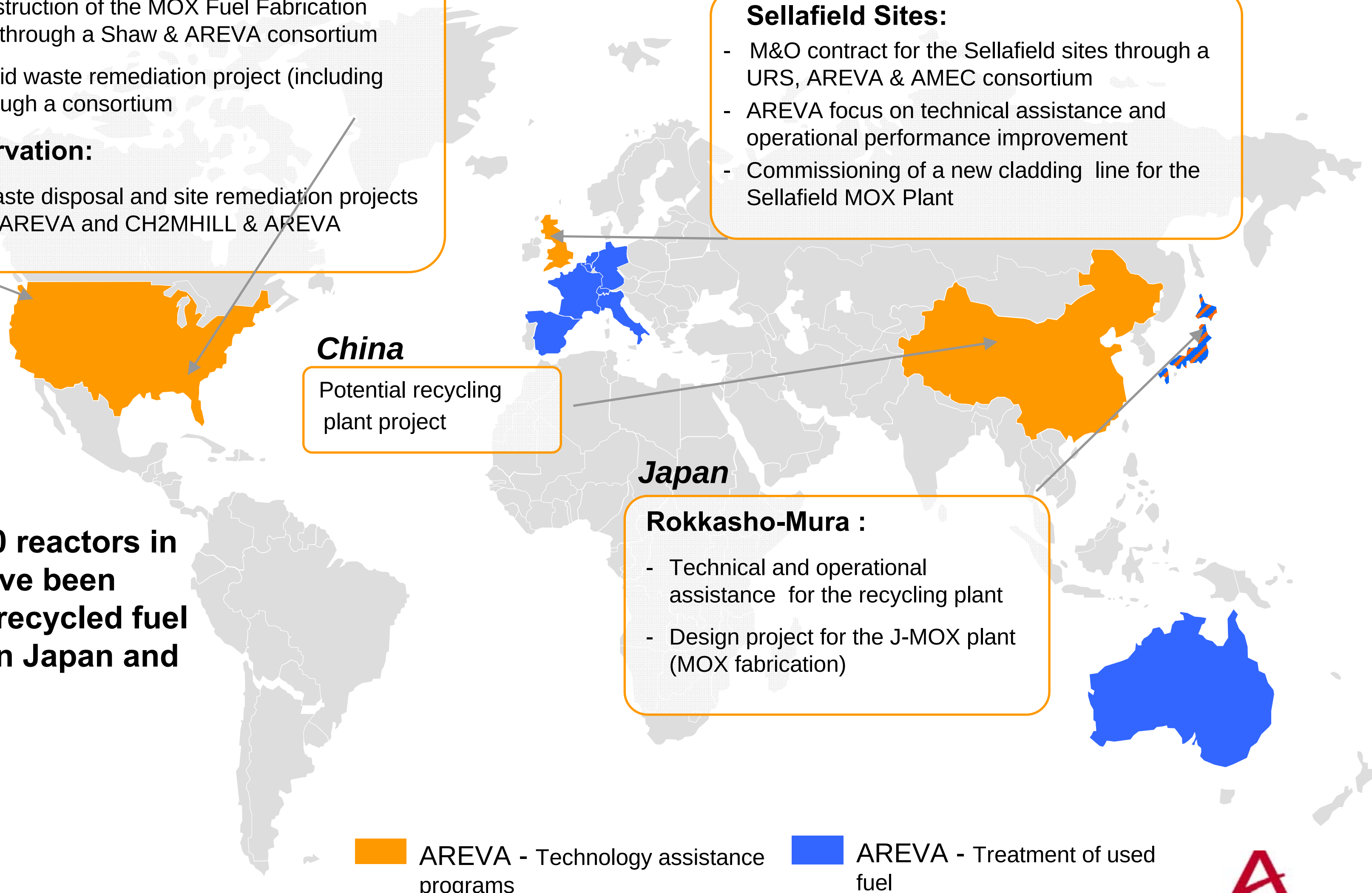
China

Potential recycling plant project

Japan

Rokkasho-Mura :

- Technical and operational assistance for the recycling plant
- Design project for the J-MOX plant (MOX fabrication)



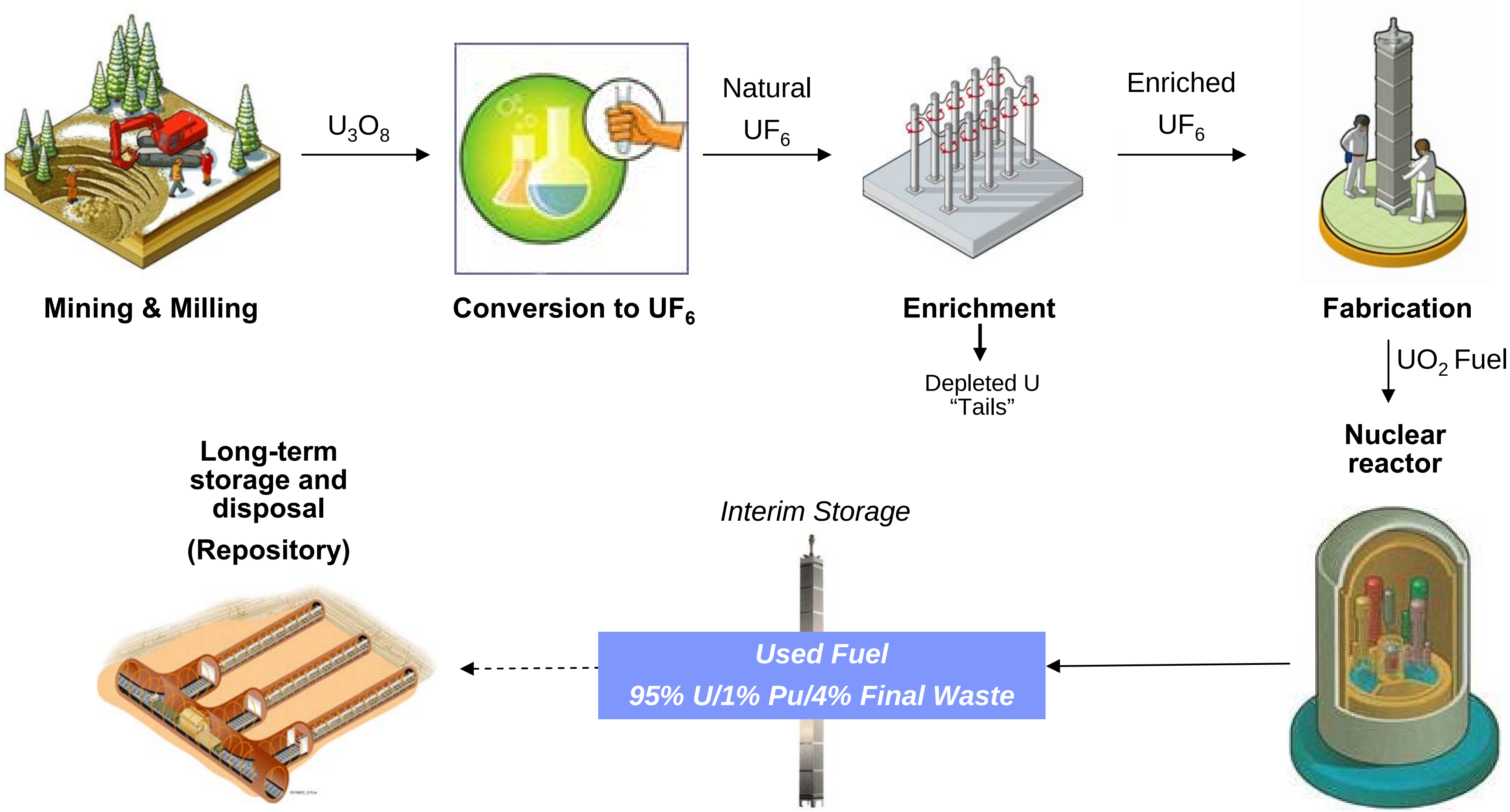
- **More than 70 reactors in the world have been loaded with recycled fuel (in Europe, in Japan and in the USA)**

AREVA

3

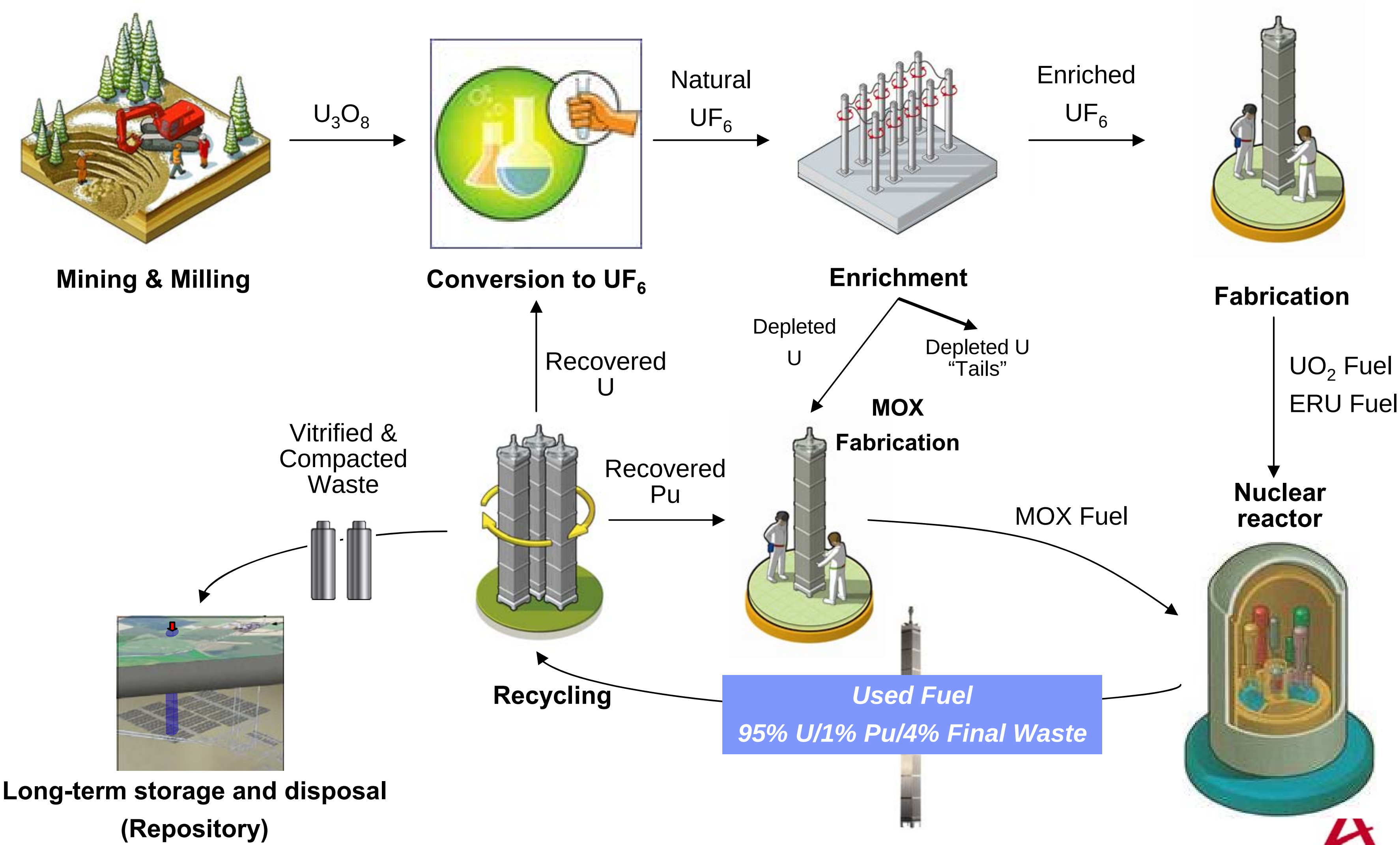
What is Recycling?

Overview of the LWR “Once Through” Fuel Cycle



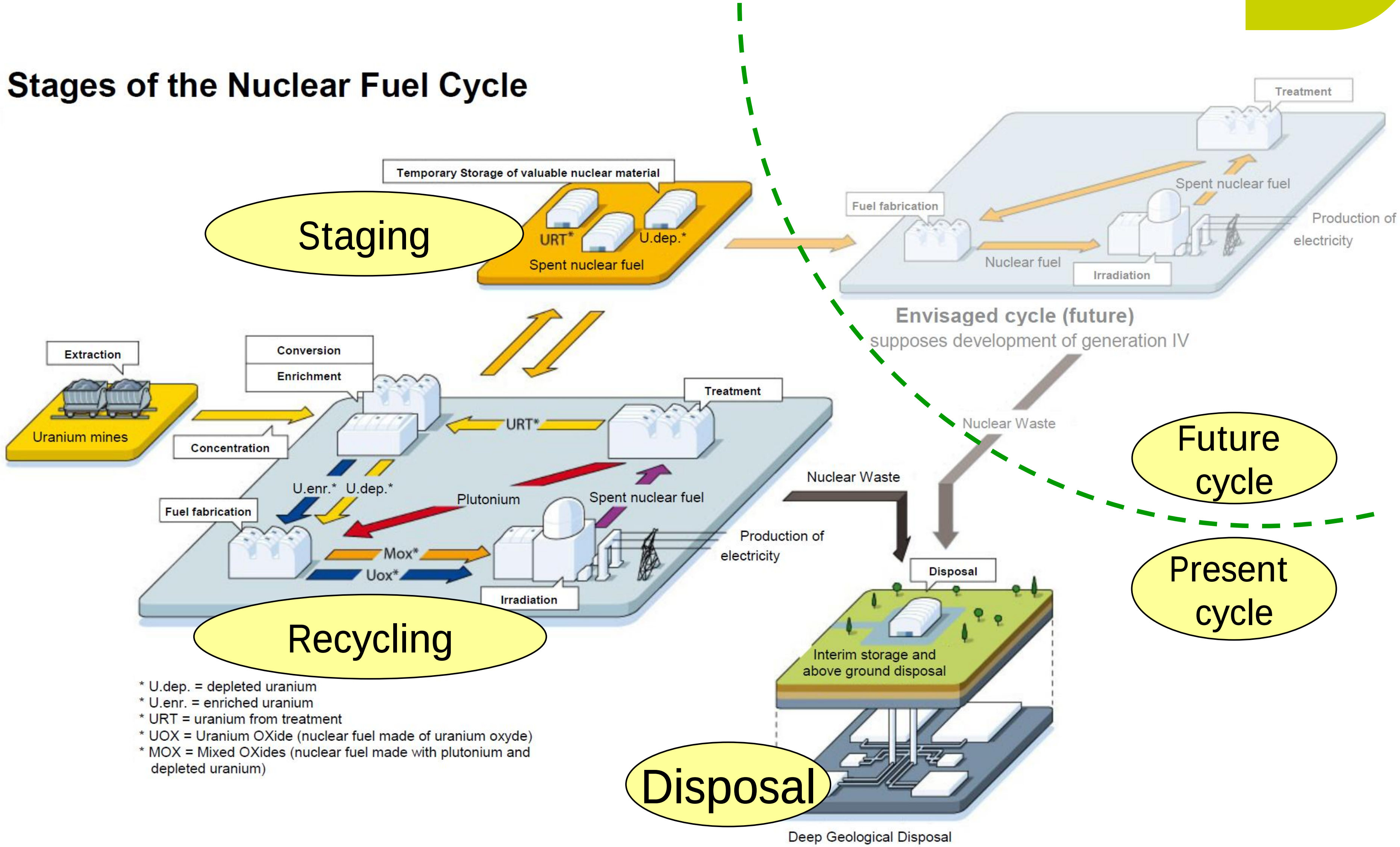
Current U.S. approach is the “once-through” fuel cycle in which used fuel is ultimately sent for disposal in a geological repository

Overview of the LWR "Closed" Fuel Cycle in France



AREVA

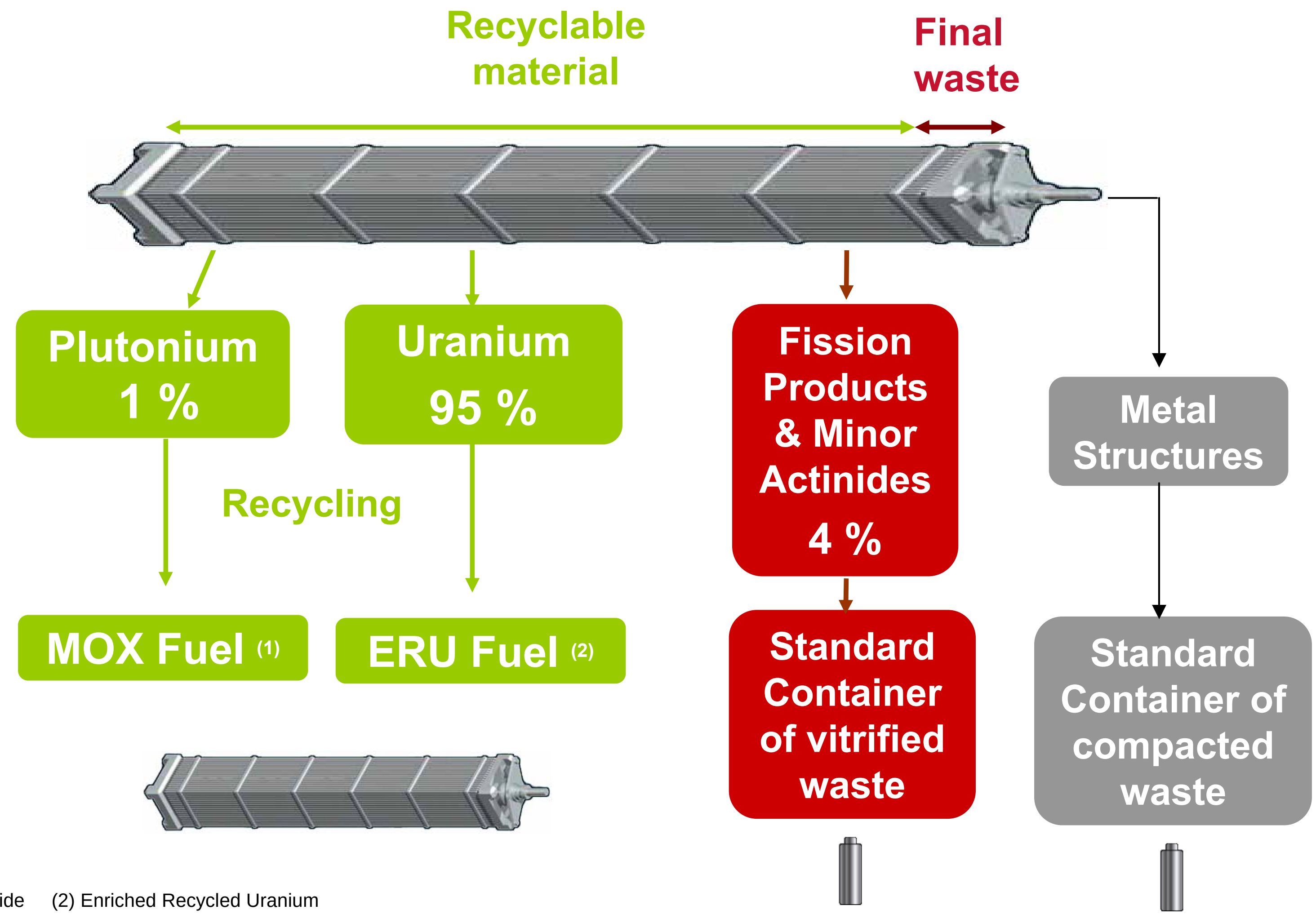
The French Nuclear Fuel Cycle



* U.dep. = depleted uranium
* U.enr. = enriched uranium
* URT = uranium from treatment
* UOX = Uranium OXide (nuclear fuel made of uranium oxyde)
* MOX = Mixed OXides (nuclear fuel made with plutonium and depleted uranium)

96% of the content of used nuclear fuel is recyclable

- The composition of light water fuel after irradiation in a reactor

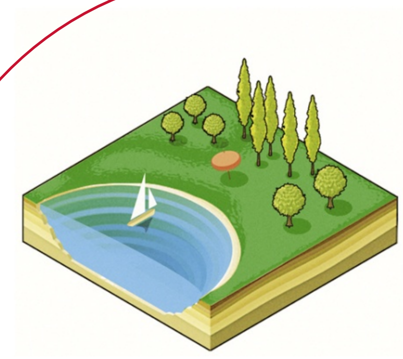


(1) MOX : Mixed Oxide (2) Enriched Recycled Uranium

4

Why Recycle?

Why Recycle? – The French Perspective (1)



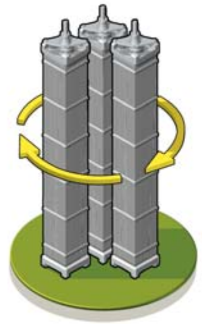
- **Enhances security of fuel supply**
  - **Used nuclear fuel is a vast domestic energy resource**

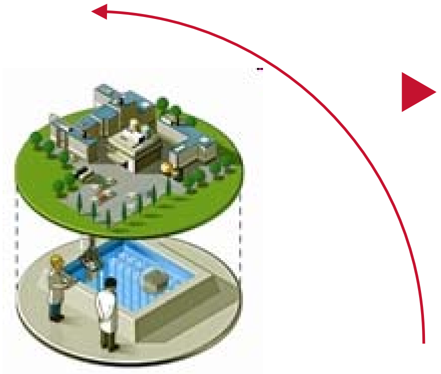
- **Natural resources savings**
  - **Used fuel contains 96% of reusable materials**
  - **Up to 25% natural uranium savings**
- **Improved final (repository-bound) waste management**
  - **Optimizes scarce repository capacity**
  - **Standard, highly stable, specifically designed waste forms and containers**

AREVA

Why Recycle? – The French Perspective (2)

- **Positive economic and social impacts**
  - **Comparable economics to “once-through” strategy**
  - **~14,000 direct jobs during construction/6,300 during operations**
  - **Provides attractive economic benefits for host sites and communities**





- **Supports Non-Proliferation Objectives**
  - **Stabilizes or reduces the total inventory of Pu**
  - **Establishes leadership in international fuel cycle activities by removing the economic rationale for other nations to develop indigenous programs**
- **Improves public acceptance of nuclear energy**
  - **Directly addresses the primary public concern about nuclear energy**
  - **Sustainable solution - addresses concerns about generational inequity**
  - **Provides confidence that used fuel is appropriately managed**

AREVA

Energy Recovery from Used Nuclear Fuel

- **Accumulated commercial used fuel in the United States is an expansive energy reserve. The existing 60,000 MT of used-fuel =**

Oil contained in the Arctic National Wildlife Refuge (10 billion barrels)

or

8 years of fuel supply for the entire US nuclear reactor fleet

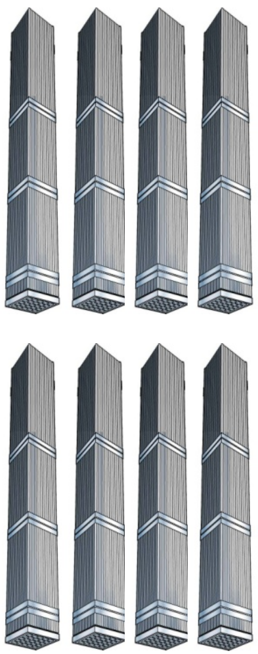
- **On an ongoing basis, recycling 2,000 M Tons of used fuel/year corresponds to approx. 1.9 Trillion cu. feet natural gas per year**
  - Equivalent to the US total projected imports of LNG in 2010

Energy recovery potential is significant and enhances energy security

AREVA

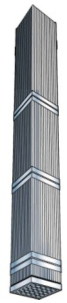
Recycling is a way to save natural resources

Recycling allows the **reuse of the energy still contained within** used fuel, saving up to **25% of natural Uranium**



8 spent UOX fuels =

1
ERU fuel
(Recycled Uranium)



1
MOX fuel
(Mix of Plutonium and Uranium)

1 gram of Plutonium or 100 grams of Uranium supply more energy than one ton of oil.

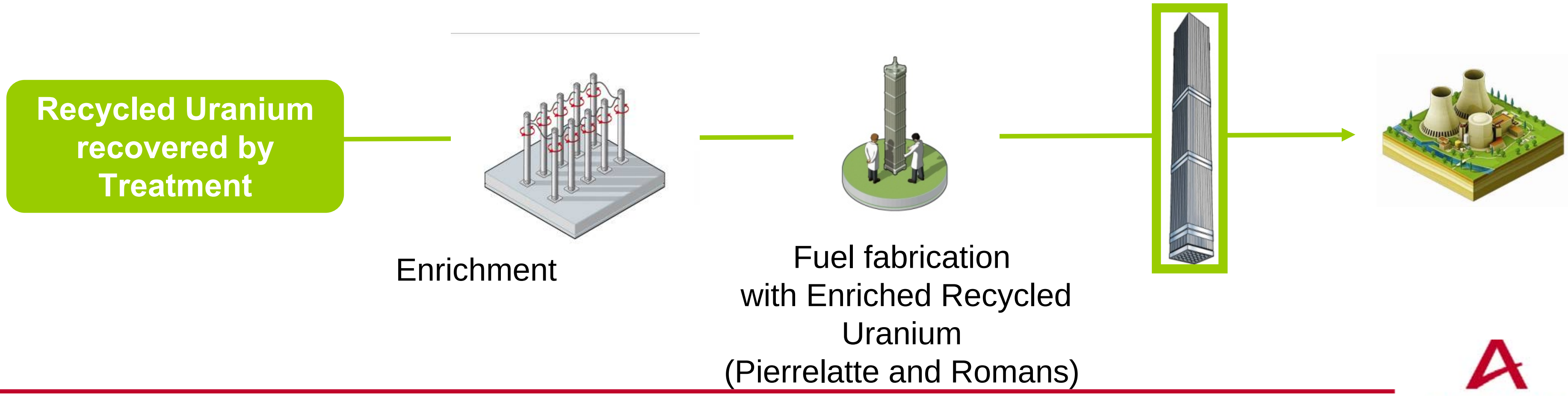
AREVA

Uranium : a recyclable and recycled material

- **Electrical utilities choose to recycle uranium on a short or long-term based on:**
  - **The economical attractiveness** of recycled uranium as compared to natural Uranium
  - The choice of a **secure supply policy** (to build a strategic reserve)

- **Worldwide, around 50 reactors** are authorized to operate with ERU

"Recycled Uranium is comparable to natural Uranium"



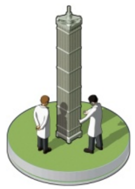
AREVA

Plutonium : an incomparable energy potential

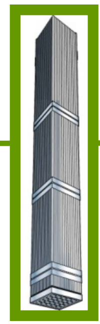
- **MOX fuel is fabricated at the AREVA MELOX plant**
- **Worldwide, 40 reactors** have been loaded with MOX fuel since 1972

> **"In France, each year 120 tons of MOX supply more than 10% of the country's electricity produced using nuclear energy"**

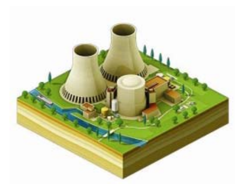
Plutonium recovered from used fuel



MOX (Mixed Oxide) is fabricated at MELOX



MOX = average of 8.5 % Pu and 91.5 % depleted U



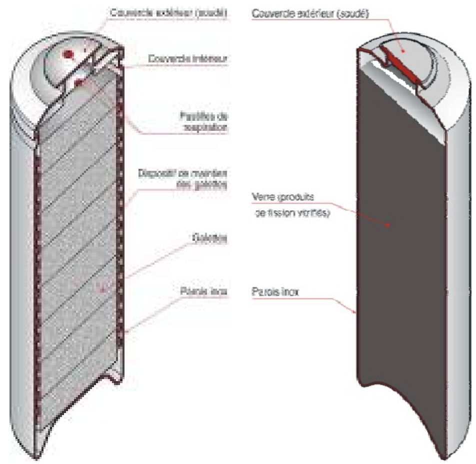
AREVA

Recycling simplifies the challenge of final (repository-bound) waste management

- **Recycling reduces the volume and radioactivity of the waste that must be stored in a geological repository**
- Vitrified and Compacted Canister :
  a standard, safe and stable packaging
  for the very long term.

> *"French vitrified waste amounts to **5 grams per inhabitant per year**"*

Foreign waste is
transported back to its country of origin.
French waste is stored on-site awaiting the commissioning of the **deep geological storage site.**



Standard packaging

AREVA

Types of Final (Repository-bound) Waste

The non-reusable materials are conditioned into a stable and compact form suitable for simplified transport, storage and final disposal

- Encapsulation of Fission Products in a stable, homogeneous, and durable glass matrix with a long-term predictable behaviour

- Compaction of structural pieces (hulls and end-pieces)

- Both the glass matrix and compacted waste are encased in a standard **"Universal Canister"**

Internationally Accepted Waste Specifications

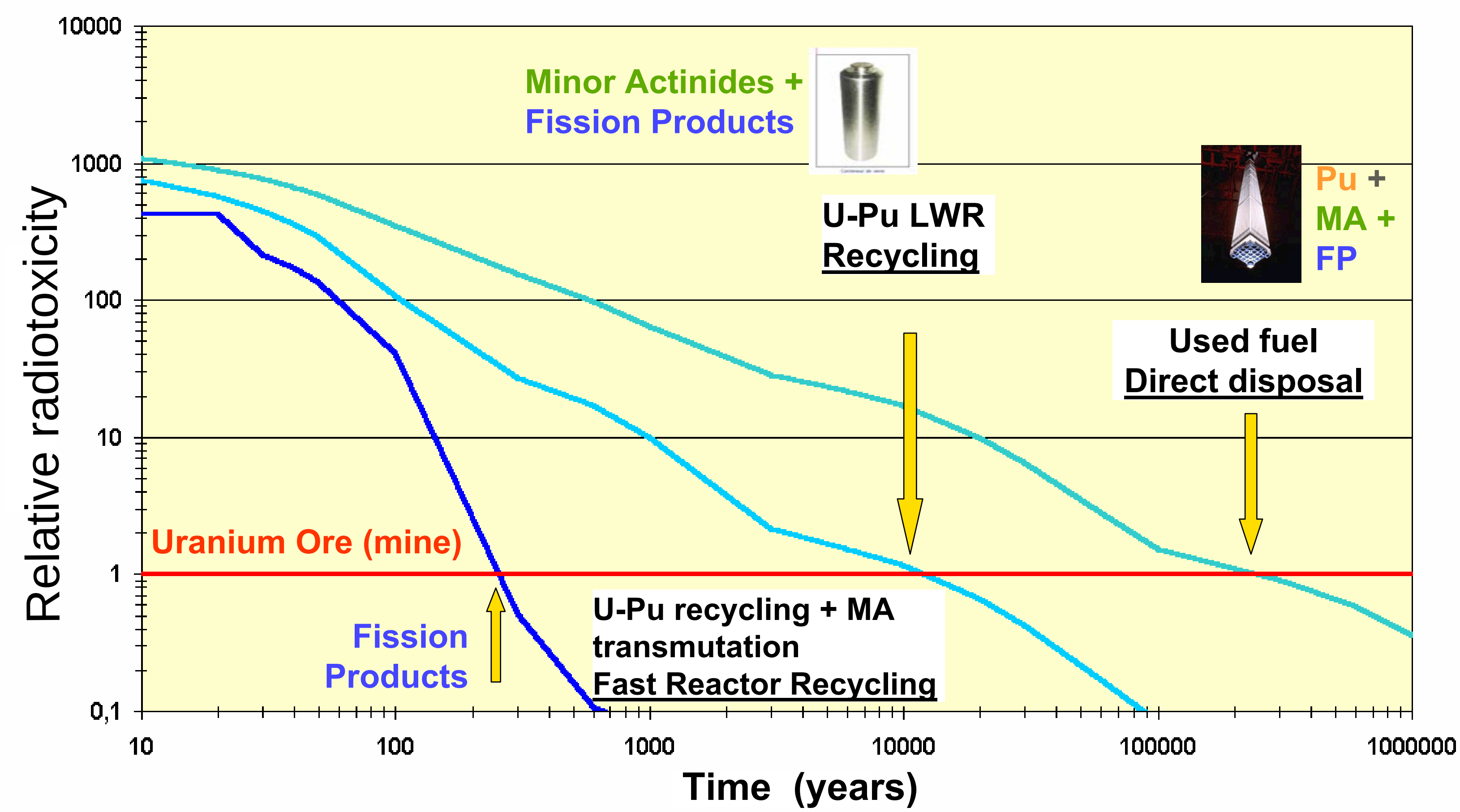
- **Final (Repository-bound) Waste packaged according to internationally accepted standards**

Stream	Final waste	Specifications qualified by safety authorities in
Fission products	Glass	France, Japan, Germany, Belgium, Switzerland, Netherlands In progress: Spain, Australia
Hulls and end-fittings, dry active waste	Compacted	France, Japan, Germany Belgium, Switzerland, Netherlands

- **Results in simplified licensing for repositories**

AREVA

Repository Potential Radiotoxicity



- **Assuming an optimistic 100% efficiency in the partitioning and transmutation of all Minor Actinides with Gen IV recycling**

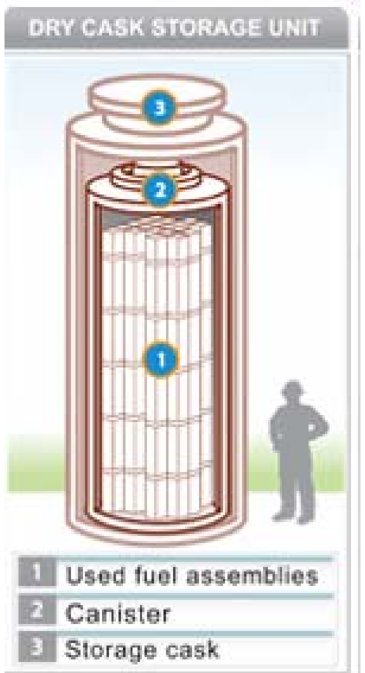
Final (Repository-bound) Waste Interim Storage: French Example

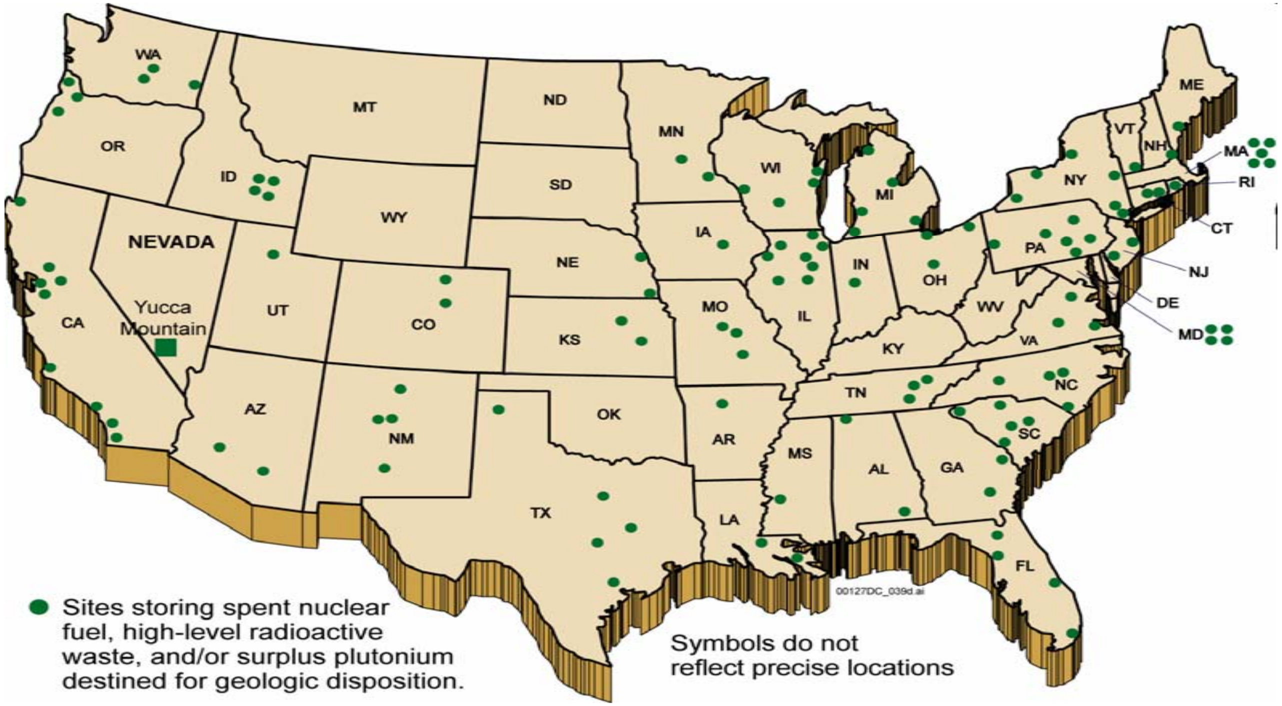
The vitrified waste canisters corresponding to 40 years of French nuclear electricity production lined up side by side would occupy only one soccer field

One of the three interim storage units on the site for vitrified canisters : EEVSE

AREVA

Final (Repository-bound) Waste Interim Storage: U.S. Example





60,000+ MT at Multiple Locations in 35 States

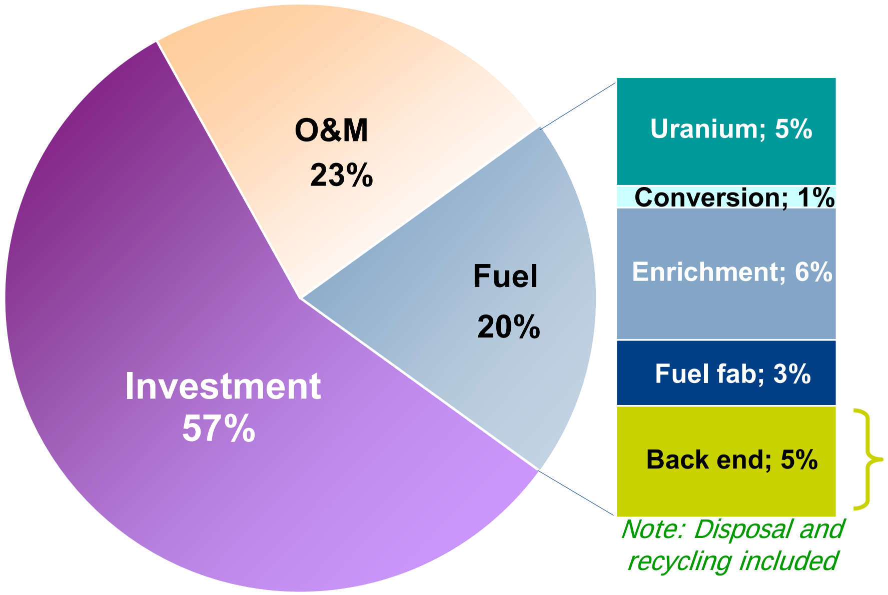
Recycling Strengthens Non-proliferation Objectives

- **Recycling restricted to a few global centers under international safeguards**
  - Offering recycling services to a wide range of customers
  - Avoiding the accumulation of fissile material in multiple storage sites worldwide
  - Returning to customers a final waste form that is not subject to IAEA safeguards
- **Plutonium recycled in MOX fuel**
  - Consumes roughly one third of the plutonium and controls overall Pu inventory
  - Significantly degrades the isotopic composition of the remaining plutonium and thus the potential attractiveness for non-peaceful usage
  - ***"Once the (MOX) fuel has been irradiated in nuclear reactors, the plutonium is no longer readily weapons usable."*** **Secretary Chu, 53rd IAEA General Conference, September 14, 2009**
- **Commercial recycling facilities such as La Hague and MELOX have a perfect track record with respect to fissile materials safeguards**
- **Recycling contributes to international non-proliferation initiatives**
  - Complements weapons-grade plutonium disposition program (MOX Fuel Fabrication Facility in the US)
  - Securing "gap material"

AREVA

Economic aspects of recycling

Cost structure of nuclear kWh*



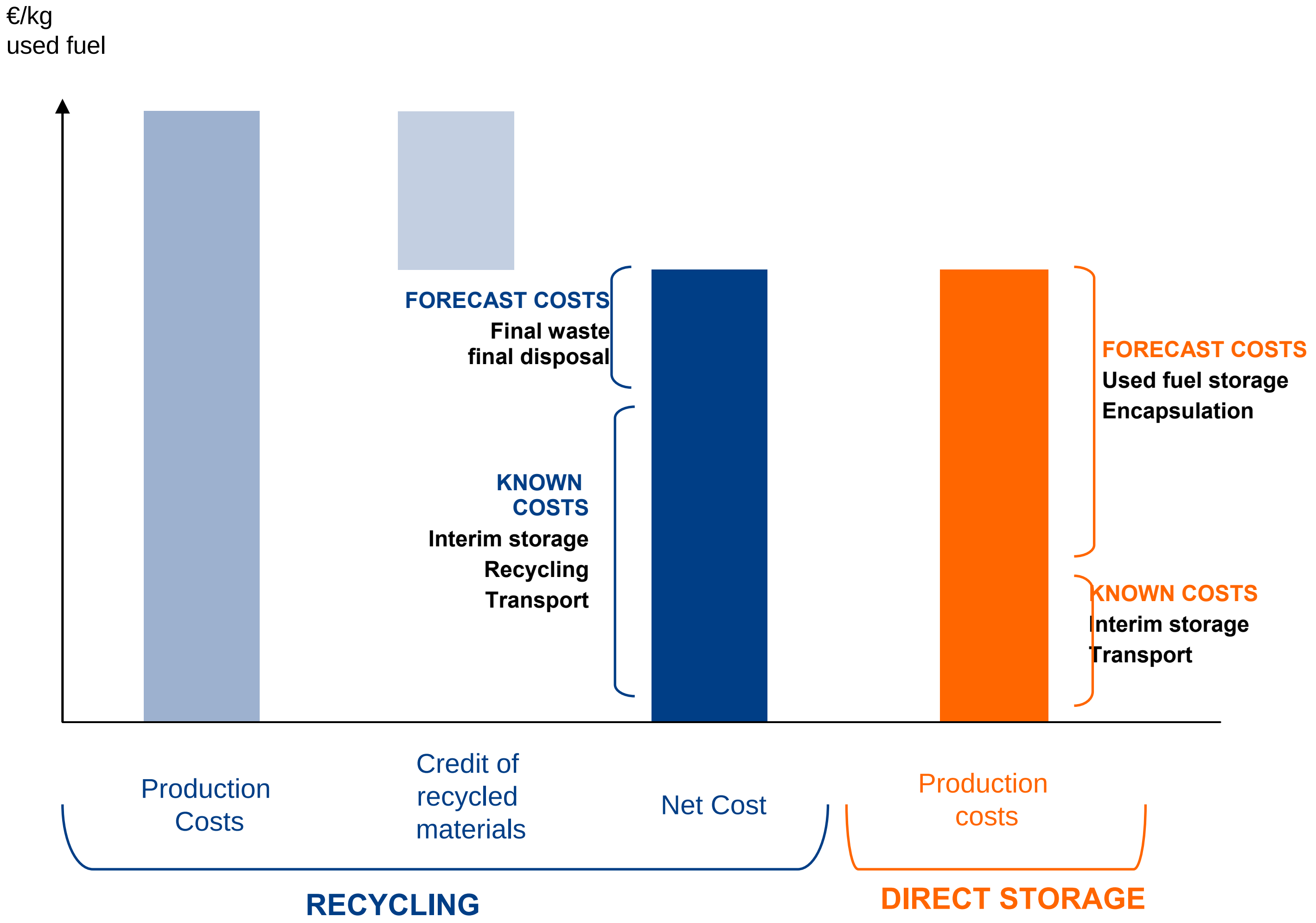
- **Fuel costs represent only ~20% of the total cost of generating electricity with nuclear energy**
- **Back-End costs (*either* open or closed cycle) represent about 5% of the total cost of electricity generation**
  - Open and closed cycle economics are comparable
  - The greatest amount of uncertainty is associated with the cost of geological disposal

» Economics have a minor impact on the policy choices for the management of the Back-End

*** Source: OECD/AEN 2002 "*Trends in the Nuclear Fuel Cycle: Economic, Environmental and Social Aspects*"**

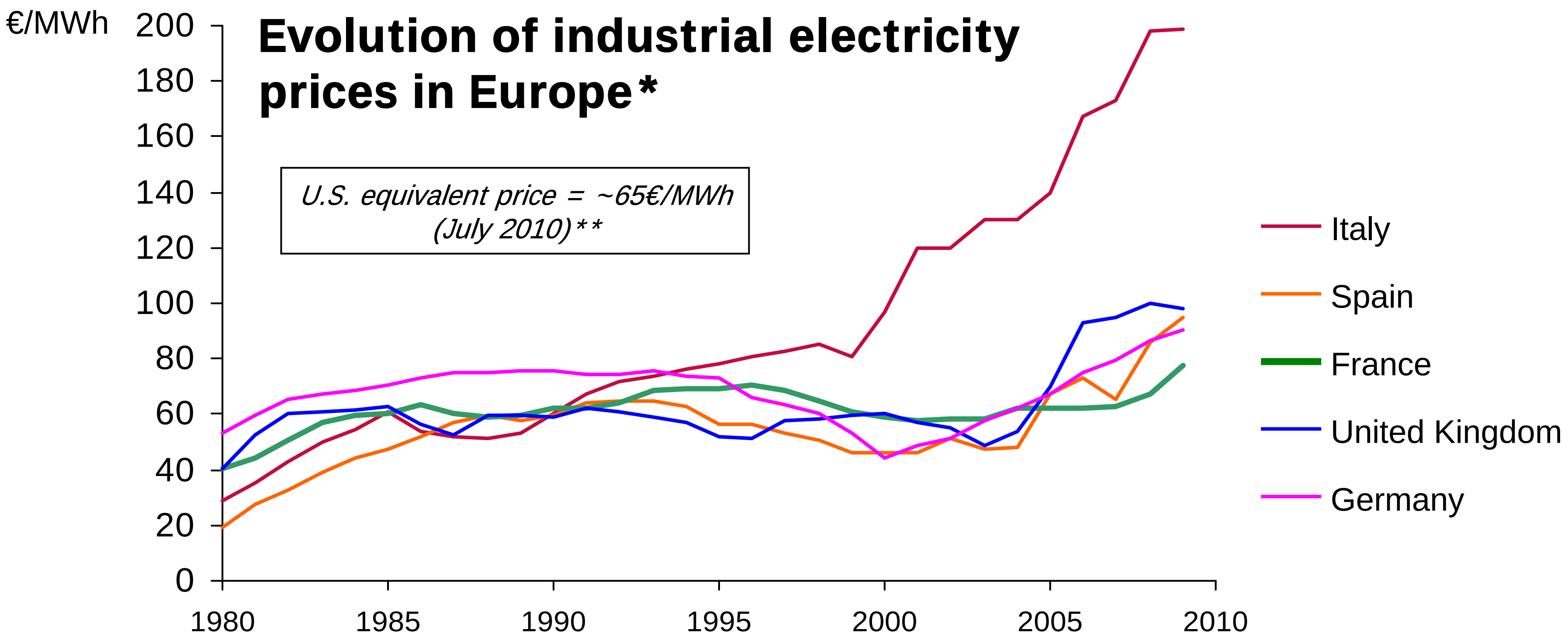
AREVA

Recycling is economically comparable to direct storage



Source: International benchmark AREVA

Broader Economic impact of recycling



Nuclear power <u>with recycling</u> provides French industries with some of the most stable and competitive electricity prices in Europe

***Source: Enerdata (*www.enerdata.net*)**
****Source: U.S. Energy Information Administration; Bloomberg Financial**

Lessons Learned from the French Experience

- **Benefits of starting early vs. "wait-and-see"**
  - **Avoids shifting heavy technical and management burdens to future generations**
  - **Allows the development of the industrial infrastructure and experienced workforce essential to a secure and sustainable fuel cycle solution**
  - **Demonstrates commitment to the sustainability of nuclear energy**
  - **Keeps all options open**
- **Benefits of the "pilot project" approach**
  - **Directly addresses the key challenge of moving from laboratory-scale R&D to full scale industrial deployment**
  - **"Evolutionary" approach has a proven track-record vs. "leap-frogging" strategy of focusing only on R&D in the near-term**
  - **Combines the benefits of industrial continuous improvement with the ability to implement advanced technologies as they are developed**

AREVA

French Policy is Consistent with the Recommendations and Principles of EDRAM Members

- **Any solution for long term waste management should respect the principle of *intergenerational equity*:**
  - **The burdens and responsibilities of taking care of radioactive waste should not be passed on to future generations**
  - **Indefinite storage of the waste in adequate surface facilities shifts heavy burdens and responsibilities on to future generations**
  - **Wait-and-see policies shift the burden of deciding on the future of the waste and of managing it on to future generations**
- **Precautionary principles**
  - **Establish a policy as soon as possible**
  - **Establish adequate funding**
  - **Create a flexible decision-making process**

» **The existence of remaining uncertainties is no reason for not choosing a management solution**

Source: Jean-Paul MINON, Chairman of EDRAM, "LONG-TERM MANAGEMENT OF HIGH-LEVEL WASTE: DEFINING NATIONAL STRATEGIES AS A SOUND APPLICATION OF THE PRECAUTIONARY PRINCIPLE" *4th European Nuclear Energy Forum, Prague 28-29 May 2009*

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**

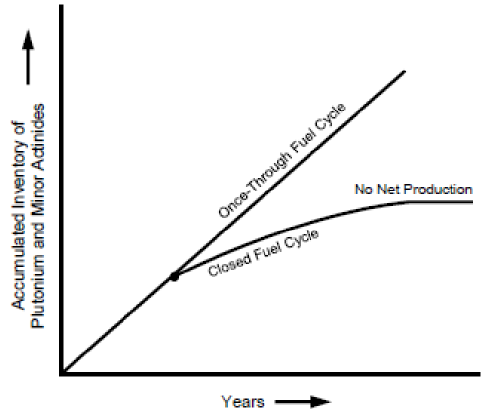
- **With no decision, the path forward for used fuel disposal will remain uncertain, with many diverse technologies being considered and <u>no possible focus on a practical solution to the problem</u>**

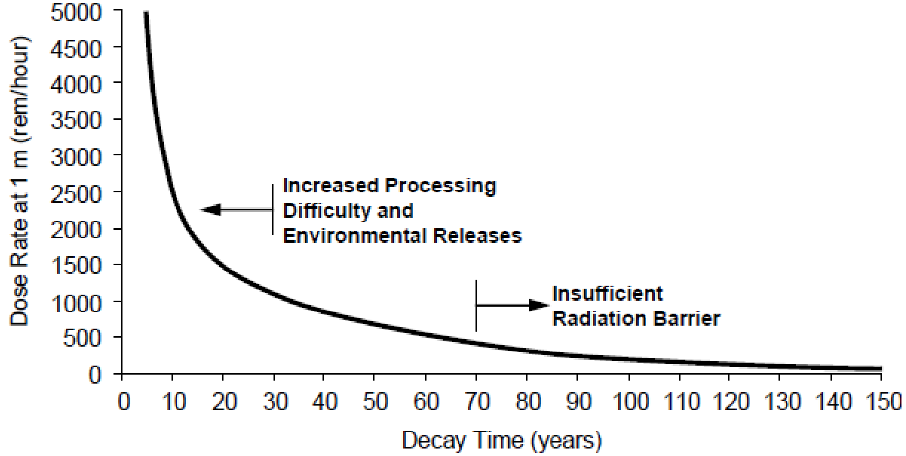
- **However, a decision to move forward with used fuel recycling and to take advantage of processing aged fuels and incorporation of near-complete recycling can provide the <u>focus needed for a practical solution to the problem of nuclear waste disposal</u>**

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

17 Managed by UT-Battelle
for the U.S. Department of Energy

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

5

AREVA's La Hague Facility

Over 40 years of industrial experience in used nuclear fuel recycling

UP2-800

UP3

UP2-400

Two production units offering equal performances:

- **UP2 800**, commissioned in 1994
- **UP3**, commissioned in1990

Annual authorized capacity of **1700 tons of used fuel treatment,** or the equivalent of 80 reactors

The first production unit is in a self-funded dismantling process
UP2 400, commissioned in 1966

The world's largest commercial facility for recycling used nuclear fuel

Map

In total, over 26,000 tons* of used fuel treated at la Hague

As of 01/01/2011

	Tons processed
EDF *France*	*16 129*
German utilities	*5 483*
Japanese utilities	*2 944*
Swiss utilities	*771*
Synatom *(Belgium)*	*671*
EPZ *(The Netherlands)*	*326*
SOGIN *(Italy)*	*190*

More than 75% of the world's recycled fuel has been recycled by AREVA

* UOX or MOX type fuel

AREVA

AREVA La Hague : a major economic player

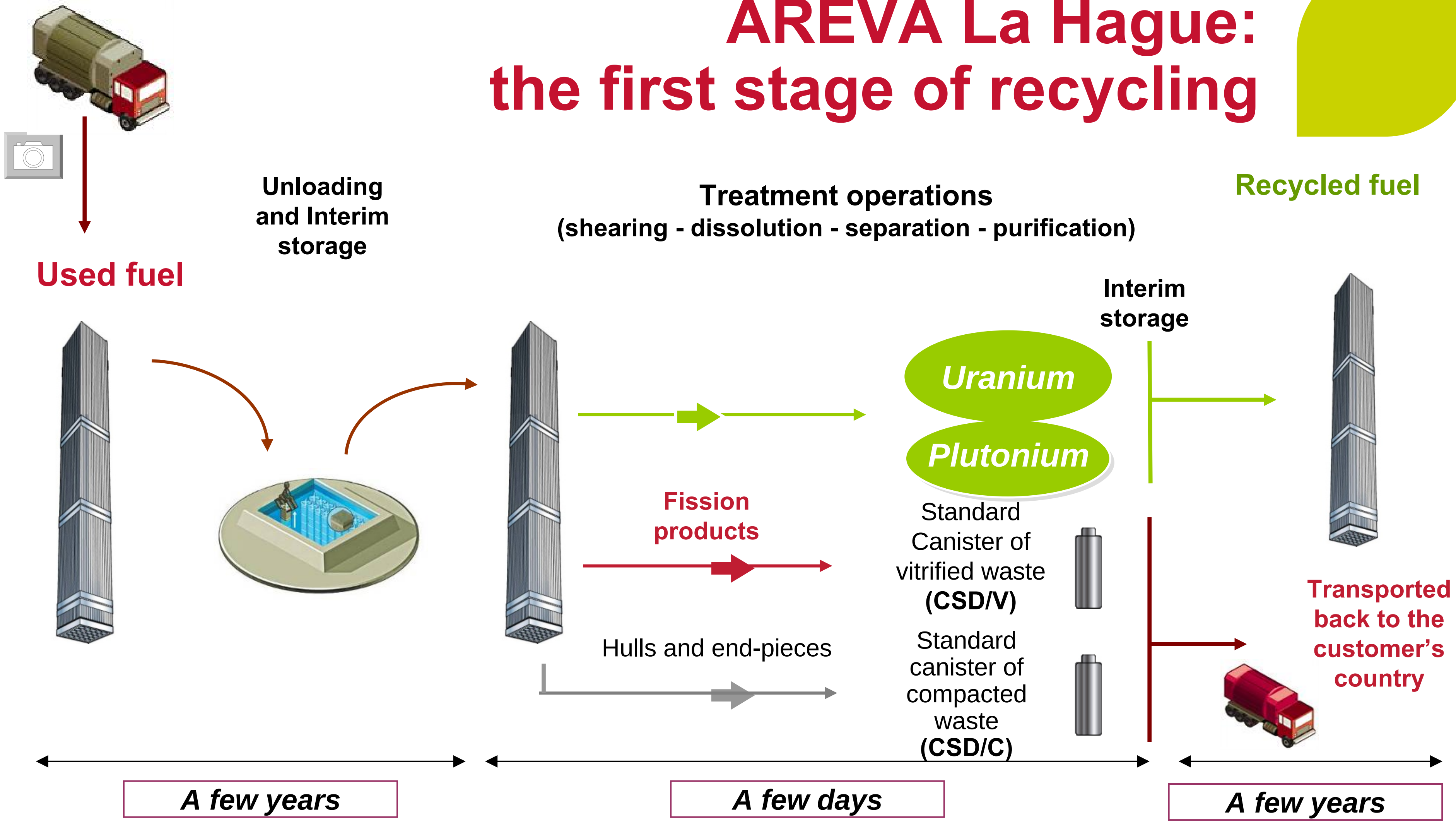
Purchasing:
nearly **€ 370 ($500) Million** in purchasing per year, of which around 75% is from local suppliers

Investment: € 80 ($108) Million (2010)

Duties and taxes: € 75 (101) Million (2010)

The largest employer in the Nord-Cotentin area with 3,000 AREVA La Hague employees and 2,000 subcontractors

AREVA La Hague: the first stage of recycling



At each stage, nuclear material is accounted for in accordance with EURATOM and IAEA safeguards

La Hague is a Powerful Platform for Implementing Continuous Improvements

- **Examples of La Hague plant continuous improvements:**
  - **While designed for 33,000 MWd/T UOX fuel, has been able to recycle a wide variety of fuels**
    - Burn-up increase up to 55,000 MWd/T
    - Used MOX
  - **Implementation of on-line conditioning of waste**
  - **Simplification of the number of cycles used in the purification process**
  - **Radioactivity released <u>reduced by a factor of 20</u> (systematic in-plant recycling of process flows)**
  - **Total dose to exposed workers <u>reduced by a factor of 30</u>**

- **La Hague continues to progress**
  - **Further adaptation to fuel evolution such as new cladding materials**
  - **Systematic implementation of State-of-the-art manufacturing optimization techniques (TPM, six-sigma)**
  - **Increased capacity and efficiency through the introduction of new technologies such as the Cold Crucible Melter for vitrification**

A dynamic facility with the demonstrated ability to be upgraded to implement advanced technologies as they are developed

Lessons from La Hague

- **AREVA's design, engineering, and operational expertise is recognized globally**
  - **Unique skills and understanding developed over decades of doing**

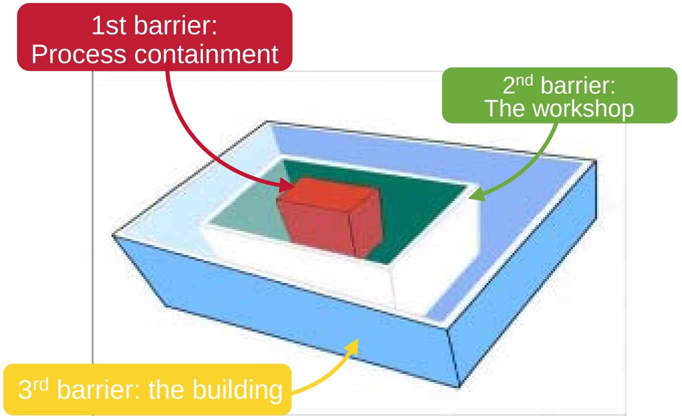
- **The lessons learned from operations at La Hague would be incorporated into future facility designs**

- **Key enhancements would include:**
  - **Co-location of recycle and MOX facilities**
  - **Implementation of AREVA's COEX™ process**
  - **Lessons learned and technological improvements made in operating plants**

AREVA

Safety, Health, Security and respect of the Environment : AREVA's core values

AREVA



Safety : an absolute priority

Safety depends on:

◆ Technical **design** features:

In-depth defense,

Containment,

Cooling,

Remote operations…

◆ Organizational **operating** measures :

24/7 safety management,

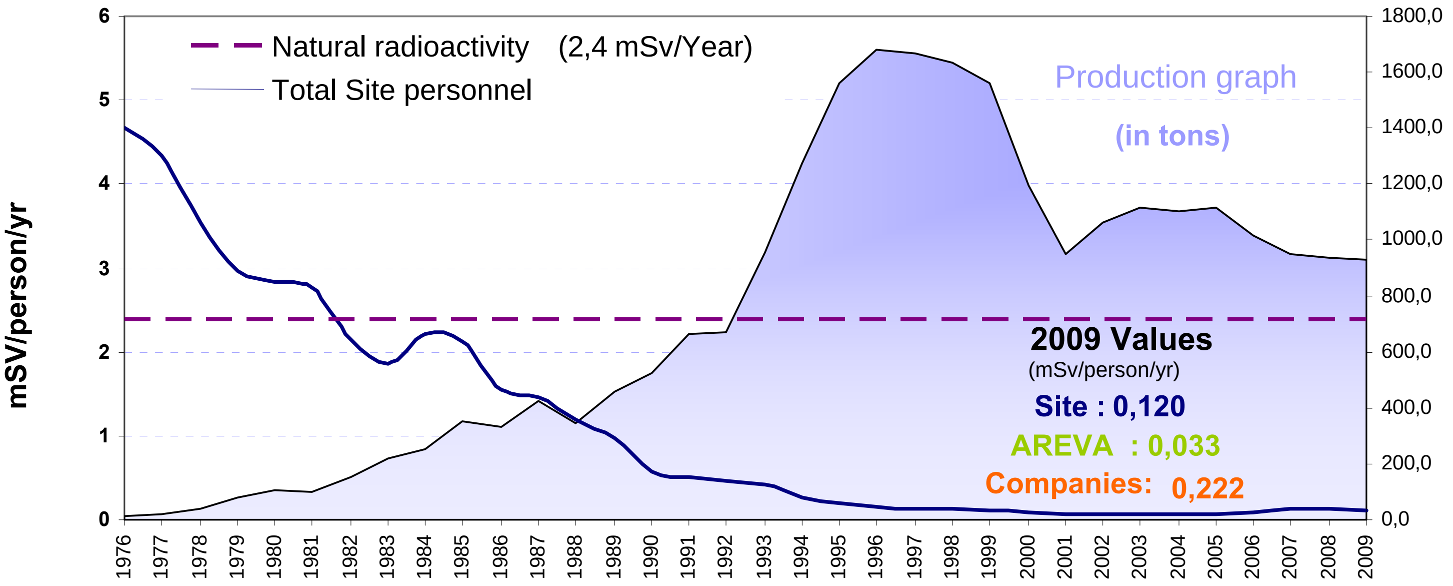
Safety analysis for each operation,

A culture promoting feedback and continuous improvement

In the event of an incident, implementation of :
The **IEP** (Internal Emergency Procedure)
The **SIP** (Specific Intervention Procedure)
tested through drills

Worker's health is protected and monitored

Evolution graph of the radioactivity exposure of site personnel



▶ As part of our continuous worker protection improvement program, we have noted a **significant drop in staff exposure over the years** with the commissioning of two new production units

▶Average exposure for site workers is

- ▶ **200 times below** the regulatory threshold for European nuclear industry workers (20 mSv/year)
- ▶ **20 times below** the average natural radioactivity in France (2.4 mSv/year)

mSV

AREVA

Environmental Monitoring

- **Significant commitment to environmental monitoring**
  - **Radiological aspects: 23,000 annual samples and 70,000 analyses**
  - **Chemical aspects: 2,100 annual samples and 5,000 analyses**
- **Sample types include:**
  - **Atmospheric**
  - **Terrestrial: soil, vegetation, milk, meat, fruits, vegetables**
  - **Hydrological: rivers and streams, groundwater, potable water**
  - **Marine: marine life, seafood, algae, sand sediment**
- **Required surveillance plan established by l'Autorité de Sûreté Nucléaire (ASN)**

AREVA

Radiological Impact Assessment

- **Environmental monitoring results combined with meteorological data to calculate radiological impact**
- **Focus on transparency**
  - **AREVA's evaluation is independently verified by experts from le Groupe Radioécologie Nord-Cotentin (GRNC)**
    - Independent group established in 1997 by French ministries of Health and of the Environment
    - Mission is to follow the impact of chemical and radioactive releases on the environment
    - Representatives from local organizations as well as national and international experts
  - **Environmental monitoring results available to the public on the internet:**
    - AREVA > AREVA NC > WEB SITES > La Hague > Environment > Sampling and analyses results >

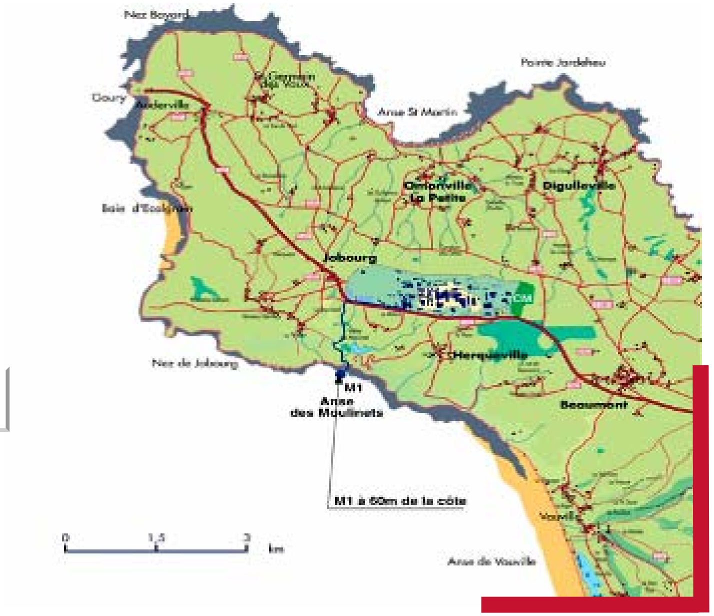
http://www.lahague.areva-nc.fr/scripts/areva-nc/publigen/content/templates/show.asp?P=6855&L=EN&SYNC=Y

Virtually No Radiological Impact on Health

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

AREVA 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 CT 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

mSV

AREVA

AREVA La Hague's responsibilities

- **A commitment to openness, transparency and information through:**

  - The Local Information Commission (CLI)
  - Visits (10,000 visitors/ year)
  - Conferences with debates
  - Participating in fairs and exhibitions
  - An external newsletter, annual reports and brochures
  - Our website *www.lahague.areva-nc.com*

- **A commitment to participate in the local socio-economic growth through:**
  - Support towards business creation or development (AREVADelfi)
  - The site's representation in economical development institutions
  - Connections with the training and research worlds

AREVA La Hague, a key local actor

6

MELOX and MOX Fuel

The MELOX plant

A high technology process for the fabrication of MOX fuel

MELOX, a leading position

AREVA is the world leader in mixed oxide fuel manufacturing with more than 6000 assemblies produced

Fabrication of recycled fuel

MOX (Mixed Oxide Fuel) is a combination of around 91,5 % of depleted Uranium powder and 8,5 % of plutonium oxide powder

A solution used for over 40 years worldwide

40 reactors in the world have been loaded with mixed oxide fuel since the 1970s, among which 36 are in Europe (21 in France, 10 in Germany, 3 in Switzerland and 2 in Belgium), and 4 in Japan

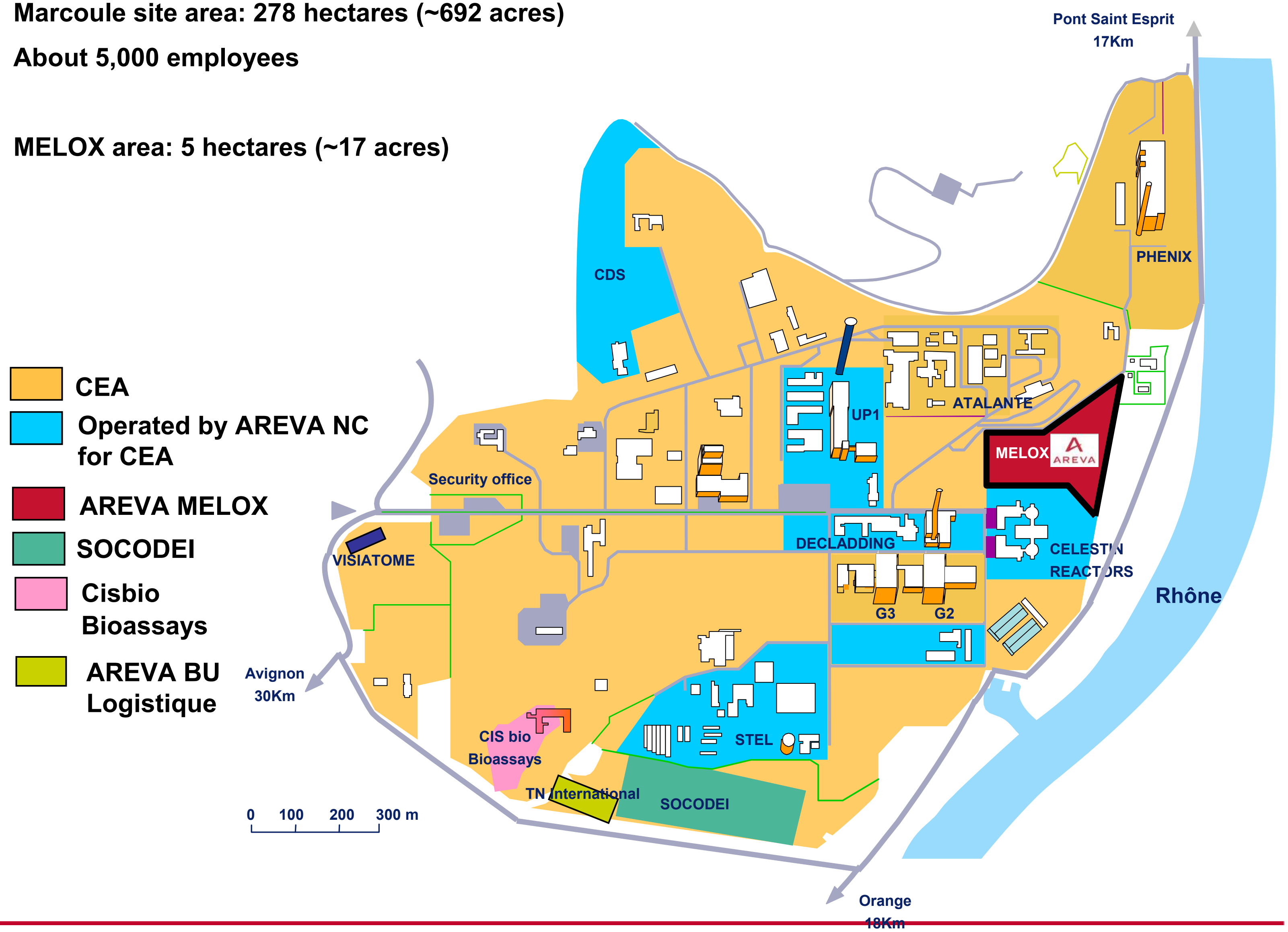
AREVA

The Marcoule nuclear site

Marcoule site area: 278 hectares (~692 acres)

About 5,000 employees

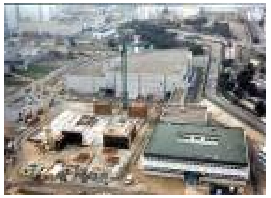
MELOX area: 5 hectares (~17 acres)



The MELOX plant

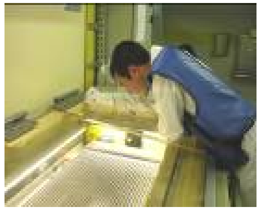
- **MOX fuel fabrication for nuclear power plants in several countries:**
  - **Fuel fabricated for multiple vendors (AREVA, MHI, MNF, NFI, GNF-J)**
  - **1,700 tHM produced as of the end of 2010**
- **The advanced, automated and flexible MELOX plant adjusts to market requirements (MOX fuel for PWRs and BWRs).**
- **Human Resources (at year-end 2010):**
  - **850 MELOX and AREVA NC employees on site:**
    - 55% shift workers
    - 45% standard working hours
  - **Approximately 400 subcontractor jobs**

MELOX: Key Dates



- 1990: **creation of MELOX plant (INB – licensed nuclear facility)**
- 1995: **start-up of MELOX plant after gradual introduction of Pu in the production building**
- 1997: **first year of production at licensed capacity: 100 tHM**

- 1999: **beginning of MOX fuel fabrication for Japanese customers**
- 2000: **one-thousandth assembly fabricated**
- 2002: **beginning of product certification for German customers**

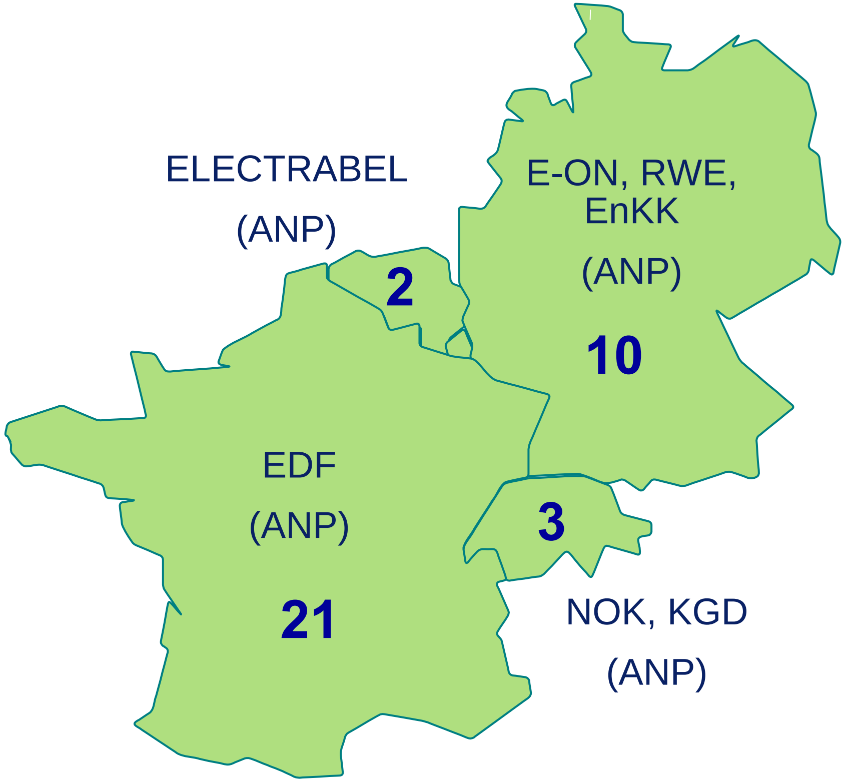


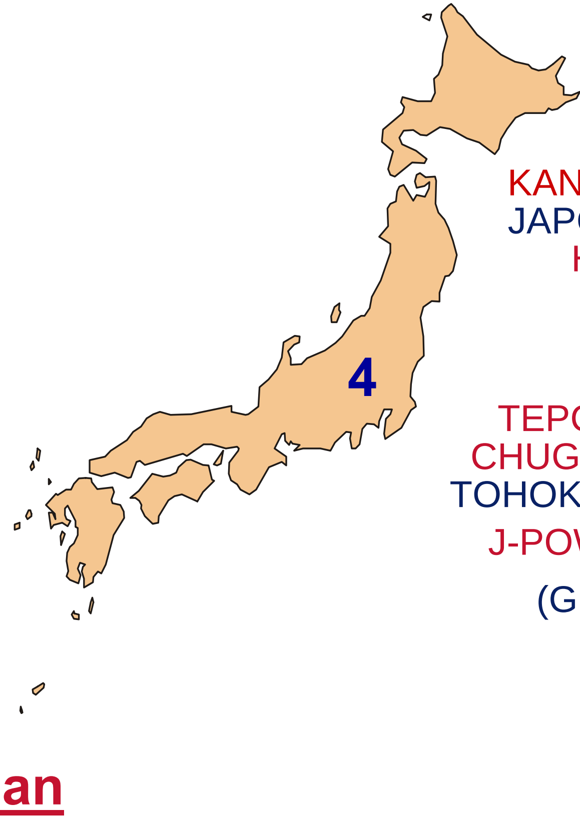
- 2003: **governmental decree allowing production to be increased to 145 tHM/year**
- 2005: **October 6: 10th anniversary – 1,000th ton of MOX**
- 2006: **3 MOX fuel fabrication contracts for Japan were signed**
- 2007: **governmental decree of April, 26th allowing production to be increased to 195 tHM/year**

- 2008: **2 MOX fuel fabrication contracts for Japan were signed**
- 2009: **2 MOX fuel fabrication contracts were signed for Japan. First MOX fuel loading in Japan.**

AREVA

MOX Loadings Worldwide





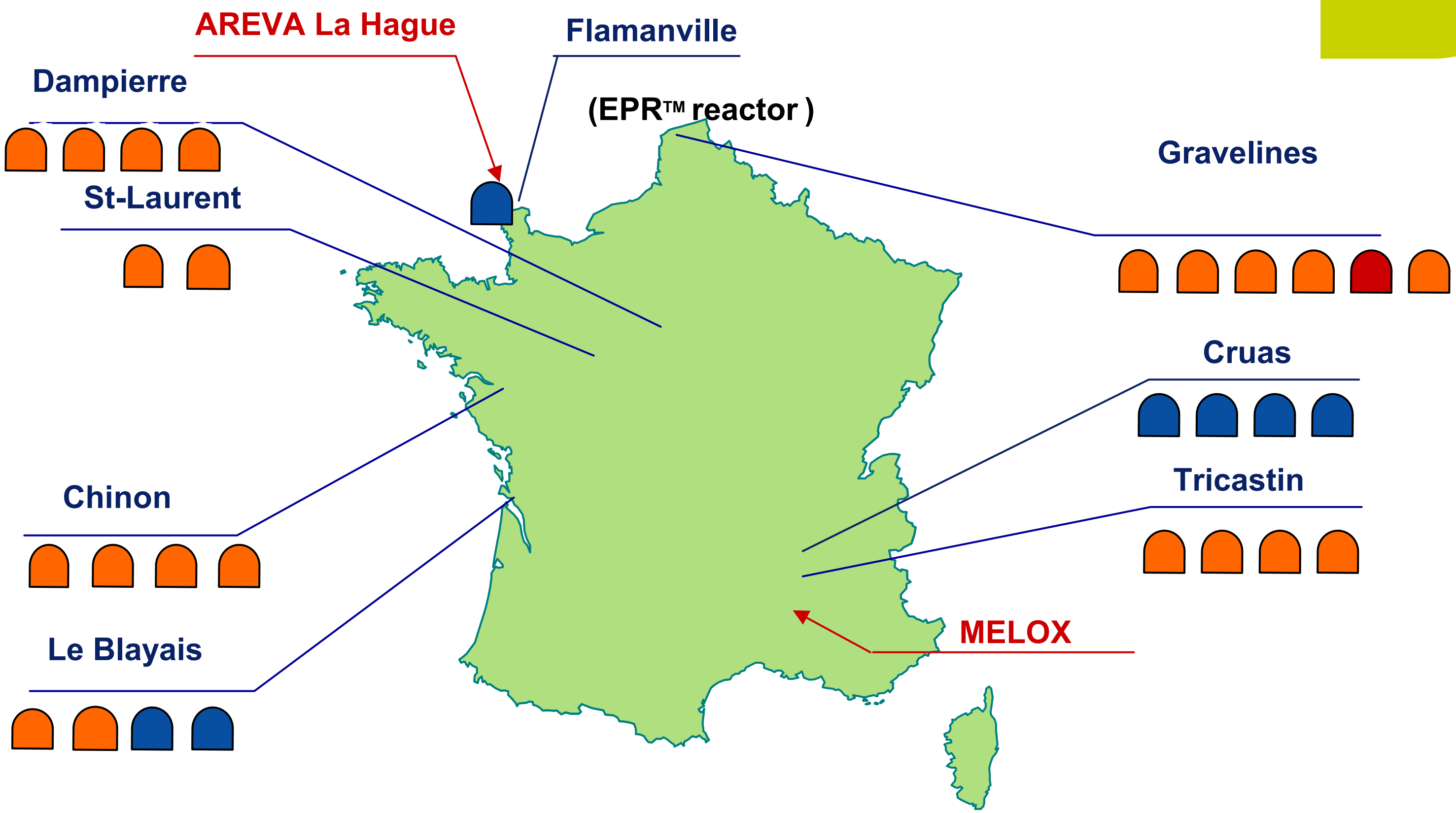
In Europe

36 "moxified" reactors

In Japan

- **11 utilities committed to loading MOX**
- **7 contracts signed for MOX since 2006**
- **Dec. 2009: first electricity production from MOX fuel in Japan**

900 MWe EDF PWRs loaded with MOX fuel



- **In France: 58 reactors in operation, 21 "moxified" reactors with 1/3 MOX in the core***

MOX loaded reactors

St-Laurent : B1 (1987), B2 (1988)
Dampierre : 1 (1990), 2 (1993), 3 and 4 (1998)
Le Blayais : 2 (1994), 1 (1997)
Tricastin : 2 and 3 (1996), 1 and 4 (1997)
Gravelines : 3 and 4 (1989), 1 (1997), 2 (1998), 6
Chinon : B4 (1998), B3 and B2 (1999), B1 (2000)

Technically capable reactors

Blayais 3 and 4
Cruas 1 to 4

Authorized reactors to be "moxified"

Gravelines C5

* EPR™ reactor: up to 100% MOX.

MOX Status in Europe

	Reactors in operation	Reactors licensed for MOX	" Moxified " reactors	First MOX loading date
▶ Germany	16	10	10	1972
▶ Switzerland	5	4	3	1984
▶ France	58	22	21	1987
▶ Belgium	7	2	2	1995

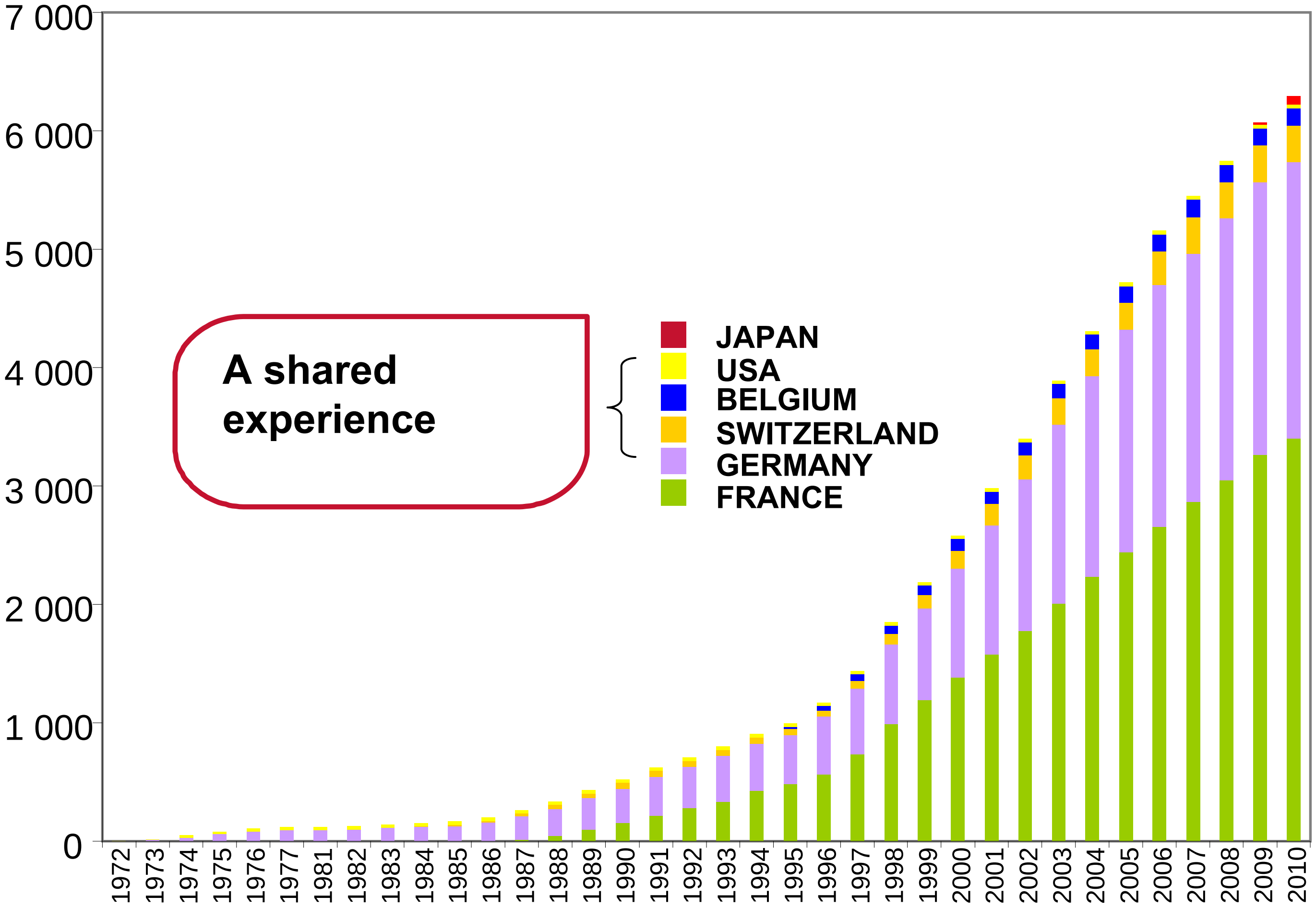
MOX, a recycling solution used for nearly 40 years

MOX Performance in Reactors

- **MOX is a flexible fuel**
  - **Can accommodate BWR and PWR Light Water Reactors**
  - **All existing fuel designs are compatible with MOX**
- **For utilities, MOX has excellent performance**
  - **Equal energy performance**
  - **MOX in-core behavior similar to Uranium fuel under normal and accidental conditions**
  - **Zero failures (leaks, etc.) due to manufacturing or design defects**
- **“MOXifying” a reactor implies minor modifications**
  - **Licensing (using worldwide experience)**
  - **Minimum equipment adaptations**

MOX: a fuel increasingly utilized

Number of MOX fuel assemblies fabricated by AREVA



MELOX Production Flow

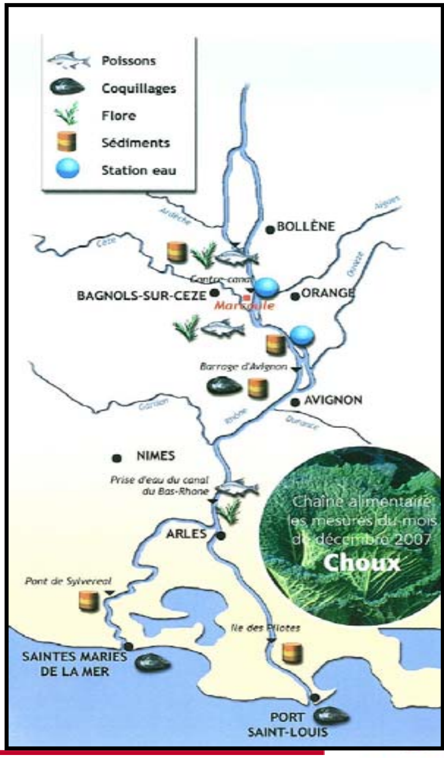
One MOX fuel assembly contains enough energy to supply a city of 100,000 with electricity for an entire year

Marcoule Site Environmental Monitoring

- **Measures (about 100,000 per year) can be seeing on Internet.**

www-marcoule.cea.fr

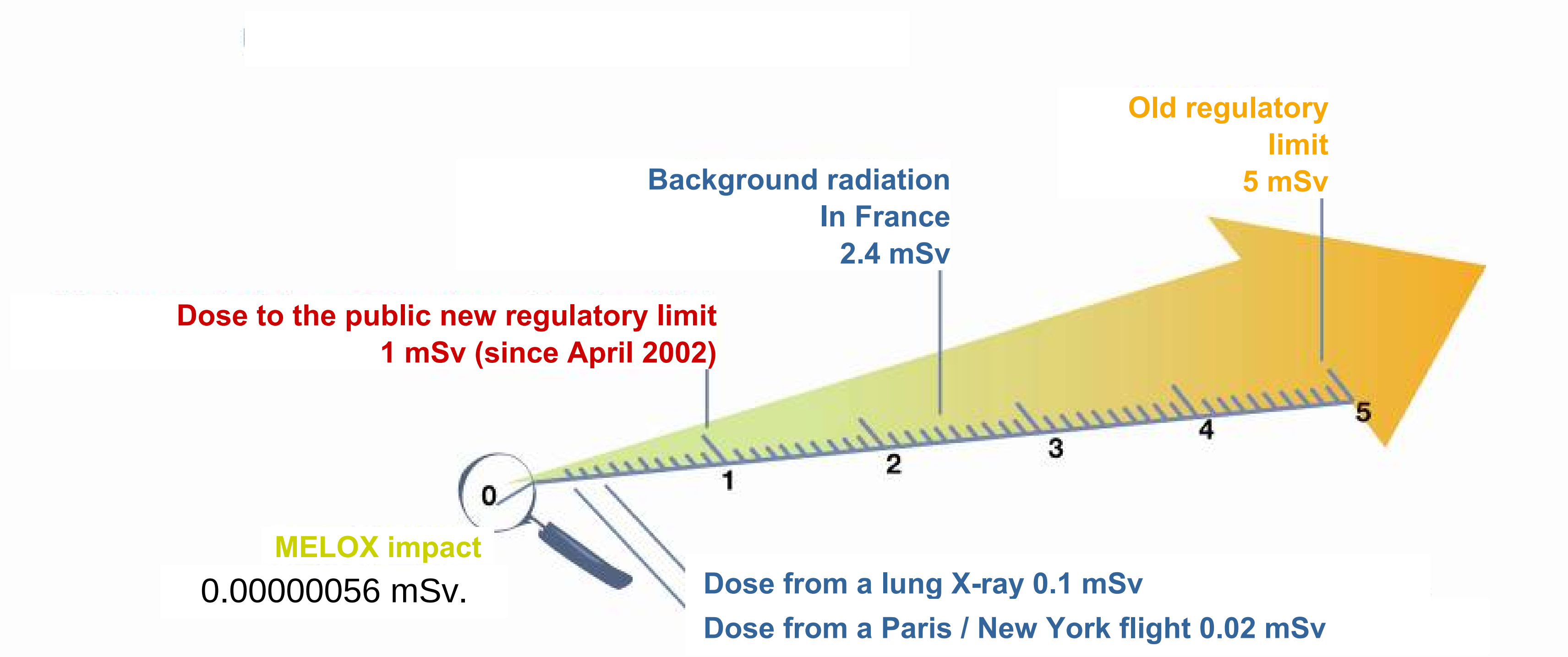
- **Impact measures of radioactivity from different elements:**
  - **Air**
  - **Grass**
  - **Water (drinkable, Rhône river and ground water)**
  - **Sediments**
  - **Radioactive effluents (gaseous, liquids)**
  - **Food chain**



AREVA

Radiological impact of the MELOX plant

- In year 2009, the impact of liquids and gaseous radioactive effluents of MELOX plant is about 0.00000056 mSv.



Maximum effluents impact allowed by the decree: 0.0017 mSv per year

7

Summary & Conclusions

Summary

- For more than 40 years, France has been safely using recycling technologies to responsibly manage used nuclear fuel
- Recycling is key to the French commitment to sustainability
  - Facilitates the management and disposal of radioactive waste
  - Minimizes the burden on future generations
  - Supports competitive electricity prices
- Demonstrated sustainable policy deployment from the front-end to the back-end is vital to ensure nuclear acceptance

» **Recycling provides France with a safe and responsible solution for the long-term sustainability of nuclear energy**

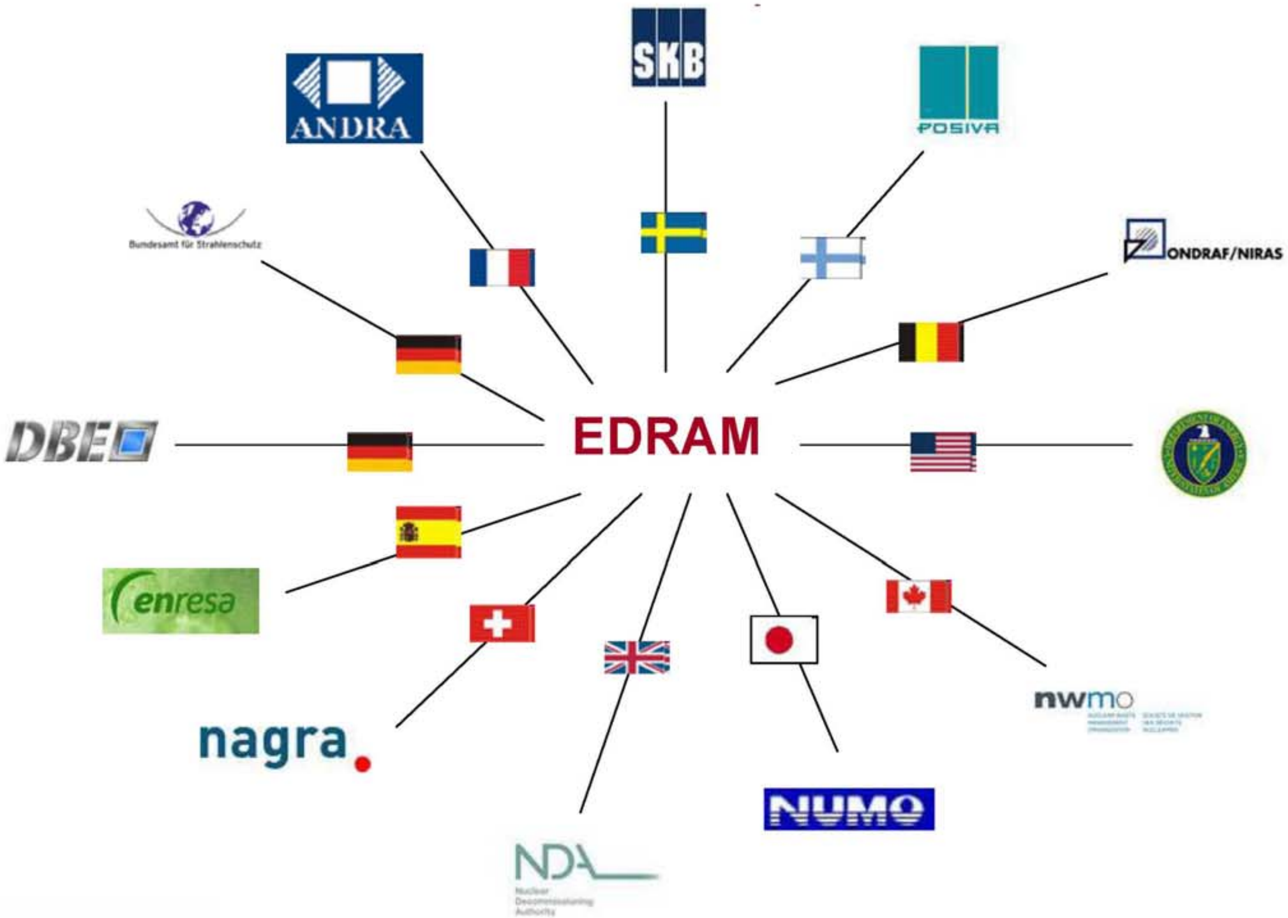
AREVA

AREVA La Hague in pictures

Appendix

Nuclear Energy

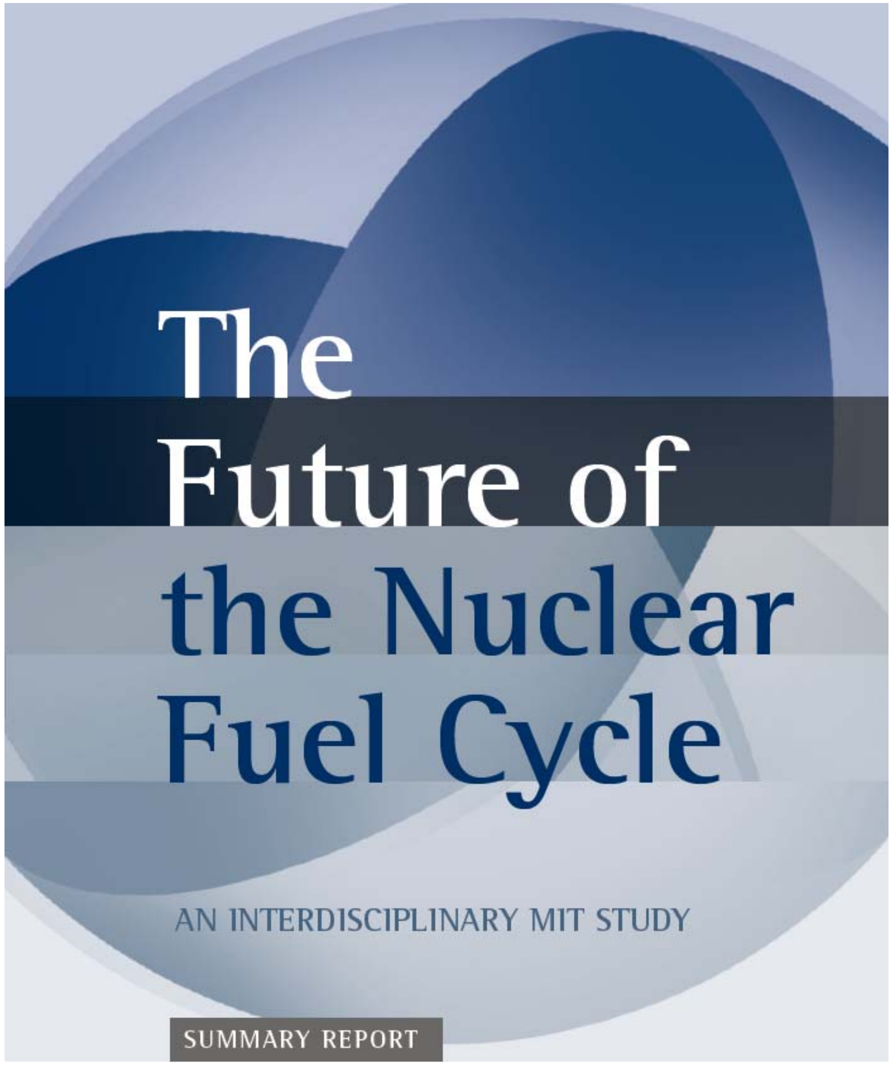
International Association for the Environmentally Safe Disposal of Radioactive Materials



EDRAM

International Association for Environmentally Safe Disposal of Radioactive Materials

A Tale of Two Studies



Compelling Reasons for Near-Term Deployment of Plutonium Recycle from Used Nuclear Fuels—A Systems Analysis Study

E. D. Collins, G. D. Del Cul, and K. A. Williams

Oak Ridge National Laboratory

collinsed@ornl.gov

Presented at

Plutonium Futures –The Science 2010

Keystone, Colorado

September 21, 2010

U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

The AREVA group

2009 Key data

		∆ 09/08
BACKLOG	*43 302 M€*	*+ 1,8 %*
SALES REVENUE	*8 529 M€*	*+ 5,4 %*
OPERATING INCOME	*97 M€*	*+ € 240 M*
CONSOLIDATED NET INCOME	*816 M€*	*+ 9,6 %*
EMPLOYEES	*47 817*	*+ 5 %*

Governance

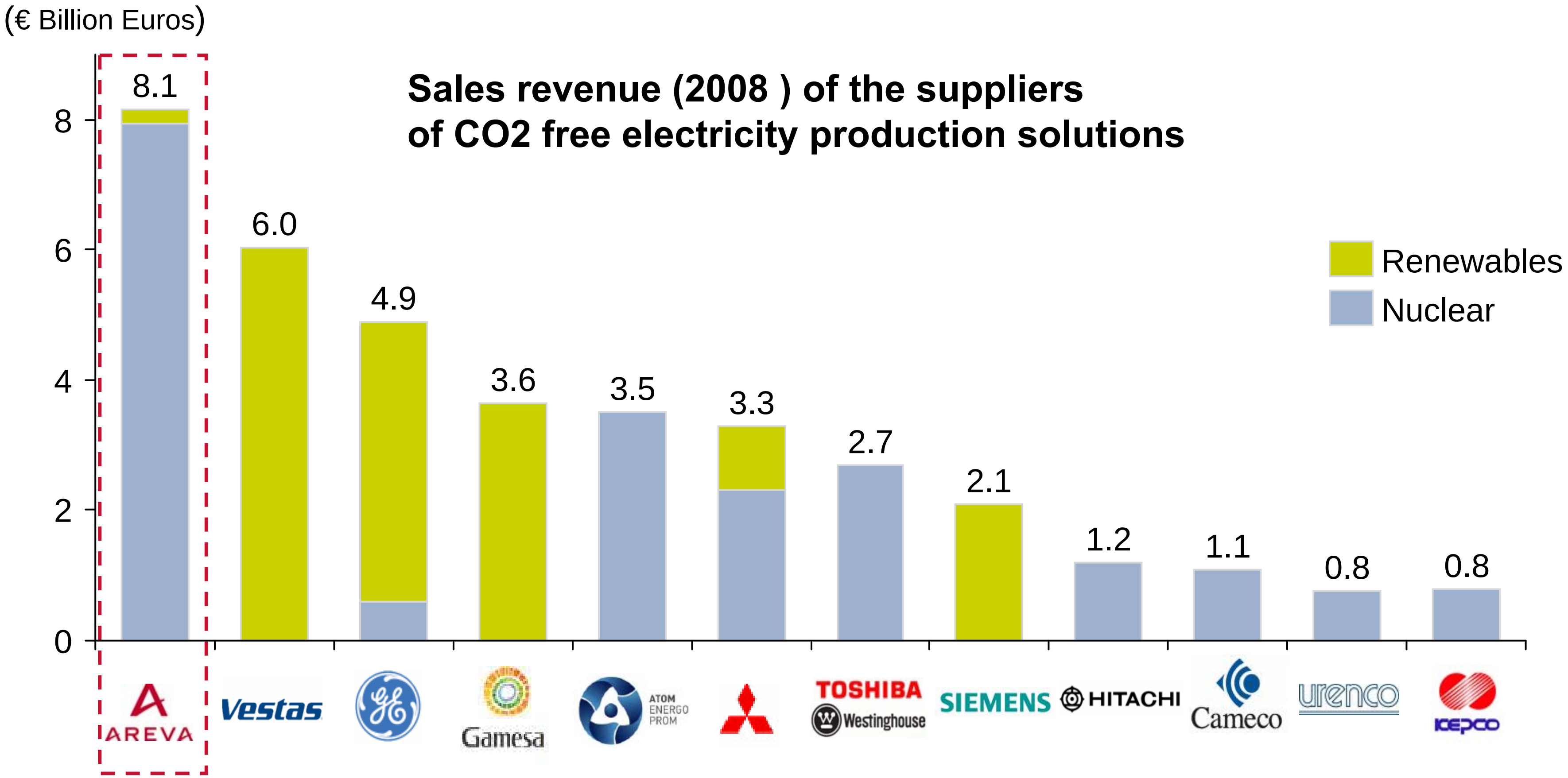
Of 01/01/2011

- **Chairman of the Supervisory Board :** ***Jean-Cyril Spinetta***
- **CEO of AREVA:** ***Anne Lauvergeon***

	Shareholders
Commissariat à l'énergie atomique et aux énergies alternatives (CEA) – French AEC	73.2%
French State	10.2%
Kuwait Investment Authority	4.8%
Caisse des Dépôts et Consignations	3.3%
EDF Group	2.2%
Framépargne (employees)	0.4%
Total Group	1.0%
CALYON	0.9%
Investment certificate holders	3.7%
AREVA Treasury shares	0.3%

AREVA

AREVA, leader in the supply of CO_2 free energy



AREVA

The AREVA organization

A strong position in the renewable energy field

WIND (AREVA Wind)

Design and manufacturing of high-power wind turbines
(E.g: 5MW Offshore farm, etc.)

BIOENERGIES

Design and construction of turnkey bioenergy plants
(E.g: biomass plants, etc)
Areva world leader

Hydrogen and Energy Storage

Developing solutions to produce hydrogen through electolysis and electricity using fuel cell batteries.

SOLAR (AREVA Solar)

Design and construction of concentrated solar thermal plants

AREVA

5 Business Groups serving our customers

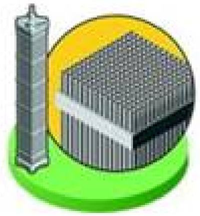
Board of Directors and Executive Committee

Functional Departments

Mines

- Uranium mines exploration and operating activities

Front-end



- Conversion and enrichment of uranium
  Design and fabrication of fuel for nuclear reactors

Reactors & Services

- Design and construction of nuclear reactors
- Maintenance and modernization of nuclear power plants

Back End

- Recycling of used fuel
- Provision of cleanup and dismantling services
- Transportation of nuclear materials

Renewable Energies

- Development of wind energy, bio-energy, solar power and hydrogen power solutions

Engineering & Project Organization

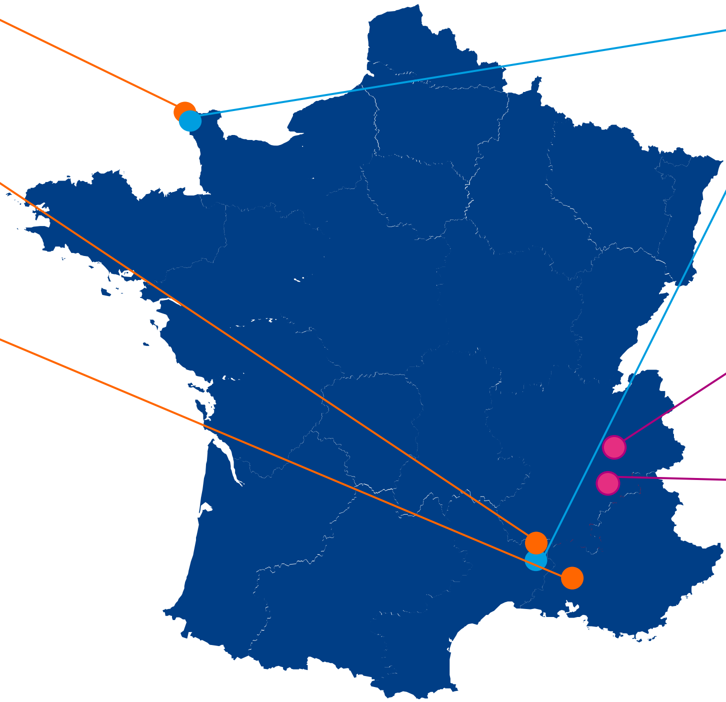
AREVA

The industrial tool

A strong industrial base

Nuclear site value

- **La Hague**
  First generation plant dismantling
- **Marcoule**
  UP1 Treatment plant dismantling
- **Cadarache**
  MOX plant dismantling



Recycling

- **La Hague**
  Fuel treatment
- **MELOX**
  MOX fuel fabrication

Fuel Fabrication

- **Romans**
  RepU fuel fabrication
- **Tricastin**
  RepU Enrichment and Conversion

La Hague

- Production Capacity :
  1700 tons per year

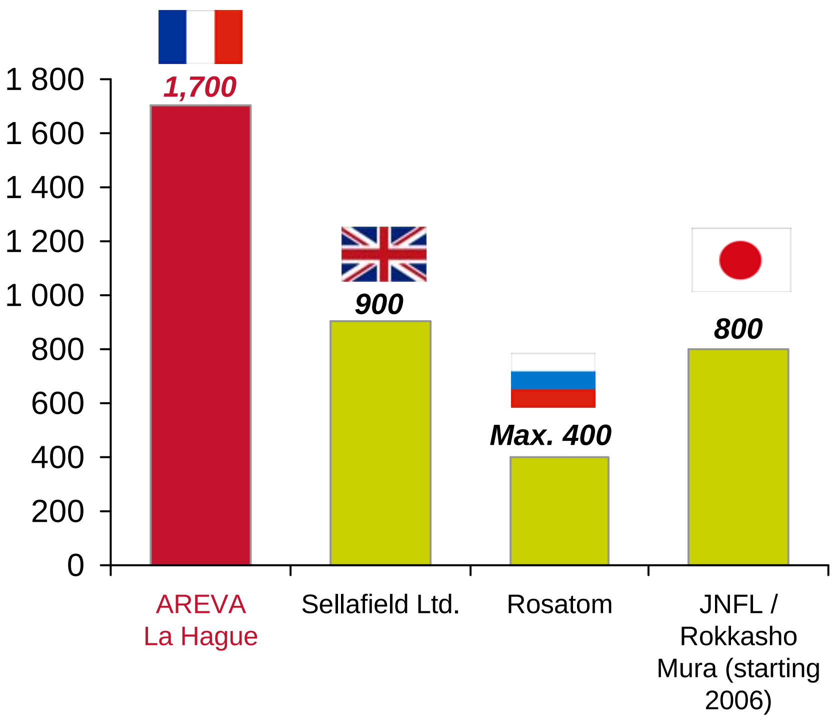
MELOX

- production Capacity :
  195 tons per year

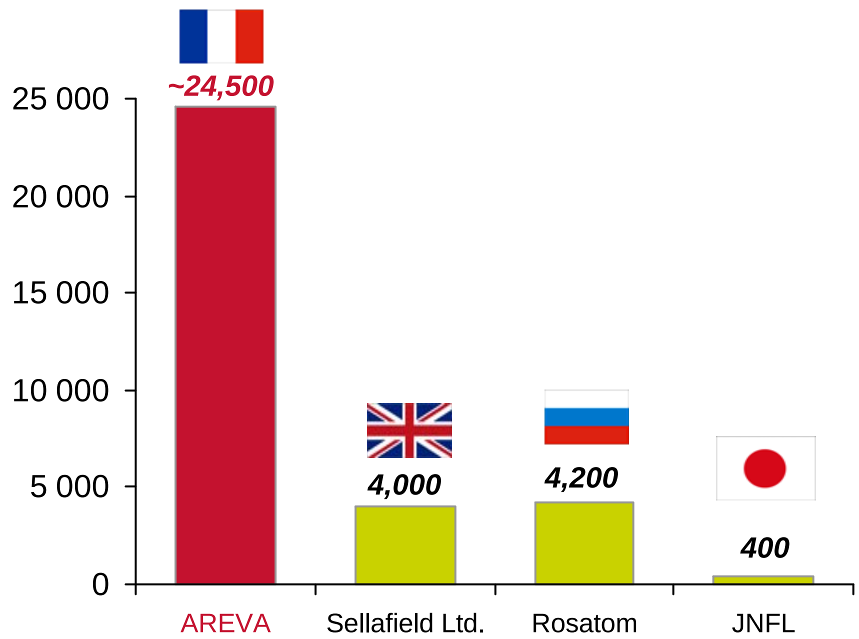
AREVA

AREVA: n°1 worldwide for used nuclear fuel treatment

Treatment capacity for light water reactors fuel (tons/year)



Cumulative production, as of dec. 2008 (tons)

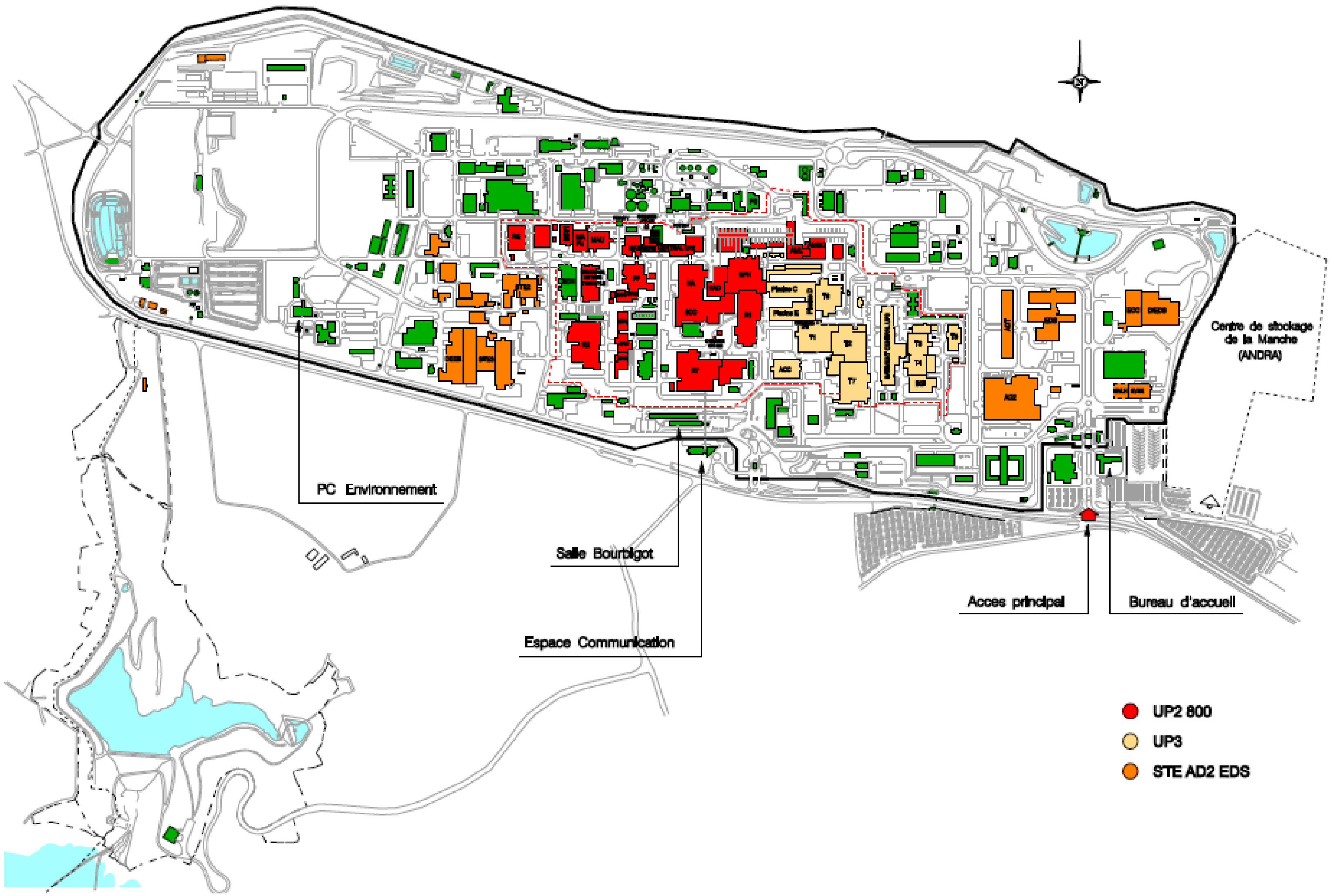


At the end of 2009, AREVA had treated ~75% of the fuel treated worldwide, i.e 25 500 tons out of 33 200 tons

Source: AREVA, World Nuclear Association

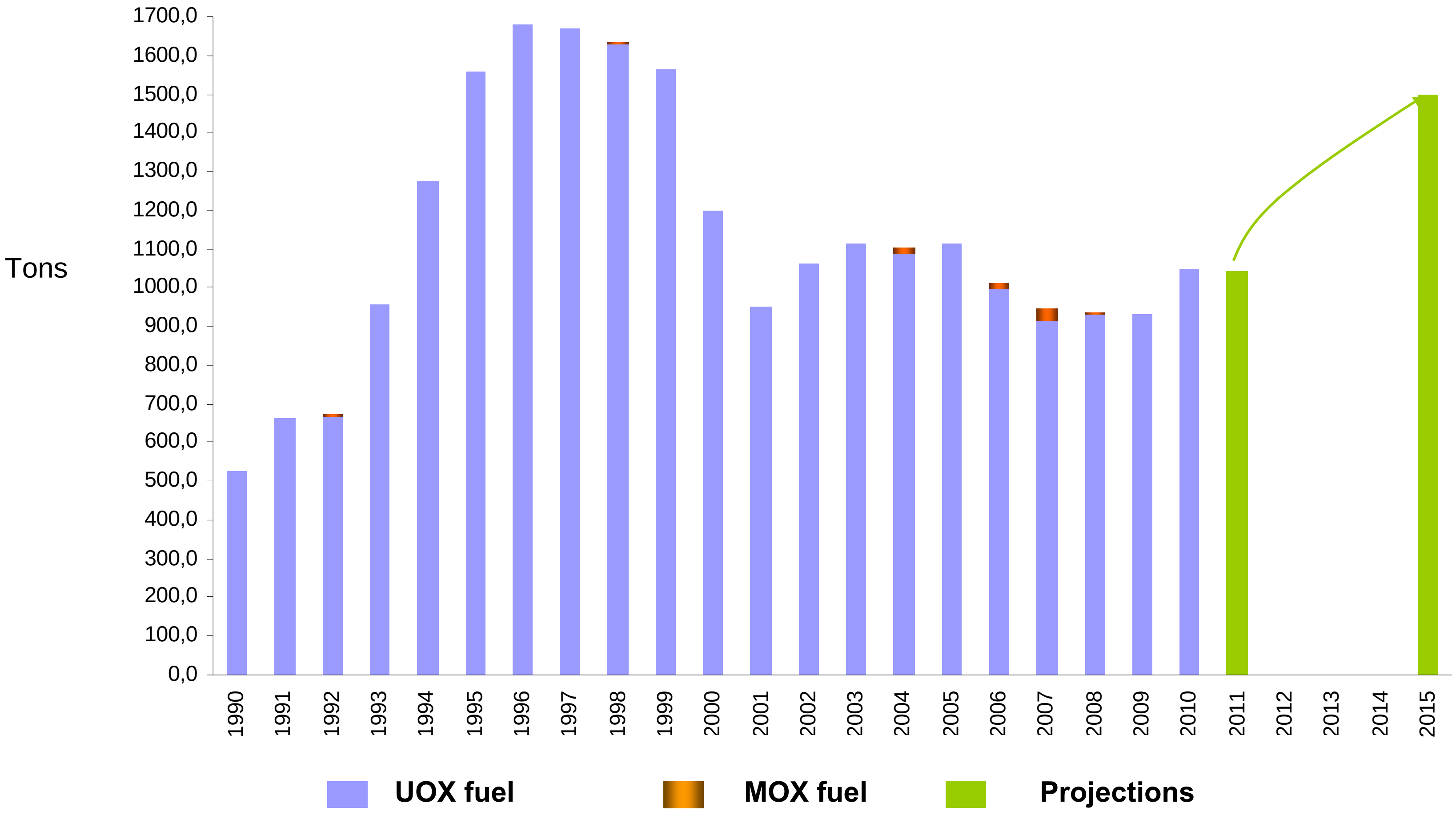
AREVA
la Hague

AREVA
la Hague map



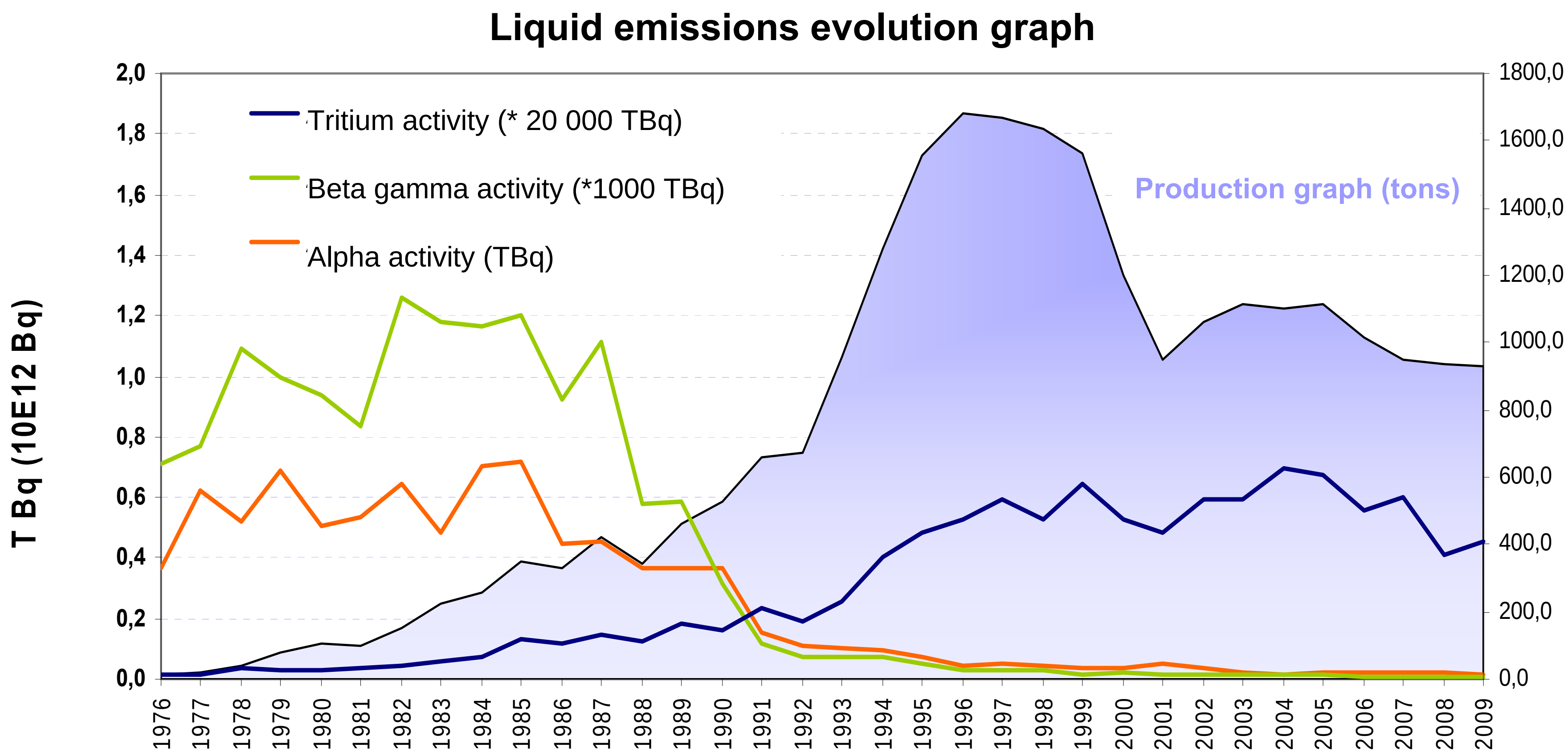
AREVA

More than 26 000 tons of used fuel treated as of January 1st, 2011



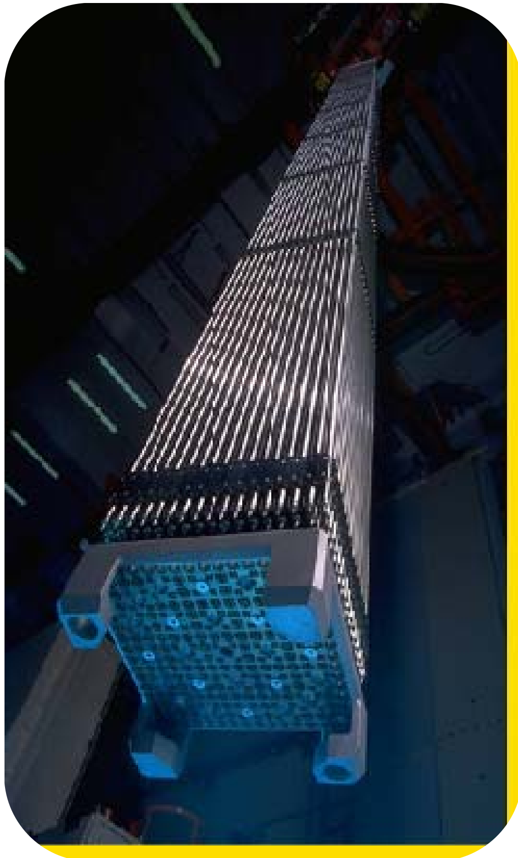
(*) UOX and MOX fuels

Liquid emissions significantly reduced over the years



Transportation of used Fuel

Used fuel
from nuclear power reactors



A PWR* fuel of 900 MW
measure **4,5 m** in height :

it is an assembly
of **264 rods**,
every tube containing
272 pellets of Uranium

PWR : Presurized Water Reactor

AREVA

Additional infrastructures

TN International rail terminal in Valognes

Cherbourg's Harbor facilities

Used fuel are transported in packages called "casks"

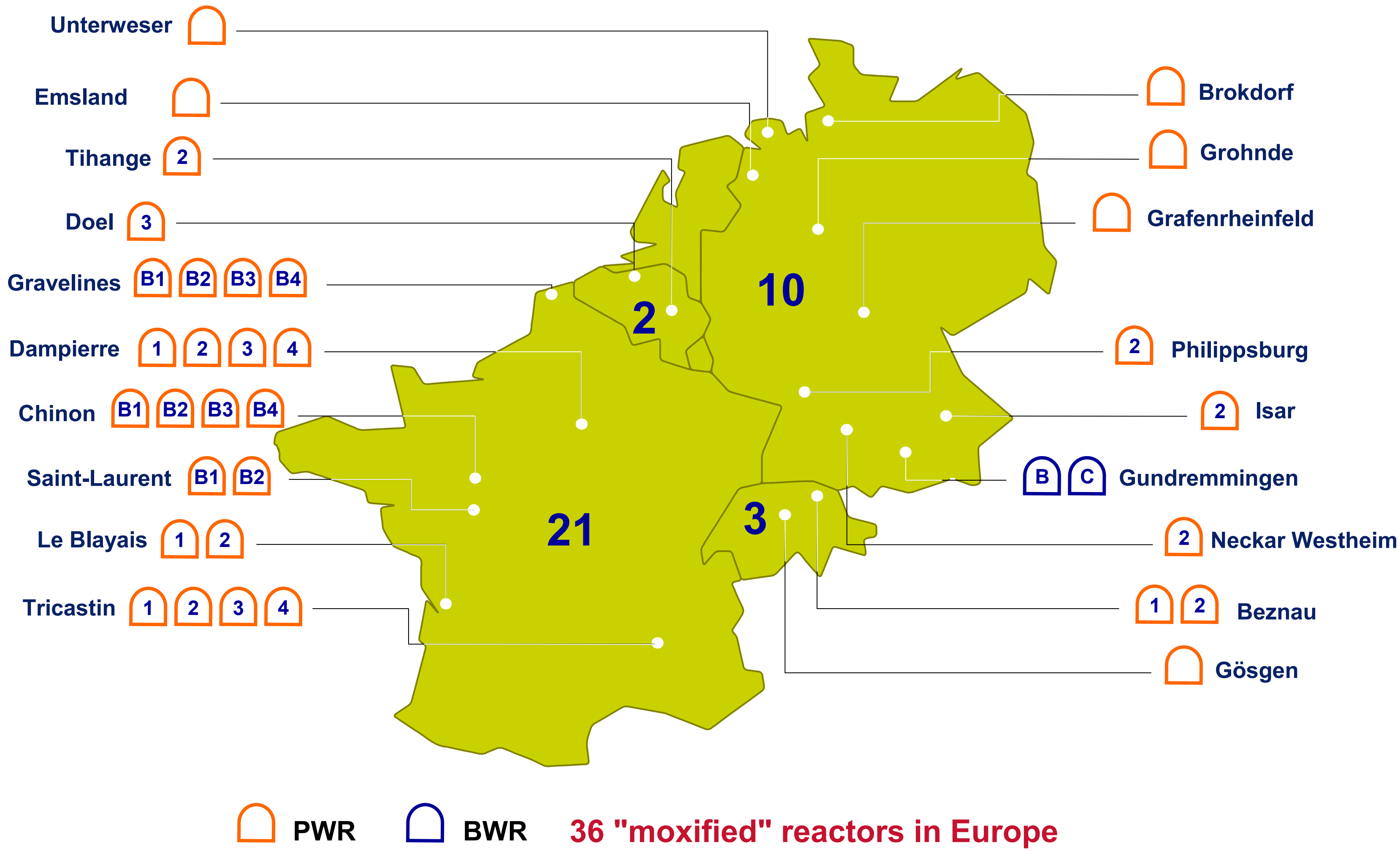
The casks arrive at AREVA la Hague plant by road from the Valognes railway terminal or from Cherbourg harbor facilities

A 110 tons cask to transport only 6 tons of used fuel

« Cask » transport TN 12

MELOX & MOX

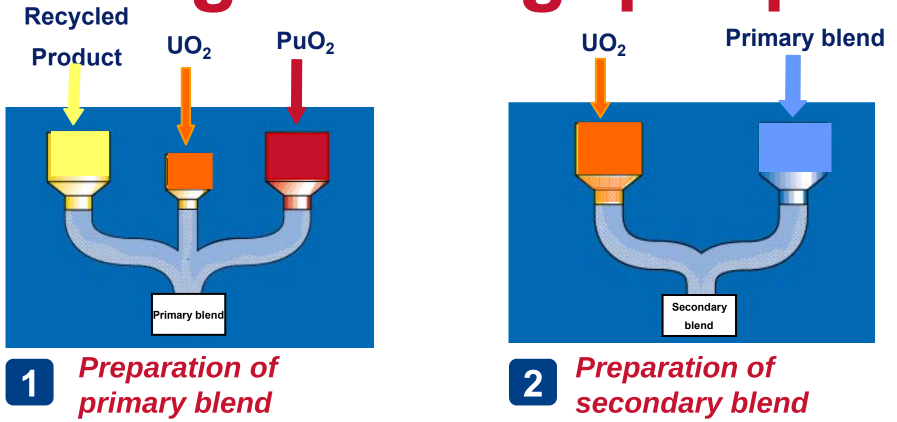
Reactors cores loaded with MOX fuel
(Light Water Reactors)



36 "moxified" reactors in Europe

AREVA

Key advantages of the advanced MELOX high-throughput process



- **Powder blending is the key to the MELOX process.**
- **The MELOX process allows an on-line recycling of almost all scrap**
- **Nearly 40 years of PWR and BWR operating experience have demonstrated the high quality of MOX fuel fabricated by the AREVA group**
- **MOX fuel behavior in the reactor is similar to UO_2 fuel in normal and off-normal conditions**

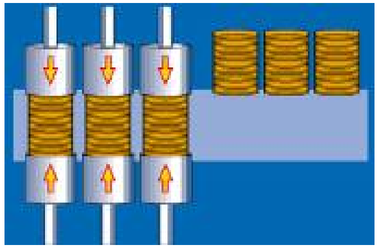
The performance and reliability of the MELOX process are recognized worldwide

MOX Fuel fabrication process

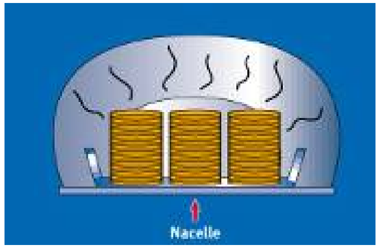
MELOX

PROCESS

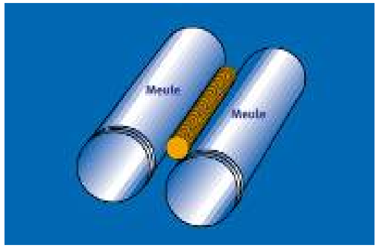
1 *Powder mixing*



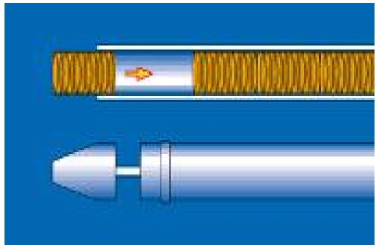
2 *Pressing or pelletizing*



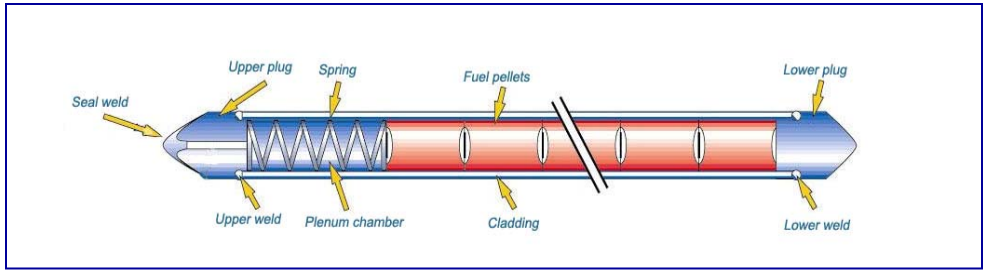
3 *Sintering*



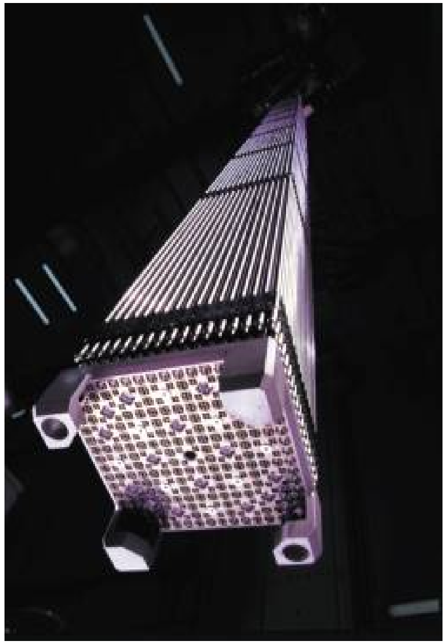
4 *Grinding*



5 *Rod cladding*



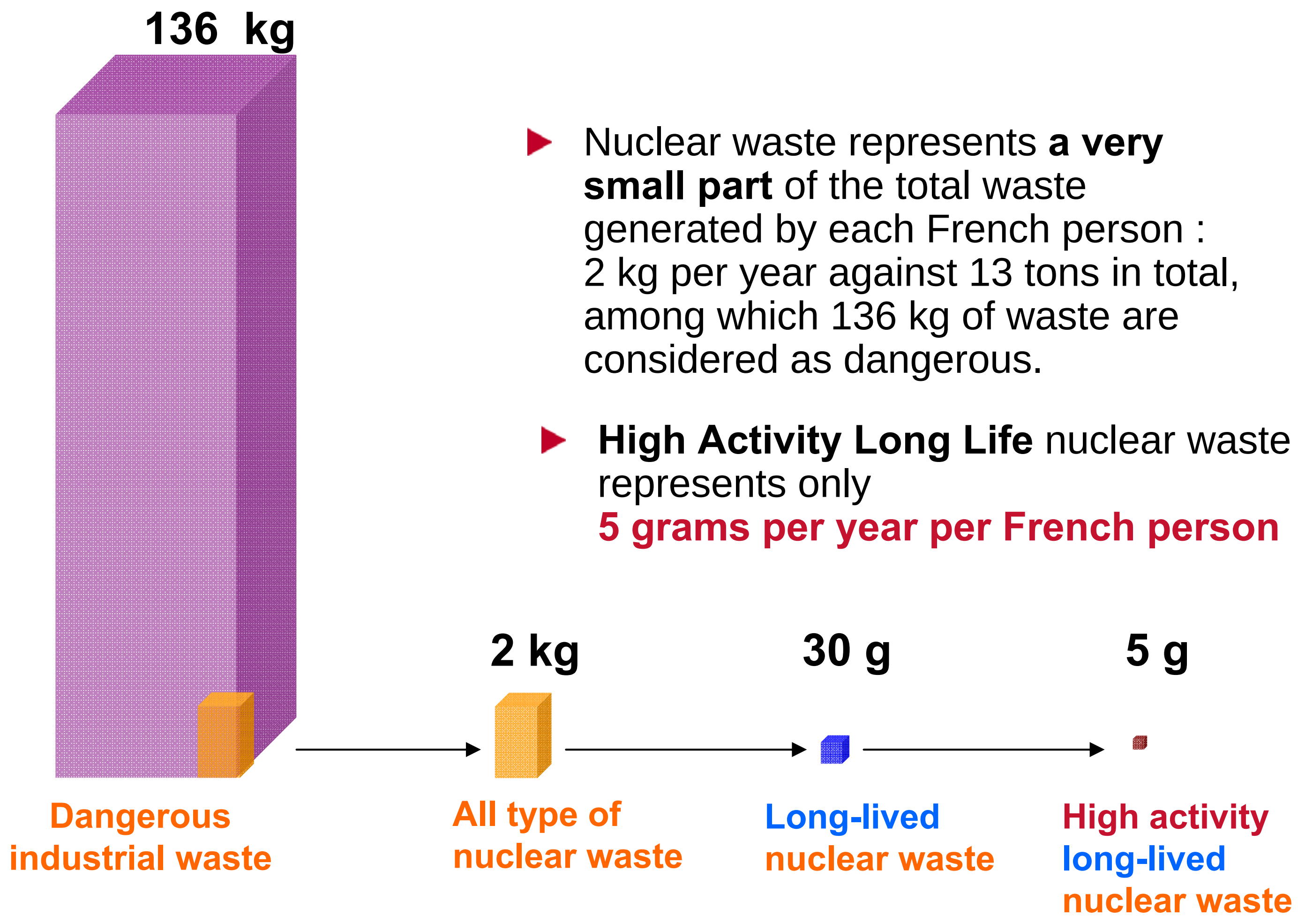
Light water reactor fuel rod



6 *Assembly fabrication*

Final waste

A small quantity of high activity nuclear waste



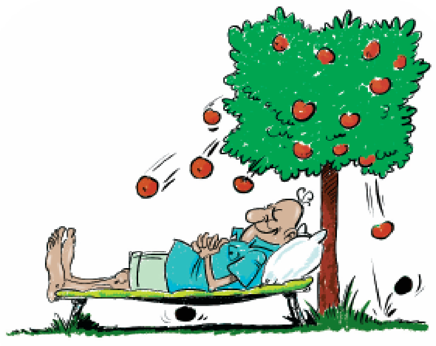
- Nuclear waste represents **a very small part** of the total waste generated by each French person : 2 kg per year against 13 tons in total, among which 136 kg of waste are considered as dangerous.
- **High Activity Long Life** nuclear waste represents only **5 grams per year per French person**

Sources : ADEME 2009, site ANDRA et Inventaire National de l'ANDRA

General nuclear knowledge

Which units measure radioactivity ?

The Becquerel (Bq) :
a unit of measure of radioactive decay (radioactivity) quantifying the number of radioactive disintegrations per second



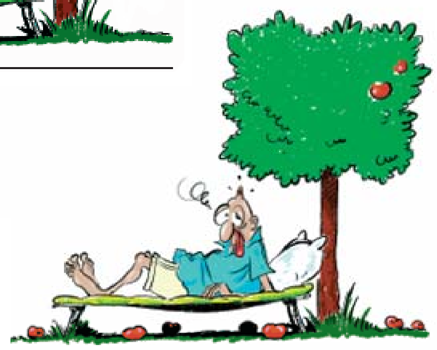
Activity (Becquerel)

The Gray (Gr) :
a unit of measure of energy absorbed by a biological organism from radiation.

Absorbed dose (Gray)

The Sievert (Sv) :
a measure of the potential biological impact of the energy absorbed by an organism from radiation

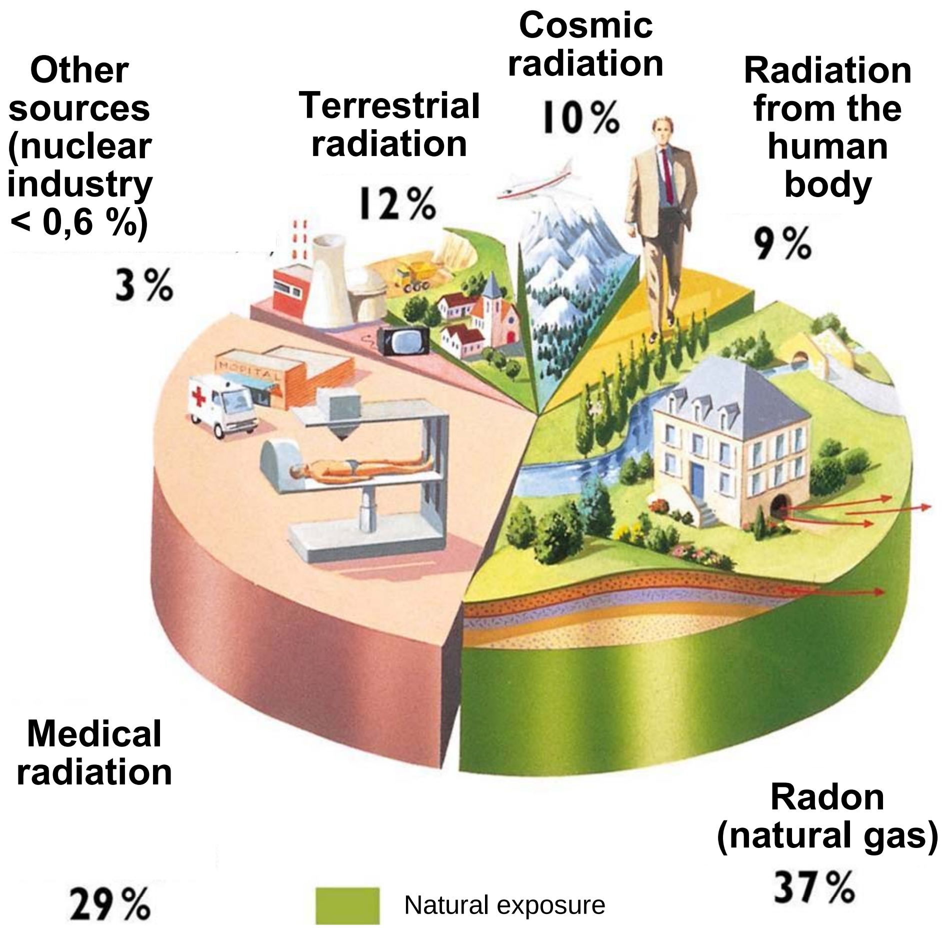
Radiological impact (Sievert)



Even though radioactivity cannot be seen or smelled, it can easily be measured !

AREVA

Radioactivity :
A natural phenomenon



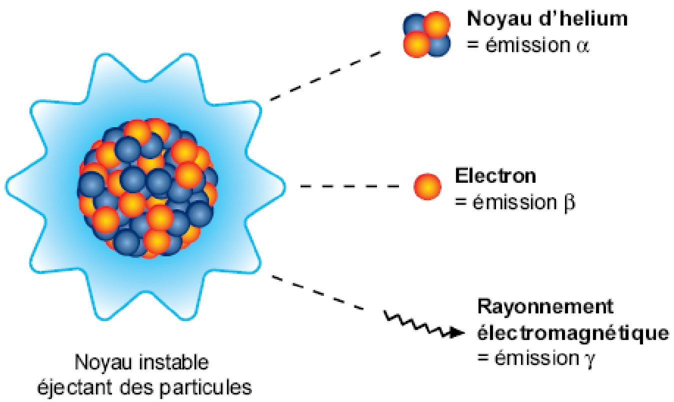
Average natural exposure in France :

2.4 millisieverts /man/year

AREVA

Radioactivity : what is it ?

- Radioactivity is the specificity which certain elements possess to be spontaneously transformed, by disintegration, into other elements, as a result of a modification of the core of the atom, by transmitting corpuscular radiations (alpha particle emission, beta) or electromagnetic



- **3 protections :**
  - Time
  - Distance
  - Screens (water, concrete, steel…)

- **2 risks :**
  - Contamination
  - Irradiation