Seminar on neutron research centre in the Øresund region

(European Spallation Source)

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ESS and its possible connection with reprocessing of spent nuclear fuel

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Is the European Spallation Source suitable for transmutation applications ?

Points to be considered

- Technical options available to apply transmutation
- ESS project history
- ESS design(s), former and latest

Technical options to develop transmutation

Three possible technical options

- **in Light Water Research Reactors**
  - **neutron flux intensity limit reached**
  - **worse neutrons production rate**
  - **no large development**
- **in Fast Breeder Reactors**
  - **neutron flux intensity limit reached**
  - **better neutrons production rate**
  - **no large development foreseen**
- **in Accelerator Driven Systems (ADS)**
  - **neutron flux intensity limit not reached yet**
  - **best available neutrons production rate**
  - **less safety concerns than with critical reactors**
  - **great development foreseen**

ESS project history: phase 1

Toward the first design of ESS

- **1991-1992: initiative of the F.z. Jülich (Germany) and the A. R. Laboratory (UK)**
- **1993: creation of ESS Council gathering neutron scattering interests in Europe**
- **1994-1996: feasibility study phase**
- **11.1996 : first design of the project**
  - **Linear Accelerator (LINAC): 1,334 MeV, pulsed source**
  - **Target station: 50 Hz, short pulse**
  - **Target station: 10 Hz, short pulse**

"The ESS RNB [Radioactive Nuclear Beam] facility could provide the nuclear data needed for nuclear waste transmutation."

Source: ESS study, november 1996

ESS project history: phase 2

Toward the intermediate design of ESS

- **1997-2000: R&D phase, main aspects and options are studied**
  Standby period for the ESS project
- **05.2000: ESS Council decides a Memorandum of Extension to make a new step toward realization. Strategic options have to be studied:**
  - **choice of the target stations types**
  - **use or not of superconducting technology**
  - **multipurpose or stand alone facility, i.e. include or not transmutation` in the facility design**
- **2000-2001: CEA-ESS cooperation on CONCERT project. CEA proposes a multi-purpose facility including a transmutation demonstrator**

"The CONCERT team concluded that a single accelerator can serve more communities and is technically feasible, without the increase in power leading to substantial extra costs for the accelerator."

Source: ESS Newsletter, July 2001

ESS project history: phase 3

The intermediate design and beyond

- **2001:** CEA abandons the CONCERT project. Reasons are unclear but could be either budgetary or/and strategic. ESS expresses regrets for that decision
- **06.2001:** ESS abandons the CONCERT project and do not mention the transmutation option anymore
- **05.2002:** ESS intermediate design is issued. It does not include transmutation applications in the 48 planned neutron scattering instruments

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- **2004:** Decision phase (project approval and site design)
- **2005-2010:** Construction phase
- **2011-2012:** Commissioning phase
- **2013:** Operation phase

ESS intermediate design as of May 2002

Main components of the facility

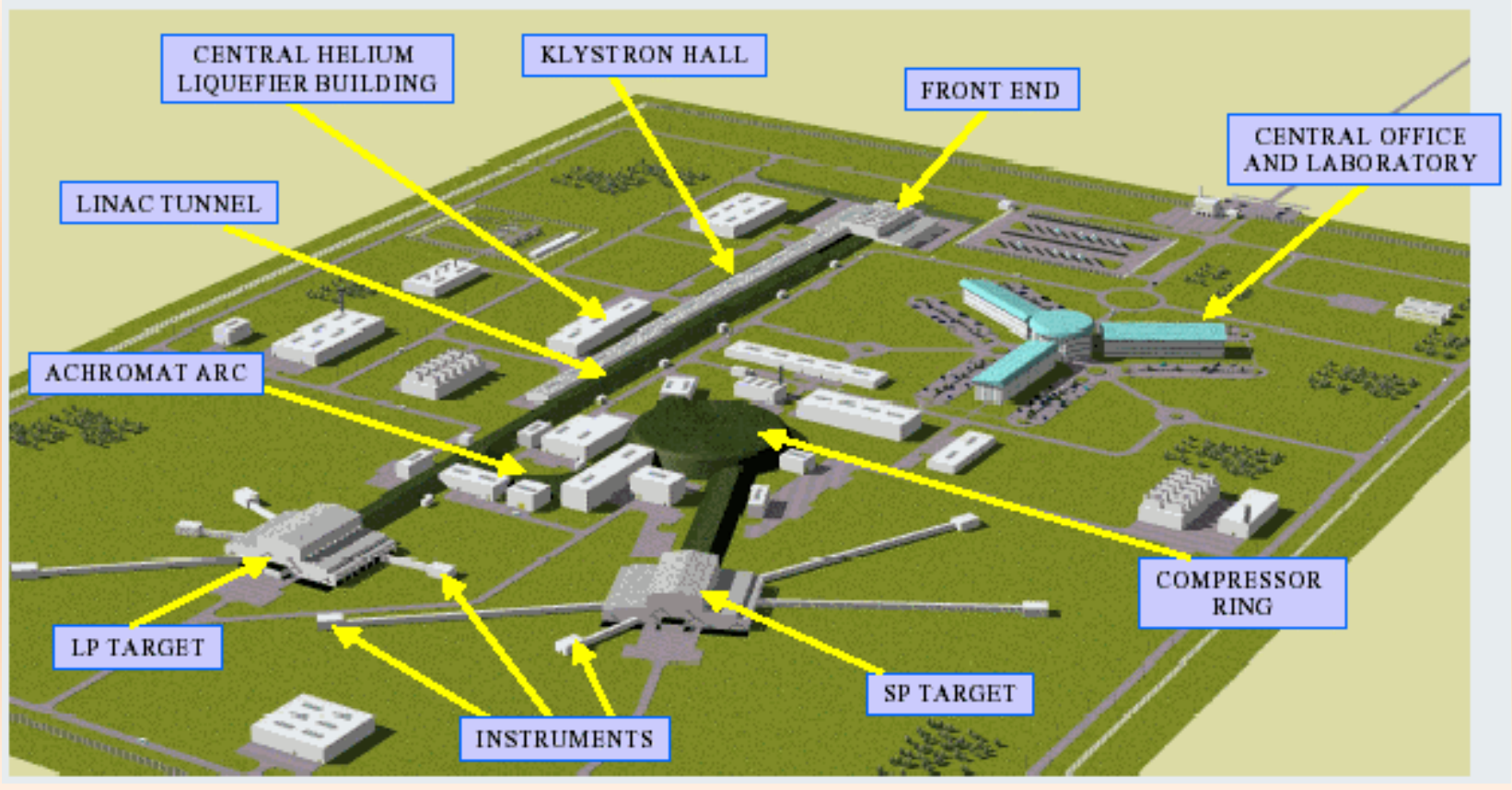
- **LINAC: 1,334 MeV, pulsed source Þ unchanged from the first design**
- **Target station: 50 Hz, short pulse Þ unchanged from the first design**
- **Target station: 16 Hz, long pulse Þ changed from the first design**
- **No RNB facility Þ changed from the first design**

⇦ **latest design and instrumentation do not include transmutation**
⇦ **but the new 16 Hz long pulse mercury target can be used for transmutation**

Conclusion on ESS ability to apply transmutation

Strategic core of transmutation technology, i.e. advanced accelerator and adapted spallation target are present in the latest design
This design allows future developments to reintegrate transmutation.

The ESS Facility: a Modular Facility



"The ESS design is rather flexible. It allows using the facility for other purposes. A number of these ***would not require major new facilities and can be added later*** *if the site layout allows for the physical space."*

Source: ESS May 2002 Study, Volume III (Technical study)

Are transmutation applications needed at ESS ?

Key components of industrial transmutation

- **Advanced separation technology applied on industrial scale**
  - **needs R&D**
  - **needs a demonstrator**

- **Large industrial facility for transmutation**
  - **needs an ADS demonstrator**

⇦ **Must demonstrate that it solves the nuclear waste management problems and do not displace the problem from one to another**

Major implications of a reprocessing industry

Waste management

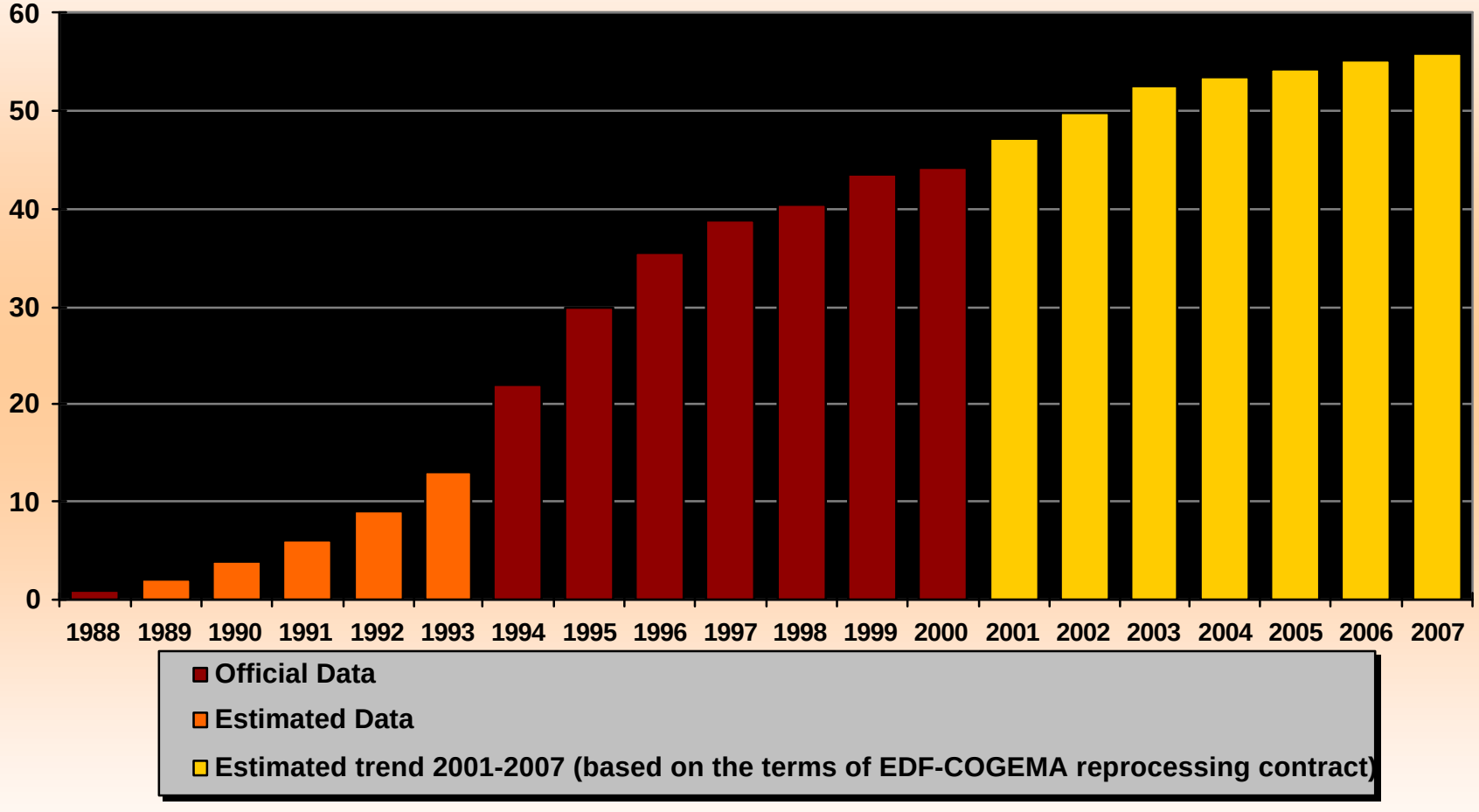
- **Countries that engaged into reprocessing encountered major problems in waste management**

- **Separation leads to arising of byproducts with no use, and create new waste management difficulties:**
  - **arising of plutonium (even if partially used)**
  - **arising of uranium (even if partially used)**
  - **create needs to manage very radioactive and hot waste (HLW)**
  - **create secondary waste (ILW, LLW) to be managed.**

⇦ **Reprocessing industry has not demonstrated its capacity to solve nuclear waste management problems**

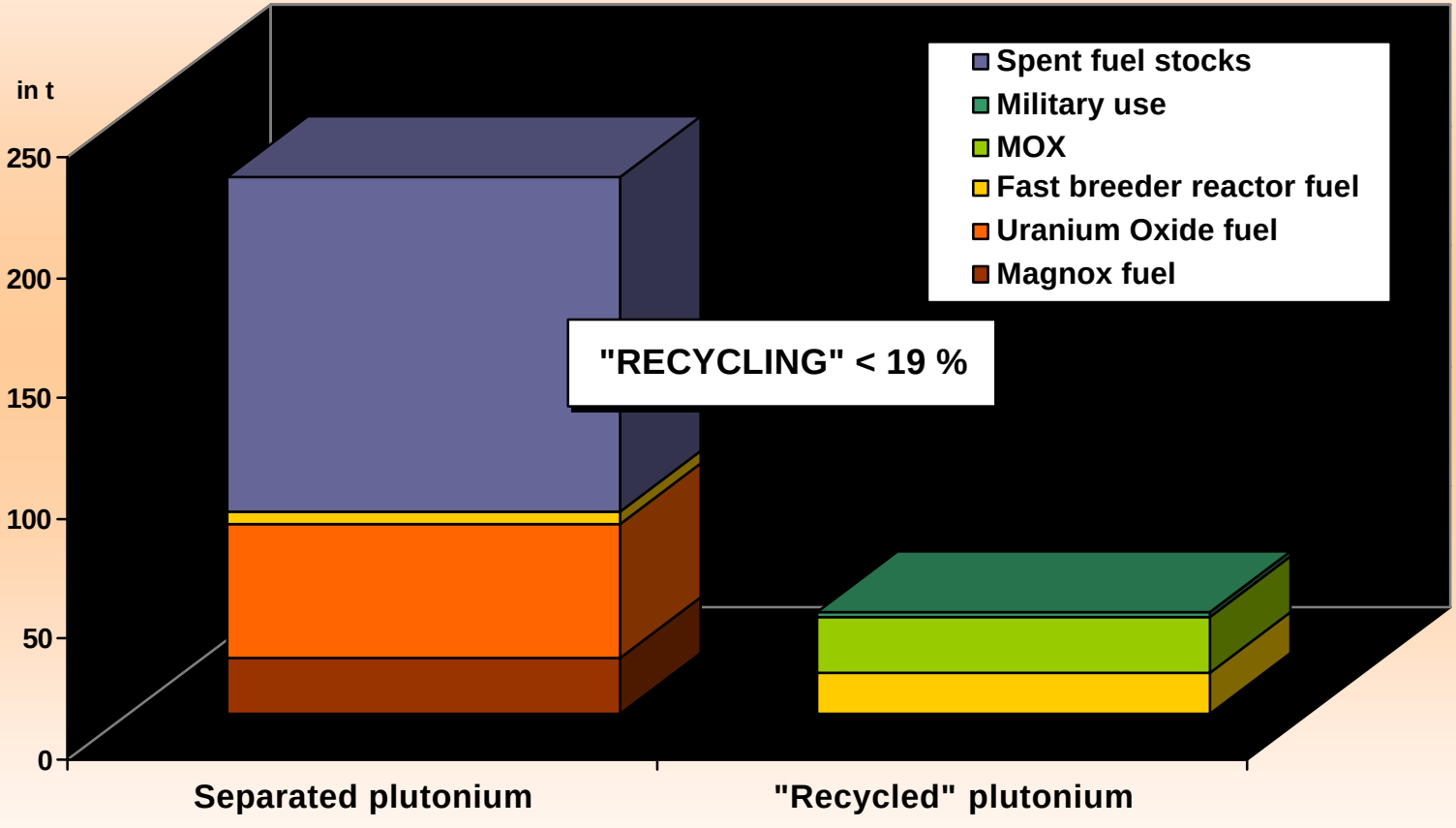
Historical and Projected French Separated Plutonium Stockpile

from 1988 to 2007 (as of 31 December of the year, in tons)



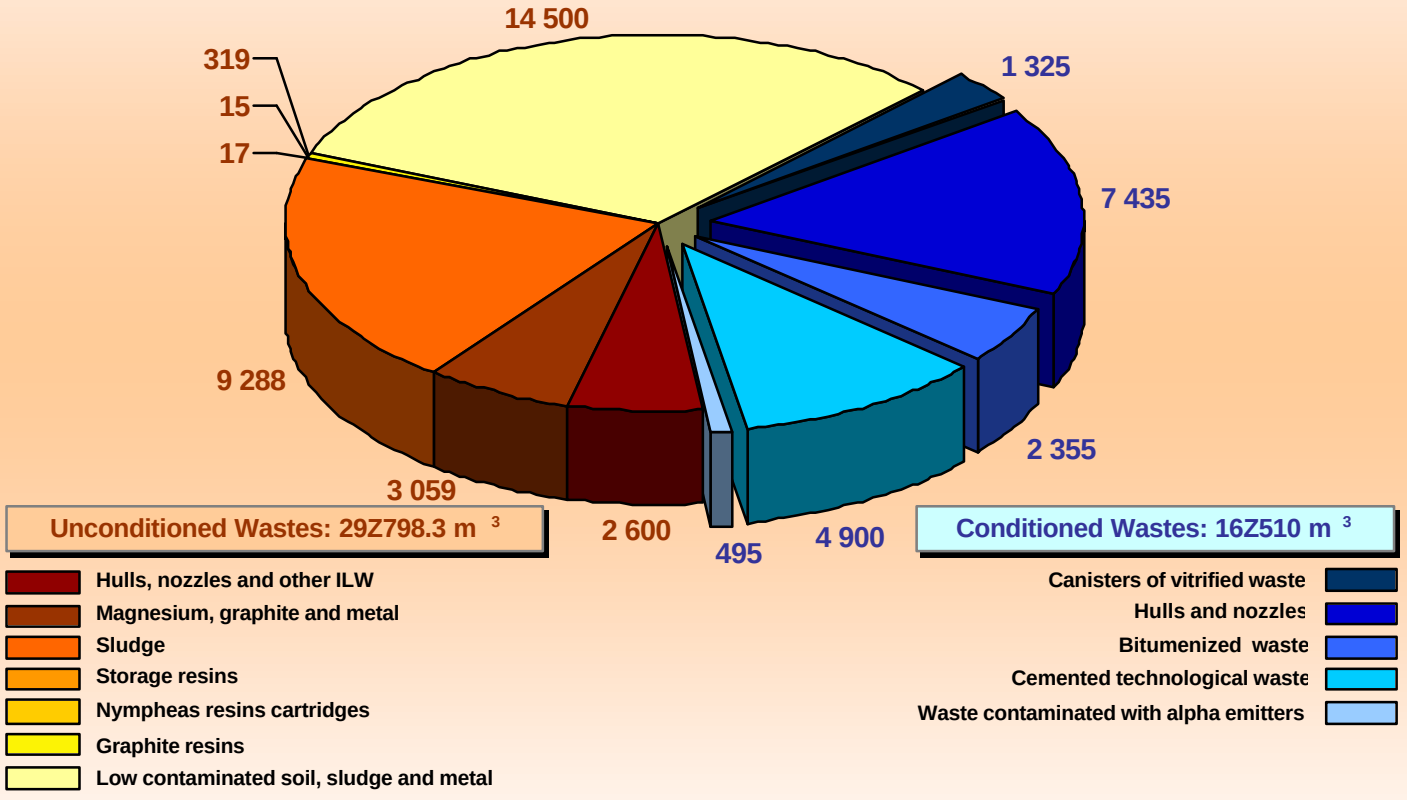
Source: EDF, MINEFI , COGEMA, IAEA

"Recycling" Rate of French Plutonium Contained in Spent Fuels Discharged
from 1956 to 1998



Source: WISE-Paris, "Recyclage des matières nucléaires - Mythes ou réalités", May 2000

Conditioned and Unconditioned Wastes at La Hague
as of 31 December 1999 (in m3)



Source: WISE-Paris, "Possible Toxic Effects From the Nuclear Reprocessing Plants at Sellafield (UK) and Cap La Hague (France)", EP/STOA, 10/2001

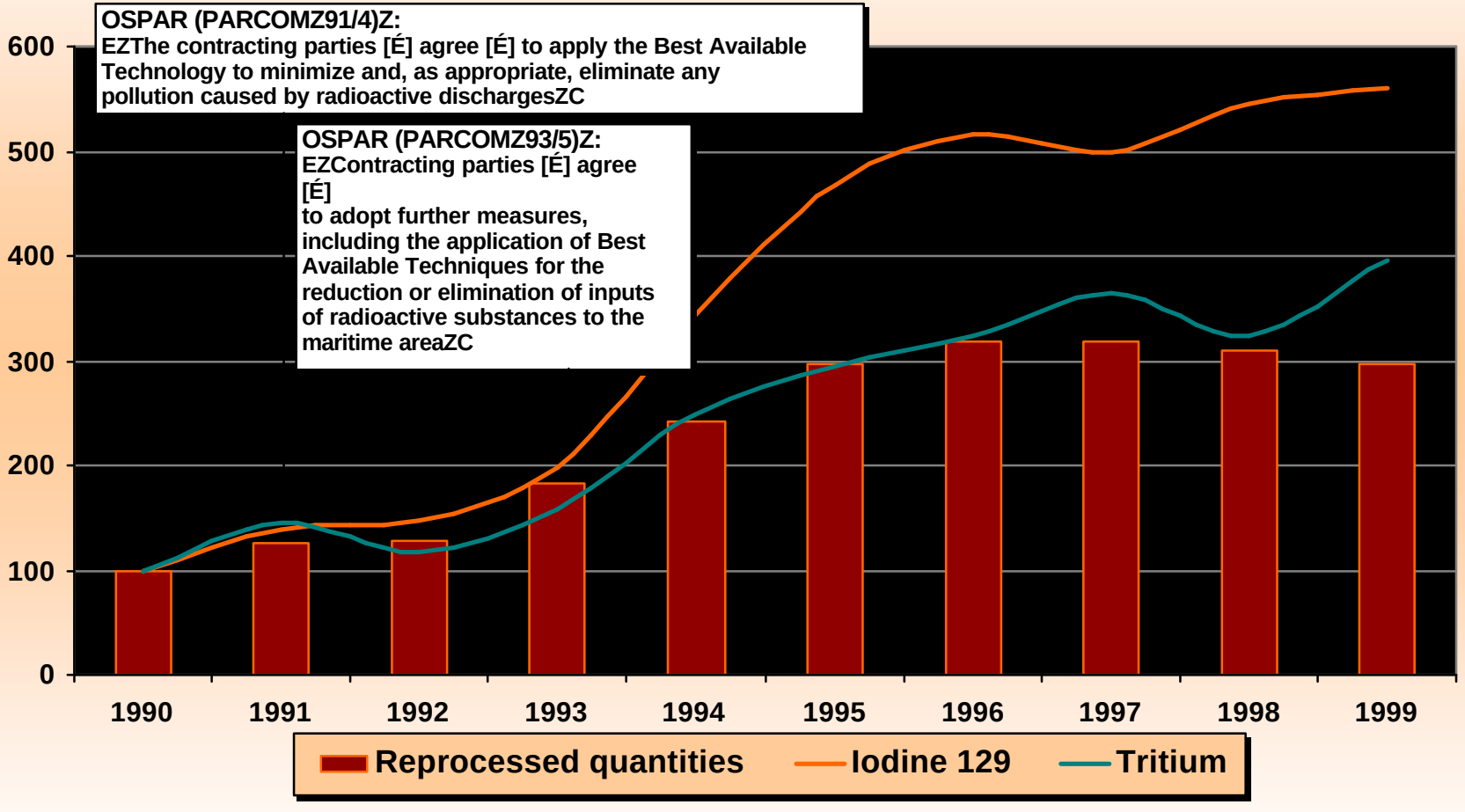
Major implications of a reprocessing industry

Environment and population protection

- **Reprocessing produces large amounts of liquid and aerial radioactive releases in the biosphere, which impacts cannot be ignored**
- **Waste production has been engaged before waste management, resulting in waste stockpiling and increased radioprotection and safety problems**
- **Reprocessing means transports of separated products and waste, it results in an increase of radioprotection, safety and security risks**

⇦ **Reprocessing of spent fuel, i.e. the separation industry, results in more radioprotection, safety and security problems than its direct disposal**

La Hague liquid discharges
from 1990 to 1999 (index 100 in 1990)



Source: WISE-Paris, "Possible Toxic Effects From the Nuclear Reprocessing Plants at Sellafield (UK) and Cap La Hague (France)", EP/STOA, 10/2001

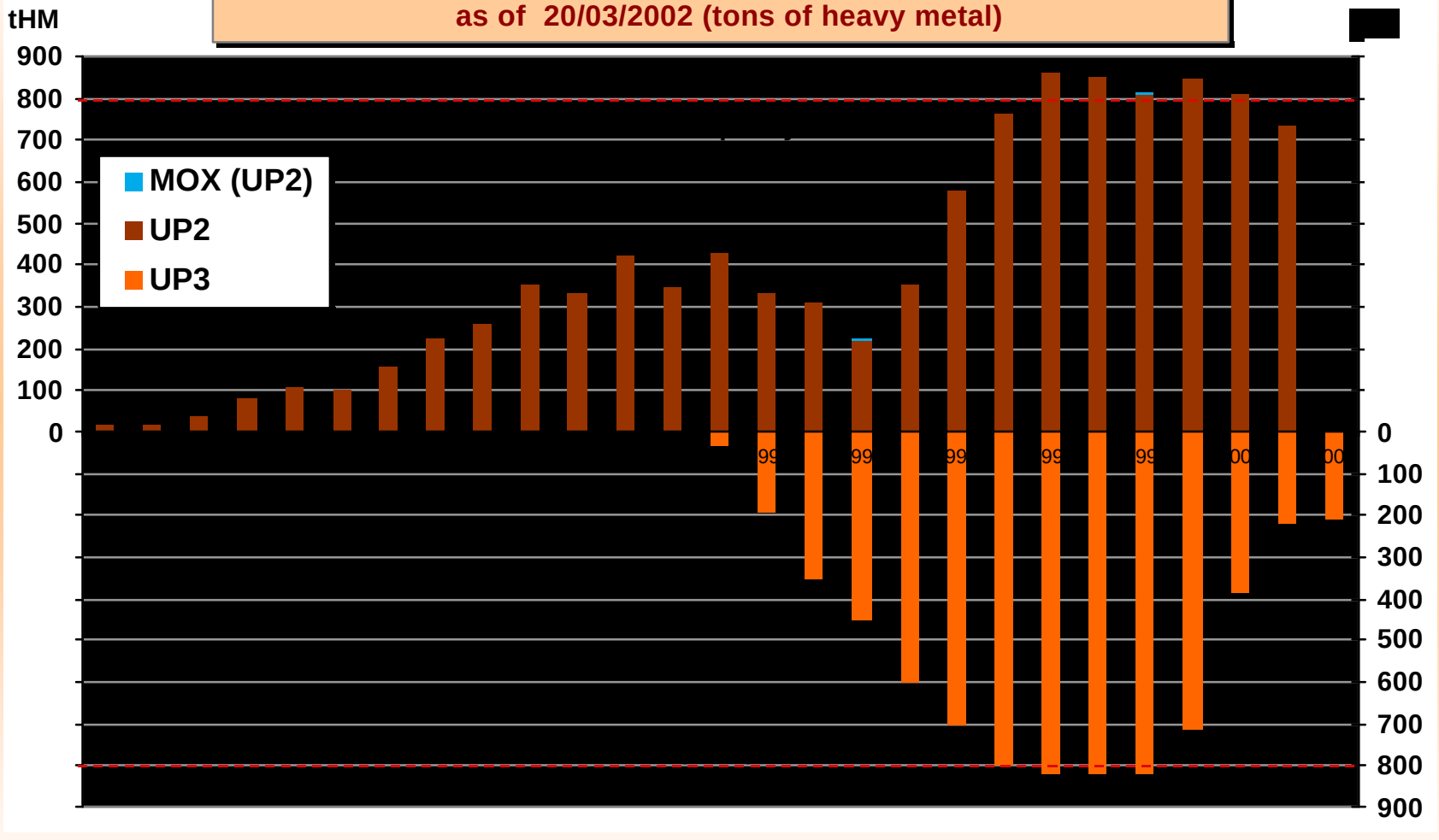
Is there a roadmap to transmutation?

Present reprocessing situation and possible future transmutation

- Only countries that have reprocessing industries keep a major interest in pursuing separation activities and R&D
- Other European countries are either engaged in a phase out process or considering the decision to stop reprocessing
- Before going further into a transmutation program, reprocessing countries should first set up a realistic waste management program
- Actinides and fission products are currently processed into vitrified waste, which the reprocessing industry regards as a final waste under an non-retrievable form

⇦ Transmutation programs need high level financing before being able to operate on a small industrial scale
It will take decades to develop and will only serve the interests of a few countries to keep their reprocessing industry alive

Annually Reprocessed LWR Spent Fuel at La Hague Plants
as of 20/03/2002 (tons of heavy metal)



Source: COGEMA 2002

Conclusion

There is no demonstration of the need for transmutation

- **US studies show that P&T is not suitable as a nuclear waste management option**
  Estimated time scale and costs are tremendous and P&T will not avoid disposal program and facilities

- **In Europe, reprocessing hasn't demonstrated it could be a complete, safe and acceptable waste management option**
  Pursuing in the P&T strategy is less a real goal than a way of keeping the reprocessing industry alive

⇦ **Pressures in favour of P&T programs should not be considered as an opportunity for the ESS project to be grounded**