INTRODUCING A NEW FUEL IN EDF REACTORS : MAIN ISSUES

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Outline

1. IN-CORE OPERATIONAL FEEDBACK ON A SUFFICIENT SCALE
2. COHERENCE OF THE NUCLEAR FUEL CYCLE : ISSUES TO BE SYSTEMATICALLY ADDRESSED
3. MIXED CORES : ANOTHER CRITICAL ISSUE
4. CONCLUSION

1. In-core operational feedback on a sufficient scale

- ✓ Fuel robustness and reliability are compulsory requests prior to the industrial use of a new fuel design

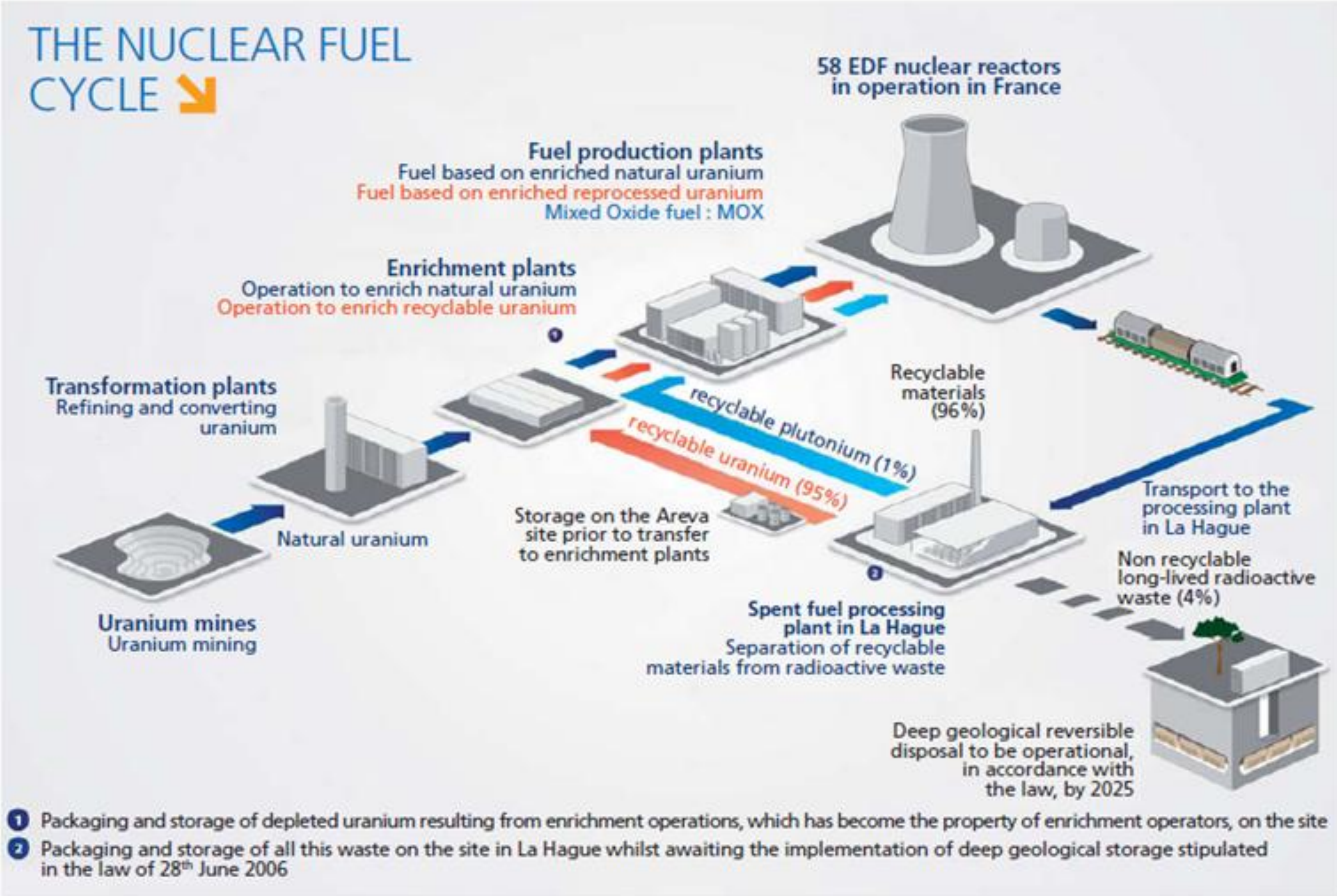
- ✓ Once all possible experimental results have been obtained for a given fuel design, in-core qualification is necessary.
  It involves several steps to gather the relevant operational feedback on robustness and reliability ***at minimum risk***
  - For a major fuel design evolution, the in-core qualification process is a long one :
    - Irradiation of a few LTA's during a number of operating cycles greater than what would be needed on an industrial scale, with specific exams and rod extractions at the end of each fuel cycle ➔ ~5 to 6 years
    - Loading whole reloads with the new fuel design in a dedicated reactor :

      especially necessary if the new fuel design is associated to a new structure design : only a full core with the new design will enable to check the behavior of that fuel with respect to GTRF and assembly bow

      ➔ ~another 5 to 6 years

The whole in-core qualification process might need more than ~10 years

2. Coherence of the Nuclear Fuel Cycle for EDF (1/3)



A change in the fuel design might necessitate an adaptation of that industrial system…

… but whatever the fuel, the coherence of the fuel cycle must be ensured.

2. Cycle coherence : issues to address whenever a change in fuel design is planned on an industrial level (2/3)

The feasibility of a new fuel design needs to be assessed for each step of the fuel cycle

✓ Fuel fabrication :

- Can the fuel be fabricated at an industrial scale, and without any potential drawbacks affecting the fuel robustness ?

  ➔ impact of pellet additives … or of a new Zr-alloy cladding, a ceramic cladding, an alternate fuel geometry : all these changes can represent fabrication challenges !...

✓ Logistics

- Can fresh / spent fuel be transported in compliance with the regulatory requirements and shipping cask approvals ? Same question for recycled fuel (ERU, MOX)
- Are buffer storage capacities sufficient ?
  - Safe and sufficient interim storage for spent fuel (at the reactors' sites and in the processing plant at La Hague), for vitrified waste and for reprocessed uranium at La Hague

✓ Spent fuel processing at La Hague

- Are La Hague technical instructions and expected performance compatible with the characteristics of the spent fuel to be processed ?

2. Cycle coherence : issues to address whenever a change in fuel design is planned on an industrial level (3/3)

- ✓ Industrial feasibility of recycling reprocessed materials (Uranium and Plutonium)
  - Can Uranium and Plutonium obtained from spent fuel processing at La Hague be recycled in EDF plants, considering the reactors safety limitations ?
  - Are cycle installations compatible with the reprocessed materials characteristics ?

    Radiation protection thresholds, thermal outputs, safety criteria, effluents… need to be checked, especially for La Hague, MELOX and ERU fuel manufacturing plants
- ✓ Final waste
  - Will final waste be compatible with long –term deep geological disposal?

    Volume of High Activity vitrified waste delivered by La Hague

3. Mixed cores : another critical issue

✓ Entering a new fuel design necessitates the justification of mixed cores combining the former fuel design and the new one

- That justification is all the more important - and difficult - that the new fuel design is significantly different

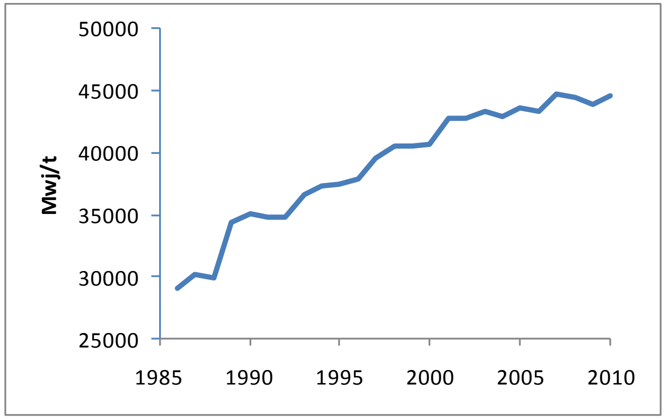
  ➔ That might particularly be the case if the new fuel design has very different geometric characteristics…

  (It can be noted that just introducing IFM's would represent a major evolution for EDF with respect to mixed cores issues)

- If the justification of mixed cores is not possible for the selected design, the ultimate solution would be to entirely discharge the core and reload it with the new design only

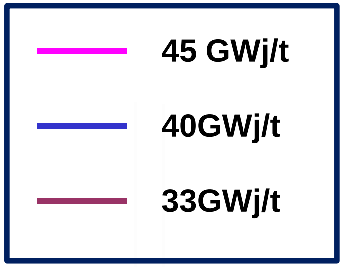
  ➔ That very costy fuel change would hardly be economically justified.. unless maybe if the reactor duration life were at stake.

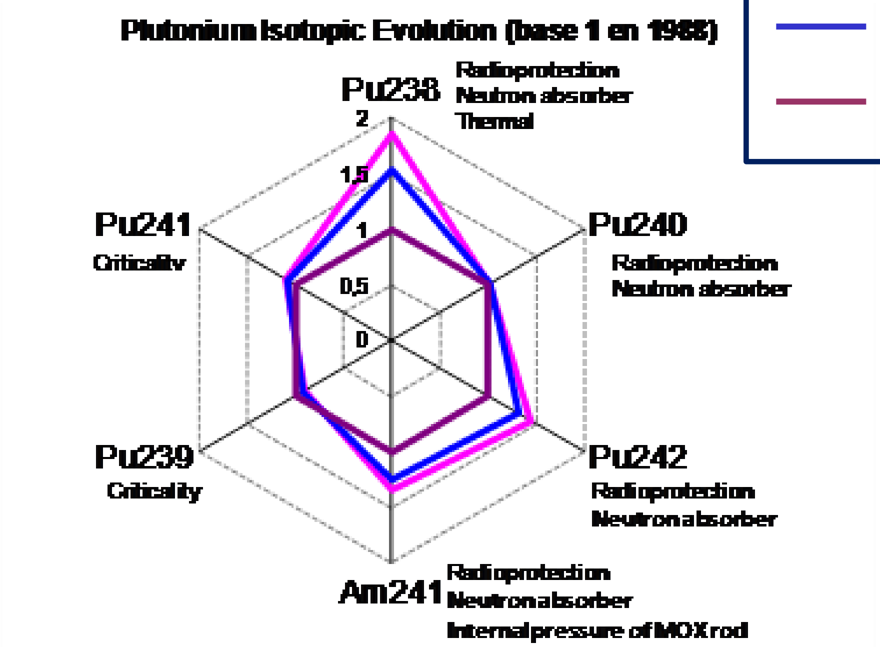
Change in reactor management and impact on the characteristics of recyclable materials

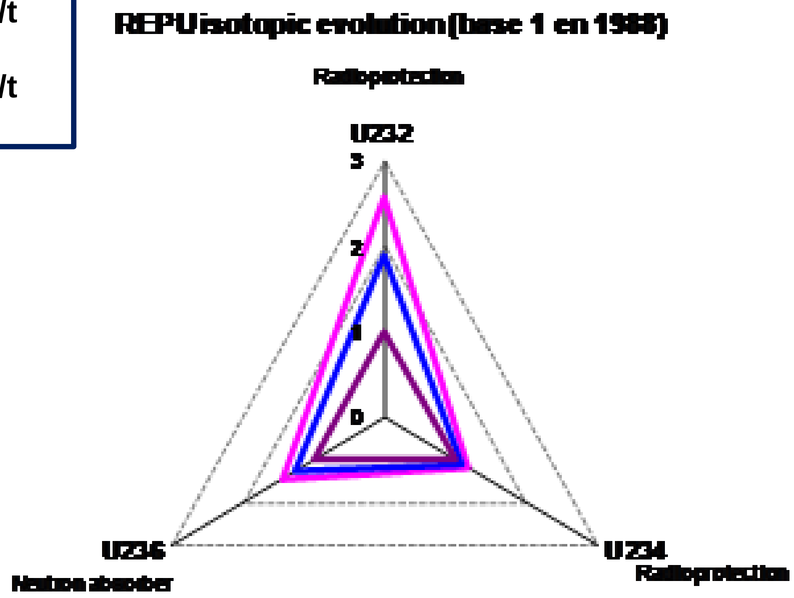


Like most nuclear operators, EDF has increased the average fuel discharge burnup from ~ 33 GWd/t in the nineties to ~45 GWd/t today, while achieving an overall increase in operating cycle lengths by simultaneously increasing enrichment with uranium 235

➔ Changes in the quality of recyclable materials







Adaptations to be implemented to manage the changes in Pu isotopic quality

TN112 container for spent fuel transport

Extension of the approval to manage the increase in Pu content

The Hague – Processing spent fuel

EDF reactors

Increase the plutonium content of MOX used in reactors (Submission of MOX NT2012 file)

Adaptation of the transport container to accomodate the increase in thermal output

FS47 container for Plutonium

Extension of the approval to manage the increase in Pu content

Operational improvements and potential sources minimization, such as the reduction in volume of certain waste to limit the dose impact

MX8 container for MOX fresh fuel transport

MELOX – MOX fuel assemblies fabrication

Done

Planned

Conclusion

- ✓ Time-scales are unusually long in the nuclear industry
  - ❖ The fuel stays several years in the reactor, and that contributes to a very long qualification process for a new type of fuel, especially if a new type of structure is also considered
  - ❖ On an even larger scale, the nuclear fuel cycle has to be considered to ensure :
    - Either that all current specifications are met
    - Or that the needed changes and associated investments (new type of shipping cask,…) have been anticipated

- ✓ EDF feedback illustrates that main fuel design evolutions have needed a lot of time to be industrially implemented.

- ✓ However, depending on the remaining life duration of the reactors, it might be worth considering a breakthrough technology for PWRs if the safety margins are significantly improved.