Sustainable Fuel Cycle: Regulatory Framework to Support Options to Address Used Fuel in the US

Back-End of the Fuel Cycle/Spent Fuel Issues

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Summary

- To support nuclear growth in US, we need an integrated used fuel management (UNF) strategy, including recycling and disposal
- Need regulatory framework(s) to address all practicable approaches to meet this strategy
- Implementation responsibility transferred to a new, commercially focused organization (FedCorp)
- Nuclear industry cannot wait for transformational solutions from the government to manage UNF
- A "Two Step" recycling approach is proposed: Start recycling in existing reactors (with MOX) and evolve towards Fast Reactors when ready
  - Initial 800tHM/y "Pilot" facility producing LWR MOX, as a first step towards closing the fuel cycle in the US
- A progressive / regional deployment is recommended
- Concerns such as non-proliferation and economics associated with recycling can be appropriately addressed but need regulatory stability

Enablers/Drivers of a "Two-Step" Approach

- **Long Term Storage of Significant Quantity of UNF in the U.S.**
  - **Used Fuel Pool storage space tight**
  - **Dry Storage not inexpensive, potential for long-term issues, orphaned sites, & "interim"**
- **Security of UNF**
  - **UNF is considered self protecting if the >100 rem/hr at 1m from UNF**
  - **Some of current UNF stockpile approaching or has fallen below this limit**
  - **Limit may be adjusted upwards to 250, 500, 1000 or 10,000 rem/hr**
- **Stabilizes/Reduces Total Inventory of Pu in Fuel Cycle**
  - **LWR with ~30% MOX core consumes about as much Pu as it produces**
  - **Reduces Pu & U in final repository**
- **Final Repository "Starting Over"**
  - **Opportunity to provide uniform, stable, durable HLW forms**
  - **Optimization of volume/densification of stored waste**
- **MOX Fuel Fabrication Facility Experience**
  - **NRC Issued Final SER in 2010 (10CFR70)**
  - **Includes aqueous separations and MOX fuel fabrication processes**

Nuclear Generating Infrastructure

- **No market driver to move away from existing LWR infrastructure for the foreseeable future**
- **Gen IV reactors are 50 years away from deployment**
  - **R&D infrastructure costs ~$4B**
  - **R&D ~$B**
  - **Cost of reactor > existing LWRs**
- **As interim step propose management of products from recycling in existing LWRs**
- **Transition to new fuel cycle over a long period of time**

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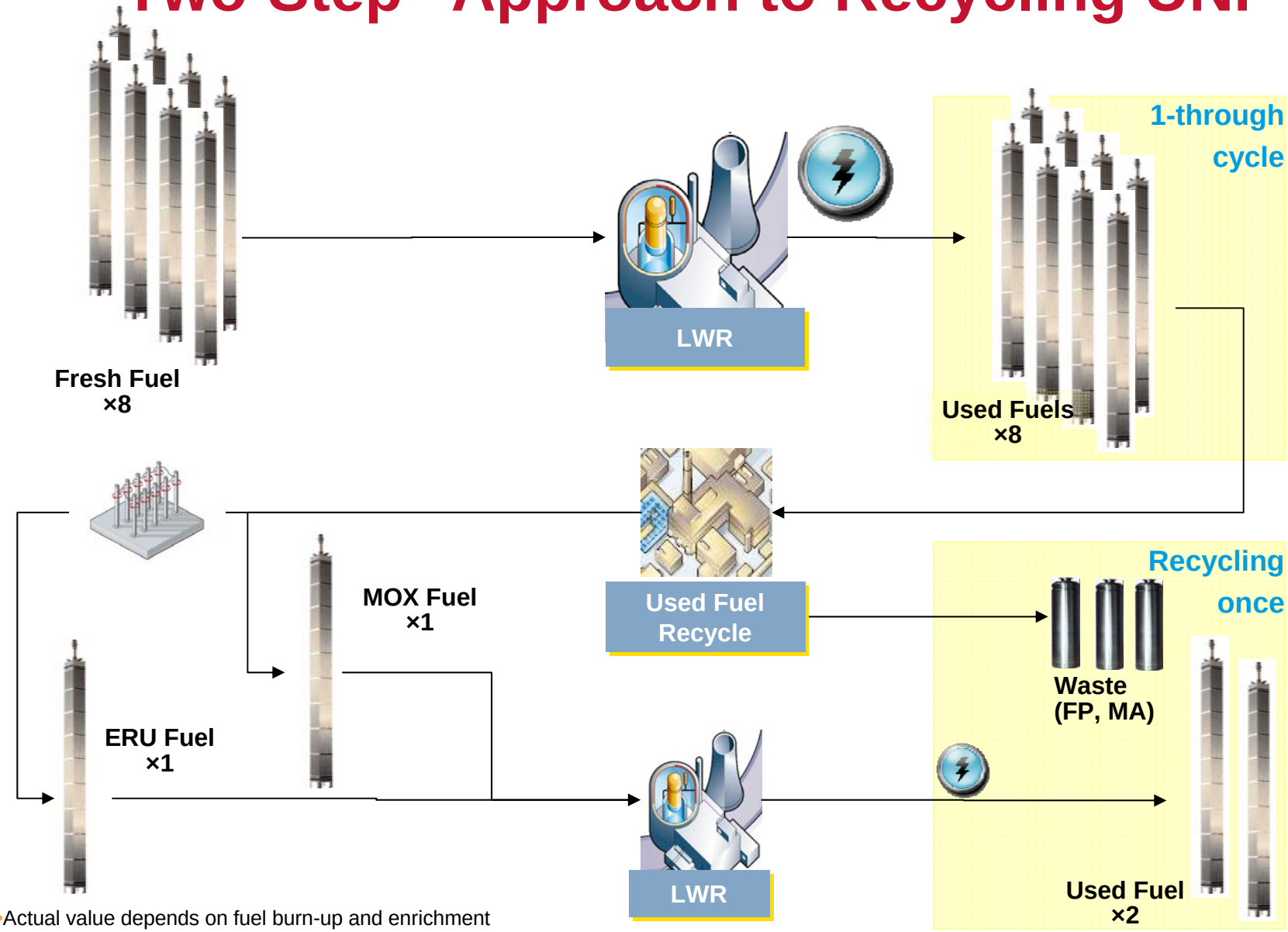
"Two-Step" Approach to Recycling UNF



•Actual value depends on fuel burn-up and enrichment

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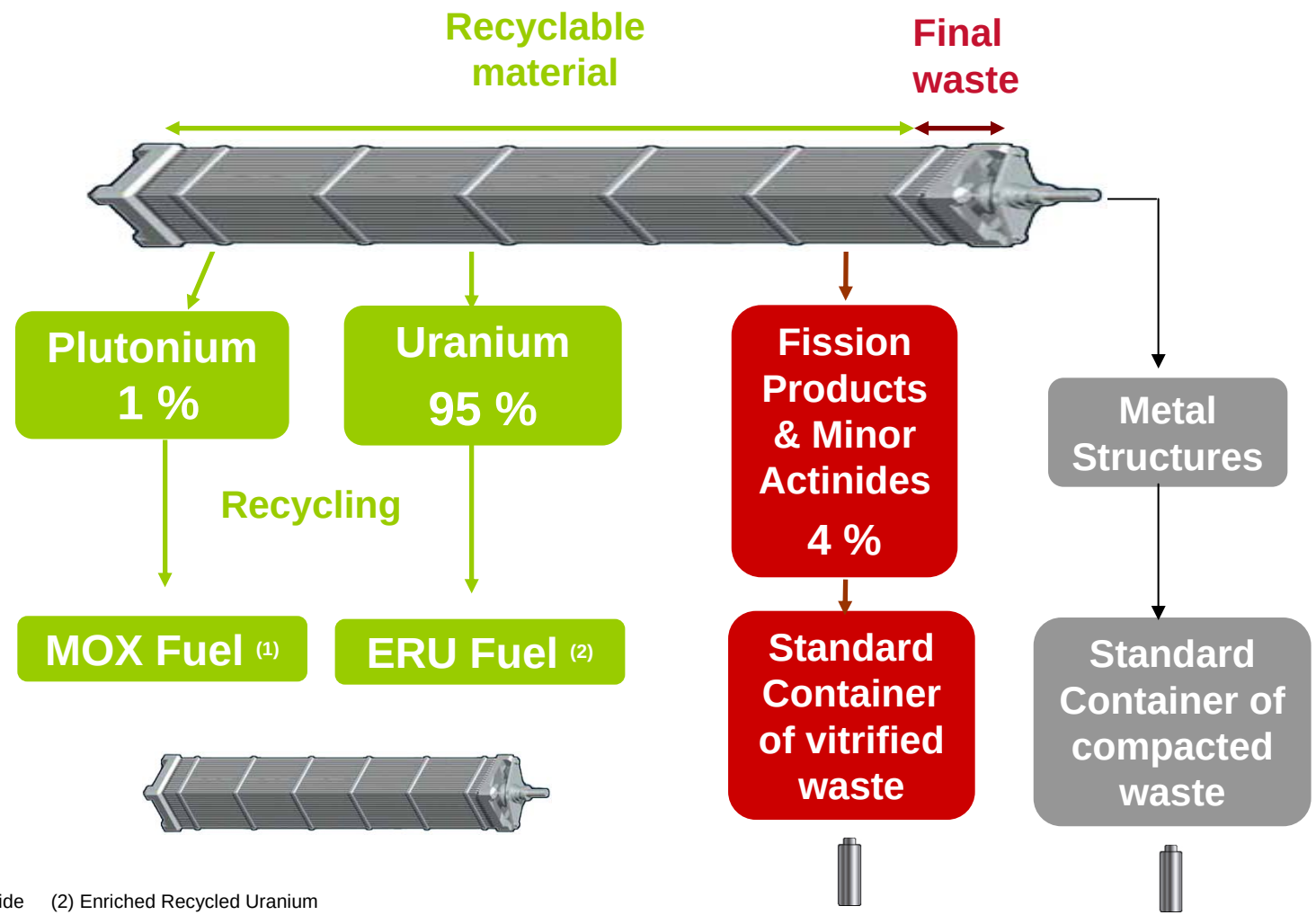
96% of the Content of Used Nuclear Fuel is Recyclable

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



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

Initial Facility

- **Balanced fuel cycle**
  - **Recycling capacity matched to product demand**
- **Propose an initial "*Pilot*" 800 tHM/y capacity plant that builds on best available technology to minimize risk**
  - **COEX™ Separations process proposed with "NO" separated Pu**
  - **Manage product using existing nuclear infrastructure while DOE develops Gen IV Reactor (50 plus years for first commercial Unit.)**
- **LWR MOX is therefore an "*interim*" step for closing the cycle**
- **Pilot Facility could supply fuel to:**
  - **Limited number of existing LWR's or**
  - **~4 Gen III+ reactors or**
  - **500 MWe SFR**

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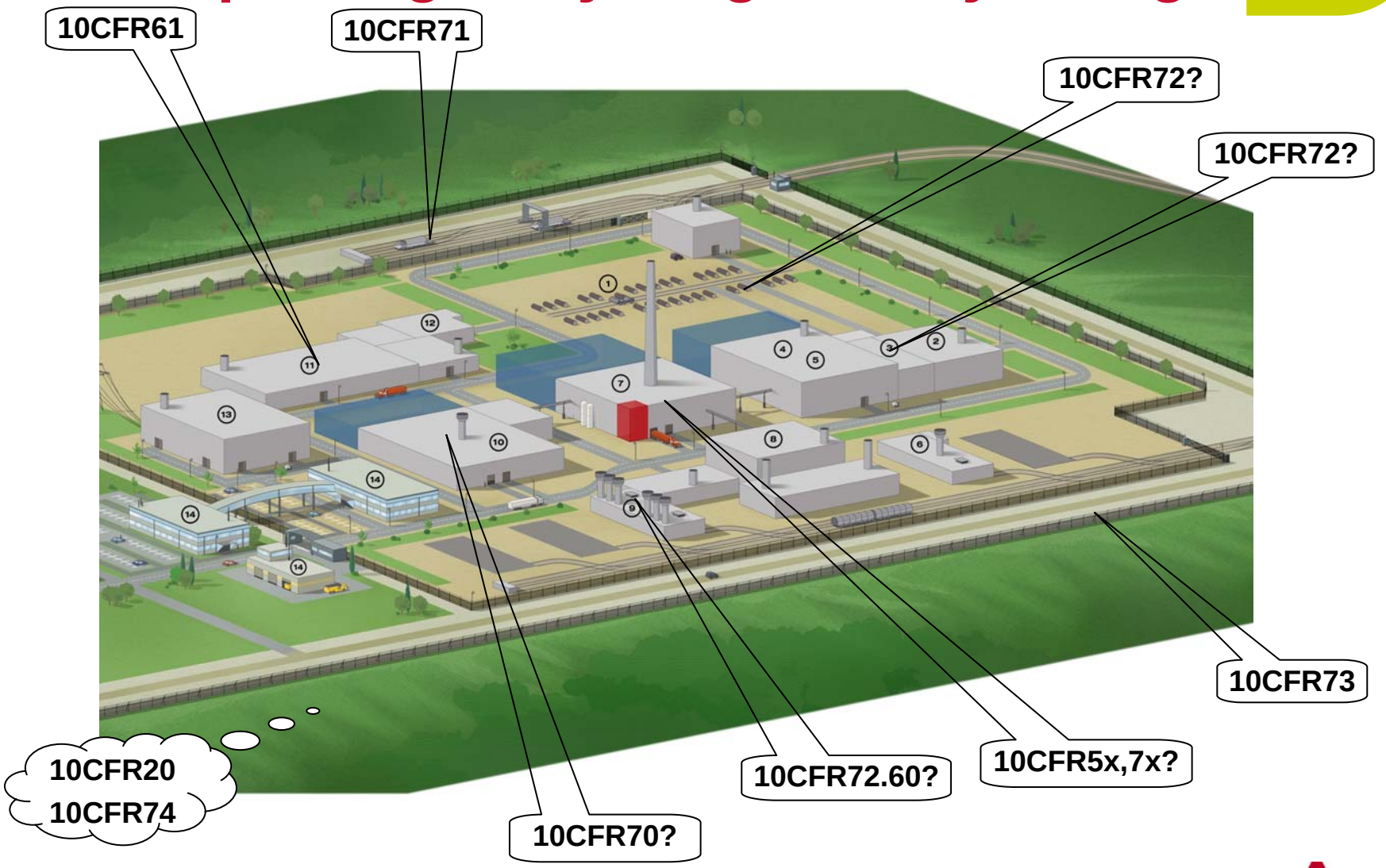
Some of the NRC Regulations Potentially Impacting Recycling Facility Design



Regulatory Framework Needed to Support Recycling (et al.) Option: All in Flux?

- **Regulation for Recycling Facility (10CFR5x/7x)**
  - **New regulation or revision to existing regulations (e.g., 10CFR70)**
  - **One-step licensing option like reactor COL process**
  - **Issued by 2015 to support construction (2020) & operating (2030) schedules**
- **Other Significant Regulations Impacting Recycling Facility**
  - **10CFR61 – low level waste classification (risk basing, WIR clarification)**
  - **10CFR60/63 – HLW & UNF repository (waste form/package, retrievability)**
  - **10CFR72 – ISFSI for recycling facility (independent storage of HLW)**
  - **10CFR73 – protection (self-protection, attractiveness levels)**
  - **10CFR74 – MC&A (removal of Category I exemption, attractiveness levels)**
  - **40CFR190 – Env. Rad. Protection Standards (limits for Kr-85 & I-129)**

For the Recycling Option:

- **Need Regulatory Structure and Stability to Effectively and Efficiently:**
  - **Design a Recycling Facility**
  - **Tailor Waste Streams for Disposal**
  - **Make an Economically Viable Case**
  - **License a Recycling Facility**

Something to Stare at… Questions?

Backup Slides

Recycling Optimizes Solid Waste Management

- **Recycling provides final waste volume and heat load reductions that can reduce repository size by 75%**
  - **Geological repository still required**
- **Low level waste volumes are minimized by industrial practices (e.g., recycling liquid waste)**
  - **Recycling adds only 2-5% to the volume of LLW produced by commercial nuclear activities in the U.S.**
- **Reduced radioactivity of waste**
- **Robust, standardized waste forms (e.g., vitrified waste)**

Recycling is complementary to geological disposal providing flexibility in timing of final repository

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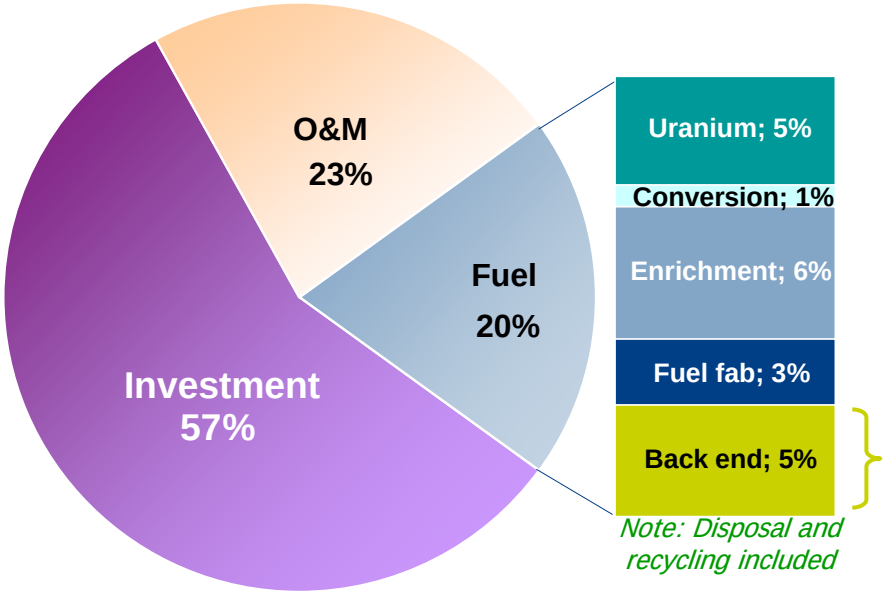
Economic Aspects of Recycling

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 a small fraction 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***"