Economic Feasibility of Closing the Nuclear Fuel Cycle

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UxC – The Ux Consulting Company

- **Industry leader in nuclear power and nuclear fuel market analysis**
- **Provides nuclear power and fuel consulting and market information services to suppliers, utilities, investors, and government agencies internationally**
- **Three major lines of business**
  - Nuclear fuel cycle consulting
    - Front & back-end
    - Nuclear power & electricity markets
  - Publishing industry market reports
  - Data services
- **Launched uranium futures contract with CME/NYMEX in May 2007**

Presentation Outline

- **Introduction: RepU & MOX as a category of secondary supplies**
- **Key argument in favor of recycling**
- **National policies related to reprocessing & recycling**
- **Economics of recycling**
  - Current state of the nuclear fuel markets
  - Costs of recycling
- **UxC RepU / MOX forecasts to 2030**
- **Key takeaways**
- **Discussion**

Current Role and Key Drivers for Use of MOX & RepU

- **MOX and RepU play an important, but a relatively minor role**
  - UxC estimates displacement of ~10 million lbs U3O8e in 2016
  - ~6% of global reactor requirements
- **Initial interest in recycling was driven in large part by uncertainty regarding world uranium reserves**
  - This concern is no longer valid
  - Total identified U resources recoverable at cost of <US$130/kgU are 5.72 million tU
- **Main argument in favor of reprocessing & recycling today is management of spent fuel**
  - To reduce total volume of waste & increase repository capacity

National Policies for Reprocessing and Recycling

- **Different motivations to recycle: political, strategic, & economic**
  - Can be difficult to separate
- **Existence of nuclear power program necessitates policy for handling spent fuel**
  - Once-through (open) / closed / “wait and see”
  - Large nuclear power programs incentivize closed fuel cycle (U.S. the exception)
  - Reprocess yourself or overseas reprocessing
  - Policies haven’t been constant

Economics of Recycling

- **(National policy permitting), utility's first decision is whether to reprocess or not**
  - Historically, reprocessing has been expensive with increasing costs
- **Once reprocessed, owner of RepU / Pu has choices:**
  - Recycle (costs for processing into fuel)
  - Store as a valuable resource (storage costs)
  - Dispose of (disposal costs)
- **Global inventory of RepU / Pu are increasing**
  - Reprocessing has generally exceeded recycling
  - Ex. France's EDF is a holder of large inventory of RepU
- **Assessing the economics of recycling:**
  - *Is complex, but to simplify (if you own a stockpile) comes down to comparing the cost of fresh fuel from NU + storage of RepU vs. the cost of manufacturing fuel from RepU*
- **Key to understanding the limited use of MOX and ERU today is recognizing the challenge presented by the competing front-end markets**

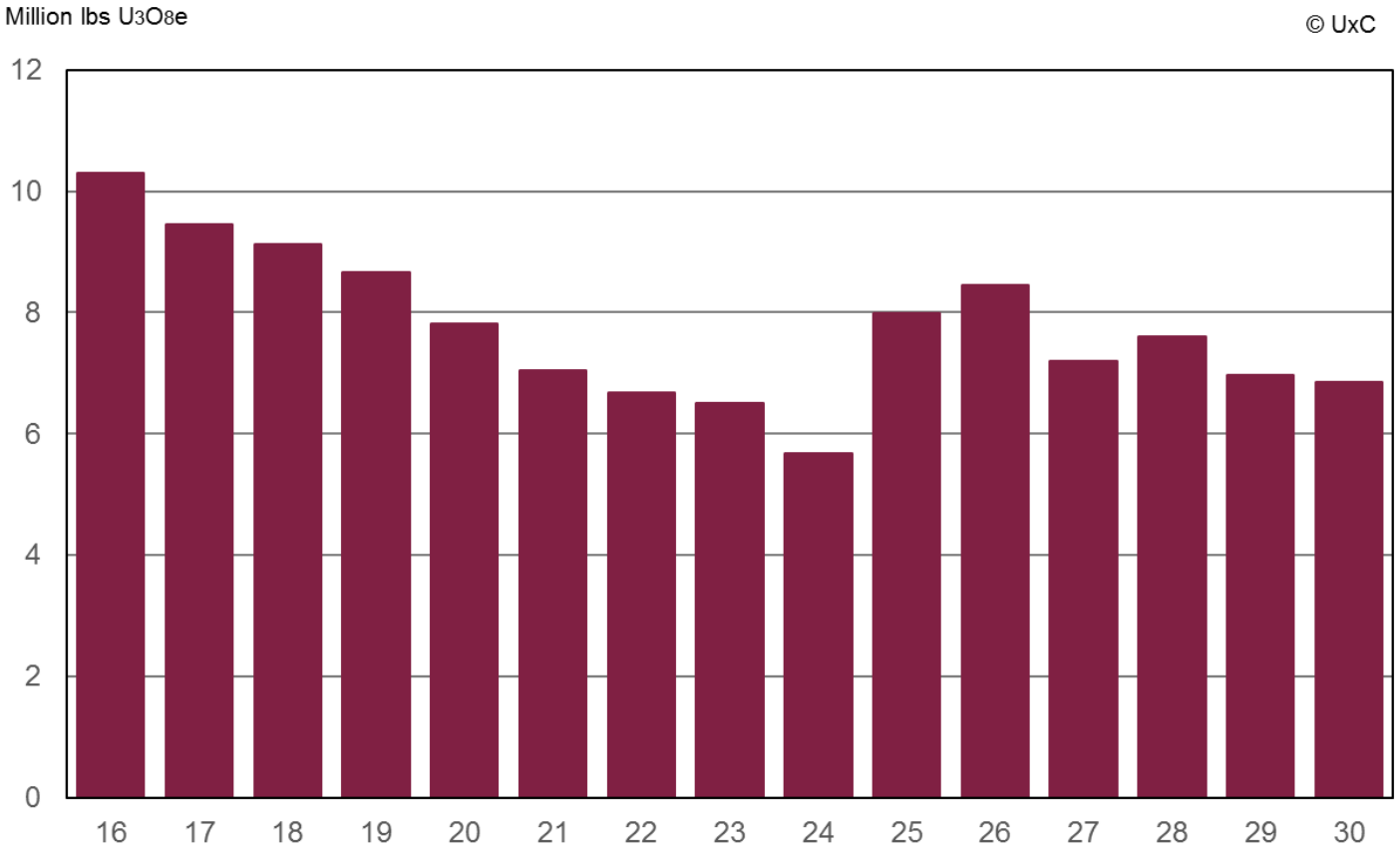
Nuclear Fuel Markets Today

- **Last surge of interest in recycling, mid-2000s when market prices spiked**
- **My message from ATOMEXPO 2016 presentation:**
  - Uranium market is in a state of oversupply with slow supply response
  - The conversion market balance is tight, supply prone to disruption; but any shortfall in primary supplies would be handled from inventories
  - Enrichment market remains in substantial oversupply situation for at least the next decade
- **Generally remain valid today; although some supply response in uranium, conversion, & enrichment industries**
  - Including from suppliers previously considered to nonresponsive to market signals
- **From the utility perspective, this continues to be a buyer's market with plentiful cheap fuel for the foreseeable future**

Costs of Recycling

- **Evaluating the costs of the recycling option is challenging**
- **Use is restrained by the shortage of needed dedicated processing facilities**
  - Conversion to UF6 as the bottleneck
  - Cancellation of dedicated enrichment capacity to re-enrichment
- **Absence of international market for RepU/ERU**
  - No market price for RepU; utilities have no interest in consuming RepU belonging to others
  - Must be substantially discounted compared to ENU; discount varies
- **Increased political and public opposition**
- **Not easy to compare to the costs of procuring fresh fuel**

UxC Base Case MOX & RepU Utilization Forecast, 2016-2030



UxC Base Case MOX & RepU Utilization Forecast, 2016-2030

- **Forecasts reflect the current state of the market**
  - Can change if new commitments to recycling are confirmed & proven
- **Use of RepU generally decreasing:**
  - Active Western European RepU program has been substantially reduced
  - Russia's RBMK program will see retirement of all units by 2034
  - Limited plans to utilize RepU in China (CANDU)
  - Exception is France – anticipated completion of strategic review – UxC expects utilization of RepU starting ~2025
- **MOX**
  - Uncertain future of once-promising program in Japan
  - Limited current plans for utilization in Russia
  - Not anticipated in U.S.

Conclusions & Potential Gamechangers

- **The purely economic case for reprocessing & recycling today is not encouraging**
- **Other reasons – national policy / strategic – may prove to be the deciding factor**
- **Potential gamechanger – advanced reprocessing options**
  - These would involve no separation of Pu and RepU
  - Repeated recycling
  - Yet to be proven technologically and economically feasible
- **Spent fuel take-back and recycling could prove to be attractive options for newcomer nuclear power countries**
- **Some use of recycled products will continue far into the future**
- **Fates of key programs in France, Japan, Russia and China will determine long-term success of recycling**
- **Absent any aforementioned gamechangers, UxC will continue to forecast limited – and decreasing – use of RepU and MOX**

Questions?
Вопросы?

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