

Integrating the Nuclear Fuel Markets

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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

- ▶ **The nuclear fuel cycle – an integrated view**
- ▶ **Current status and outlook for the global nuclear energy market**
- ▶ **The front-end nuclear fuel markets**
 - Status and common trends
- ▶ **The back-end of the nuclear fuel cycle**
- ▶ **Integrating the nuclear power and nuclear fuel markets**
 - Delivering on the nuclear promise
- ▶ **Key takeaways**
- ▶ **Discussion**





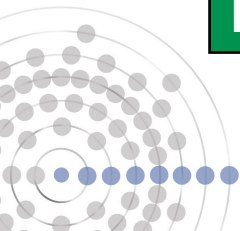
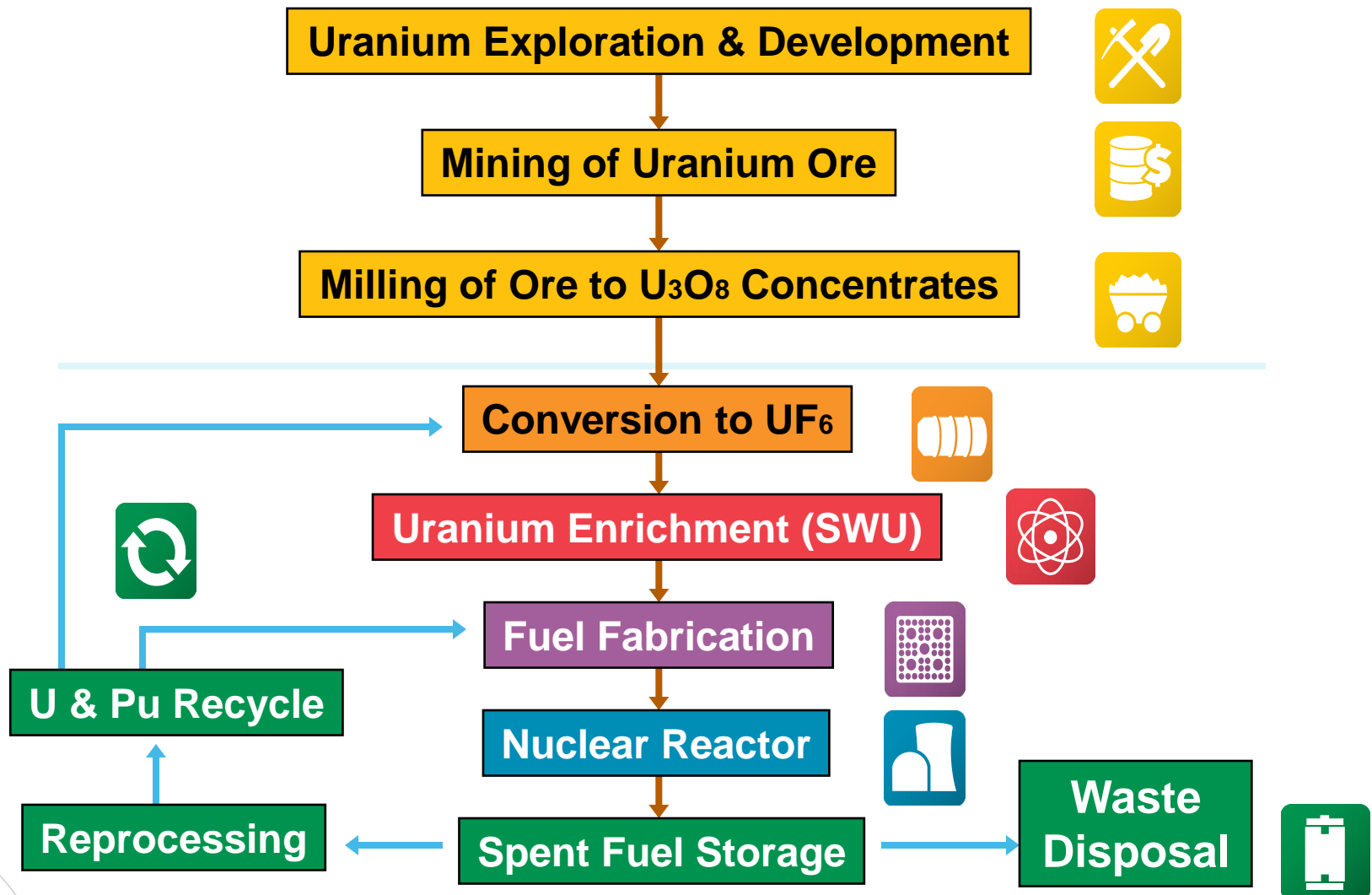
The Nuclear Fuel Cycle

- ▶ **Presents a single flow of nuclear fuel through its lifetime (the front-end, reactors, and back-end)**
- ▶ **Interconnectedness has become more pronounced**
 - Broader energy markets impact the nuclear industry overall
 - Nuclear generation and nuclear fuel markets experiencing a downturn at the same time
 - Front-end nuclear fuel markets have increased interplay
 - Inter-relationship between U3O8 and SWU
 - Bundled fuel procurement
 - Back-end as the “Achilles Heel” of nuclear power?
- ▶ **The interconnectedness of the stages of the nuclear fuel cycle is more evident than ever**



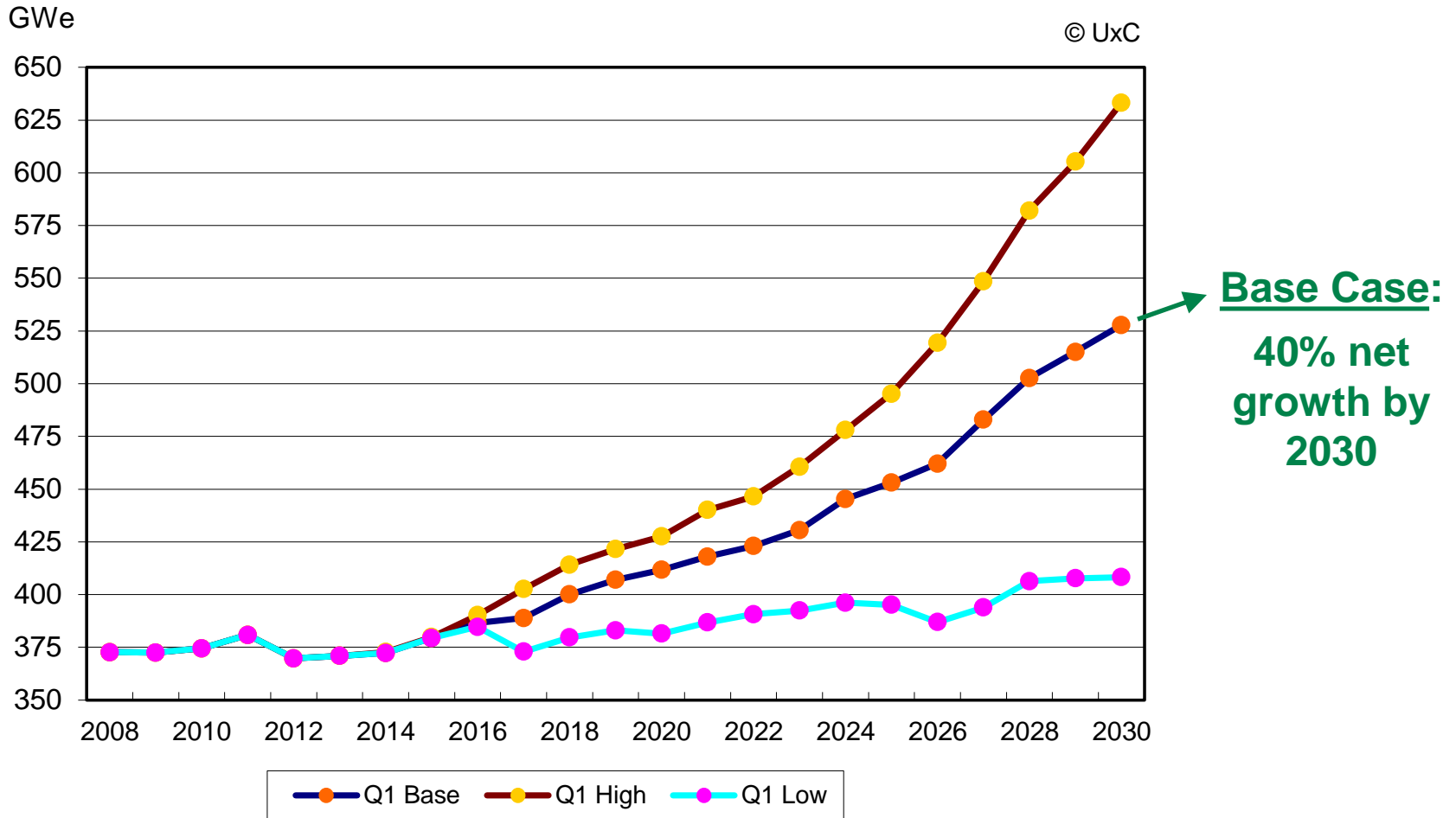


UxC Covers All Fuel Cycle Segments





UxC Nuclear Power Forecasts



Source: UxC Nuclear Power Outlook





Nuclear Power Prospects

- ▶ **Nuclear power remains a critical part of the global energy matrix and all independent forecasts show continued growth in nuclear power**
 - Case in favor of nuclear power remains strong
- ▶ **However, this growth depends on handful of countries**
 - CRIS (China, India, Russia, & South Korea) represent ~66% of all new construction through 2030
 - North America and Western Europe drop in their share of world total: from 60% to 40% of the world total by 2030
- ▶ **The challenges to nuclear power have been mounting (political issues; unfavorable electricity market designs; global energy markets, etc.)**
 - Early closure of a number of reactors (or threat of) and reduced new build
 - Resulting in a precipitous drop in demand
- ▶ **Challenges in the nuclear power sector create downward pressure from the demand side**
 - ...that must be addressed from the supply side in the front-end nuclear fuel markets to strike a new balance





Front-End Nuclear Fuel Markets: Common Trends

- ▶ **Although each segment is unique, there are a number of shared current and future trends:**
 - Lower demand growth
 - Uncertainty over Japanese reactor restarts
 - Excess supplies
 - Shifting nature of China's approach to fuel supply
 - Inventory-driven markets
 - Mid-term market focus
 - Slow supply response
 - Changing nature of secondary supplies
 - Increased influence of government and trade policies
- ▶ **These trends point to the fact that all markets are going through a period of readjustment and rebalancing**





Front-End Nuclear Fuel Markets' Interplay

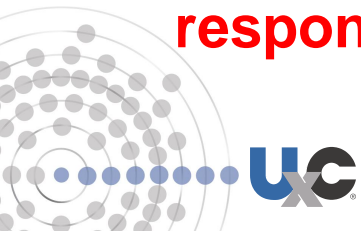
- ▶ **Key trend: interplay between the front-end markets**
- ▶ **Inter-relationship of U3O8 and SWU**
 - Underfeeding & tails re-enrichment (enrichers as uranium “producers”)
 - Enrichers as producers of EUP inventory
- ▶ **Increased procurement of bundled fuel**
 - UF6, EUP, integrated fuel assemblies
 - Supplier response: strategic marketing alliances





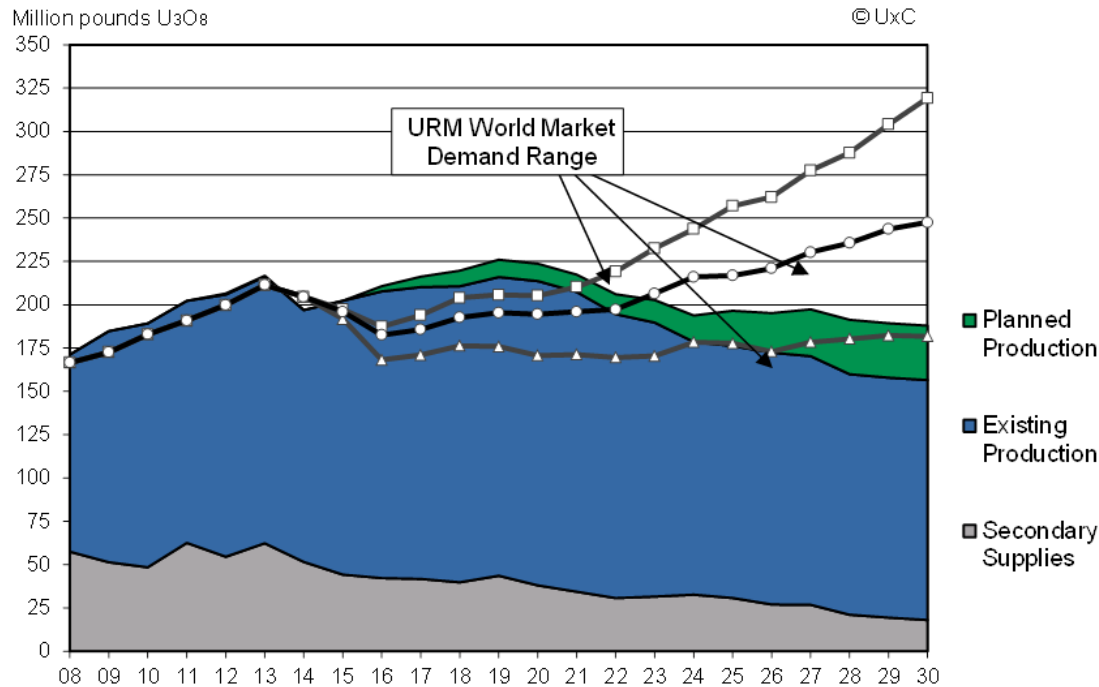
Uranium Market Status & Outlook

- ▶ **Worldwide uranium production jumped by 13 million pounds U3O8 (or 9%) to 158 million pounds U3O8 in 2015**
 - ...erasing the production decline of 9 million pounds U3O8 from 154 million pounds in 2013 to 145 million pounds in 2014
- ▶ **UxC estimates a 2015 supply surplus of 33 million pounds U3O8 in 2015 (not accounting for inventory build-up)**
- ▶ **Suppliers have been slow to respond**
 - Response may increase in the face of mounting market pressures
 - Kazakhstan as the key factor in uranium supply
- ▶ **Shifting importance of secondary supplies:**
 - Enrichers as producers/ U.S. DOE/ Utility inventory disposition
- ▶ **Uranium inventories remain high and growing**
- ▶ **Uranium market is in a state of oversupply with slow supply response**



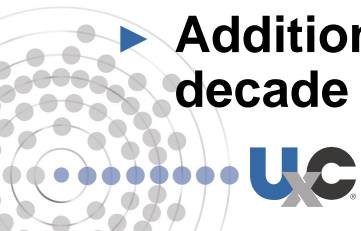


Uranium Supply vs. Demand to 2030



Source: UxC *Uranium Market Outlook*

- ▶ **Persistent oversupply in the near and medium term will be supplanted by the improving fundamentals in the long term**
- ▶ **Additional mine development will clearly be required in the coming decade to ensure adequate future supplies**





Conversion Market Status & Outlook

- ▶ **Unlike uranium market, the conversion producers have reacted with supply adjustments:**
 - Operating plants at lower capacities
 - Production cutbacks (closure of Angarsk, Springfields)
- ▶ **Primary supplies are supplemented by secondary supplies and inventory drawdown**
 - Persistent, but changed role of secondary supplies (enrichers as producers of UF₆; U.S. DOE inventory disposition, utility inventory disposition)
...which leads to continued bifurcated spot vs. long-term markets
- ▶ **New conversion plants (COMURHEX II and SCC) are being delayed – replacement (not new) capacity**
- ▶ **Continued high cost of primary production**
- ▶ **The China wildcard**
- ▶ **Existing and future capacity should be sufficient through 2030, although the next five years will require large quantities of inventory drawdown**
- ▶ **The conversion market balance is tight, supply prone to disruption; any shortfalls in primary supplies would be handled from inventories**





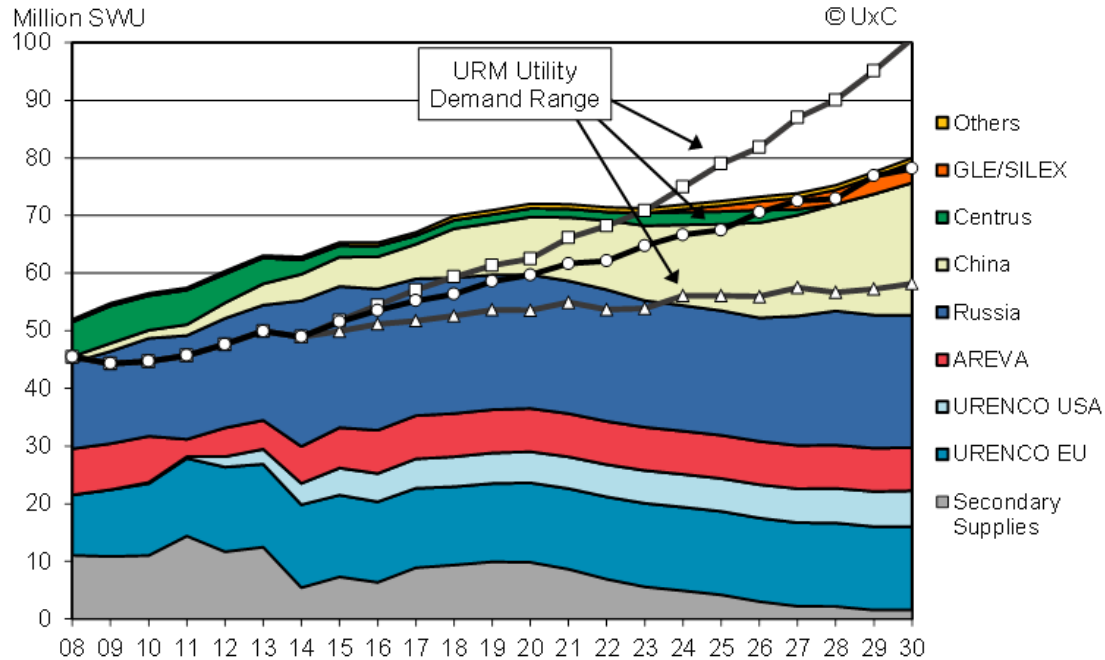
Enrichment Market Status & Outlook

- ▶ **Enrichment industry went through massive structural changes as it was hit with decreased demand**
- ▶ **Result: SWU supply and demand currently out of balance**
- ▶ **Supply response: continued optimization of capacity**
 - Enrichers as uranium producers (tails re-enrichment/underfeeding)
 - Buildup of EUP inventories (ex. URENCO inventory increased by ~€50 million between 2013 and 2015)
 - Reduction of planned enrichment capacity expansions
 - Considering shutting down older centrifuge cascades
 - Dim prospects for new projects
- ▶ **China continues rapid expansion**
- ▶ **Increased competition given lack of market demand (following increased activity in 2005-2009)**
 - Emergence of the mid-term market
- ▶ **Enrichment prices are at historic lows**
 - Moving closer towards the cost of production
- ▶ **Enrichment market is moving towards equilibrium; although it will take time to rebalance given the substantial oversupply**





Enrichment Supply vs. Demand



Source: UxC *Enrichment Market Outlook*

- ▶ **Enrichment market remains in substantial oversupply situation for the next decade (or even longer)**





Fabrication Status & Outlook

- ▶ **Fabrication is not a commodity market; it is a highly manufactured product**
 - Markets vary depending on region and fuel type
- ▶ **Characterized by overcapacity, which is expected to persist**
 - Exacerbated by the demand reduction, especially for BWR fuel
 - Regional supply variations will persist
- ▶ **Emerging changes in supply:**
 - Uncertain future of Japan's fabricators
 - TVEL & KNF attempting to enter global PWR reload markets
 - Signals that CNFC wants to become a global fabrication vendor
 - KAP looking to enter the global fabricator jointly with CGN
 - Potential increased competition in the VVER fuel market
 - Largest reactor growth in countries with national suppliers
- ▶ **Additional fabrication market trends:**
 - Declining competition
 - Rising fabrication costs
 - Development of accident tolerant and advanced fuel designs
- ▶ **There is significant excess of LWR fuel fabrication capacity through 2030; fabrication market is expected to undergo significant structural changes in the near to medium-term**





Back-End of the Nuclear Fuel Cycle

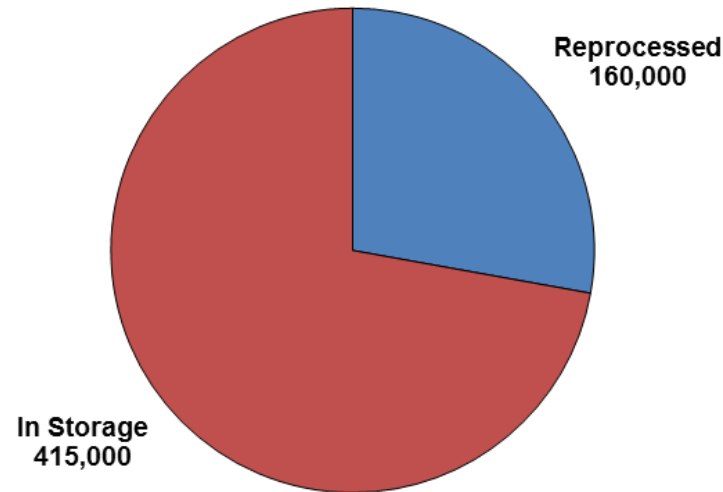
- ▶ **~10,000 MT of spent fuel (SF) is discharged each year. The WNA is reporting ~240,000 MT of spent fuel is in storage, mostly at reactor sites**
- ▶ **Different options for the fuel cycle (open, closed, and advanced closed), but many adopting the “wait and see” approach**
- ▶ **...but does this make radioactive waste the Achilles Heel of nuclear power?**
 - Failure to achieve meaningful progress on a permanent disposal solution for radioactive wastes is a key issue cited by opponents of nuclear power to argue against its use and expansion





Spent Fuel Forecast to 2030

© UxC



Source: UxC *Nuclear Industry Value Chain*

- ▶ **Nuclear fuel recycling can and does play a significant role in an integrated spent fuel management program**
 - Can increase the capacity of a deep geological repository
 - Providing a portion of the uranium fuel requirements through the use of the recycled products
- ▶ **But is challenged by the depressed state of the competing front-end markets**





Reprocessing Market Outlook

- ▶ **Key trend: desire to develop advanced reprocessing plants that do not separate a free stream of plutonium**
 - Abundance of separated plutonium in the world not earmarked for recycling
 - 2006 – U.S. reverses position (GNEP, Blue Ribbon Commission)
 - Russia – leading the way with REMIX technology
- ▶ **Drivers for further development of reprocessing industry:**
 - Global nuclear expansion increasing fuel demand
 - A rebound in the price of uranium
 - Success in offering advanced reprocessing
- ▶ **Obstacles to expansion of reprocessing**
 - Technical issues
 - Economic challenges
 - Concerns over proliferation resistance





Key Takeaways

- ▶ **Interrelationships between the stages of the nuclear fuel cycle are more evident than ever**
- ▶ **Nuclear power is reeling from the broader energy and electricity market challenges (both short and longer term), exerting downward demand pressures on other stages of the fuel cycle**
- ▶ **The nuclear fuel markets have had to react to this decreased demand and inventory overhang**
 - But the response has been protracted
- ▶ **The front-end of the nuclear fuel market has seen increasing interrelationships as well**
- ▶ **Questions about the impact of the lack of solutions on the back-end of the NFC on the future development of nuclear power**
- ▶ **The nuclear industry remains in the state of turmoil, seeking to find a new balance. Fulfilling the “nuclear promise” will require complex, integrated solutions given the new, reinforced view of the nuclear fuel cycle**





Questions? Вопросы?

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