

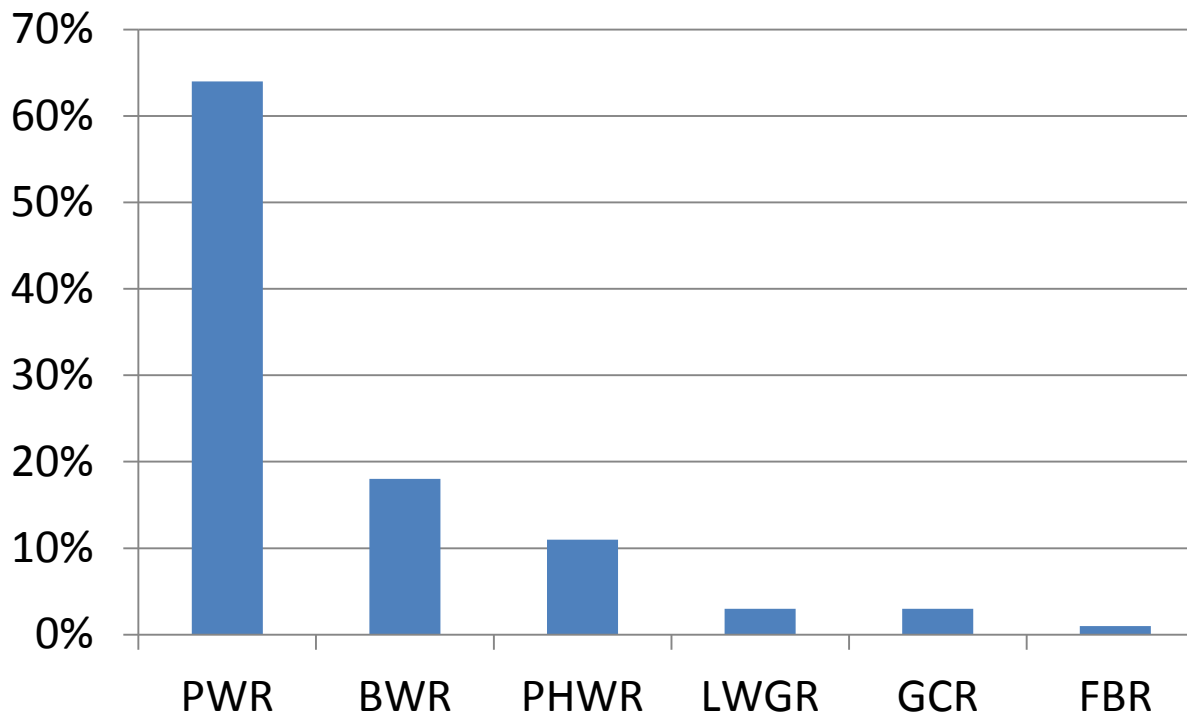


**NUCLEAR
FUEL CYCLE**
ROYAL
COMMISSION

**Further Processing and Manufacture
ANU Energy Change Institute
11 April 2017
Tony Irwin**

2017 World Power Reactors

% Reactor type



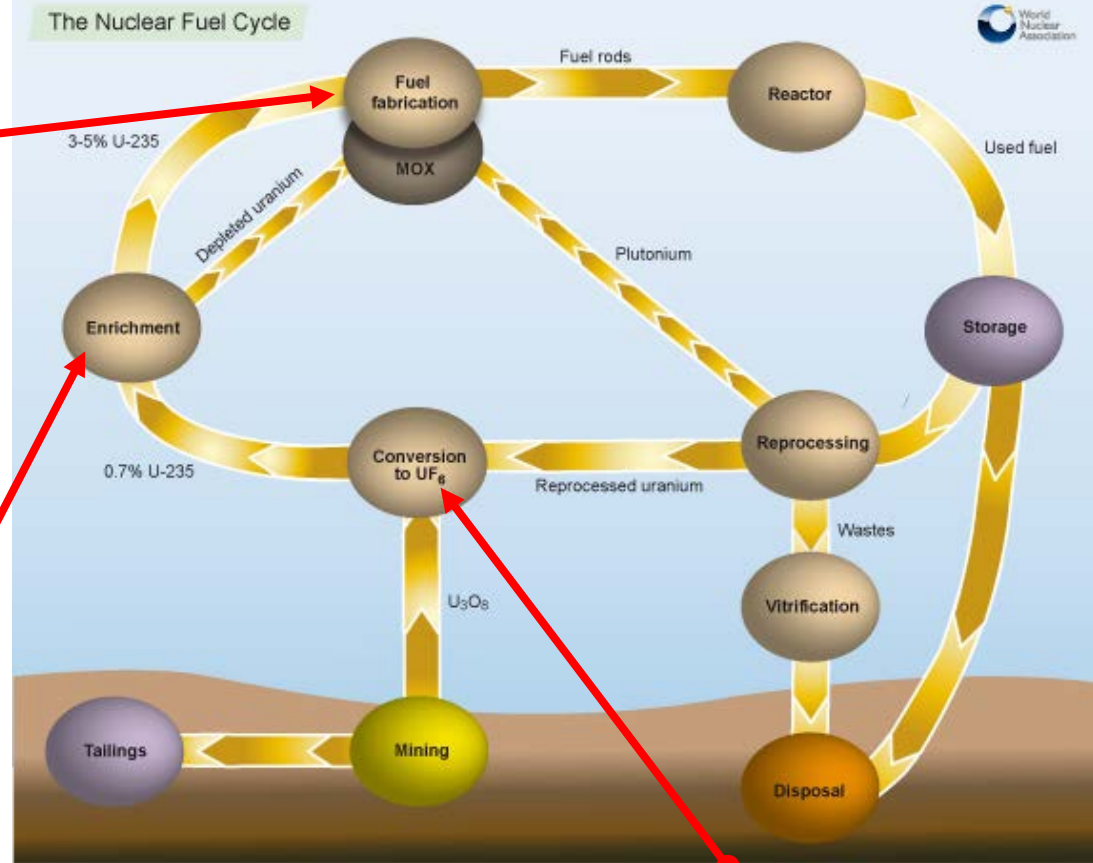
PWR	Pressurised Water Reactor	282
BWR	Boiling Water Reactor	78
PHWR	Pressurised Heavy Water Reactor	49
LWGR	Light Water Graphite Reactor	15
GCR	Gas Cooled Reactor	14
FBR	Fast Breeder Reactor	3

90% of operable reactors require enriched uranium (392 of 441)

93% of reactors under construction require enriched uranium (55 of 59)

Fuel fabrication

- Ceramic uranium oxide (UO_2) pellets
- Cladding
- Fuel rods arranged as fuel assemblies



Enrichment

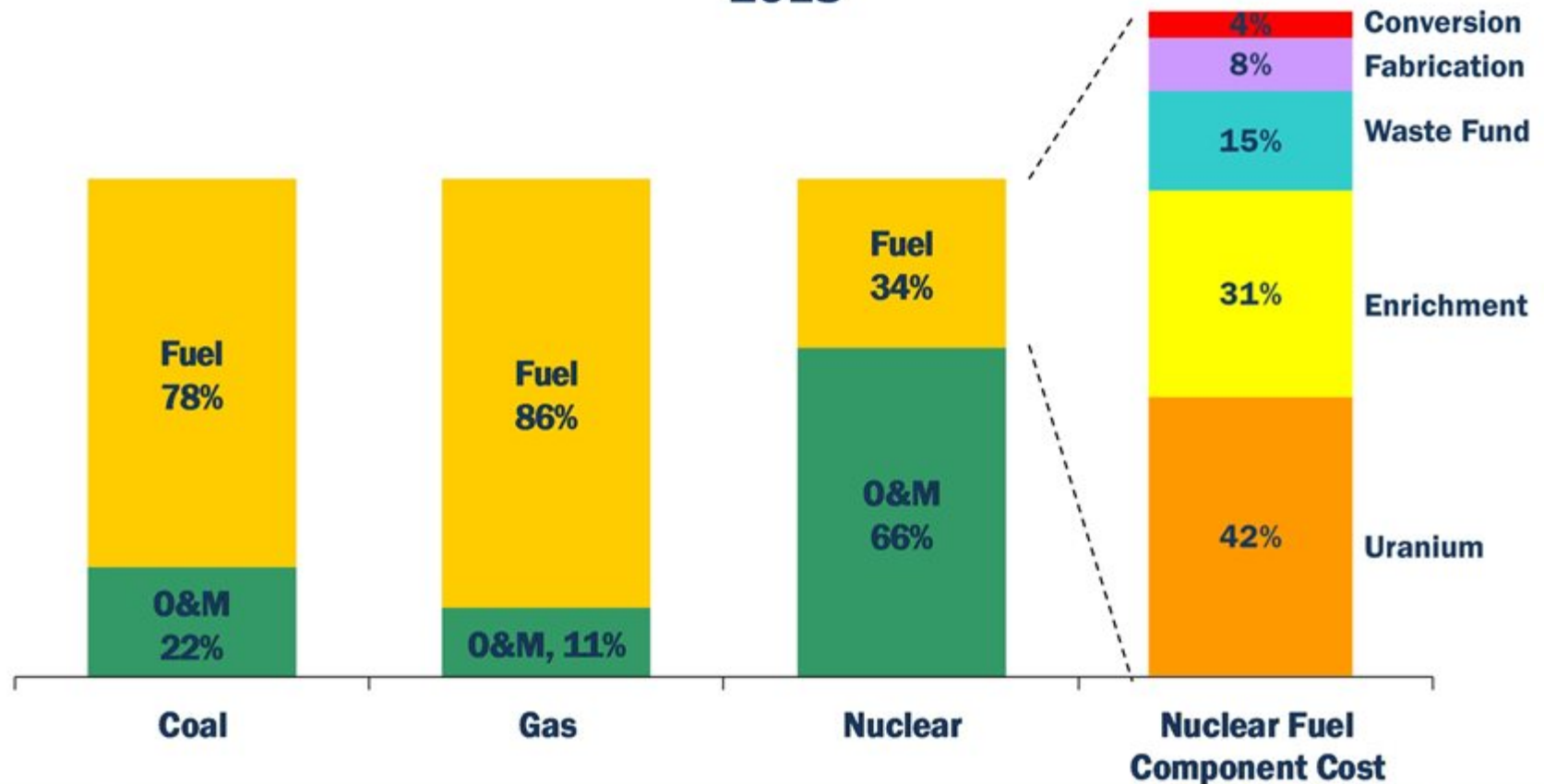
- 3-5% for power reactor fuel
- Gaseous diffusion
- Centrifuge
- Laser
- Downblended HEU

Conversion to UF_6

- Uranium in gaseous form for isotope separation

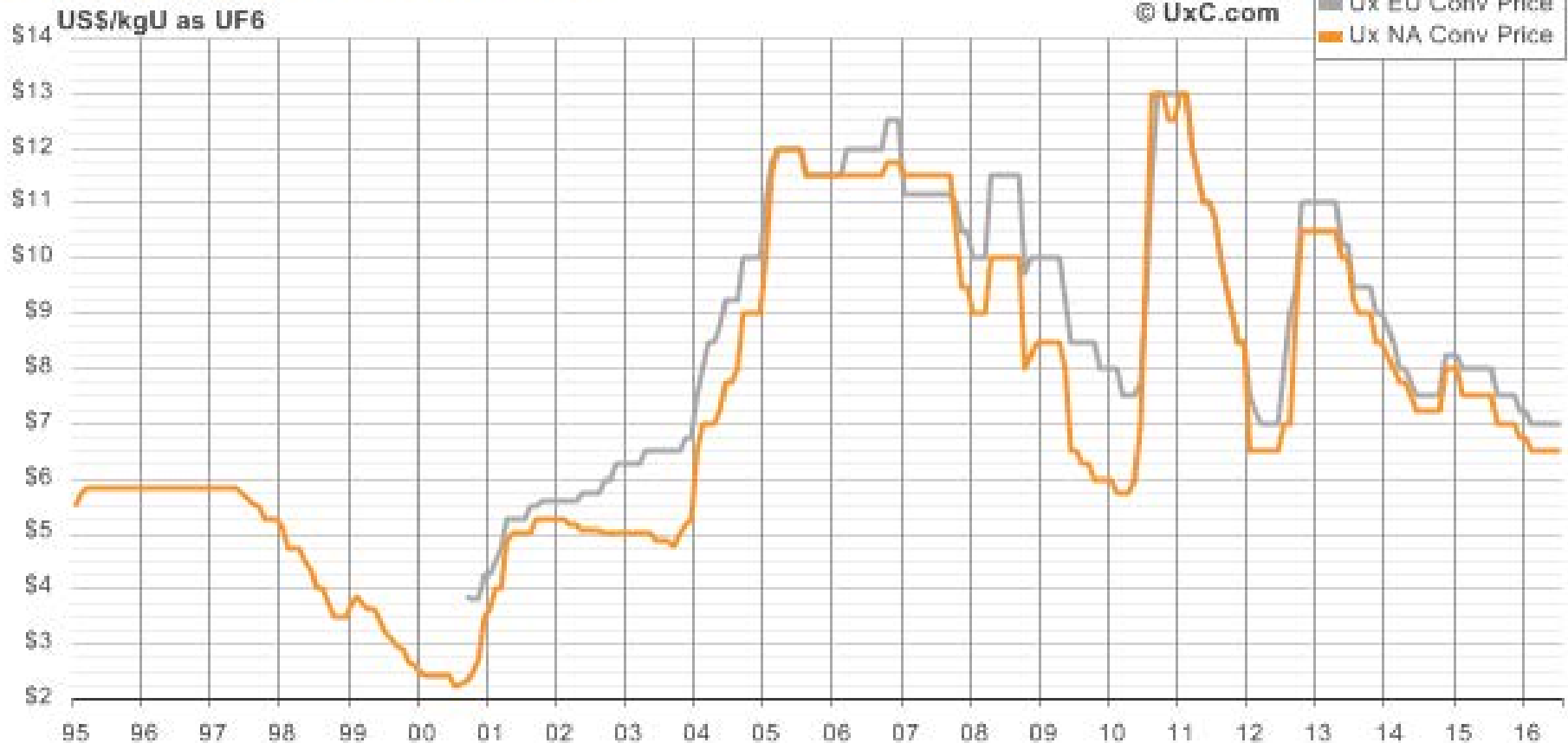
Fuel as a Percentage of Electric Power Production Costs

2013



Historical Conversion Prices

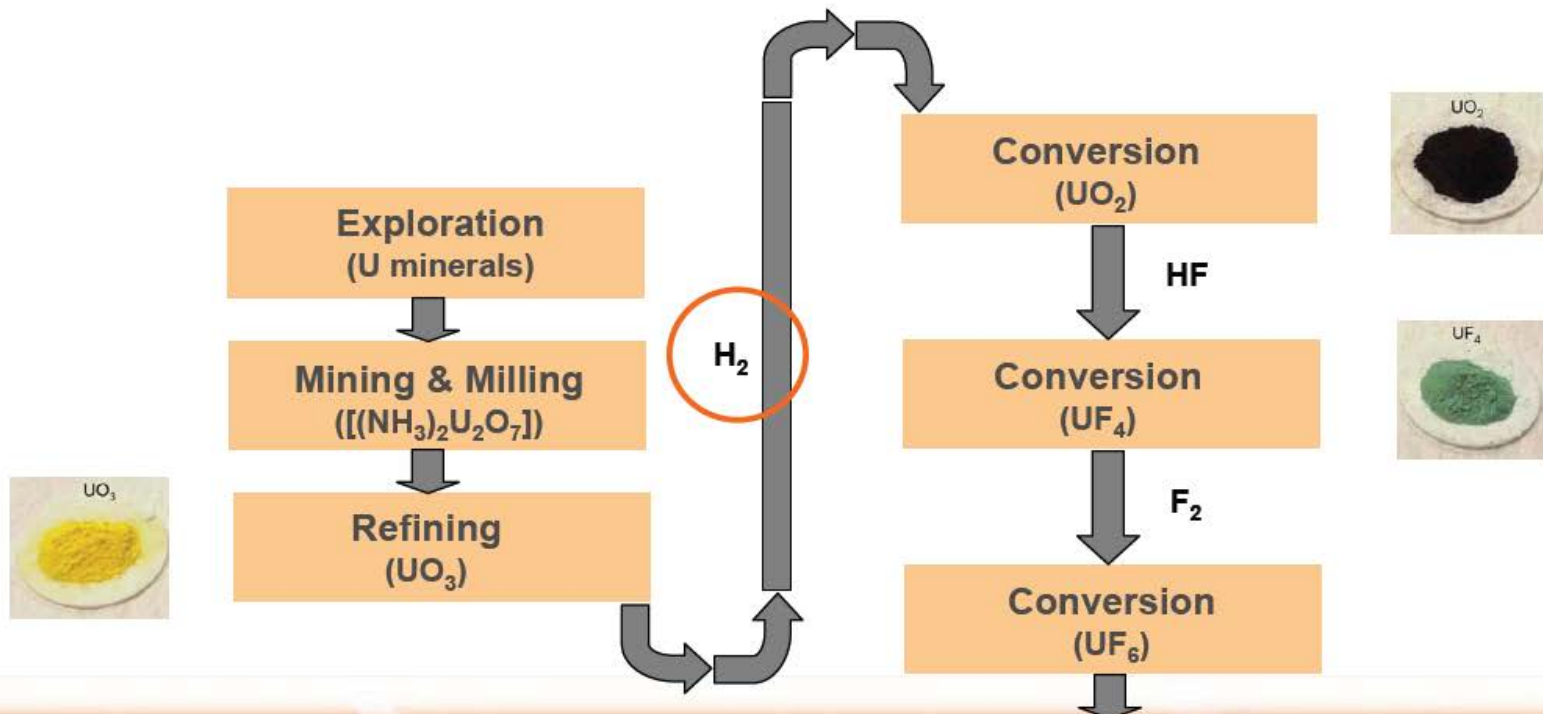
Ux NA & EU Conversion Price



NFCRC used long-term average of US \$16 /KgU for financial analysis

Source: The Ux Consulting Company, LLC, <http://uxc.com>

Conversion Steps



Chemical process – most significant safety and environmental risks are posed by toxic, corrosive and potentially explosive chemicals rather than the radioactivity of the materials (NFCRC)

Conversion Facilities

Country, Location	Company	Nameplate capacity tU as UF ₆	Status
Canada, Port Hope	Cameco	12,500	
USA, Metropolis	Converdyn	15,000 (7,000 from 2017)	could increase to 23,000
France, Malvesi and Tricastin	Areva	15,000	new plants, increase to 21,000
Russia, Irkutsk and Seversk	JSC	12,500	
China, Lanzhou	CNNC	5,000	increasing
Brazil,	IPEN	100	
	World Total	60,100 tU	

UK Springfield (Cameco), capacity 6,000 tU, shutdown Aug 2014

Estimated capacity utilised 2015 = 46,320 tU (most plants operating at 70% capacity)

Supply and Demand for Conversion Services

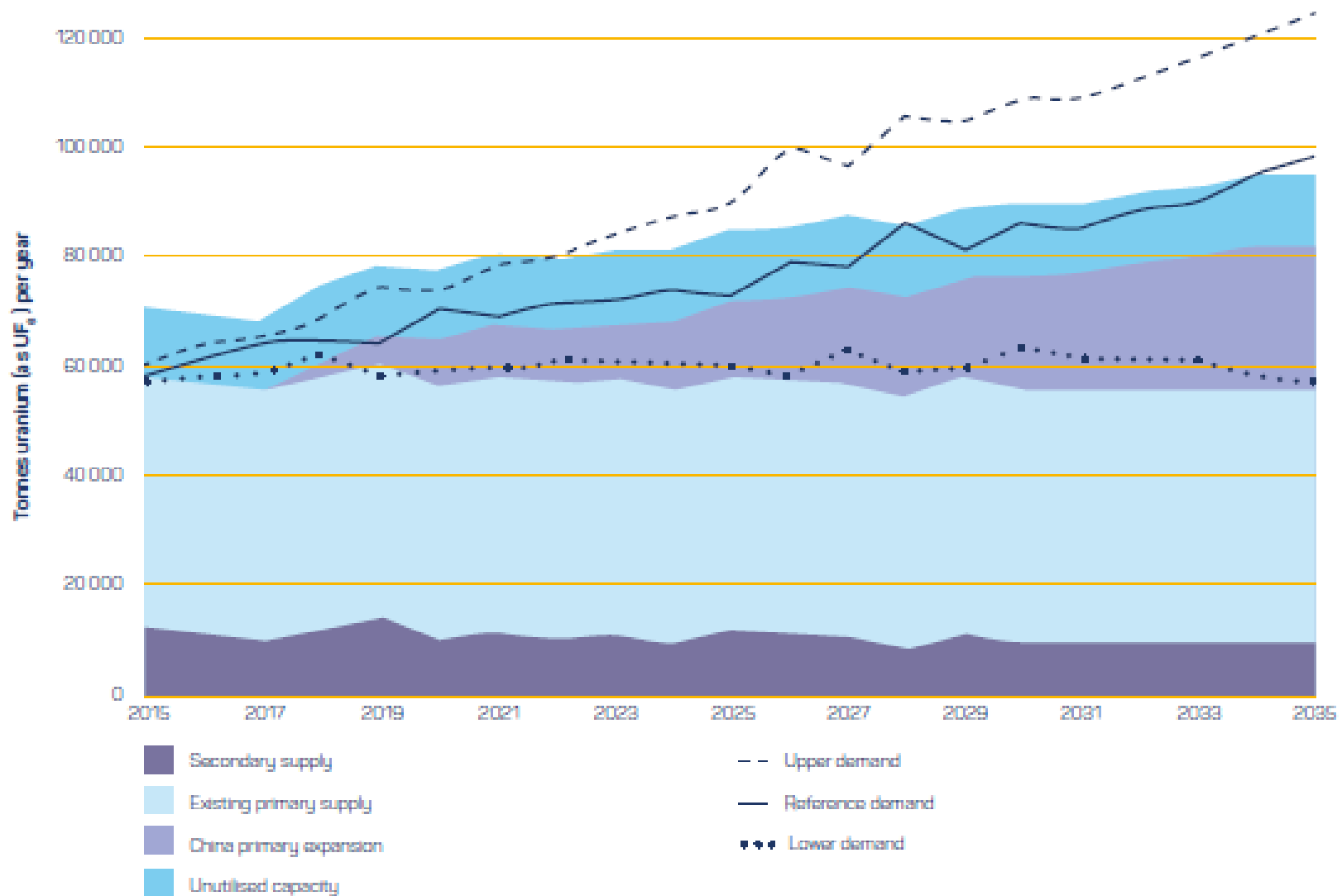
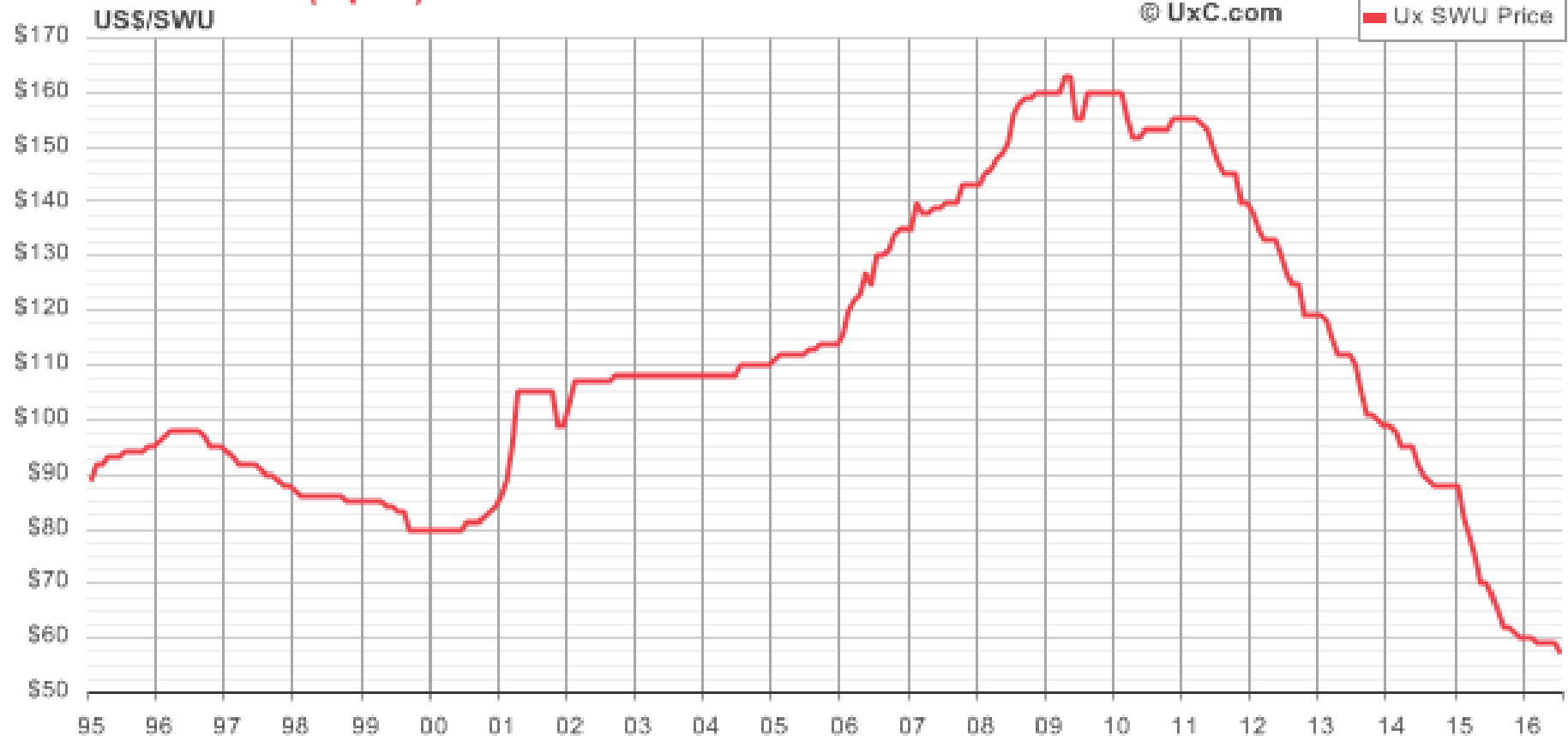


Figure 3.1: Current and projected global demand and supply for UF_6 conversion (tonnes uranium)

Data sourced from World Nuclear Association, *The nuclear fuel report: Global scenarios for demand and supply availability 2015–2035*, 17th edn, 2015, p. 117, fig. 6.3

Historical Enrichment Prices

Ux SWU Price (Spot)



NFCRC used long-term average of US \$141/SWU for financial analysis

Source: The Ux Consulting Company, LLC, <http://uxc.com>

Enrichment Facilities

Country Location	Company	Capacity million SWU/yr	
USA, New Mexico	URENCO	4.7	operating from June 2010
France, Tricastin	AREVA George Besse II	7.5	commercial operation from April 2011
Germany, Gronau	URENCO	} total URENCO 14.4	
Netherlands, Almelo	URENCO		
UK, Capenhurst	URENCO		
Russia	Tenex	26.6	
China, Lanzhou	CNNC	3.5	6.5 by 2020
China, Haunzhun	CNNC	2.2	
Japan, Rokkasho		1.5	
Brazil		0.2	
	World total	~60 m SWU/yr	

Current demand ~ 47m SWU/yr

Supply and Demand for Enrichment Services

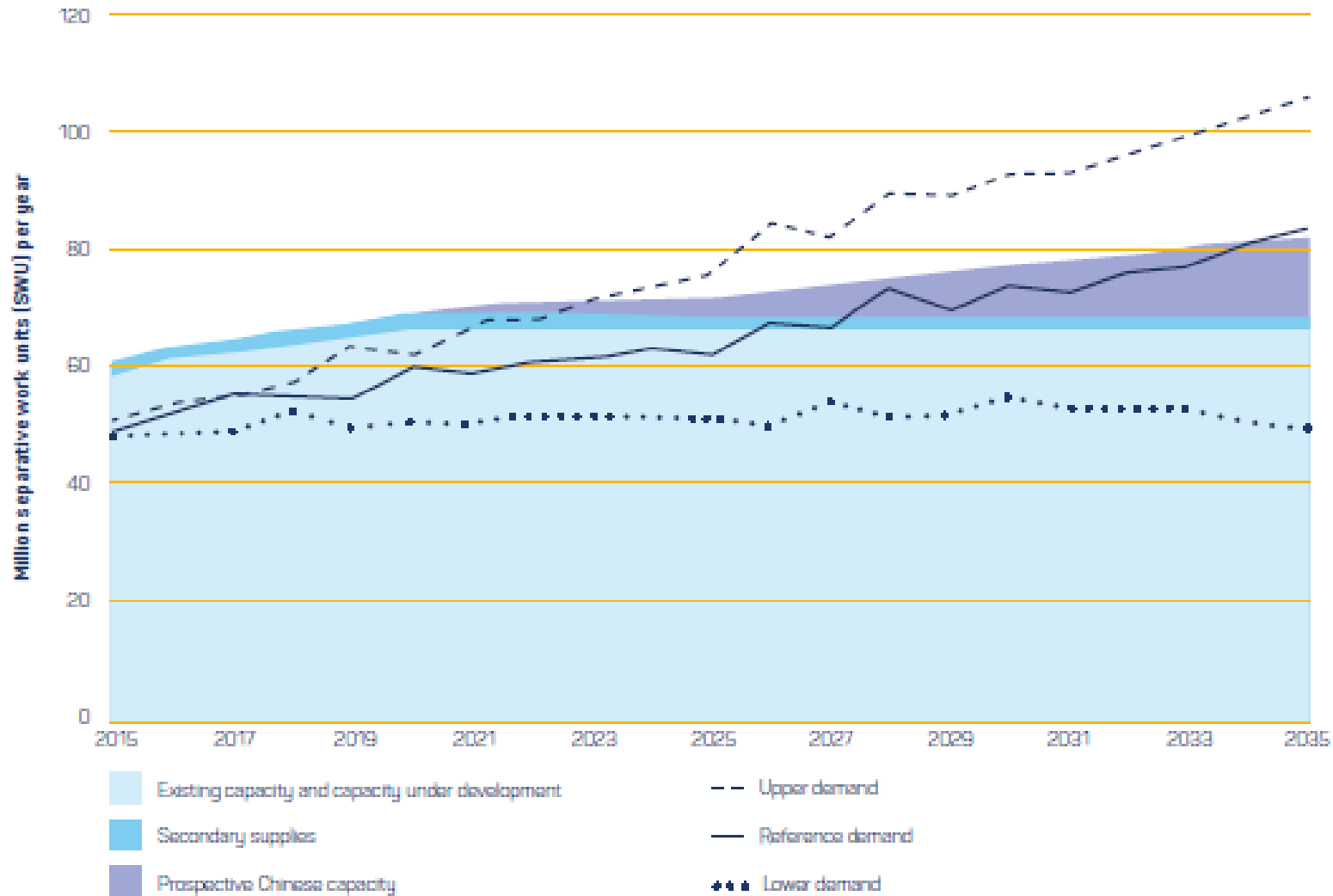
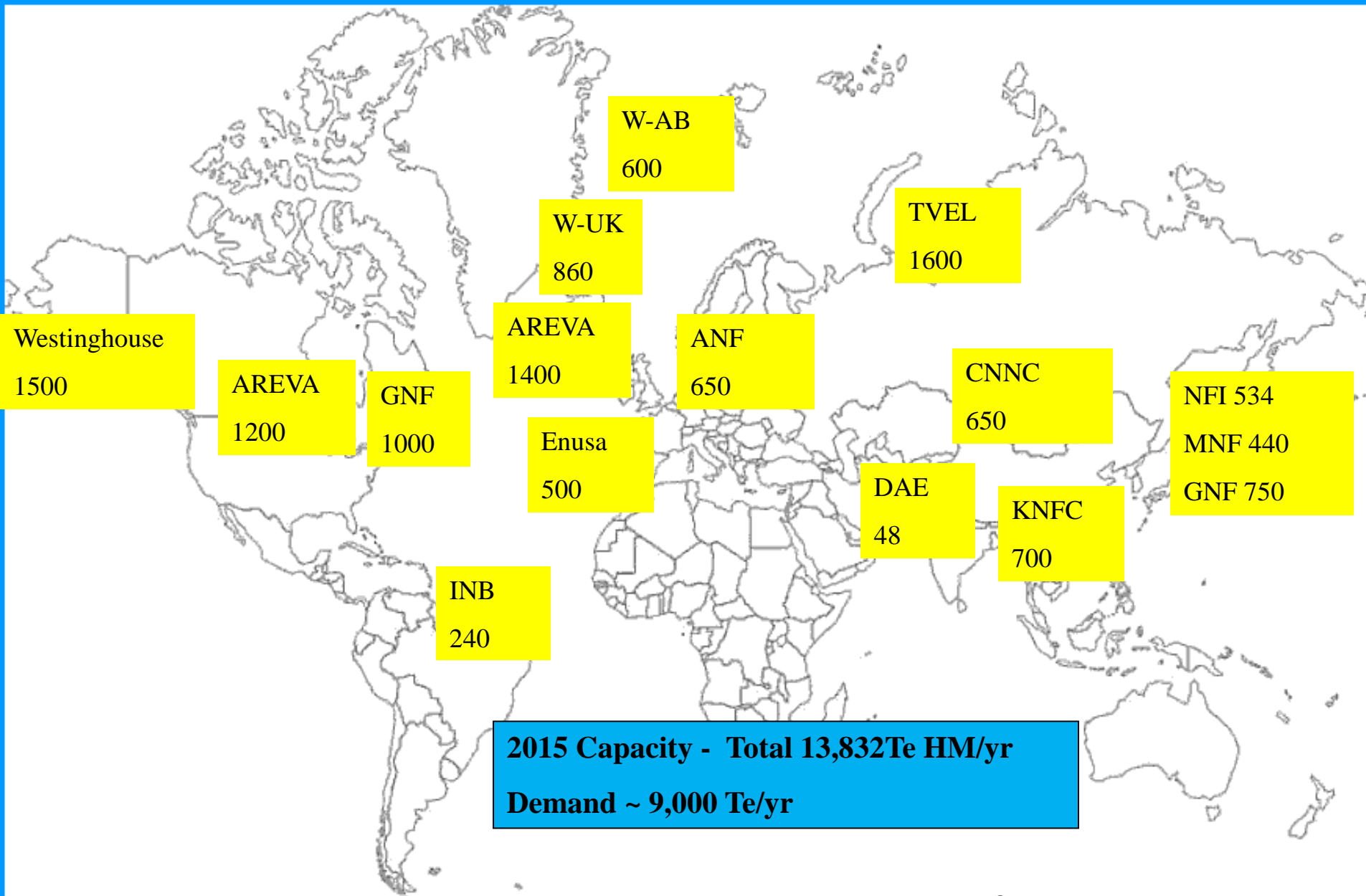
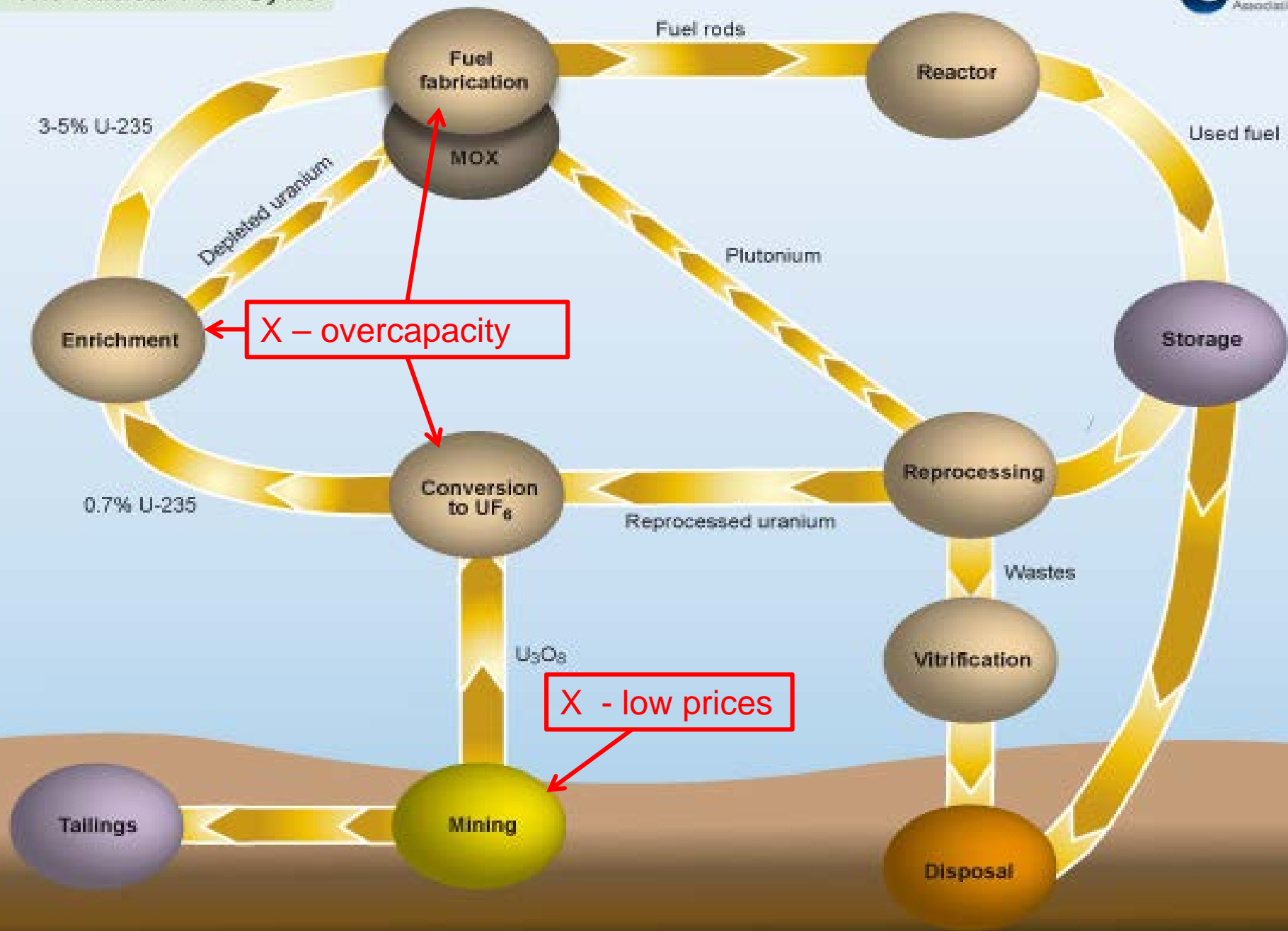


Figure 3.2: Current and projected global demand and supply for enrichment services

World Power Reactor Fuel Fabrication Capacity



The Nuclear Fuel Cycle



NFCRC Recommendation 6

Remove at the state level and pursue removal at the federal level, existing prohibitions on the licensing of further processing activities, to enable commercial development of multilateral facilities as part of fuel leasing arrangements.

Not supported by the South Australia Government due to limited economic opportunities and significant barriers to entry