Expansion of World Fuel Cycle Facilities

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FCIX2008

TWFN
Auditorium
NRC

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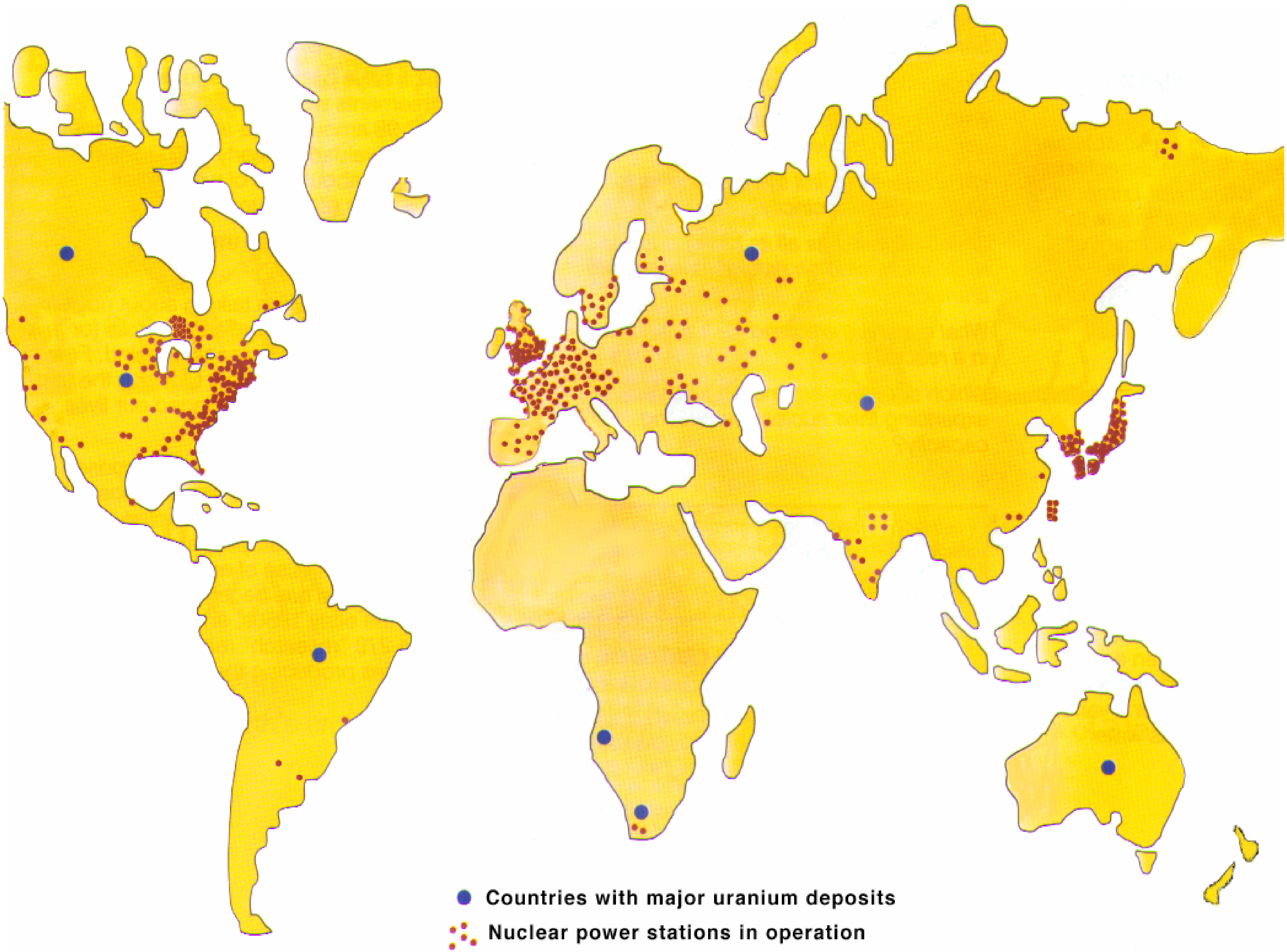
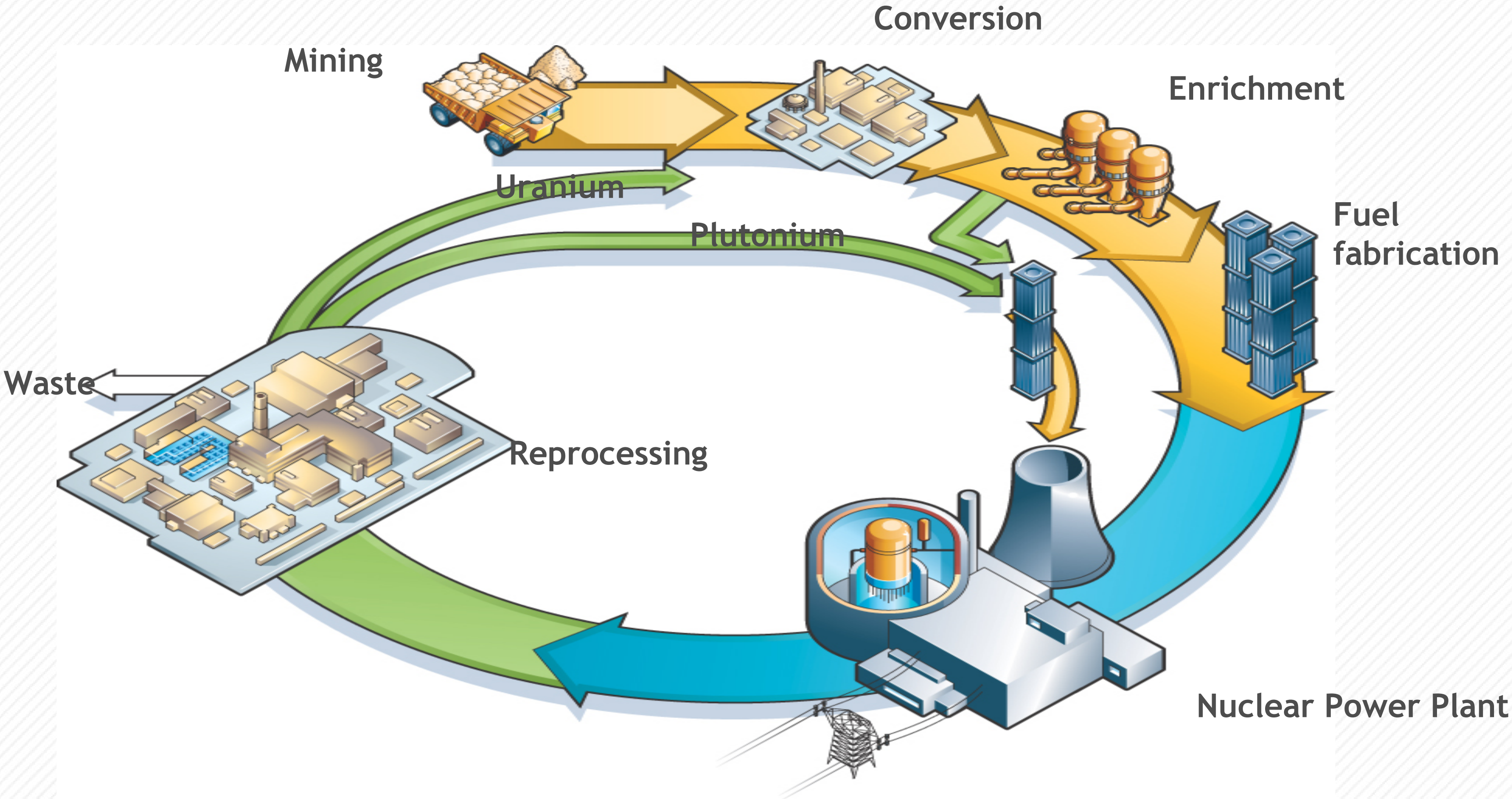

Countries with major uranium deposits
Nuclear power stations in operation

The nuclear fuel cycle



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Cost of 1 kg of enriched uranium

Uranium	9 kg U308	$25 per lb	495
Conversion	7.6 kg U	$13 per kg	99
Enrichment	7 SWU	$135 per SWU	945
Fabrication	1 kg	$300 per kg	300
Total			$1839

Need about 20 tonnes of enriched uranium for an average large reactor refuel, so cost will be about $40 million

Total front end world market is now worth about $15 billion annually

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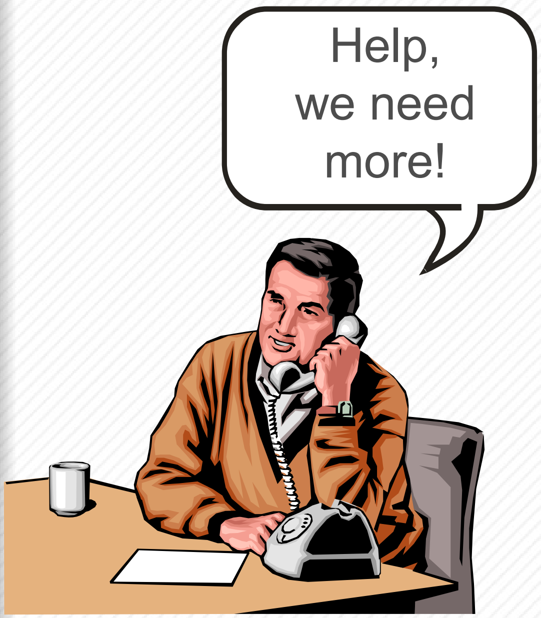
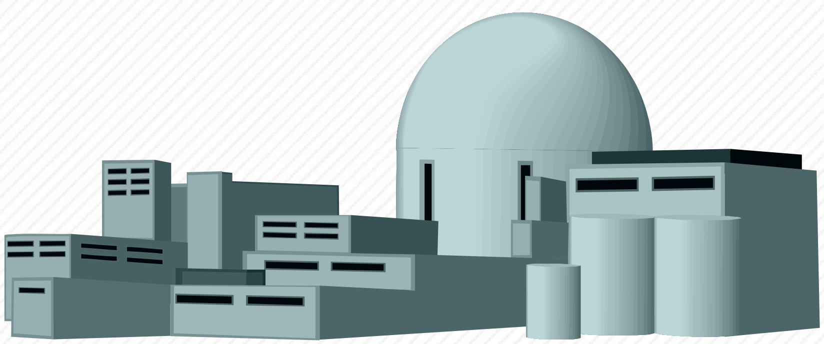
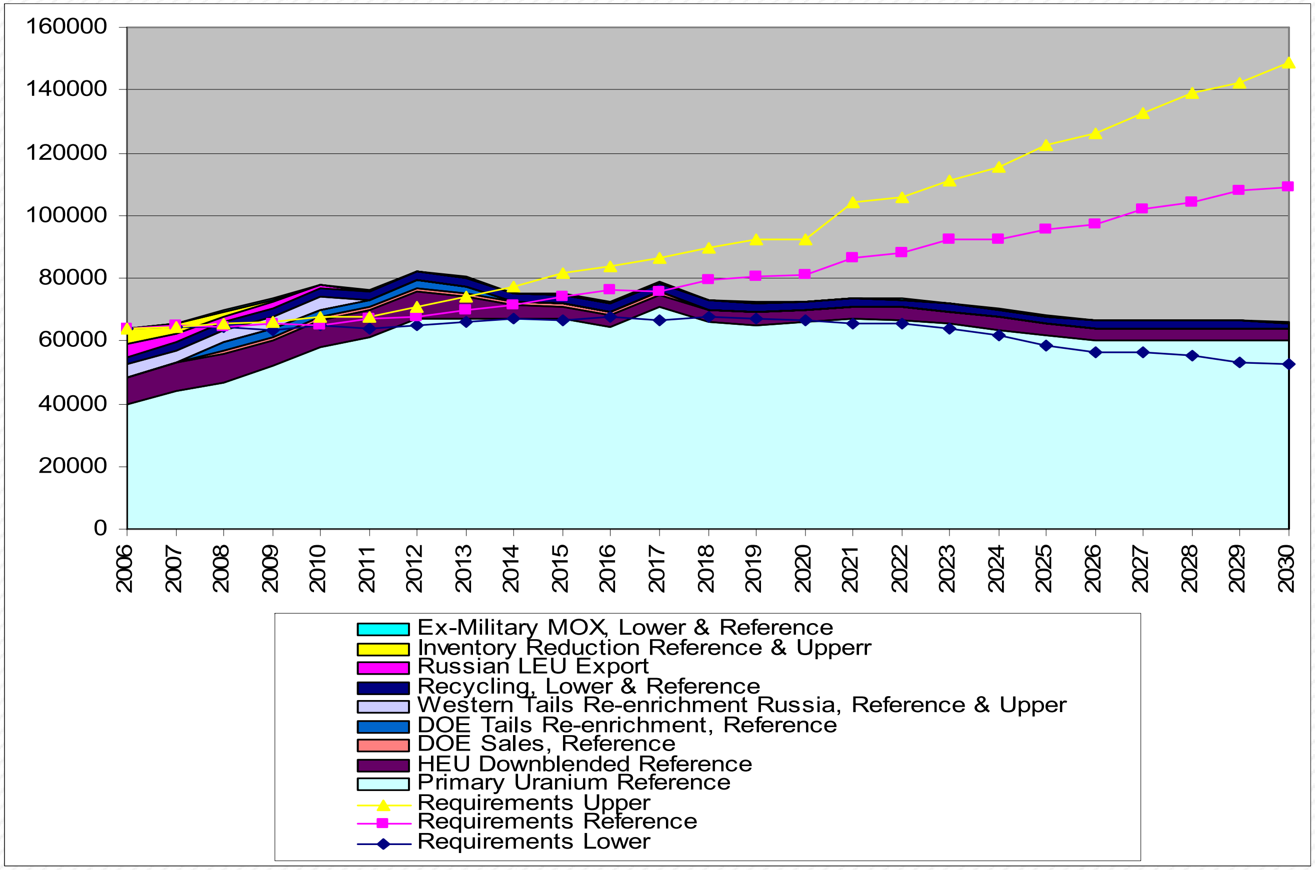
Will the future look like this?





WNA world reactors and reference case supply



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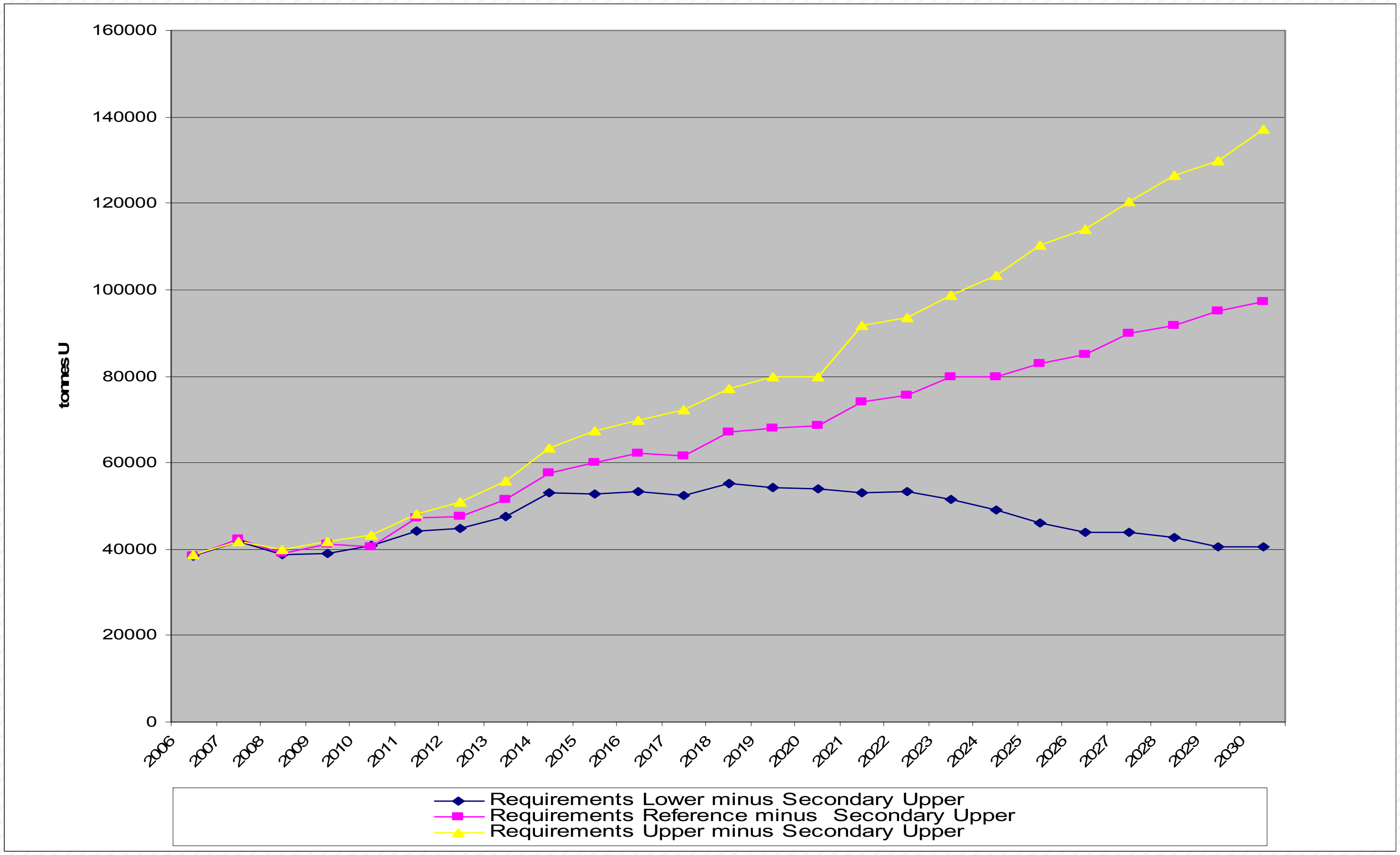
WNA implied requirement for primary uranium production



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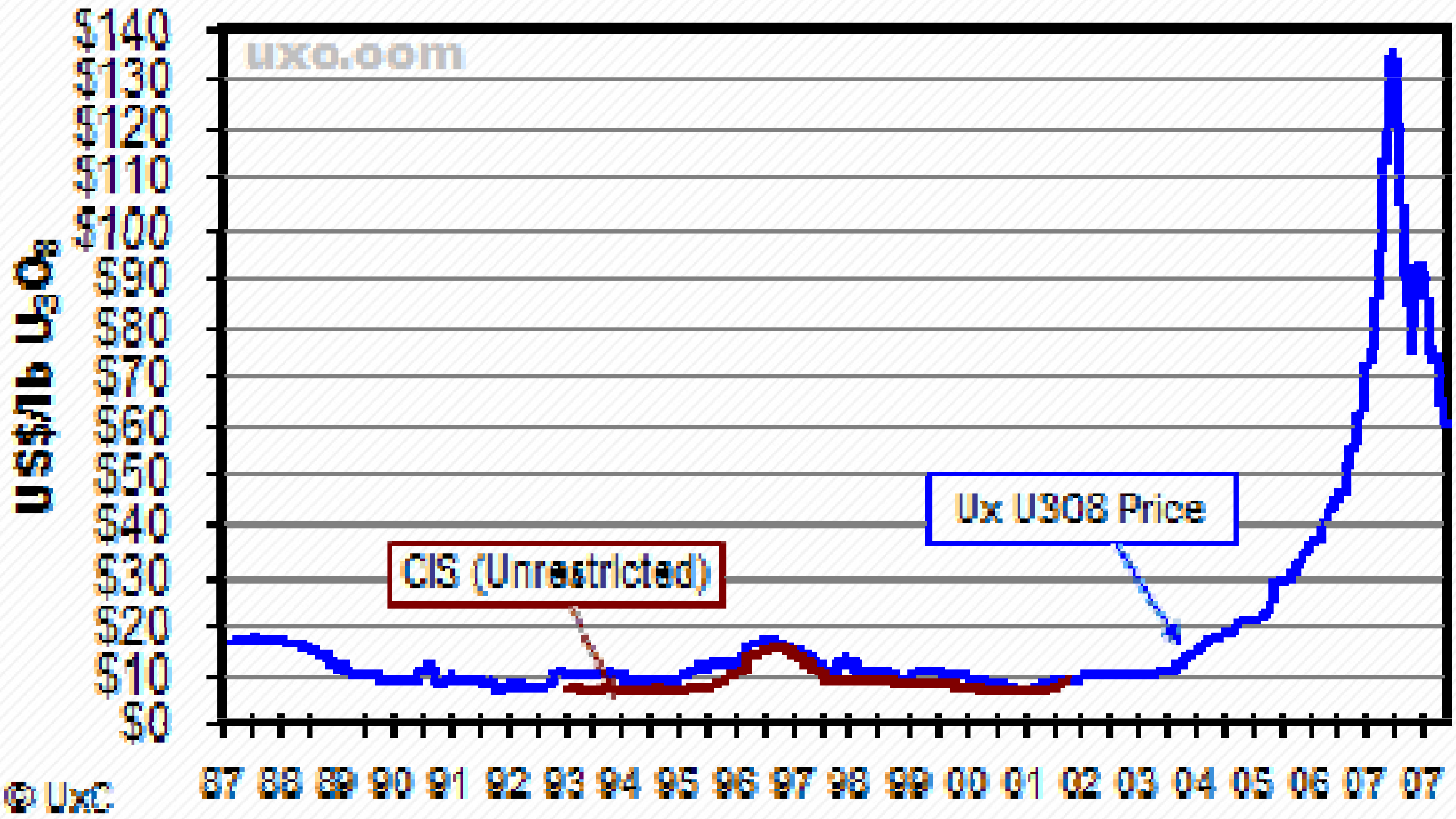
Spot uranium prices - current



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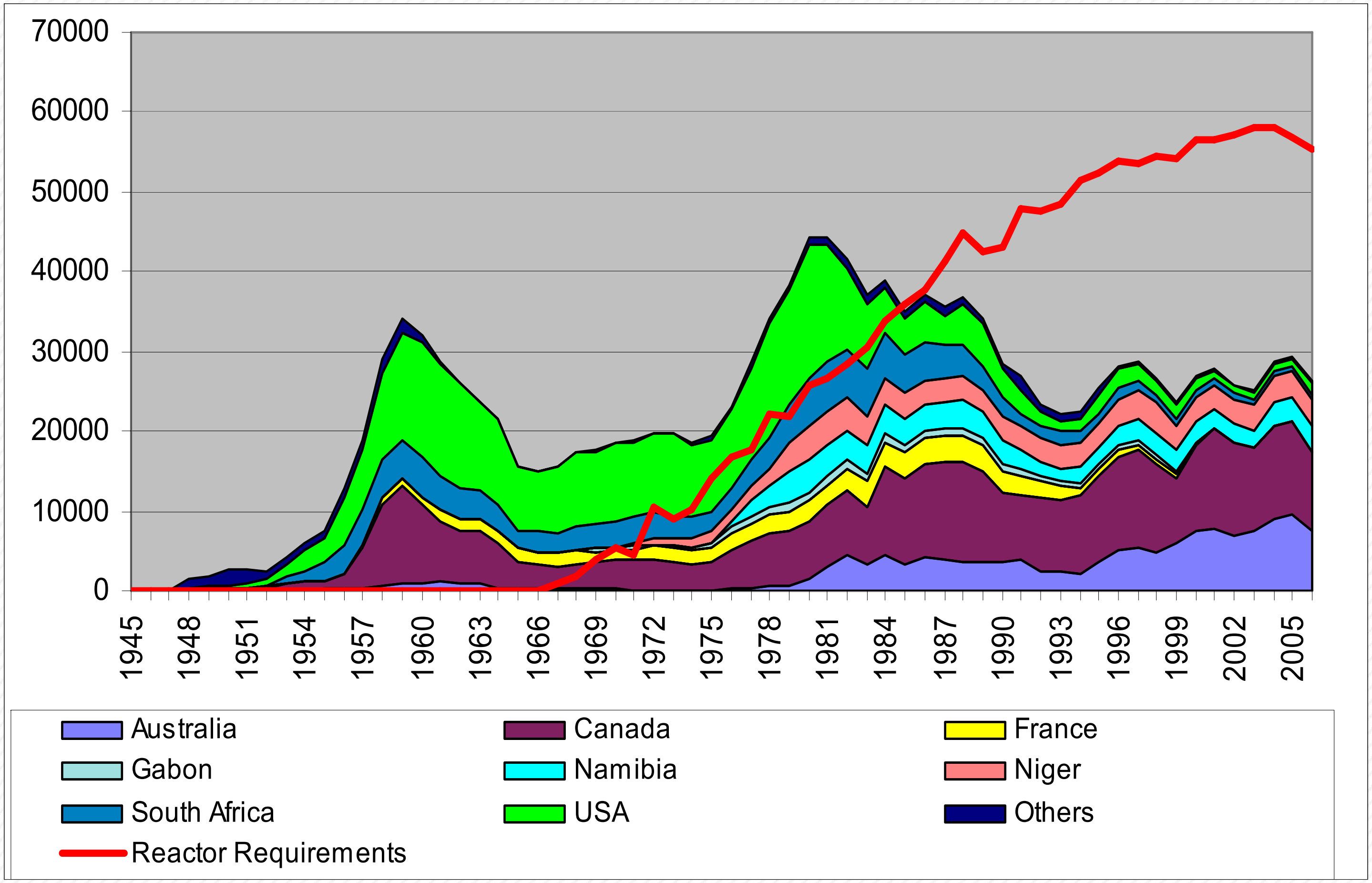
Western world uranium demand & supply



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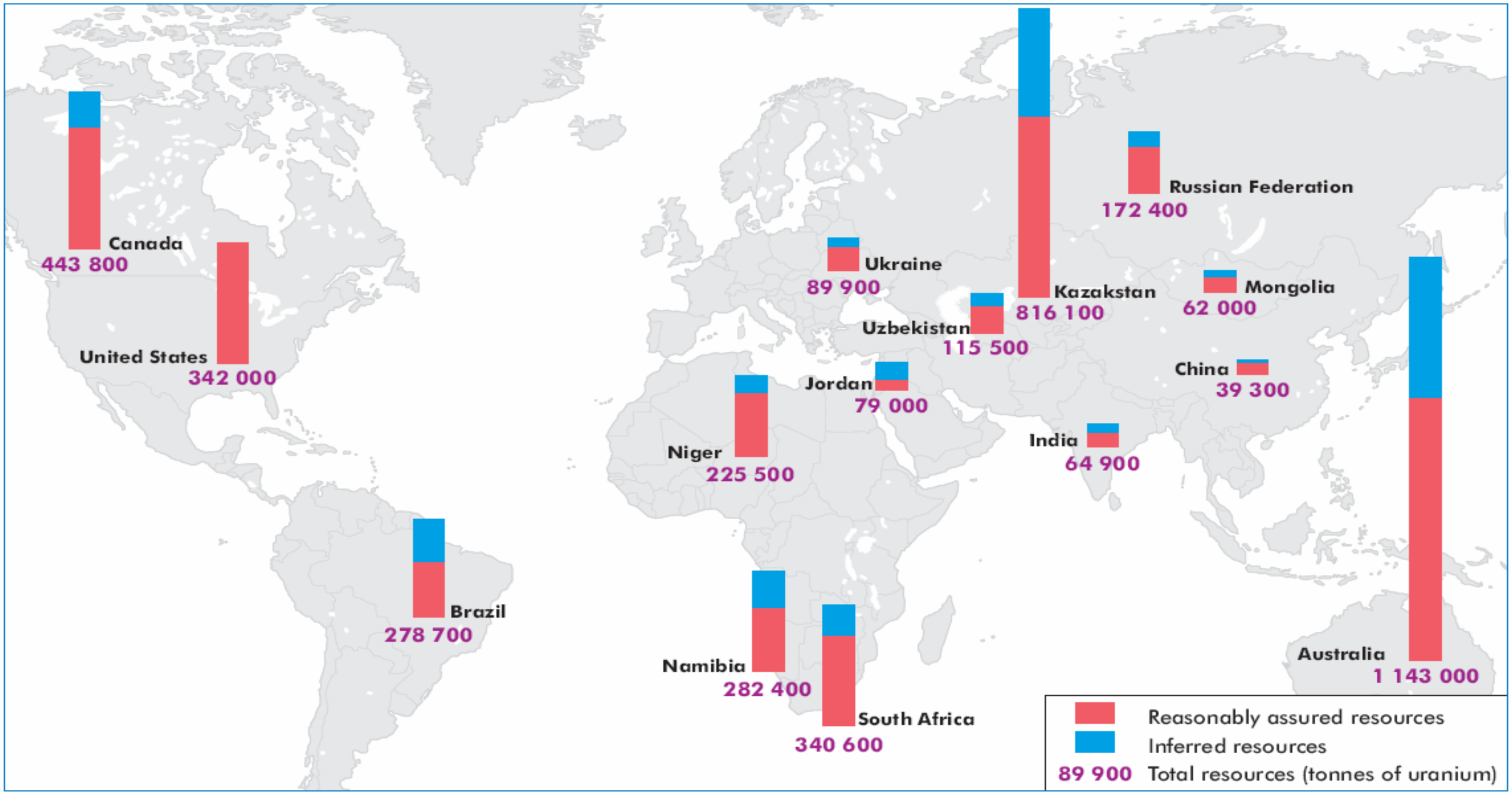
Global distribution of uranium resources



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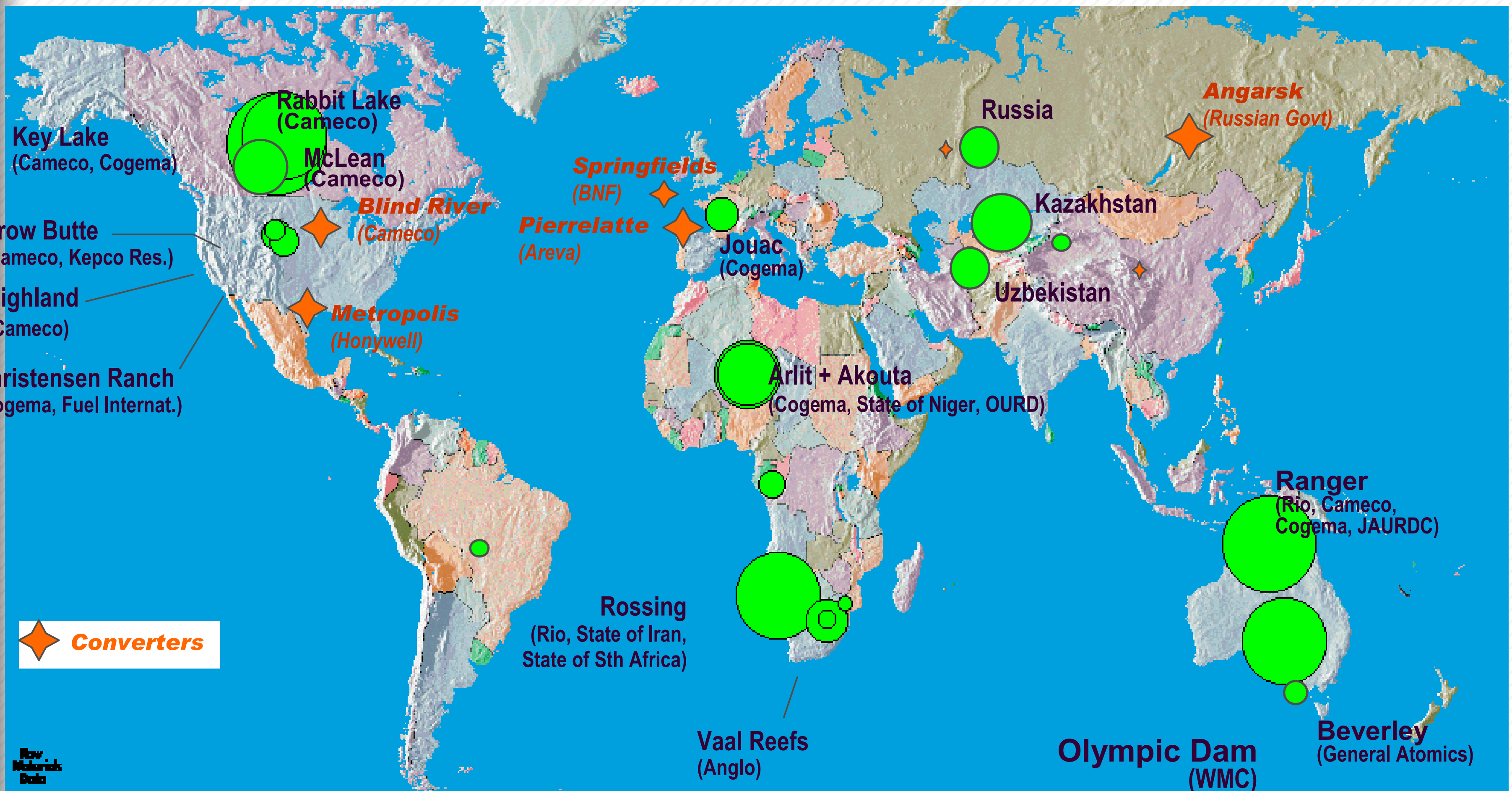
Major uranium operations



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World uranium production 2006, tU

Canada	9862
Australia	7594
Kazakhstan	5279
Niger	3431
Russia	3262
Namibia	3067
Uzbekistan	2260
USA	1762
Others	3009
Total	39526

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Top uranium mines 2006, tonnes U

McArthur River	7200
Ranger	4026
Rossing	3077
Krasnokamensk	2900
Olympic Dam	2868
Rabbit Lake	1972
Akouta	1869
Arlit	1565

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Companies producing uranium, 2006, tU

Cameco	8038
KazAtomProm	4929
Rio Tinto	4870
Areva	4466
TVEL	3262
BHP Billiton	2868
Navoi	2260
Others	8883
Total	39526

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Uranium production by mining method, 2006

Open pit	41%
Underground	24%
In situ leaching (ISL)	26%
By-product	9%
Total	100%

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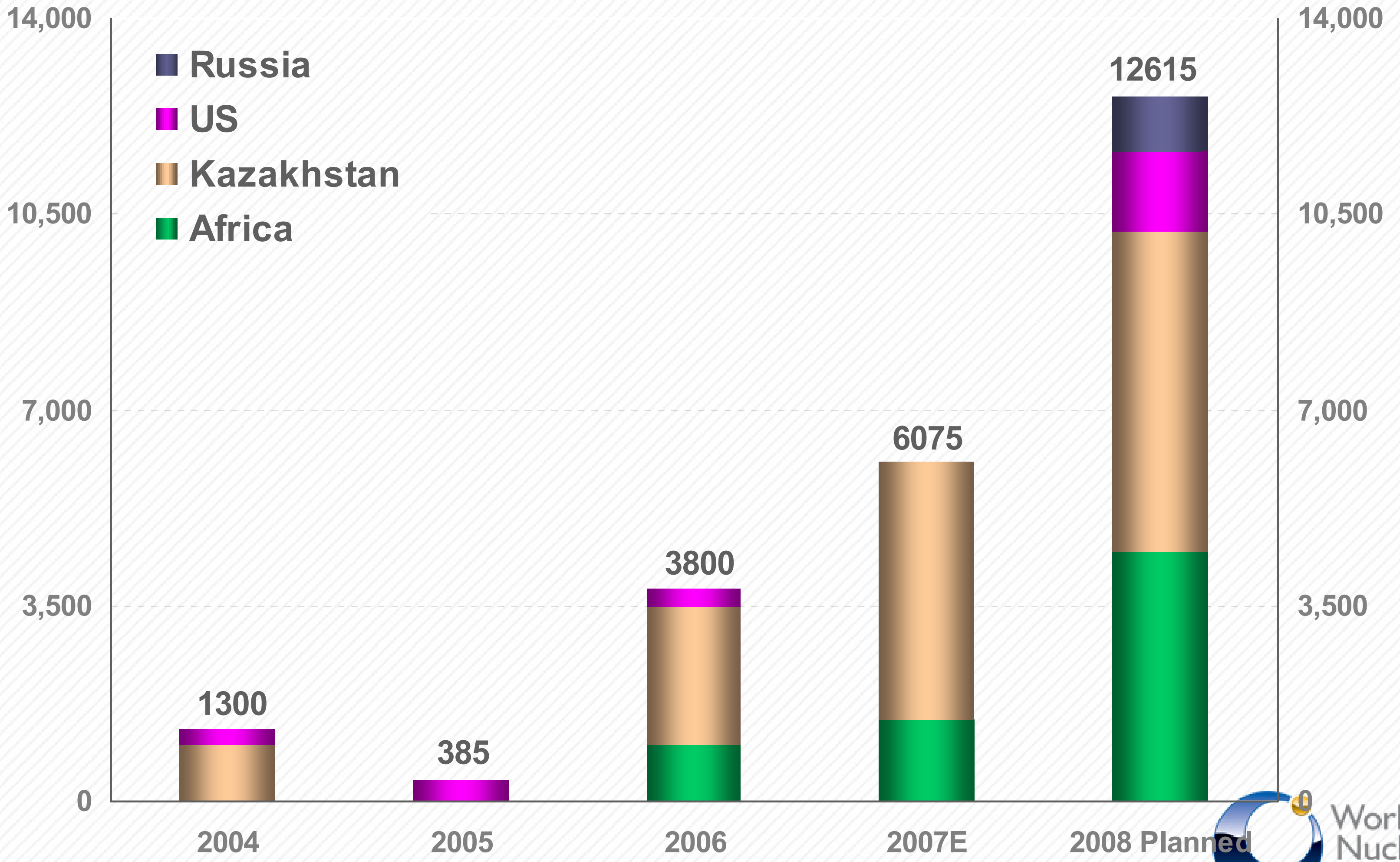
New Uranium Production by Country

tonnes U (Projected startup, time to capacity will vary)



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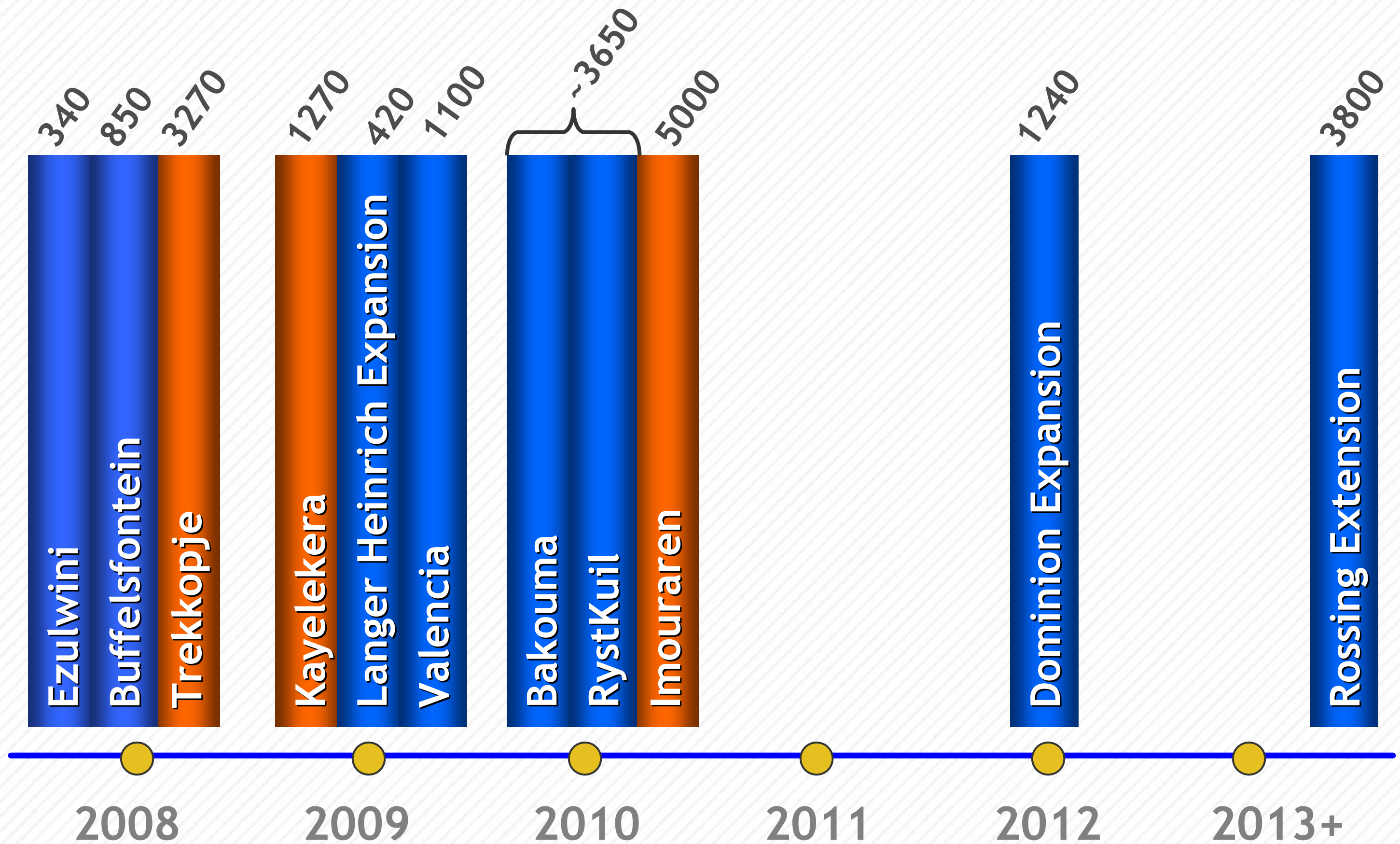
Potential Future Production - Africa

Annual Production Capacity - tonnes U



Year represents projected start-up date; time to reach full capacity will vary

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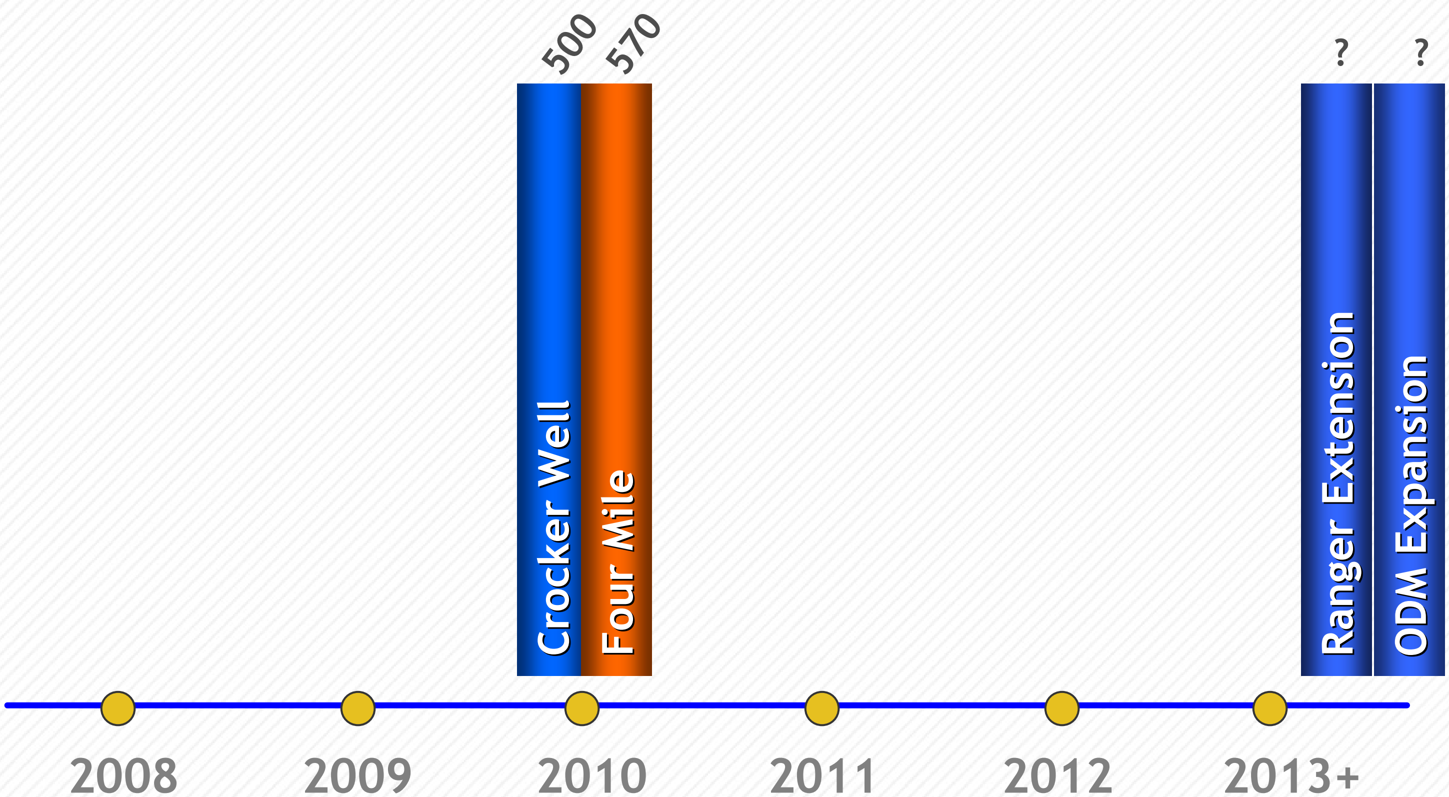
Potential Future Production - Australia

Annual Production Capacity - tonnes U



Year represents projected start-up date; time to reach full capacity will vary

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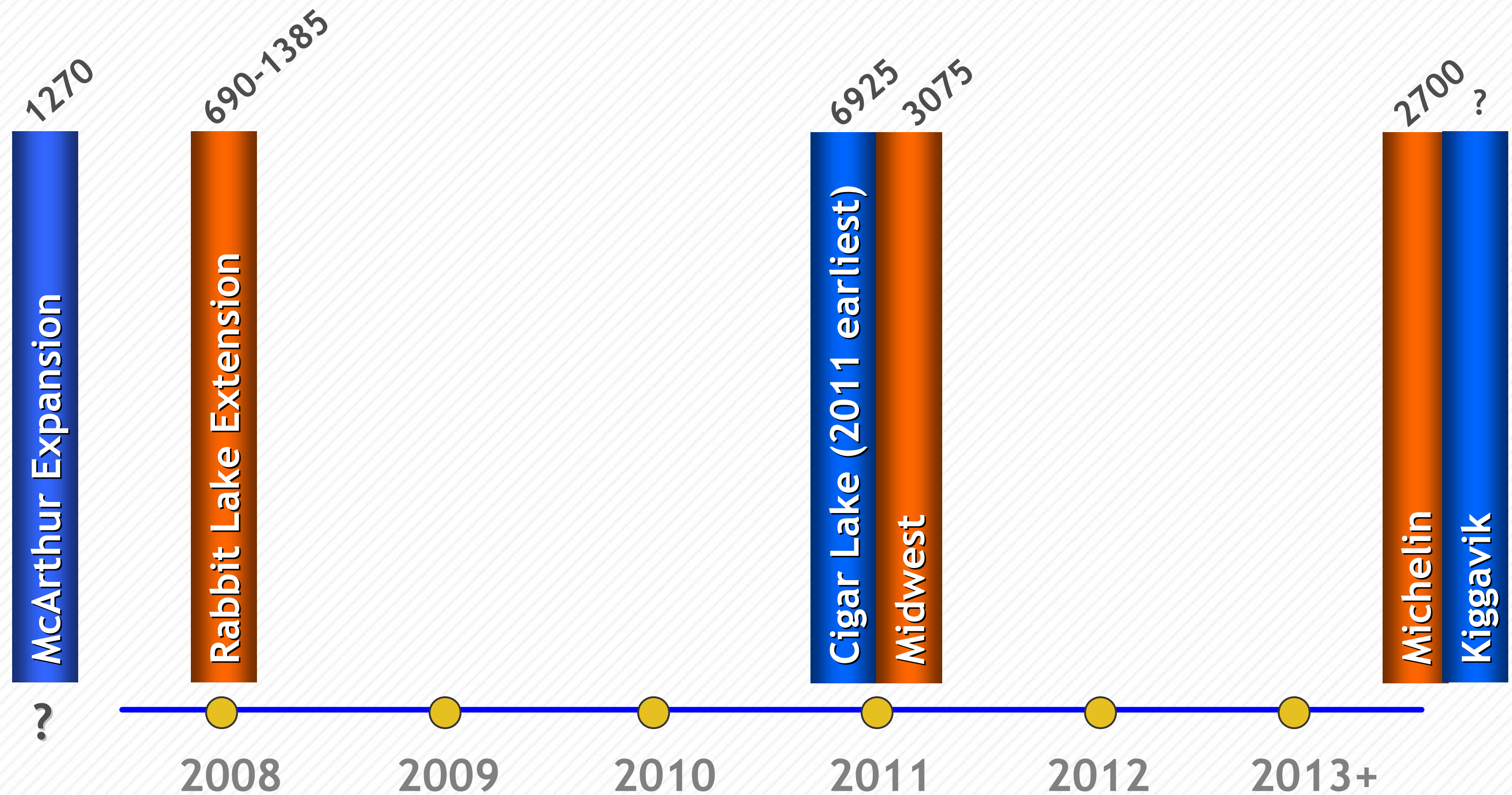
Potential Future Production - Canada

Annual Production Capacity - tonnes U



Year represents projected start-up date; time to reach full capacity will vary

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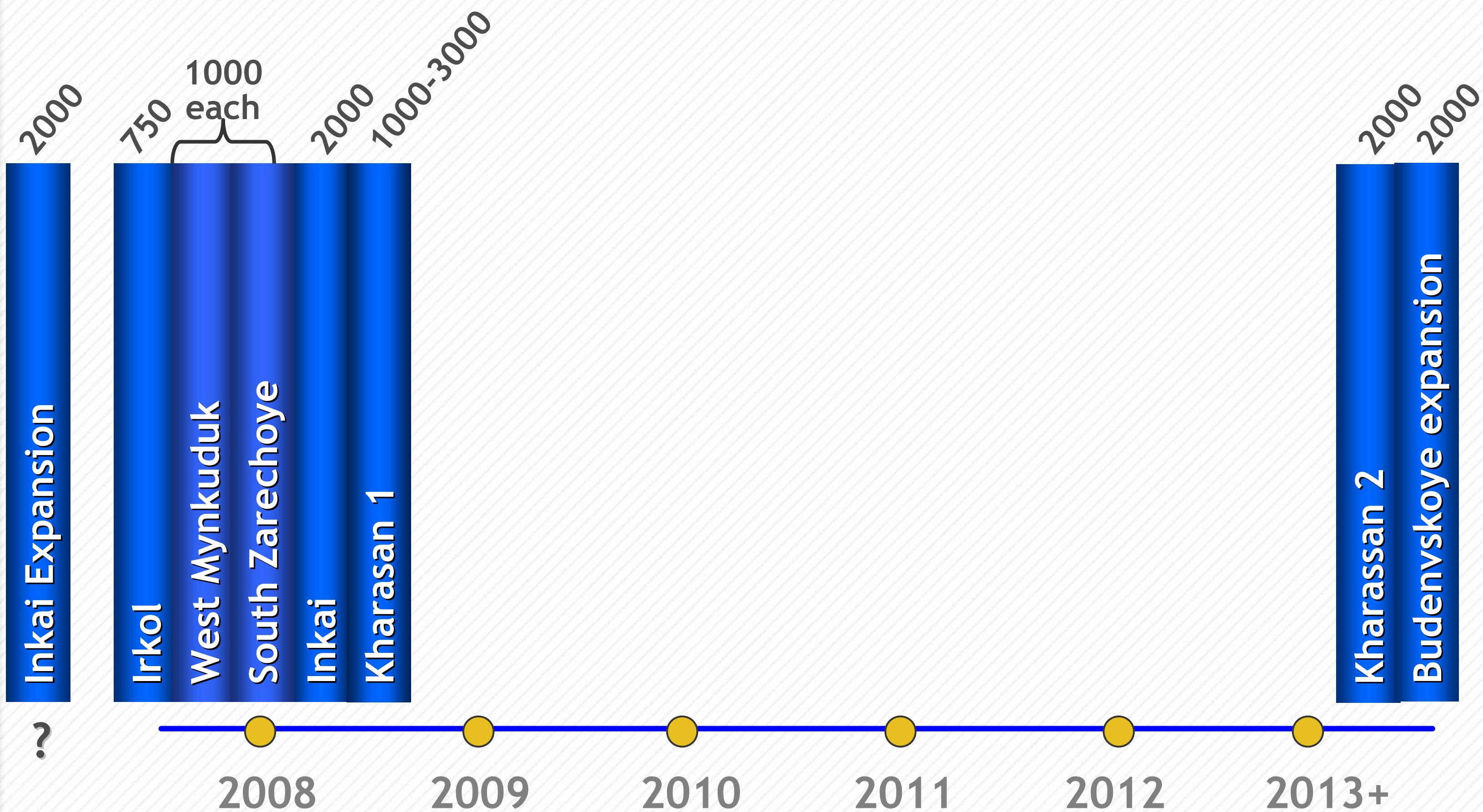
Potential Future Production - Kazakhstan

Annual Production Capacity - tonnes U



Year represents projected start-up date; time to reach full capacity will vary

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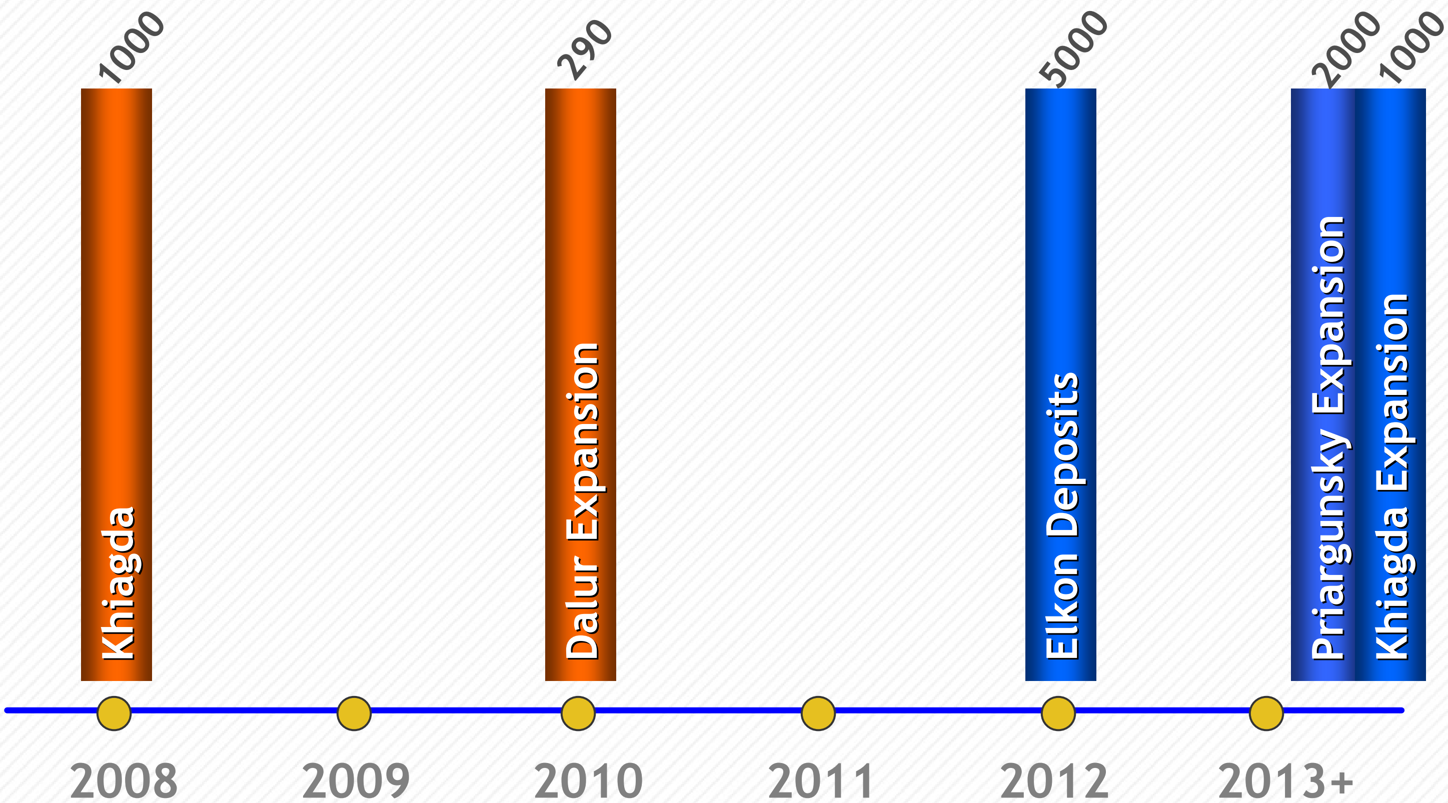
Potential Future Production - Russia

Annual Production Capacity - tonnes U



Year represents projected start-up date; time to reach full capacity will vary

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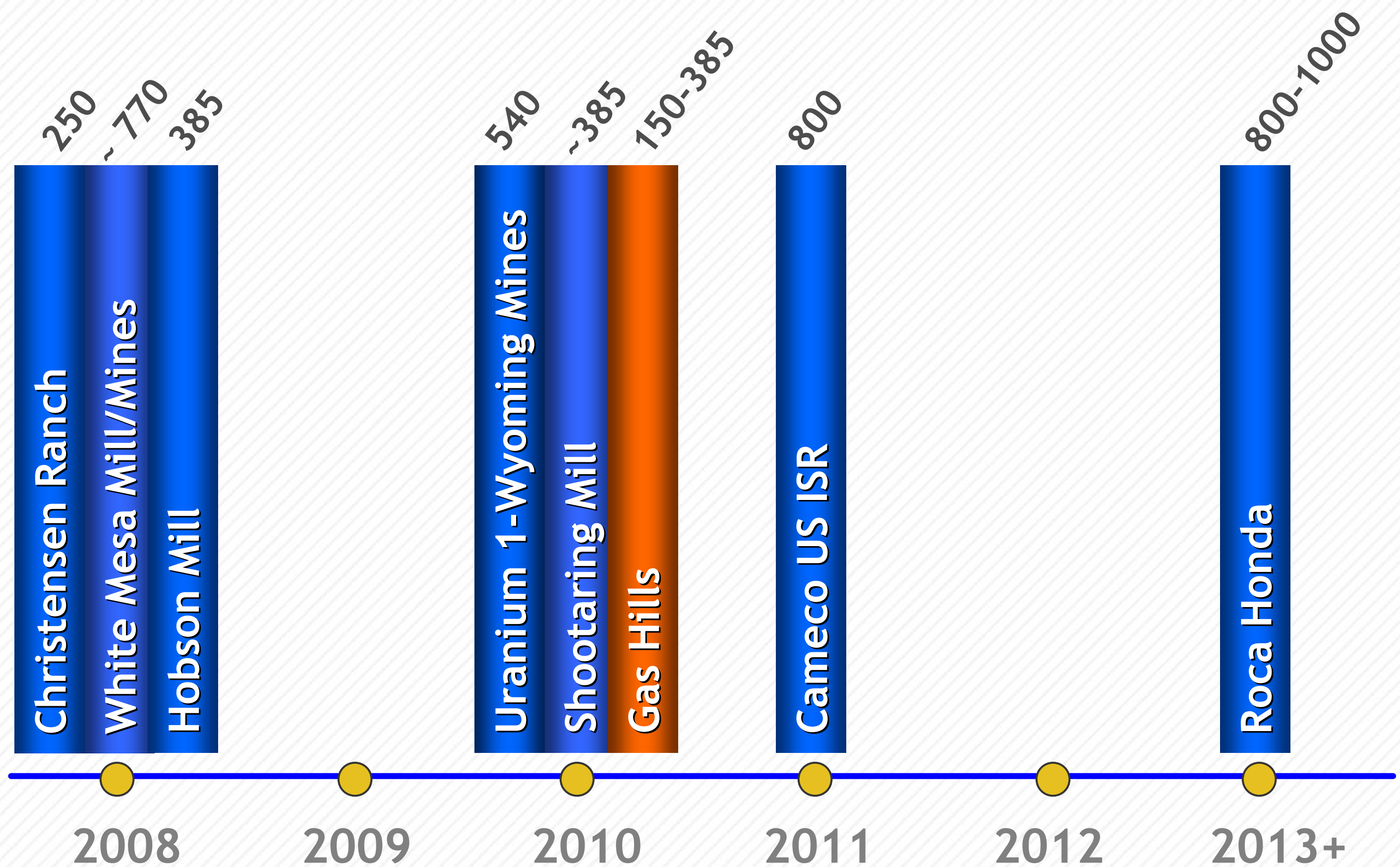
Potential Future Production - US
Annual Production Capacity - tonnes U



Year represents projected start-up date; time to reach full capacity will vary

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Uranium production plans of Kazakhstan

2006	5,279 tU
2007	6,637 tU
2008	9,500 tU
2009	15,000 tU
2010	18,000 tU
2011	19,000 tU
2015 onwards	25,000 tU per annum

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Industry organisation in Kazakhstan

- Continuing production from old mining areas - 3,000 - 4,000 tU per year
- Joint ventures with Cameco (Inkai) and Areva (Katco) - each up to (eventually) 4000 tU per year
- Investments by Uranium One in Akdala, South Inkai and Kharasan-1 deposits - up to 4,000 tU per year
- Joint ventures with Japanese partners
- Supply arrangements with other Japanese partners

  (could supply 40% of Japanese U demand - 5,000 tU)
- Joint ventures with Russia
- Further expected investments and supply arrangements with Korea and China

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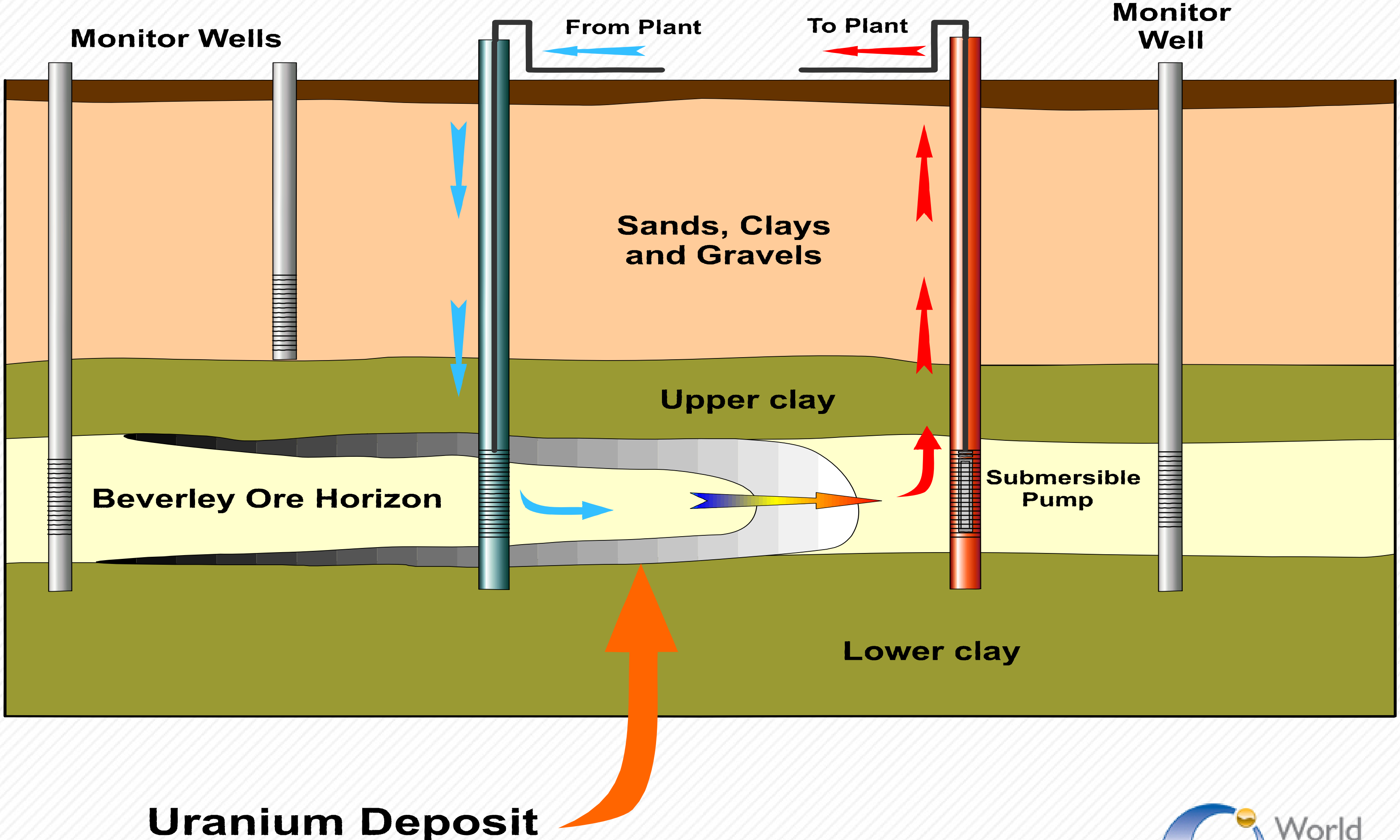
ISL mining



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ISL mining - wellfield

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ISL operation - process plant

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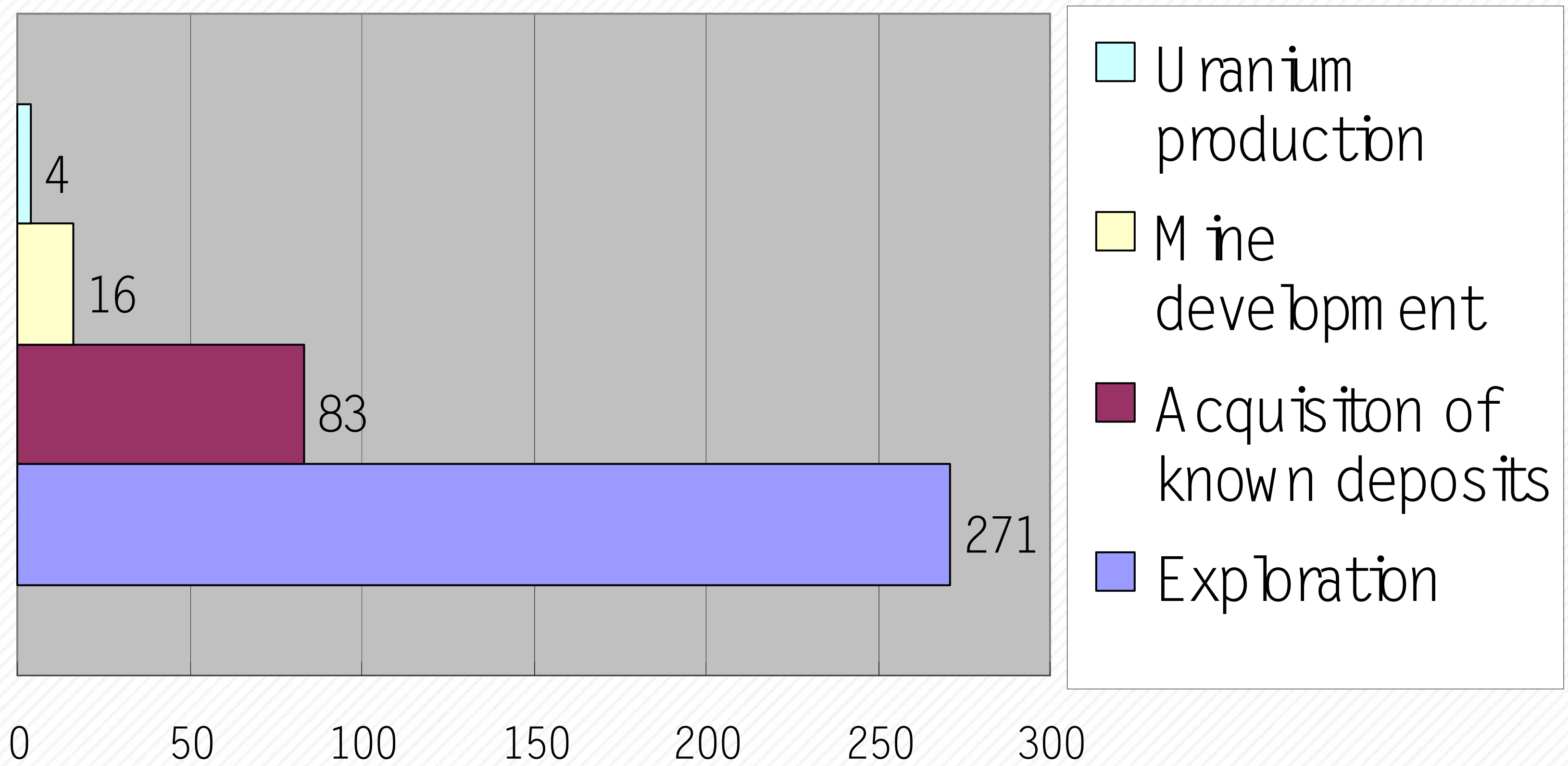
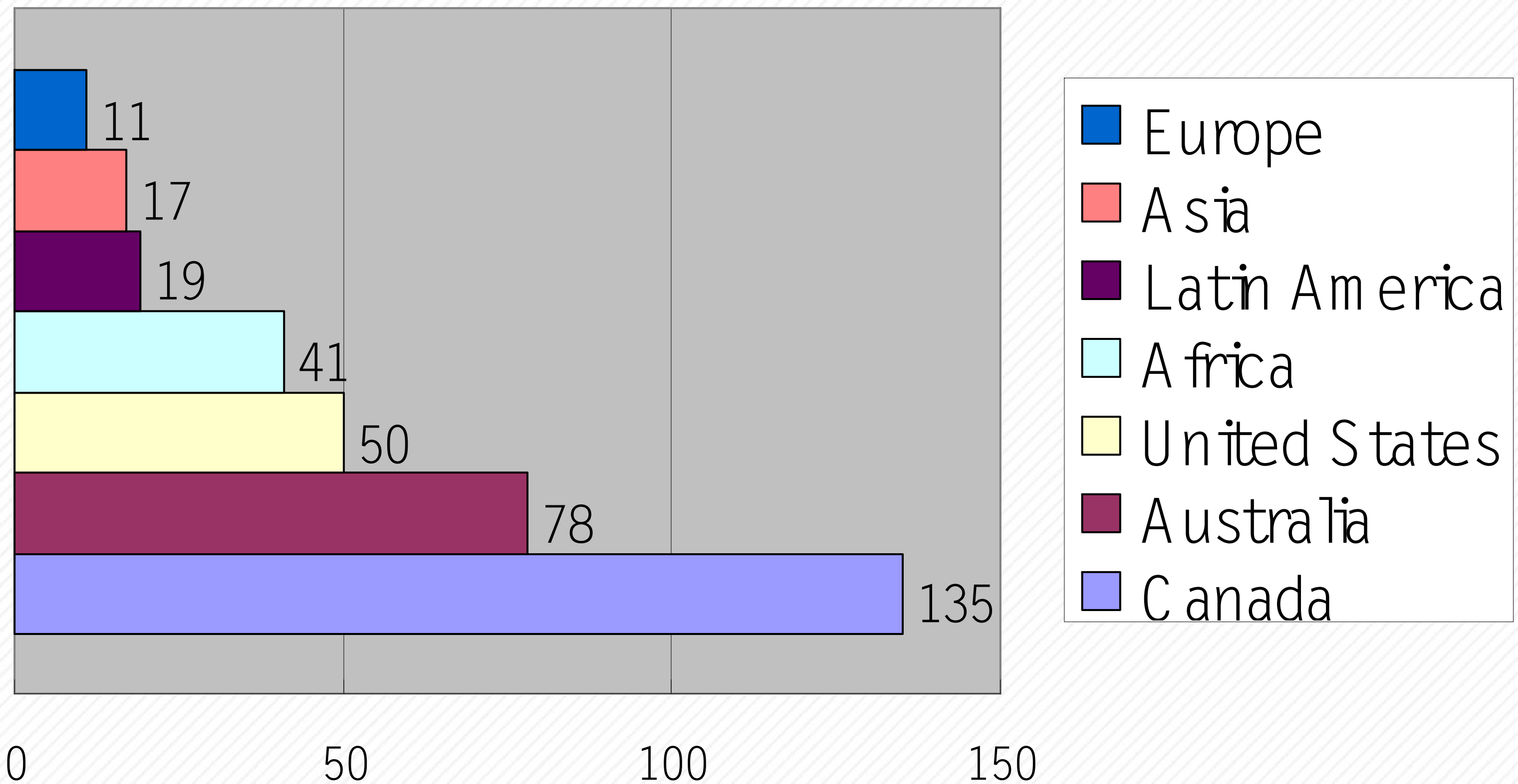
Junior uranium companies - activities



Junior uranium companies - location of activities



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Future of secondary supplies

- Can be regarded as previous uranium production, held off the market for an extended period
- Will remain an important element in nuclear fuel supply
- Ex-military materials – further HEU down-blending?
- Government inventories
- MOX and RepU fuel

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MOX and RepU fuels

- Reprocessing plants separate uranium and plutonium from used fuel
- RepU is re-enriched by centrifuges or blending to produce fresh fuel
- Extracted plutonium is introduced as the primary fissile element in MOX fuel
- Major reprocessing plants in France and UK with one nearing completion in Japan
- Could return as a major force – MOX plant in US, GNEP etc

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UF_6 conversion capacity, tU

Cameco	Canada	14,000
COMURHEX	France	14,500
CNNC	China	3,000
ConverDyn	USA	15,000
Rosatom	Russia	15,000
Westinghouse	UK	6,000
Total		67,500

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UO_2 conversion capacity, tU

Argentina	160
Canada	2700
China	200
India	435
Korea	400
Romania	150
Total	4045

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Conversion - now and future

- Market for conversion to UF_6 has been quite tight
- Clear shortfalls when plants have been “down”
- Regional imbalance in supply - need for transport
- Springfields facility in UK didn’t close as originally scheduled in 2006 - some relief to supply
- Investment in expanded and new facilities
- Possible increased access to surplus Russia capacity
- Continued need for secondary supplies - particularly from down-blended Russian HEU

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Enrichment - basics

- 90% of current power reactors need fuel where the U-235 isotope is above the natural 0.71% (typically 3-5%)
- Two main technologies – gaseous diffusion and centrifuges
- Investment in laser enrichment so far unrewarded by commercial application
- Large front-end expense for utilities
- Effort expended is measured in separative work units (SWUs)
- Significant part of capacity was historically developed for military requirements

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Enrichment - supply

- Four large suppliers of primary enrichment services - USEC, Eurodif (Areva), Urenco and Rosatom
- USEC and Eurodif use gas diffusion
- Urenco and Rosatom use centrifuges
- JNFL and CNNC also primary suppliers
- Heavy current investment in new centrifuge plants by USEC and Urenco in US and by Eurodif in France (and eventually US too)
- Will SILEX prove commercially viable?

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Enrichment capacities, 000 SWUs

CNNC	China	1,000
Eurodif	France	10,800
JNFL	Japan	1,050
Rosatom	Russia	25,000
Urenco	Germany	1,800
	Netherlands	3,500
	UK	3,700
USEC	USA	11,300
Total		58,150

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Georges Besse II

Early 2008 (source : AREVA NC)

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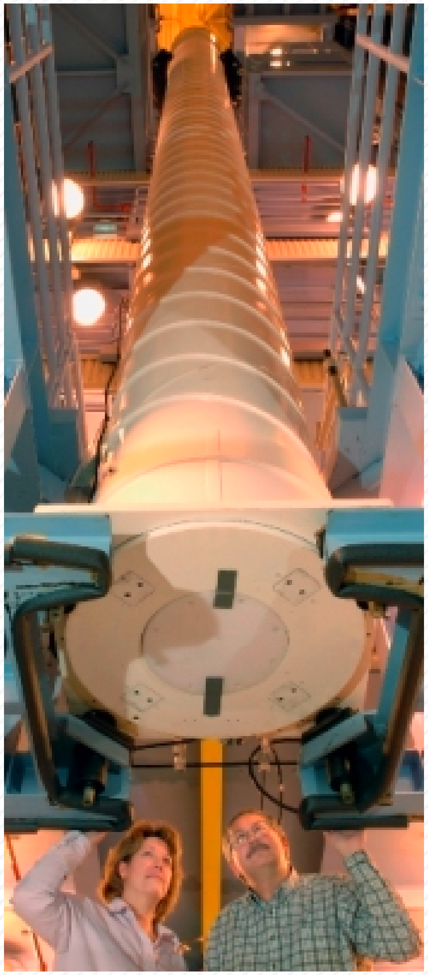
Urenco - NEF: aerial view

USEC - ACP



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Enrichment - current issues

- Acute proliferation issues surround this area of the fuel cycle - similar to reprocessing of used fuel
- Proposals for “regional fuel cycle centres”
- Significant dependence on down-blended Russian HEU - half of SWUs supplied in US in recent years
- Difficulties of access to large Russia capacity for Western reactor operators
- Significant capacity is today devoted to re-enrichment of depleted uranium (“tails”)

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Fuel fabrication – capacities etc

- Fundamentally a different process to uranium, conversion and enrichment - not a bulk commodity item - but “high tech”
- Annual requirements for LWR fuel fabrication is about 7,000 tonnes of heavy metal (enriched U)
- Annual requirements for CANDUS and other reactor types are 2,000-3,000 tU per annum
- Capacity for LWRs is around 11,500 tU per annum
- Production much more “localised” than other areas of fuel cycle
- “Big boys are Areva NP, Toshiba-Westinghouse, GE-Hitachi and TVEL
- Important smaller suppliers – CNNC, JNFL, KNFC, ENUSA

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Fuel fabrication - current trends

- PWR fuel market very competitive, BWR fuel market becoming more competitive
- Now some competition for fuelling Russian-origin reactors
- Non-LWR fuel requirements tend to be met by domestic suppliers - for CANDUs, AGRs etc
- Consolidation of suppliers apparent within the sector - BNFL with Westinghouse/ABB (then Toshiba acquired it), Framatome-Siemens merger (Areva NP) and Global Nuclear Fuels (GE and Japanese)
- Still surplus capacity

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Summary

- Uranium resources are very adequate and production will rise to meet market demand
- Conversion capacity will gradually increase and Comurhex plant in France replaced
- Huge investment in enrichment sector - both replacement and incremental
- Fuel fabrication has adequate supply
- Reprocessing may make a comeback

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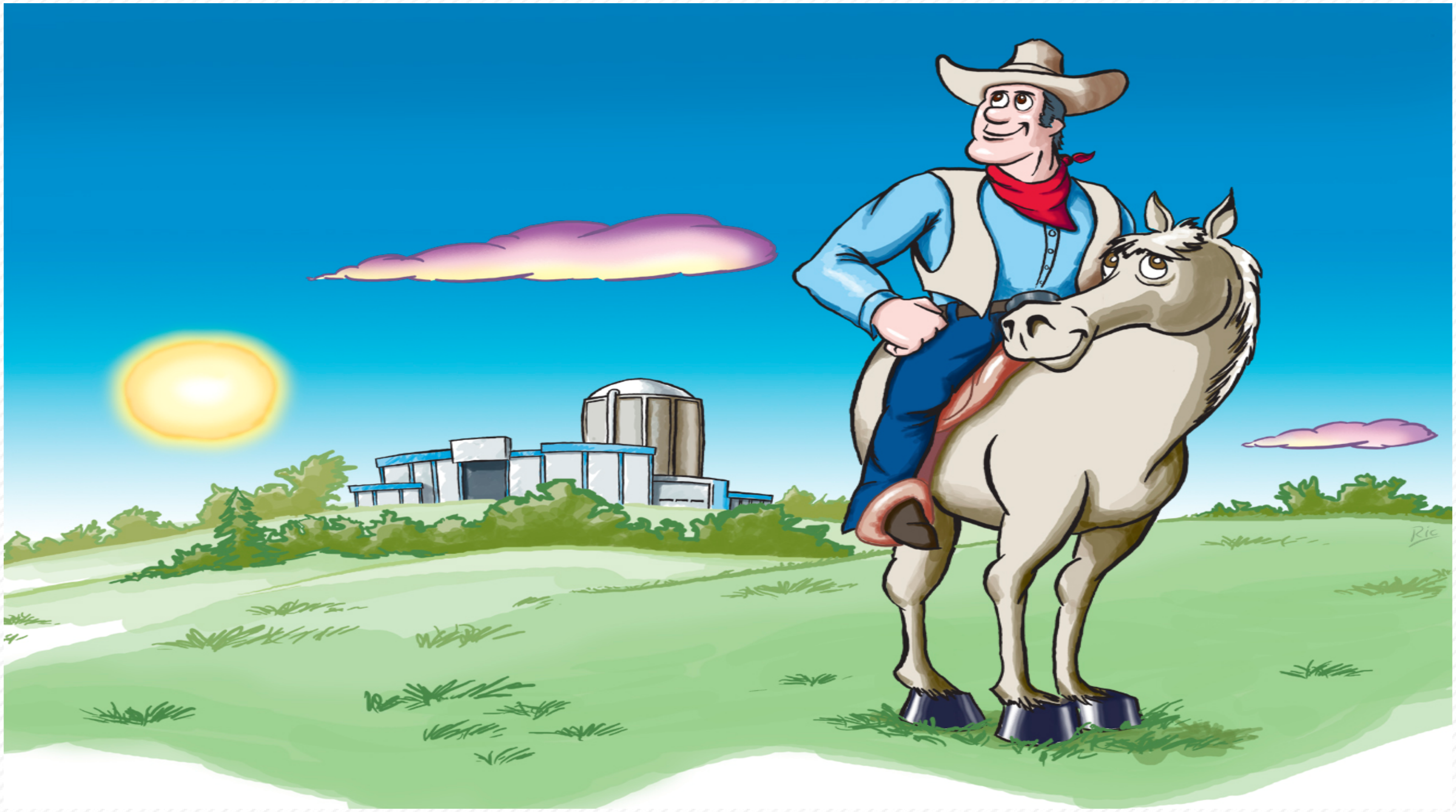
Happy future 1



Happy future 2- Beijing WNU class 2007

Happy future 3 – WNU South Africa Class 2008

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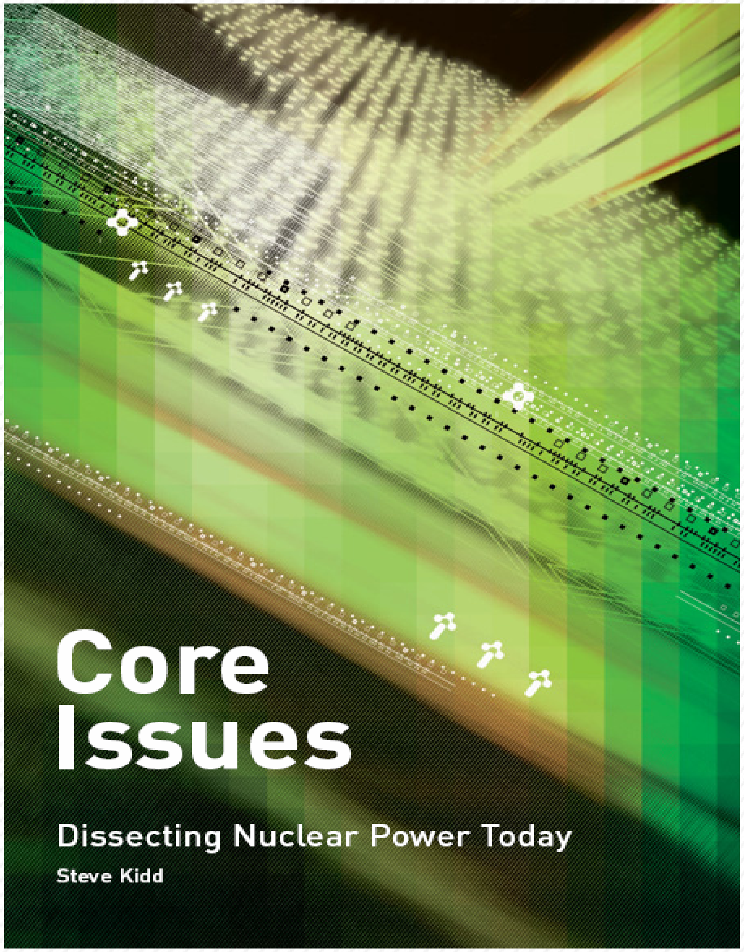
New book!



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