The IAEA uranium classification system

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IAEA
International Atomic Energy Agency

Nuclear fuel resources

- Nuclear growth projections
- Nuclear fuel cycle and its peculiarities
- Uranium resources, demand and production
- Alternatives?
- Aspects of IAEA classification scheme
- Long-term projections of fuel supply
- What next?

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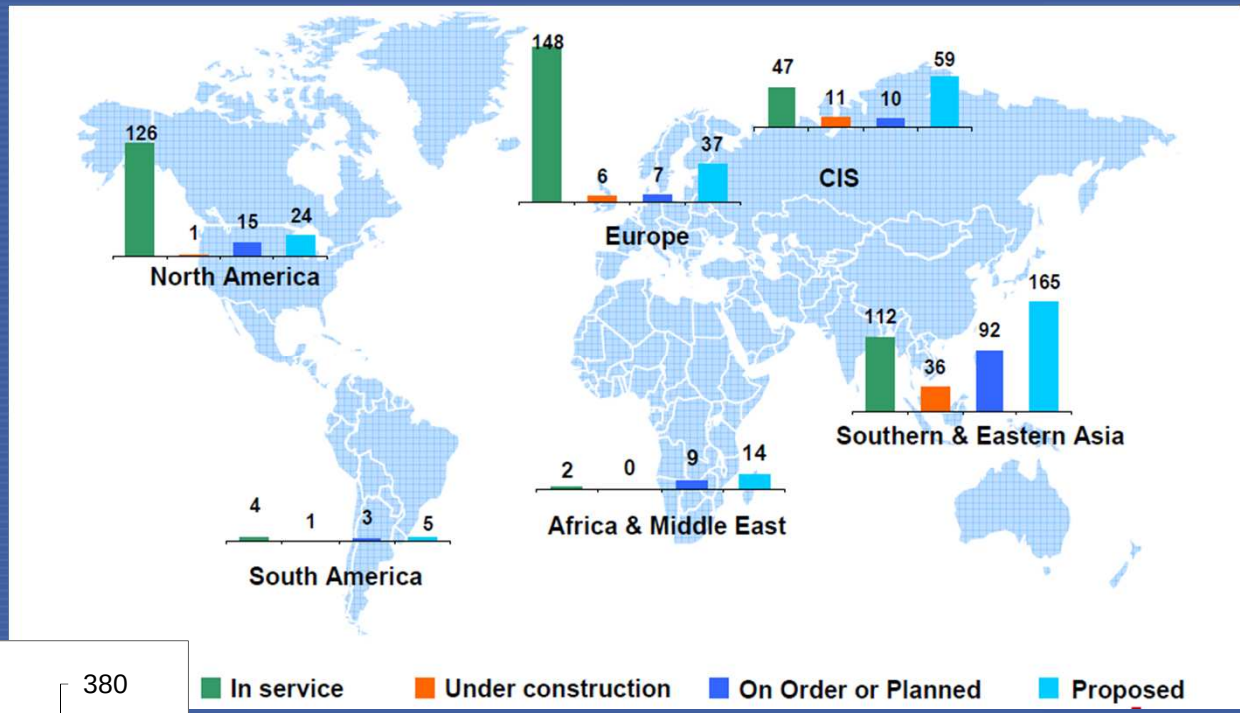
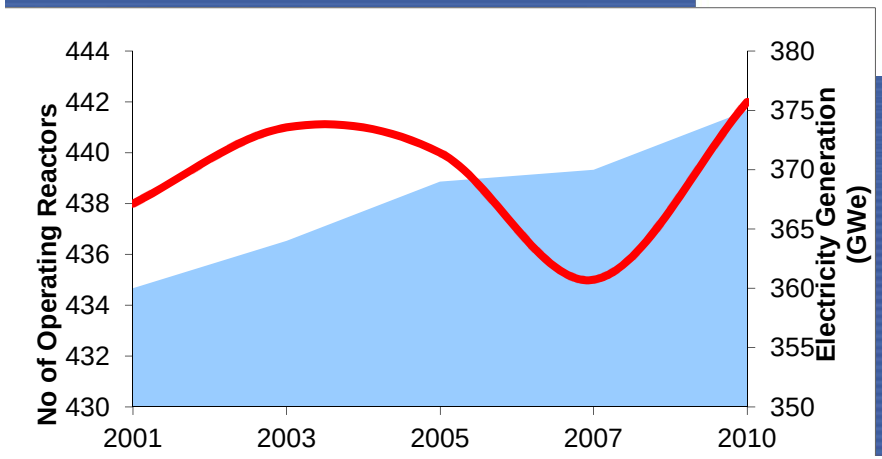
Nuclear Energy today

442 NPPs in operation with 375 GW(e)





Growth forecast for 2030

Year of the forecast	Forecast- Lower		Forecast-Higher	
	GWe	Increase (%)	GWe	Increase (%)
IAEA 2003	386	1 (Reference case)	573	1 (Reference case)
IAEA 2004	423	+9.6	592	+3.3
IAEA 2005	418	+8.3	640	+11.7
IAEA 2006	414	+7.3	679	+18.5
IAEA 2007	447	+15.8	691	+20.6
IAEA 2008	473	+22.5	748	+30.5
IAEA 2009	511	+32.4	807	+40.8

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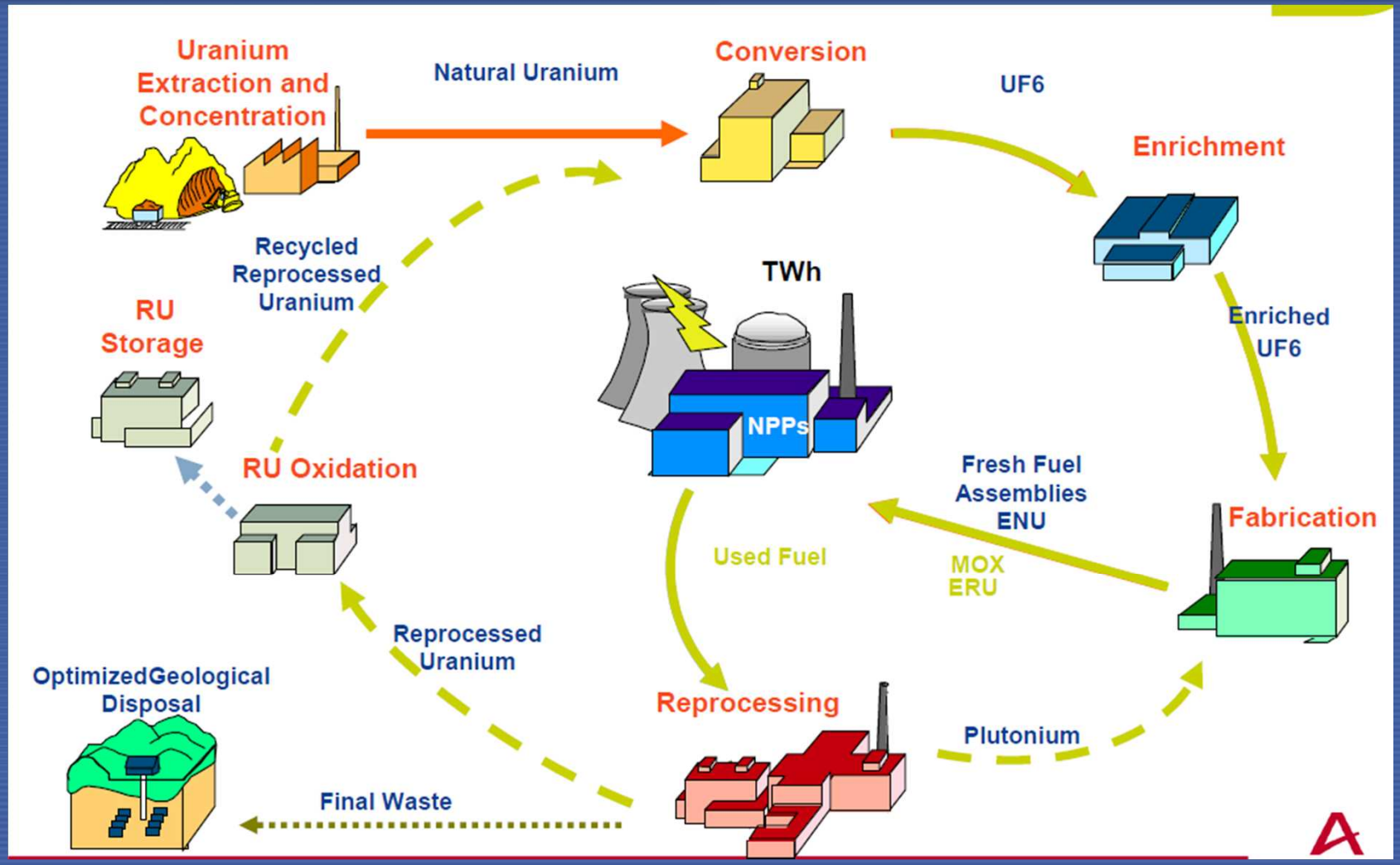
Material flow in the fuel cycle



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World distribution of uranium resources

Red Book 2009

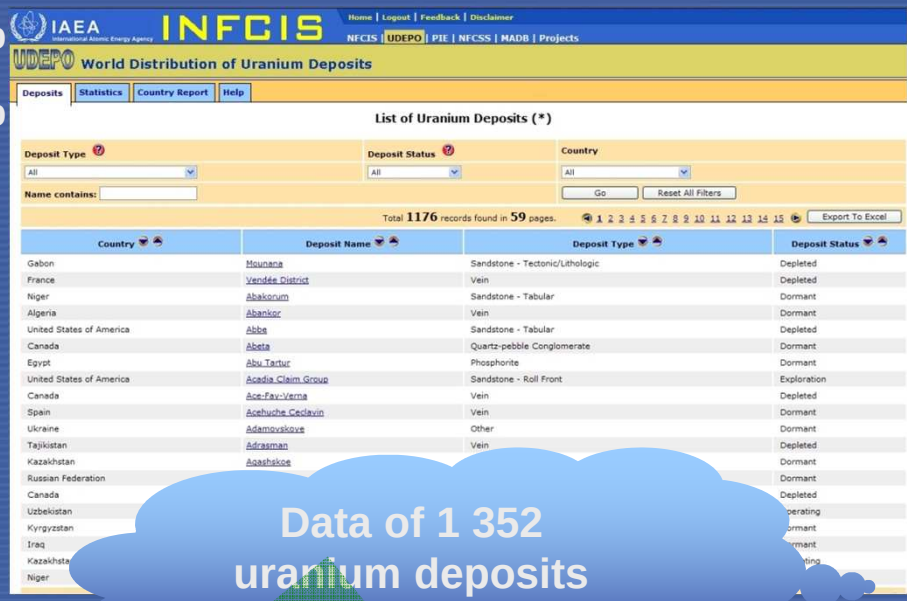
	tU	
Australia	1 679 000	26.6%
Kazakhstan	832 000	13.2%
Russia	565 000	9.0%
Canada	544 000	8.6%
United States	472 100	7.5%
South Africa	295 600	4.6%
Namibia	284 200	4.5%
Brazil	278 700	4.4%
Niger	275 500	4.3%
Others	1 079 000	17%
Total	6 306 000	100%

Recoverable Resources Identified < $260

Undiscovered Resources: 10 400 000 tU

IAEA /OECD NEA Uranium 2009: Resources, Production and Demand

iNFCIS - UDEPO



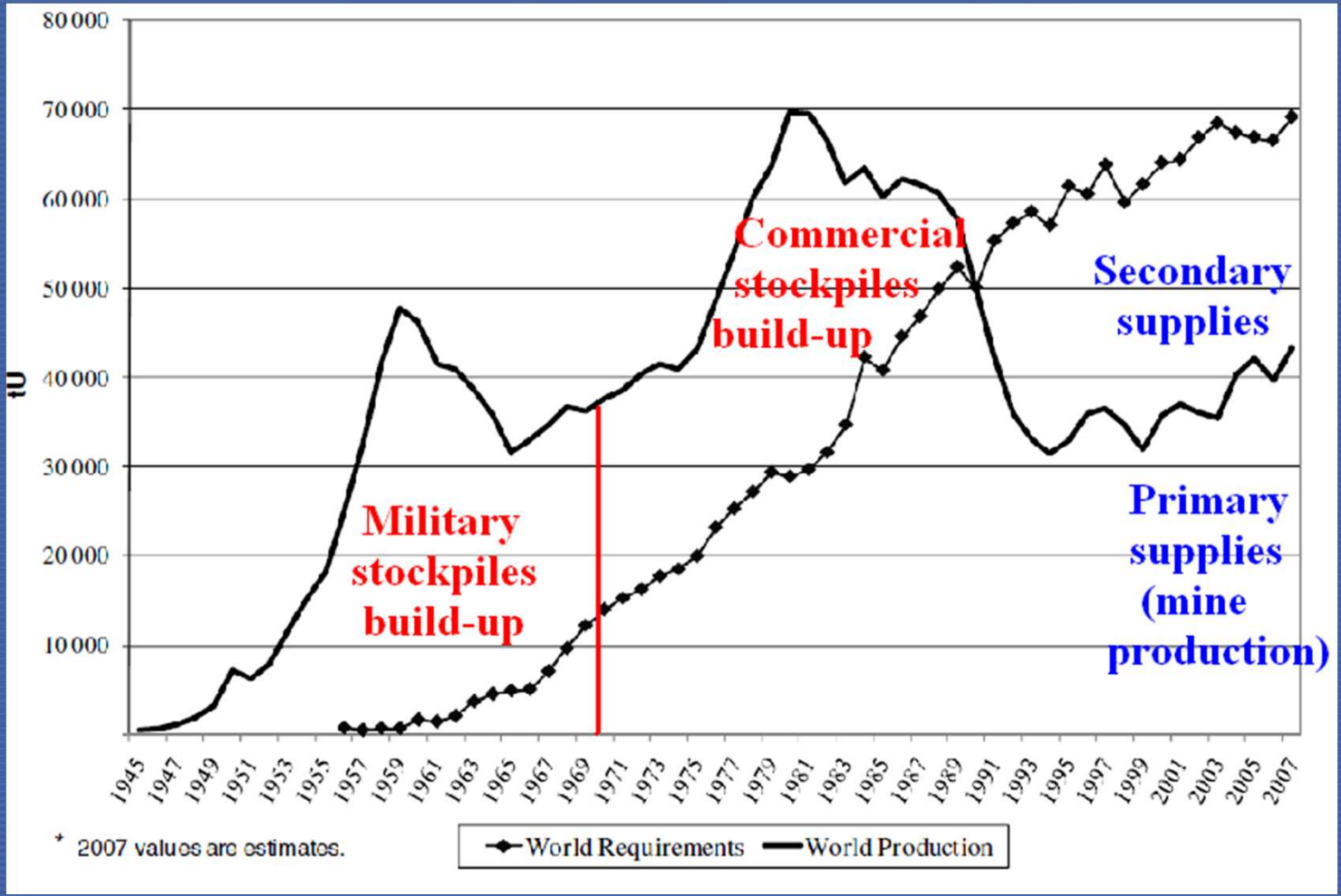
Data of 1 352 uranium deposits from 75 countries

Total Resources Identified

Total 25 982 894 tU

http://www-nfcis.iaea.org

Skewed Demand Versus Supply (1)



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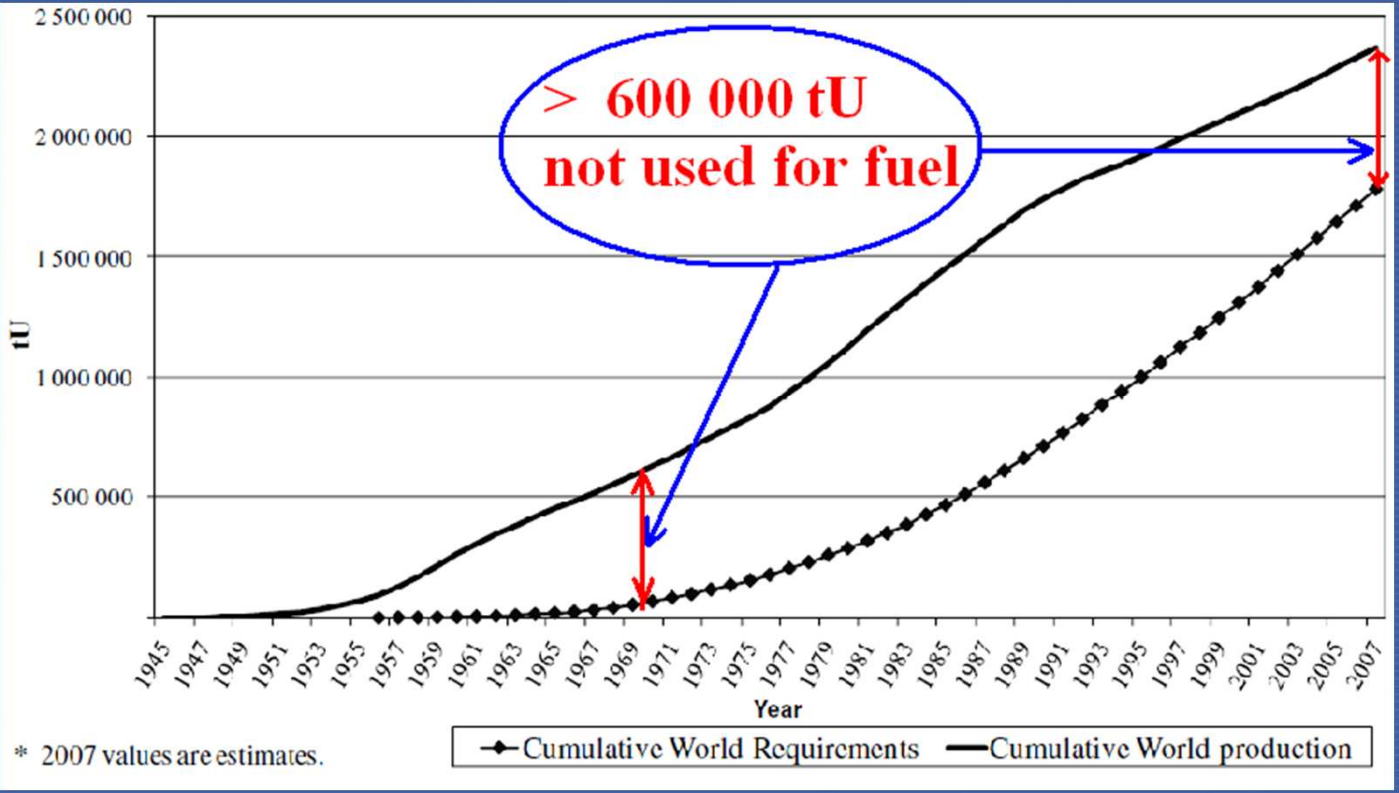
Skewed Demand Versus Supply (2)



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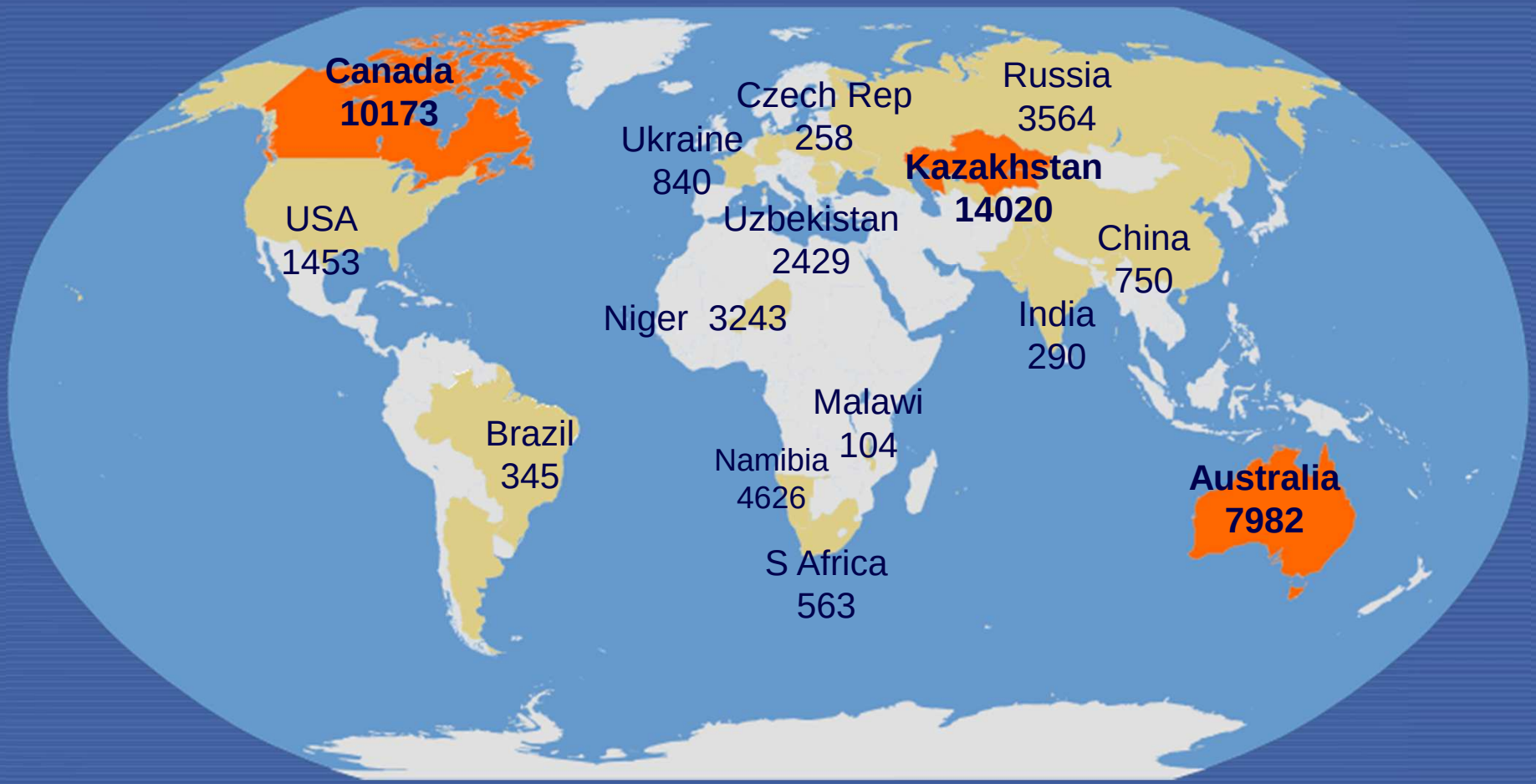
Uranium production 2009



Total 50772 tU

(Required 68646 tU)

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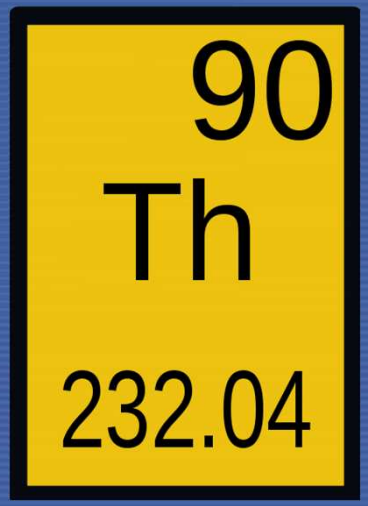
Thorium as fuel

- Large **resources** of thorium
- **Self sustained** equilibrium thorium fuel cycle
- Intrinsic **proliferation resistance**
- Better thermo-physical properties and **chemical stability**
- **High burn – up** capability
- Lesser long lived **minor actinides**
- Superior **plutonium incineration**
- Attractive in **accelerated driven systems** and energy amplifiers



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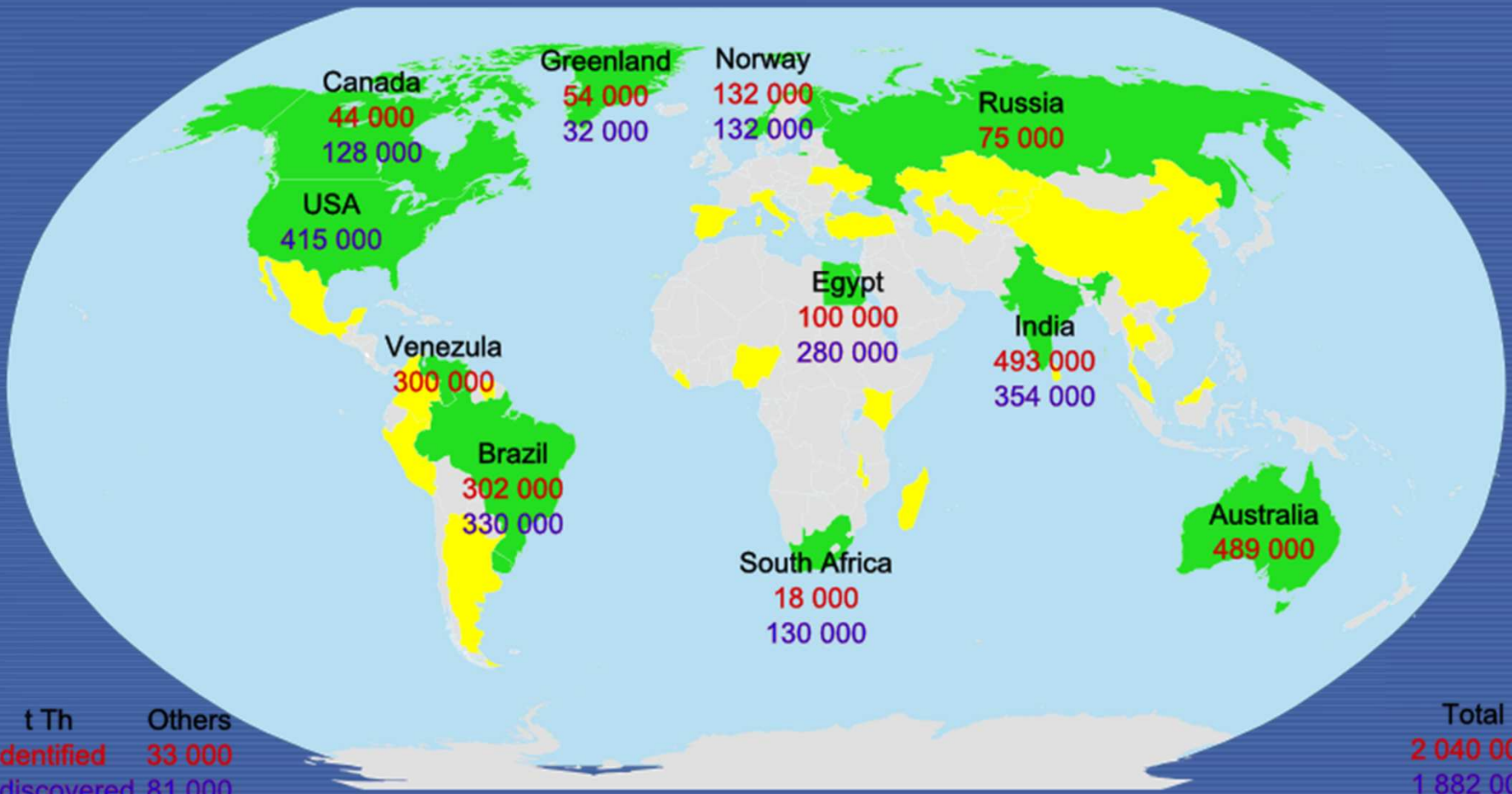
Thorium Resources



t Th	Others
Identified	33 000
Undiscovered	81 000

Total
2 040 000
1 882 000

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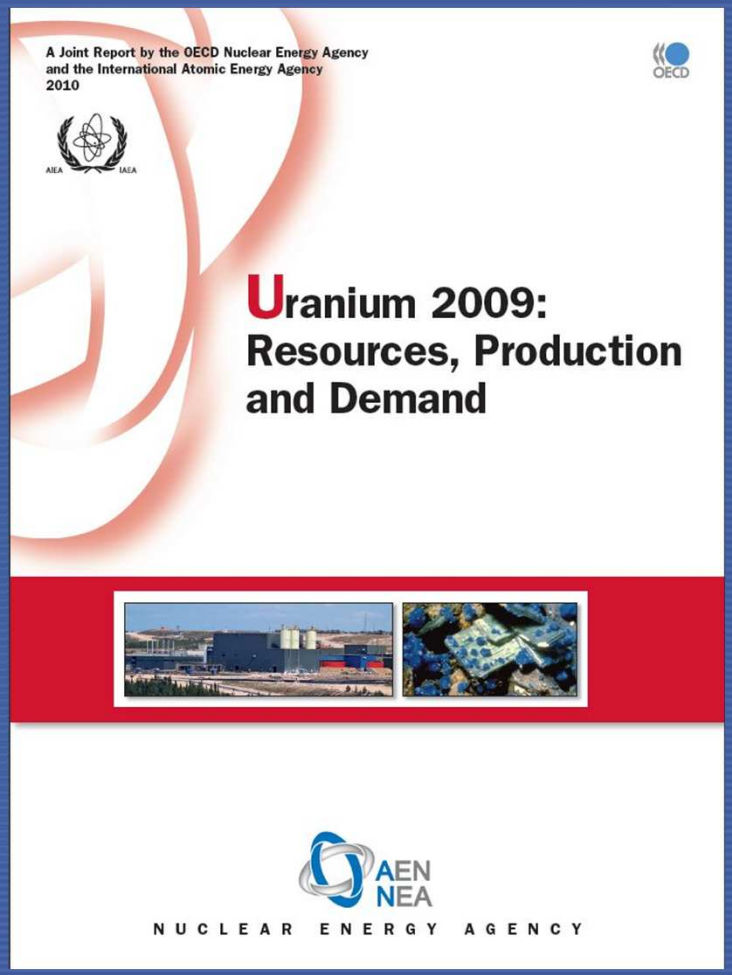
Data based on Red Book 2009 & ThDEPO 2010

The ‘Red Book’

- Publisher jointly by OECD-NEA and IAEA
- Standard for making official country resource submissions .
- All countries are encouraged to openly report their uranium resources using a classification that is compatible with the national systems.



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Aspects considered

- Consideration for recoverability
- Adjustment of estimate for past production
- Meaningful economic analysis of production cost
- Take into account all costs in economic analysis - such as infrastructure and rehabilitation following operation
- Avoid obsolete economic evaluation

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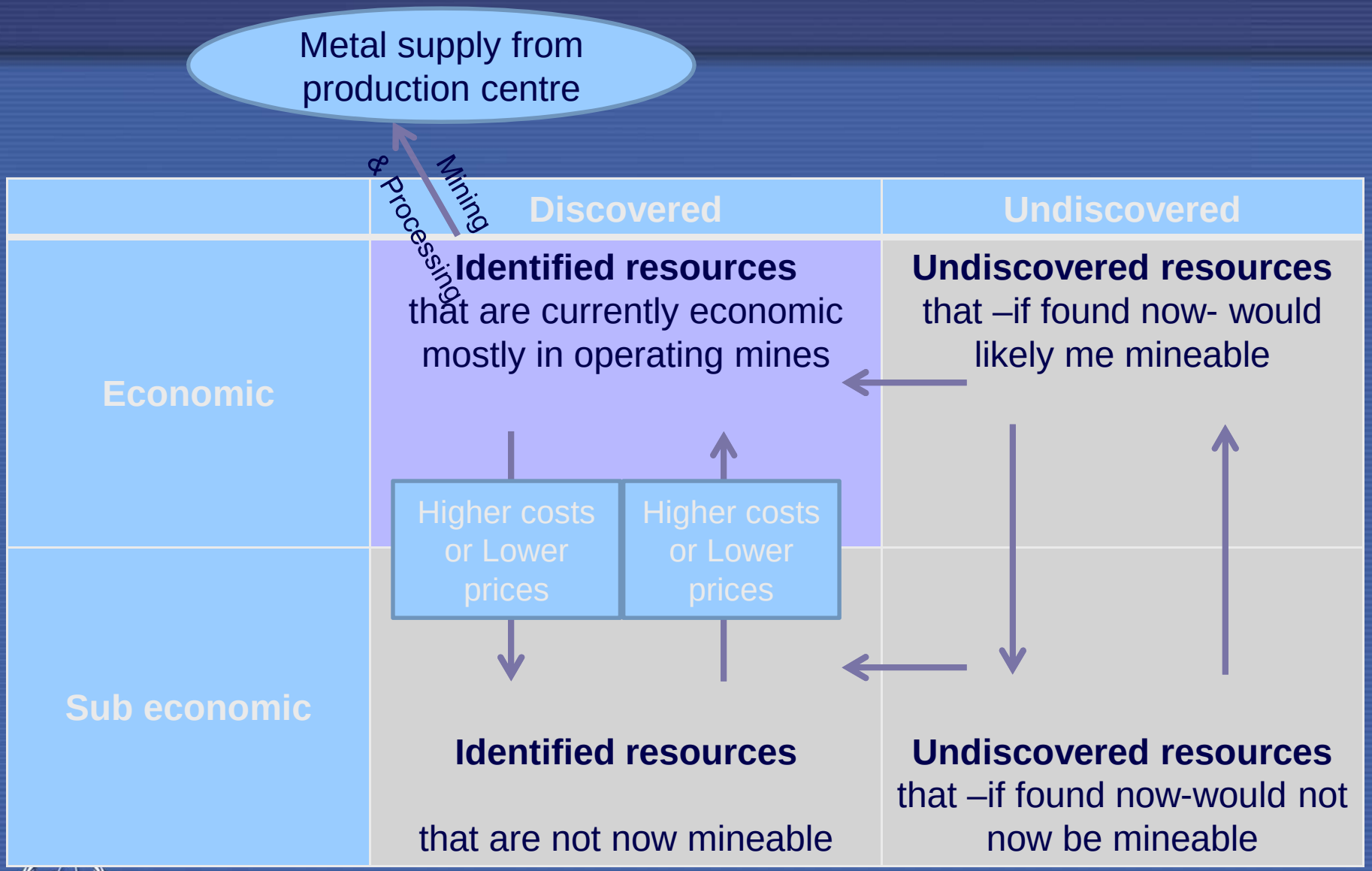
Flow of resources



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NEA-IAEA Classification Scheme (1)

Decreasing economic attractiveness

		IDENTIFIED RESOURCES		UNDISCOVERED RESOURCES	
Recoverable at costs	<USD 40/KgU	Reasonably Assured Resources	Inferred Resources	Prognosticated Resources	Speculative Resources
	USD 40-80/KgU	Reasonably Assured Resources	Inferred Resources	Prognosticated Resources	
	USD 80-130/KgU	Reasonably Assured Resources	Inferred Resources	Prognosticated Resources	
	USD 130-260/KgU	Reasonably Assured Resources	Inferred Resources	Prognosticated Resources	

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Decreasing confidence in estimates

NEA-IAEA Classification (2)

- Confidence level of the estimates
- Market based cost of producing (or recovering) the resource (ore concentrate – yellow cake).
- **Identified resources**
  - ***Reasonably Assured Resources (RAR)*** *– estimates based on specific sample data and measurements -RECOVERABLE*
  - ***Inferred Resources*** *– estimates based on direct geological evidence in the extensions of well-explored deposits; but specific data inadequate - RECOVERABLE*
- **Undiscovered Resources**
  - ***Prognosticated Resources*** *– estimates based on indirect evidence in well-defined geological trends or areas of mineralisation – IN SITU*
  - ***Speculative Resources*** *– estimates based on indirect evidence and geological explorations – IN SITU*

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NEA-IAEA classification (4)

	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES		
NEA/IAEA	**Reasonably Assured**		**Inferred**	**Prognosticated**	**Speculative**	
Australia	**Demonstrated**		**Inferred**	**Undiscovered**		
	Measured	**Indicated**				
Canada (NRCan)	**Measured**	**Indicated**	**Inferred**	**Prognosticated**	**Speculative**	
United States (DOE)	**Reasonably Assured**		**Estimated Additional**		**Speculative**	
Russian Federation, Kazakhstan, Ukraine, Uzbekistan	**A+B**	**C1**	**C2**	**P1**	**P2**	**P3**
UNFC*	**G1+G2**		**G3**	**G4**	**G4**	

* UNFC correlation with NEA/IAEA and national classification systems is still under consideration

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Recoverable resources

- Mining and ore processing losses are deducted

Method	Overall recovery factor (%)
Open pit	80
Underground	75
ISL (acid)	75
ISL (alkaline)	70
Heap Leach	70
Block / Stope Leach	70
Co/Bi product	75
Unspecified	75

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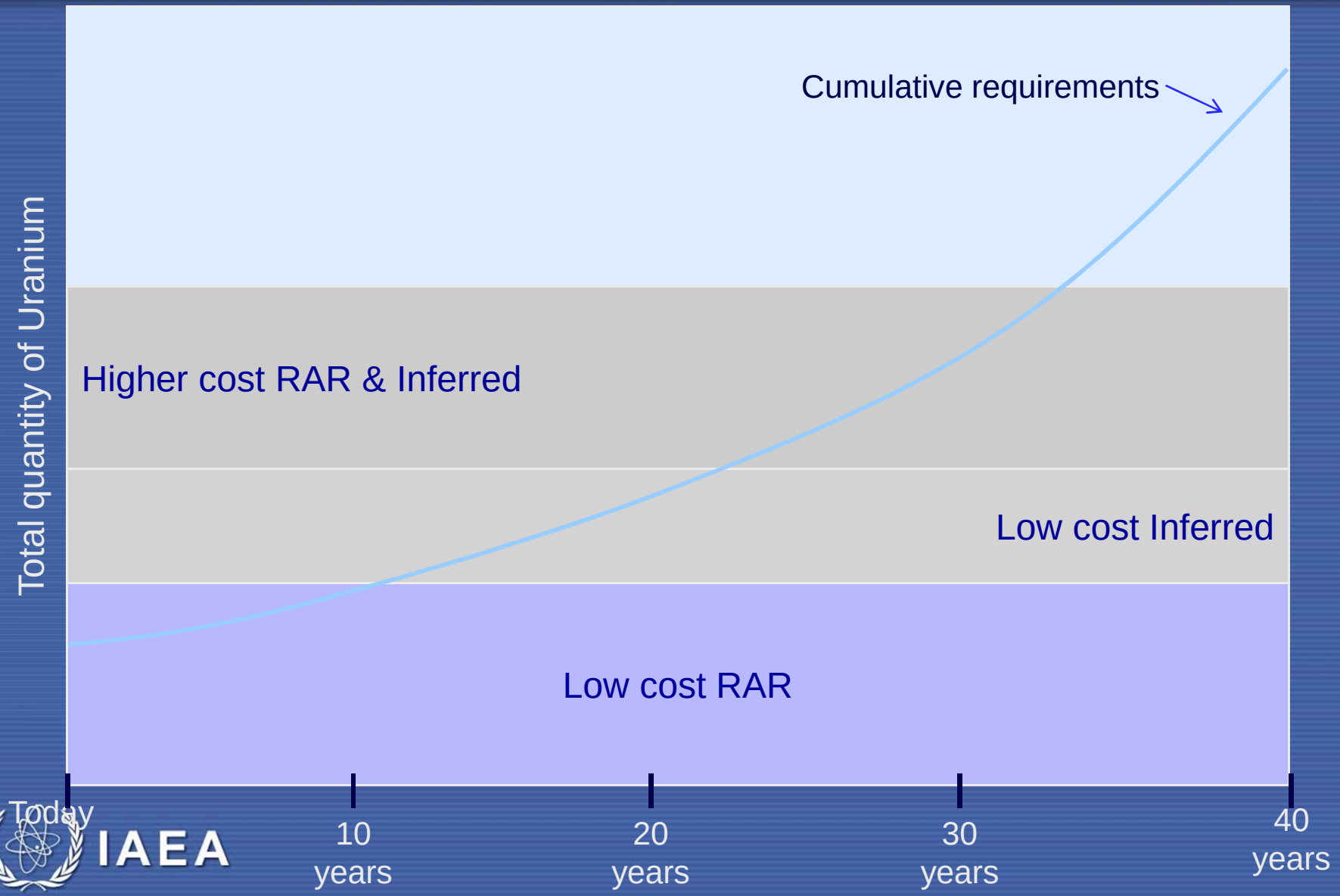
Resource versus requirements



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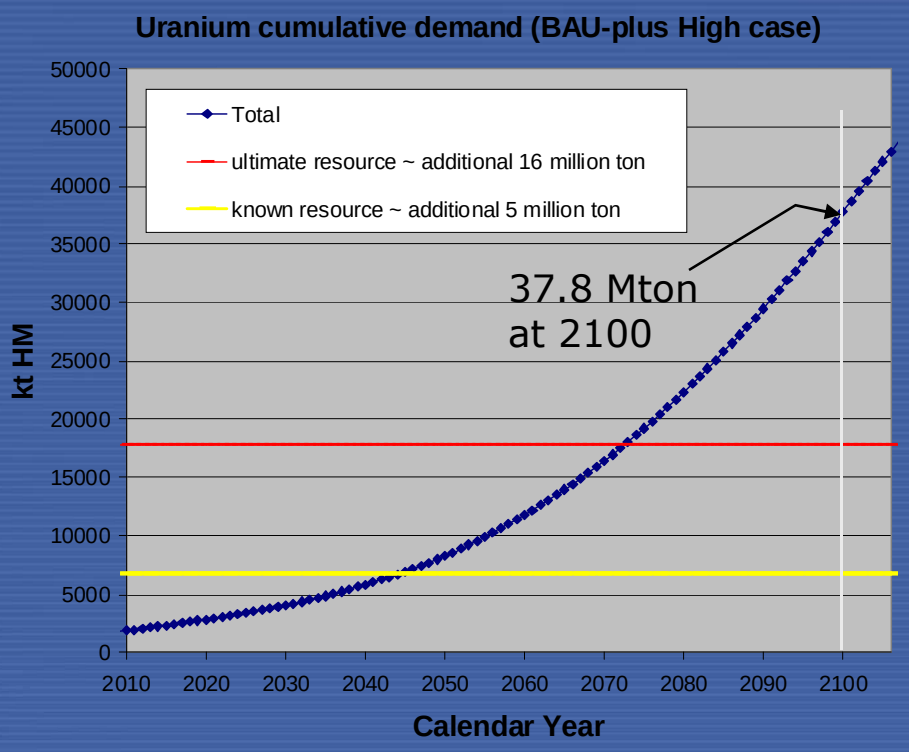
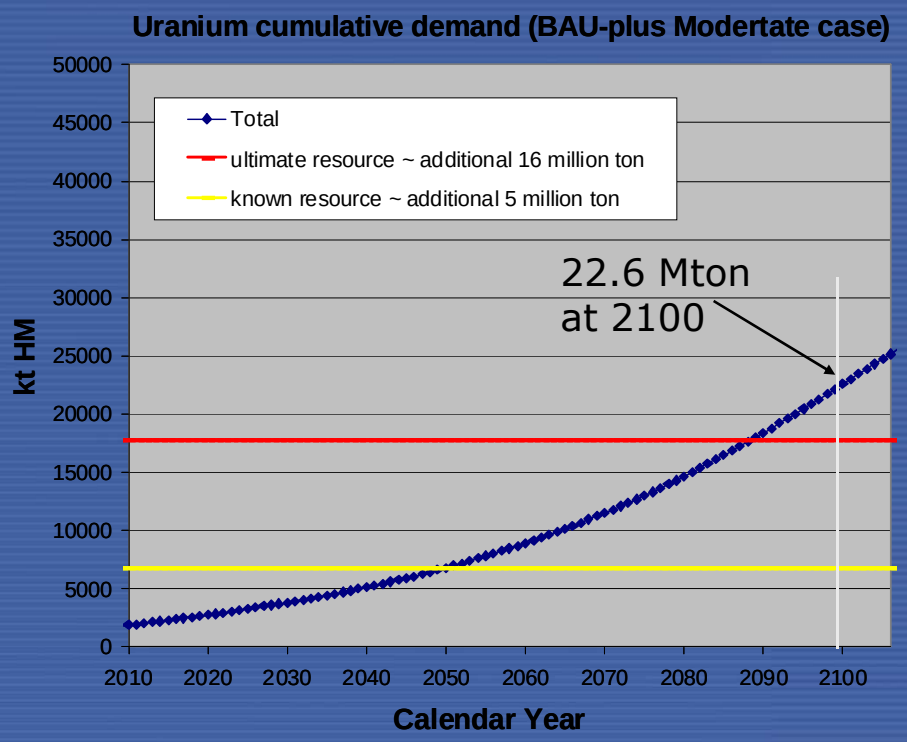
Demand projections

High case



Moderate case



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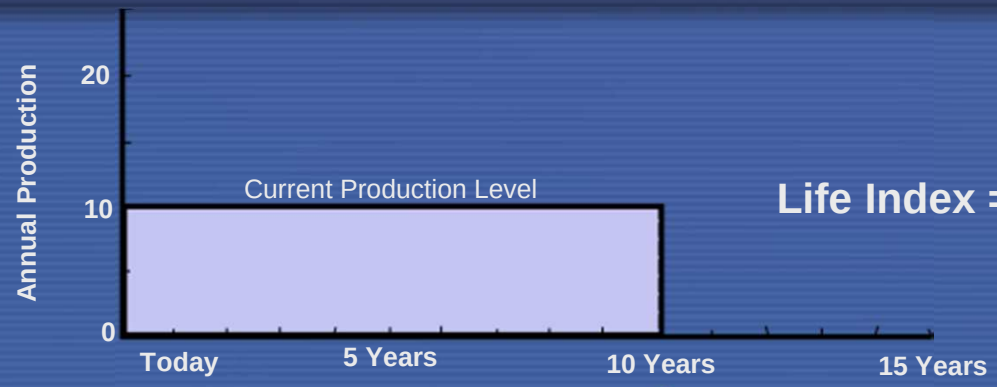
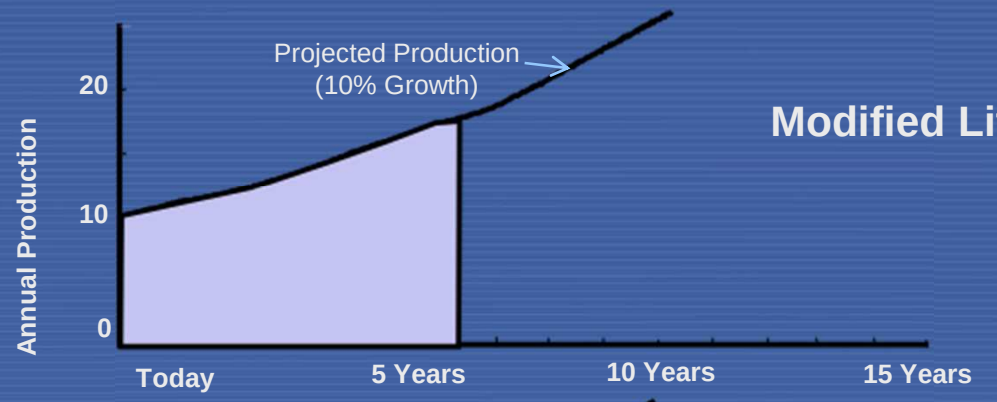
IAEA-INPRO Study 2010

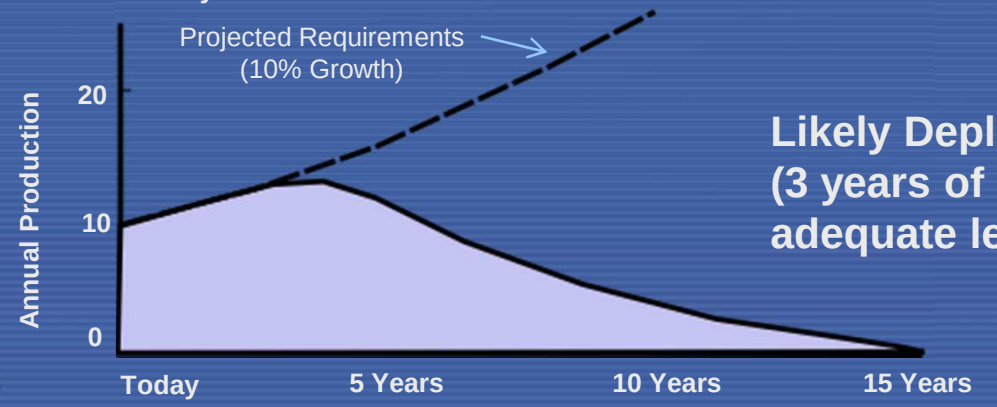
Life index and its limitations



Life Index = 10



Modified Life Index = 6.3



Likely Depletion Pattern (3 years of production at adequate levels)

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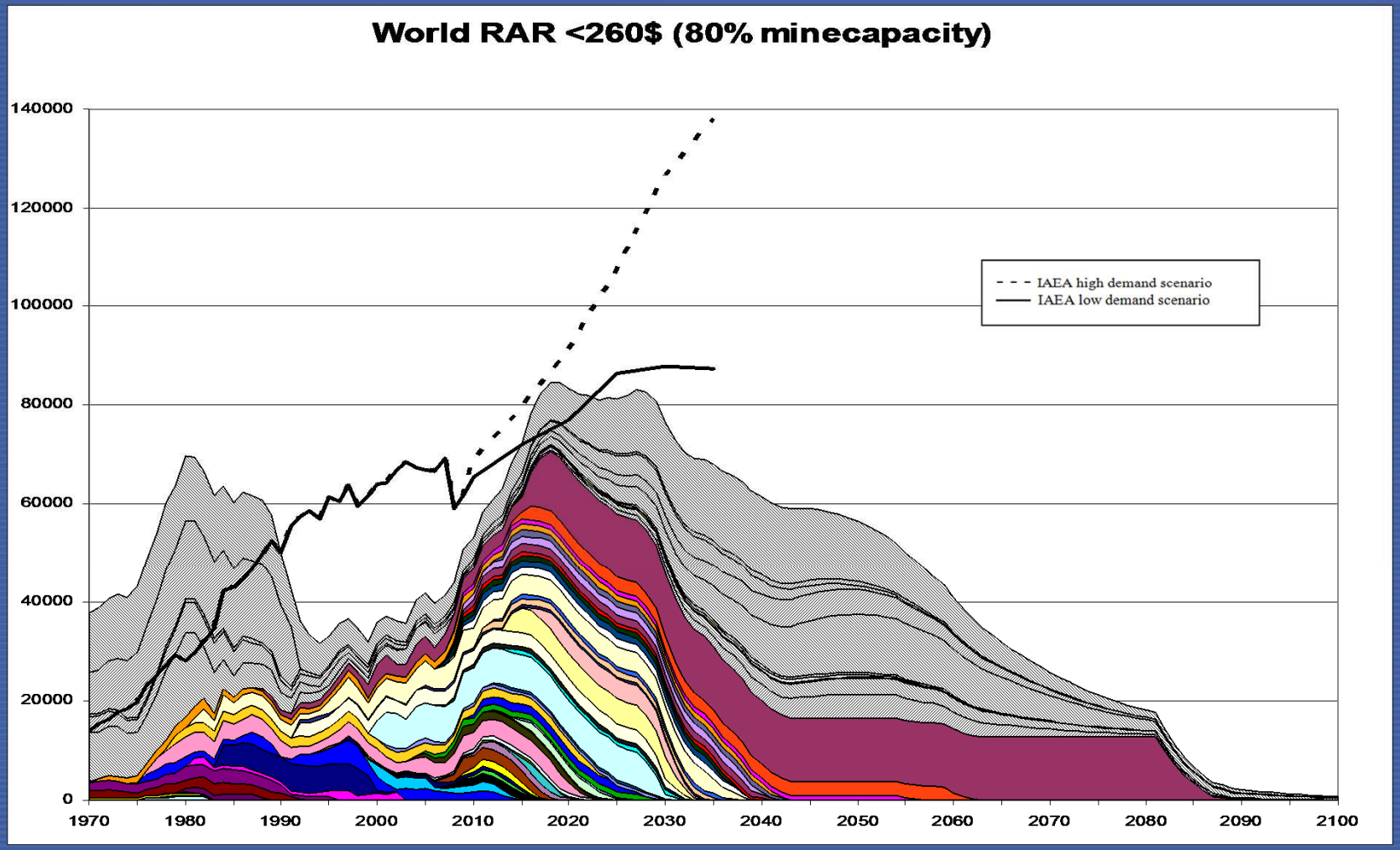
Deposit by deposit analysis



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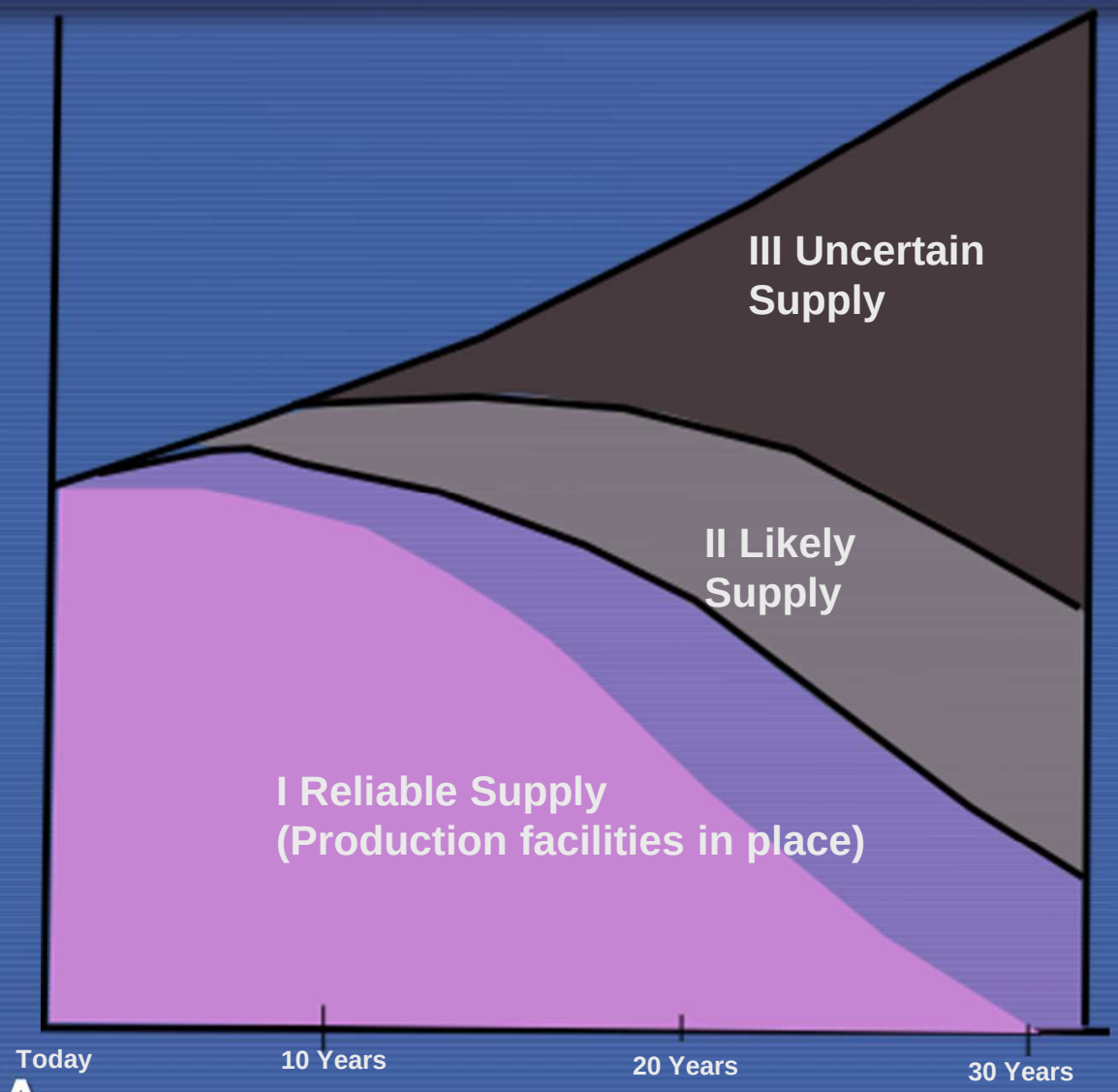
N Arnold, Univ of Natural Resources, Vienna

Projected supply



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Production terminology

- **Production centres -** a production unit consisting of one or more ore processing plants, one or more associated mines and uranium resources that are tributary to these facilities.
  - **Existing** production centres are those that currently exist in operational condition and include those plants which are closed down but which could be readily brought back into operation.
  - **Committed** production centres are those that are either under construction or are firmly committed for construction.
  - **Planned** production centres are those for which feasibility studies are either completed or under way, but for which construction commitments have not yet been made. This class also includes those plants that are closed which would require substantial expenditures to bring them back into operation.
  - **Prospective** production centres are those that could be supported by tributary RAR and Inferred, i.e., “Identified Resources”, but for which construction plans have not yet been made.

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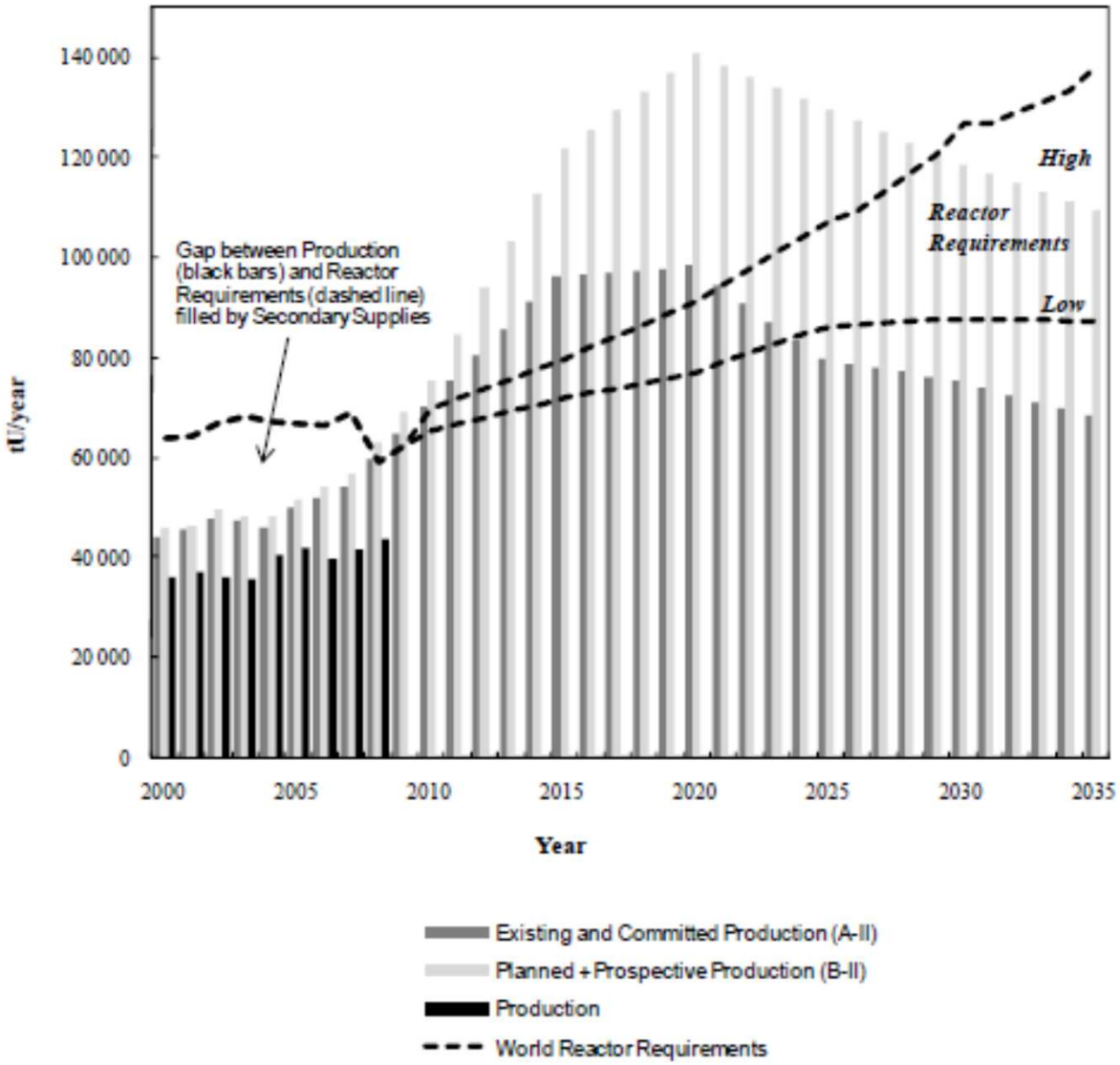
Supply from production centres (1)



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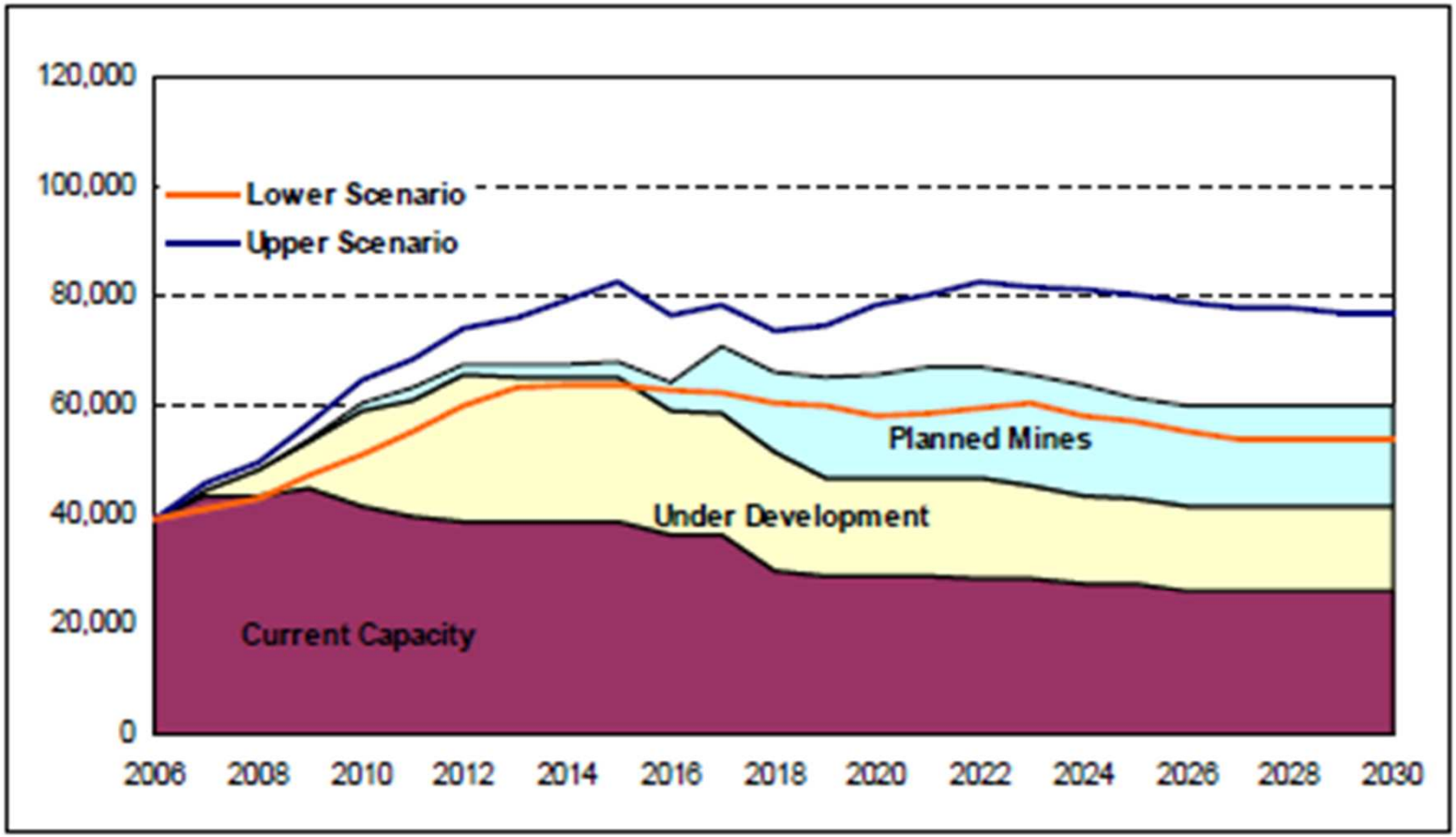
Supply from production centres (2)



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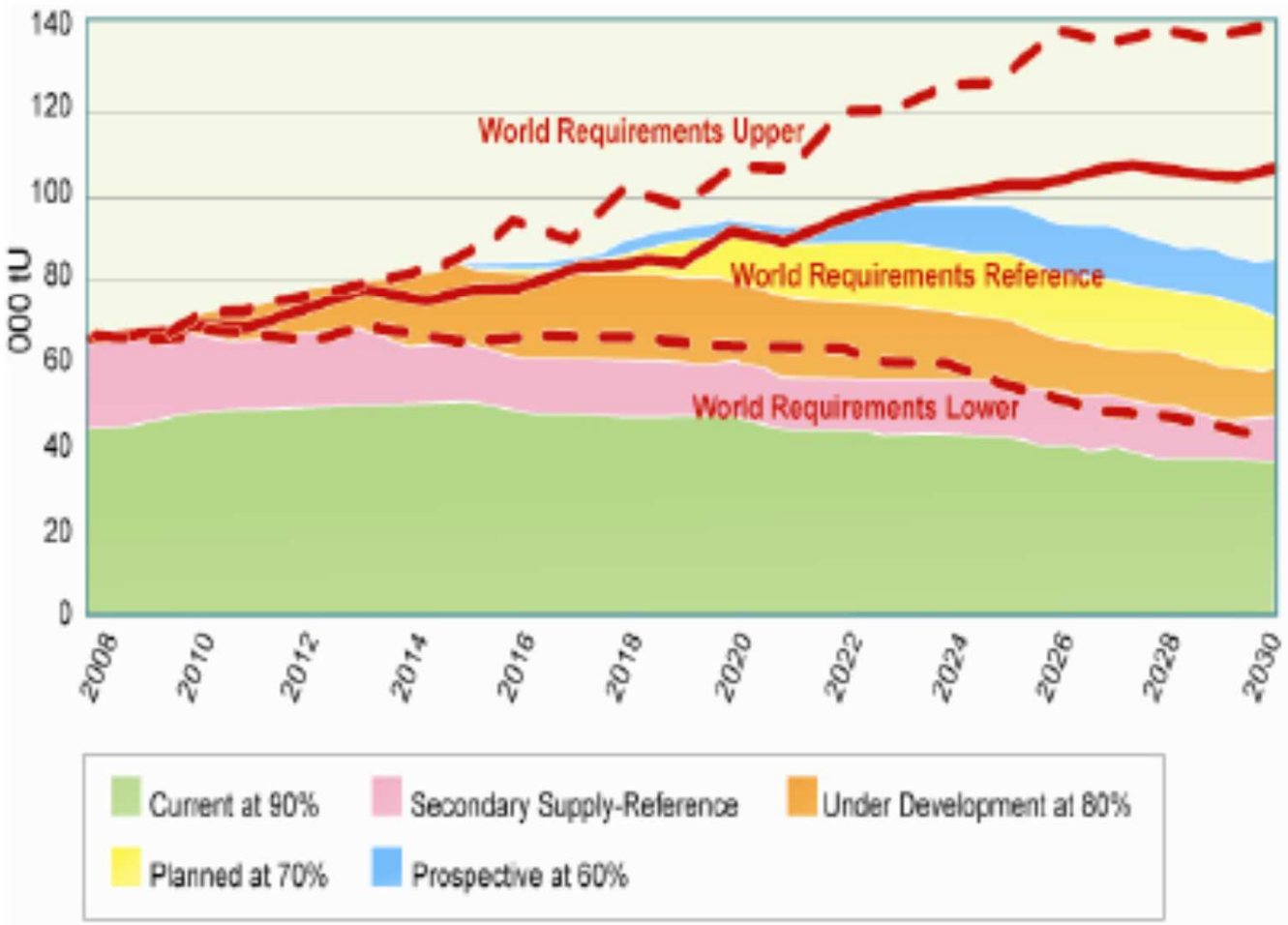
WNA Global Nuclear Fuel Market 2007-2030

Supply from production centres (3)



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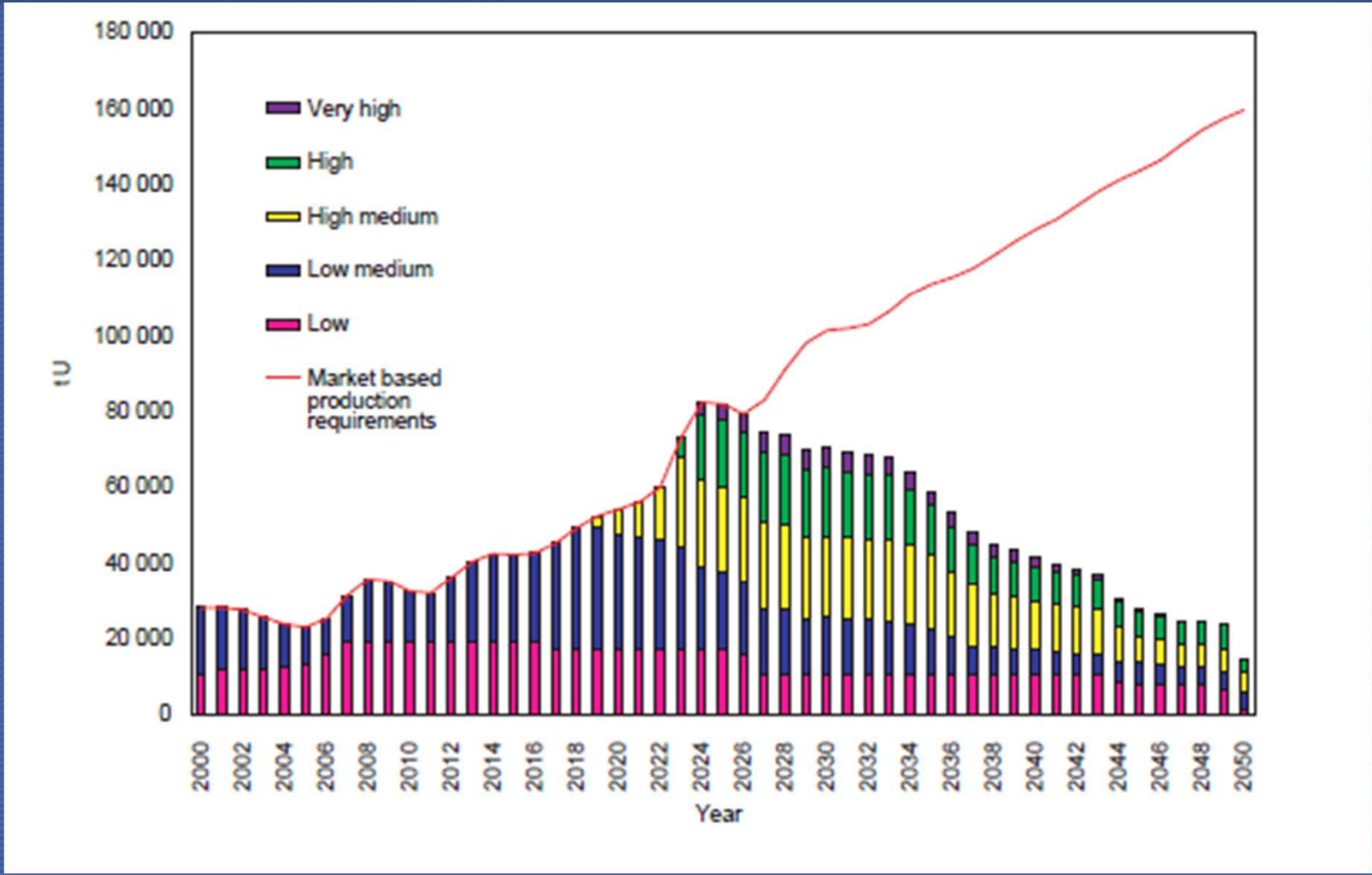
WNA Global Nuclear Fuel Market 2007-2030

Production by cost category



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Planned activities

- **2011**
  - Technical Meeting on Uranium Provinces and Mineral Potential Modeling, 20-22 June, 2011,Vienna, Austria
  - Technical Meeting on World Thorium Resources, 17-21 October 2011, India.
  - Technical meeting on Good practices in production of uranium from phosphoric acid, November 2011, Vienna, Austria
- 2012
  - Technical Cooperation Inter-regional project on Uranium production - Regional workshops, training programmes, fellowships etc.

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Thank you

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