

“Greening” nuclear fuel sources: Aleff Group / IAEA

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Renewable Reserves Workshop

@Norton Rose, London Offices

Oct 31 – Nov 1, 2012

The Greening of U

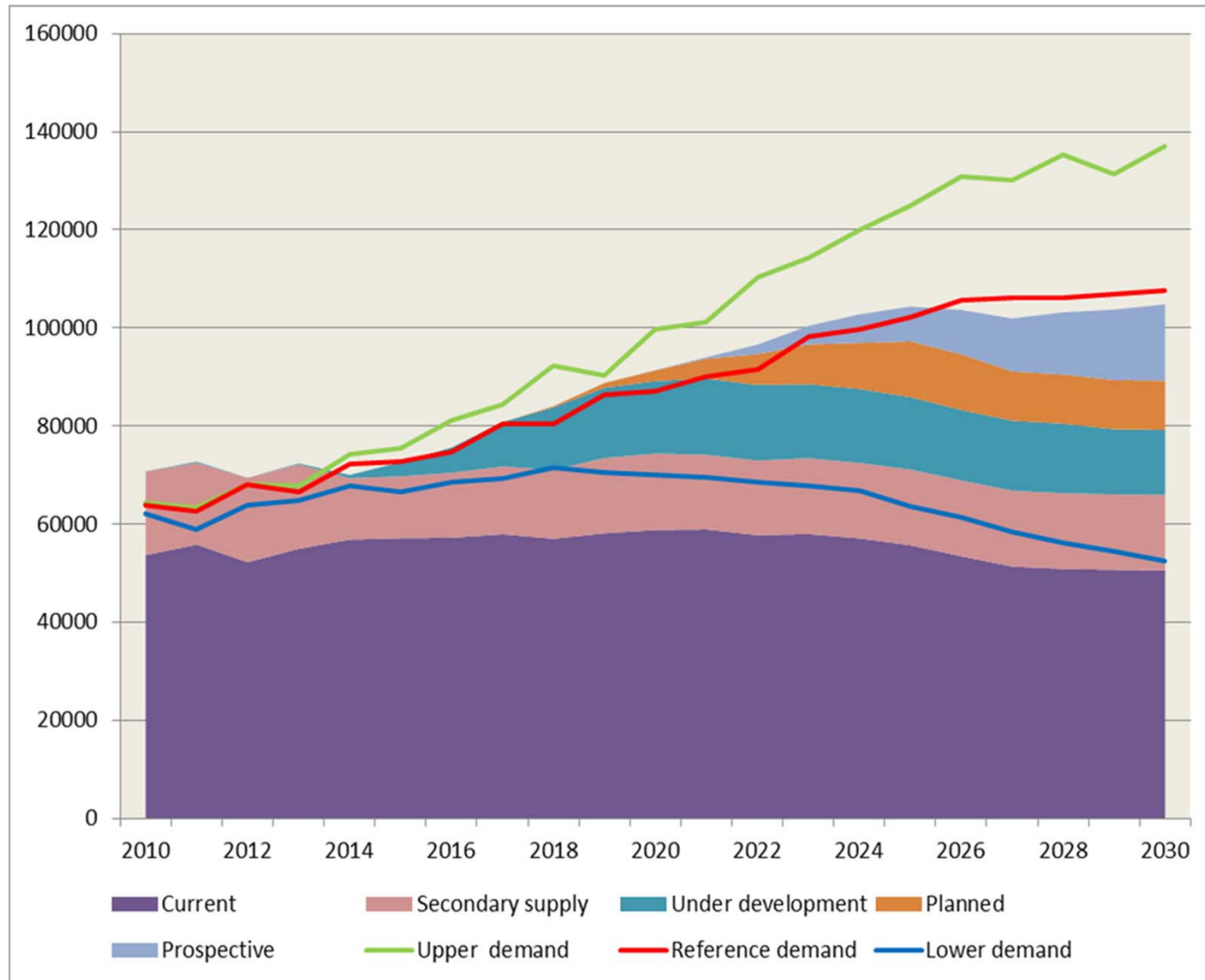
Concept ... Since 2009

Proof of Concept ... Since 2011 (?)

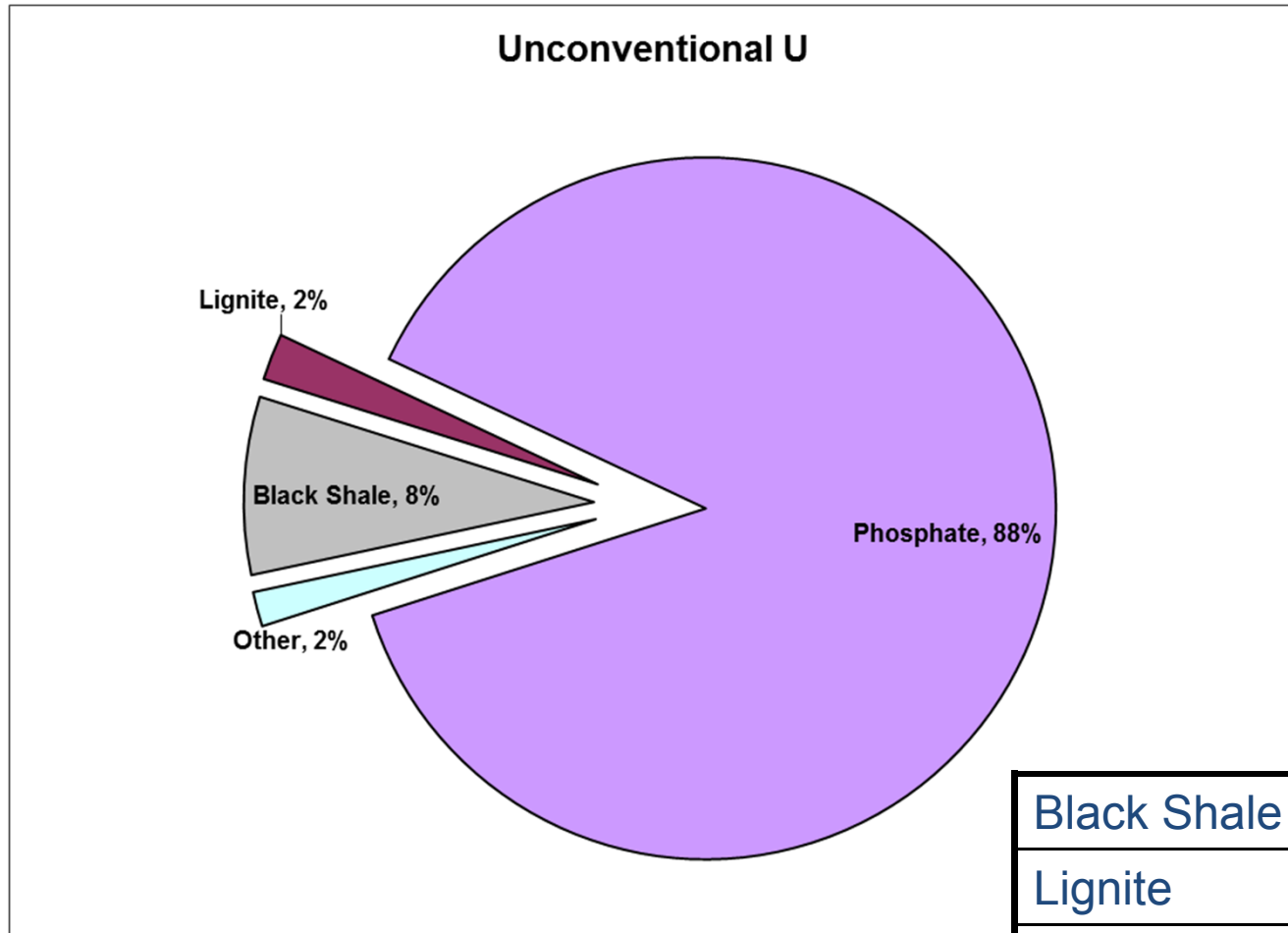
“The spot price of U is a very silly place to begin if you are trying to make good decisions about the contribution of nuclear power to energy security”

Dr. Leonam dos Santos Guimaraes,
Principal Advisor, to the CEO,
Electrobràs, Brazil
(Lisbon, October 2012)

Uranium supply reference case



Unconventional (Green?) U Resources (old/ new focus since Nov 2009)



UDEPO, 2012

Black Shale	1,199,086
Lignite	313,685
Phosphates	12,894,830
Other	234,137
Total	14,641,738

Why “Green” Nuclear Fuel?

Policy, Practice and Profit

- Fill gaps in supply (security; national self-sufficiency)
- Explore and exploit “lower impact/ footprint” U sources (little or no additional mining; low energy and water needs)
- Seek Nash “cooperative” (win/win) solutions (eg remove U, REE and other content from P fertilisers/ use for nuclear fuel)
- Increase stakeholder acceptance/ reduce stakeholder anxiety of nuclear power
- Increase efficiency and “valorisation” of mined P resource uses and all by products, eg phosphogypsum
- Reduce/ eliminate waste

Key constraints: operationalising sustainable development

- Accurate and transparent approach to essential resources and reserves (UNFC) (Natural capital/geological endowment, EGRC-3/2012/INF.1 N.34)
 - Not new concept: see Darwin’s “bank” (**Origin of Species**)
- Need for a new model to operationalise “sustainable development”
 - Energy basin approach
 - Comprehensive extraction – “disturb the ground once”
 - Life-cycle product management
 - Social licensing
- Blurring boundaries between conventional and unconventional resources

Required outcomes for sustainability

- Emphasis on closed systems (return on asset, not just return on investment = equitable balance between stakeholders and stockholders)
 - Recycling and reuse
 - Efficient use of inputs
 - Optimisation (and use) of all outputs
 - Waste elimination/ waste as designation of last resource
- Coherent and consistent global regulations
- Transparency (eg taxonomic robustness, governance, risk communications, reporting)
- Alignment of incentives

The “Green” solution...

- Concept presented first by Dr. A. Sedee, (NL) IAEA Meeting, Sept 2011: government approved contract between NPP utility company and P producer to source U from P fertilisers (part of revised approach to social licensing of Dutch NPP)
- Emerging business model to encourage joint venture between utilities (energy producers) and fertiliser companies.
 - Eg Galvani (Phosphates) and INB Brazil (Uranium) DAP and Yellowcake as dual products (Santa Quiteria)
- Impact of social licence on statements of reserves
- Building a new discourse about resources ... eg comprehensive extraction

Comprehensive extraction

- The term “comprehensive extraction” was introduced by Dr. Pingru Zhong (China) during an IAEA UxP Technical Meeting, September 26-30, 2011.
- Brought into currency during the follow-on Training Workshop, Marrakech, October 31 – November 5, 2011.

See <http://www.iaea.org/OurWork/ST/NE/NEFW/News/2011/repository/New-Comprehensive-Approaches-to-Uranium-Mining-and-Extraction.html>

What do we mean by U “mining”?



“Solid” mining



— Uranium mineral (yellow) in Granite —



— Uranium mineral (yellow) in El-Hamm —



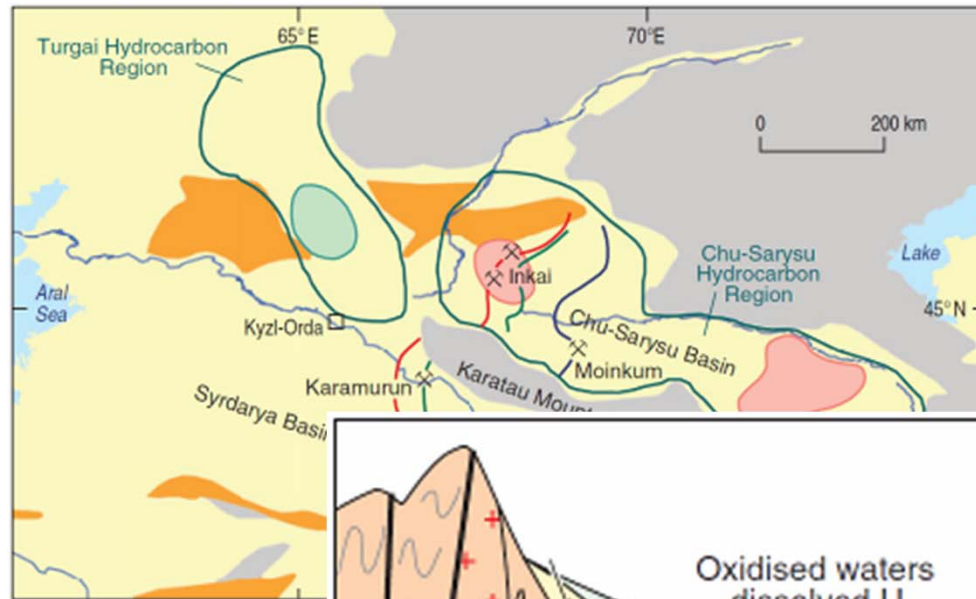
— Uranium mineral (yellow) in Granite —

NMA,
Egypt

“Liquid” mining

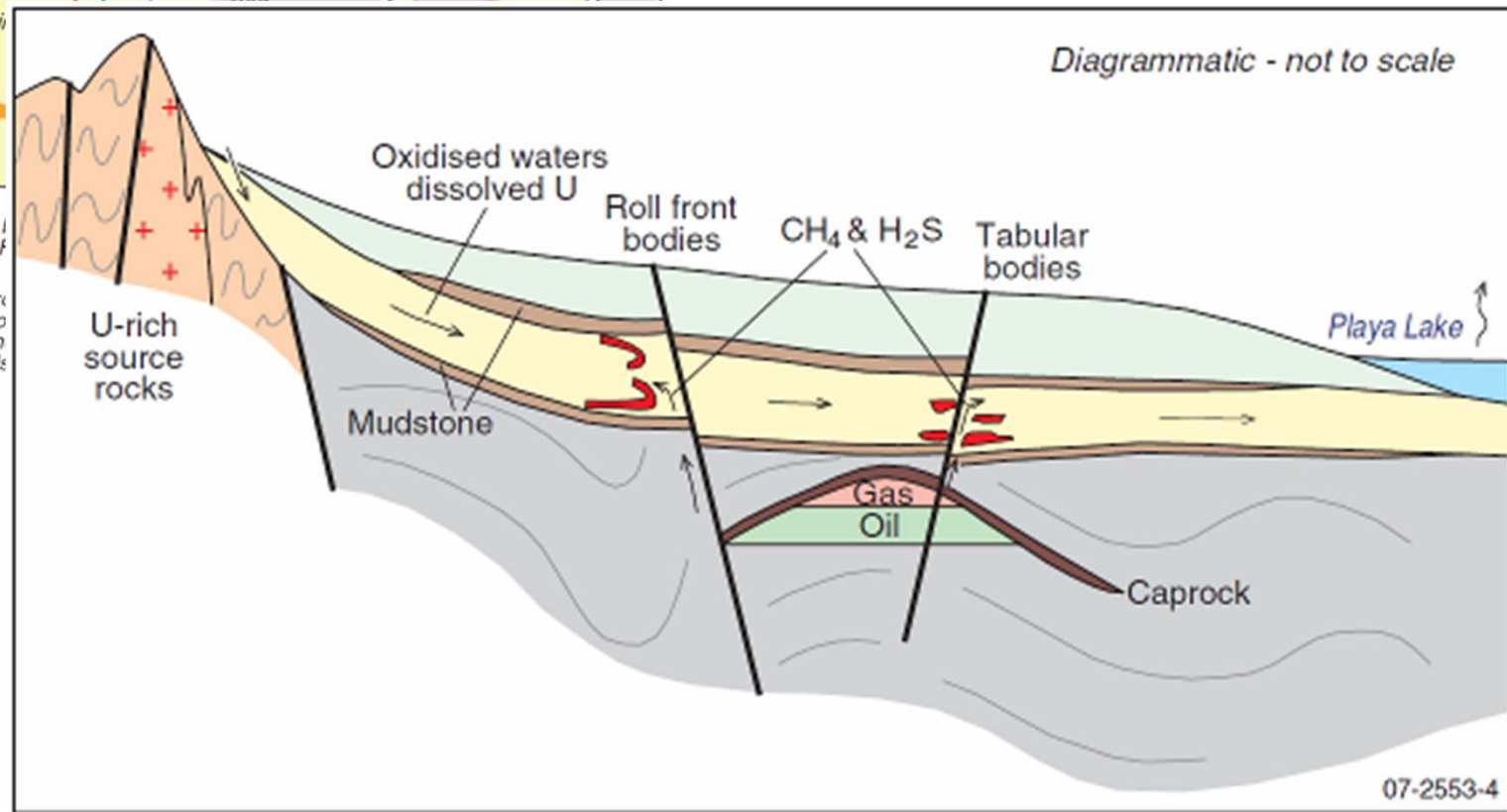


Kazakhstan – Energy basin with U and hydrocarbons



► Possible link between Oil & Gas, migration of gas along faults, tectonic control of the localisation of roll fronts...

Cenozoic Sedimentary rocks
 Mesozoic underlain by Paleozoic sediments
 Archaean, Proterozoic and Palaeozoic metasediments and granitoids



Jaireth et al. 2008

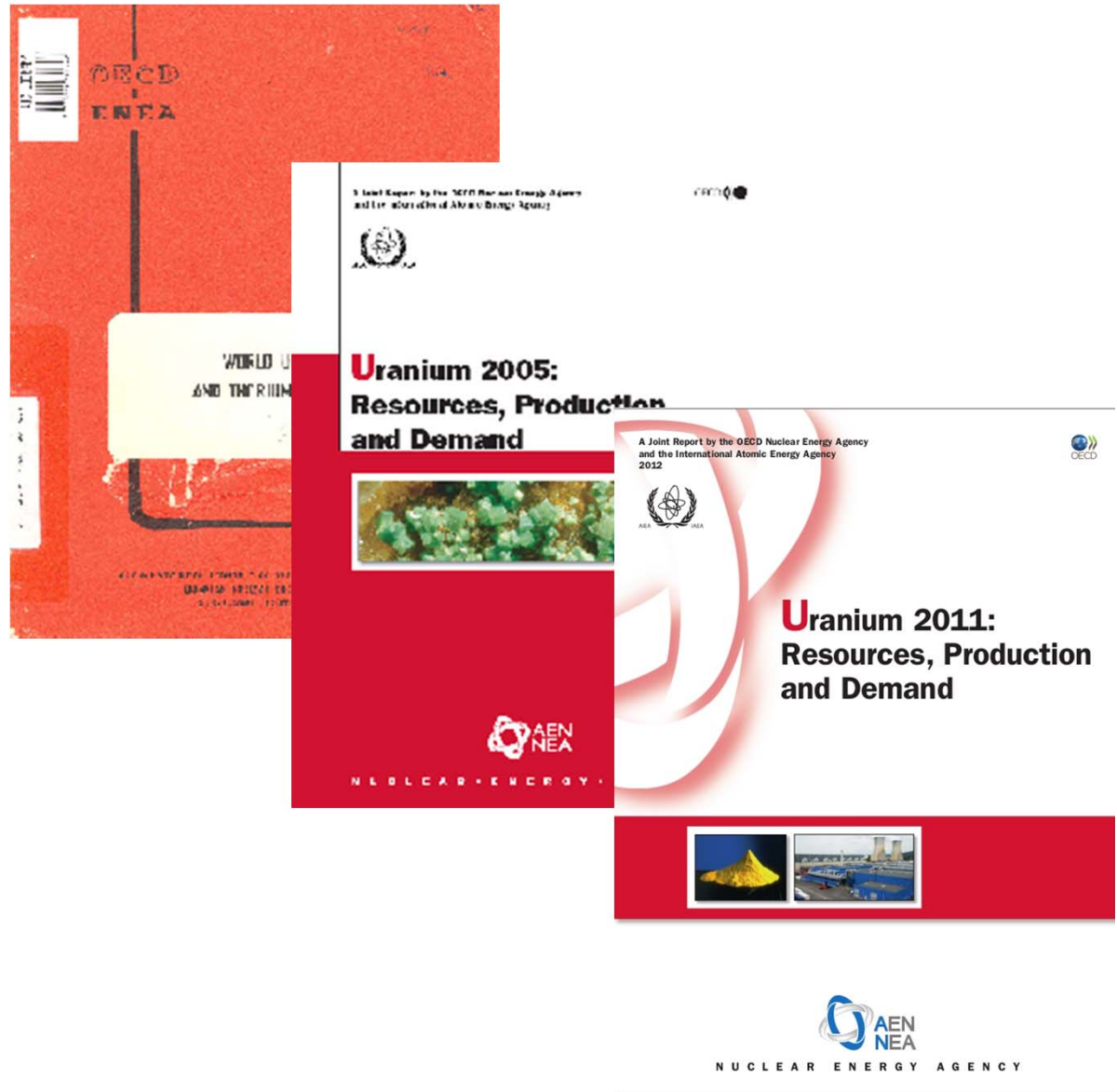
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Mapping, classifying and reporting U

From scorecard to taxonomy?

“Red Book”

- Joint IAEA – OECD/NEA Uranium: Resources, Production and Demand
- Published since 1965



Alignment with other systems

	UNFC-2009		CRIRSCO (minerals)	SPE-PRMS (petroleum)	
Known Deposit	Commercial Projects	On Production	Mineral Reserves	Reserves	On Production
		Approved for Development			Approved for Development
		Justified for Development			Justified for Development
	Potentially Commercial Projects	Development Pending	Mineral Resources	Contingent Resources	Development Pending
		Development On Hold			Development Unclassified or on hold
	Non-Commercial Projects	Development Unclassified	Not Defined		Development Not Viable
		Development Not Viable			Development Not Viable
Additional quantities in place		Not Defined	Unrecoverable		
Potential Deposit	Exploration Projects		Exploration Results	Prospective Resources	Prospect
					Lead
					Play
Additional quantities in place		Not Defined	Unrecoverable		

Spot price Vs Long-term price

- Currently uranium is traded for **\$120/Kg U to \$160/Kg U** (\$45.00 to \$60.00/lb)

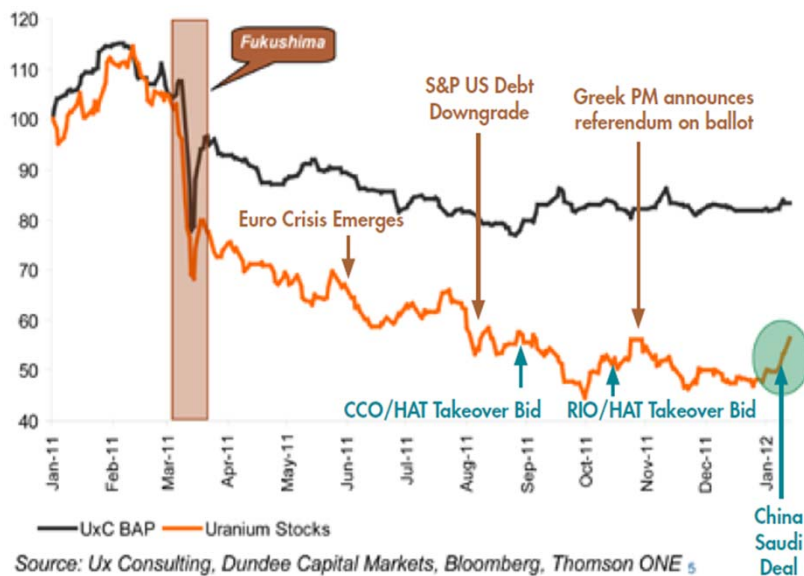
- 10-15% sales at Spot

- 85-90% sales - long-term contract = 10 years+

- For a project to be committed 85-90% term sales will have to be in place.

- **Spot prices are important indicators on which the uranium stocks are valued.,. Should they be?**

Uranium and Equity Markets in 2011



UxC Broker Average Price (BAP)

Attempting alignment (1)

UNFC Class	UNFC Sub-Class	CRIRSCO	IAEA-NEA	Status	E	F	G
Commercial Projects	On Production			Existing	1	1.1	1,2,3
	Approved for Development	Mineral Reserves	Identified Resources <\$ 130/Kg* <\$50/lb U3O8	Committed	1	1.2	1,2,3
	Justified for Development			Planned	1	1.3	1,2,3
Potentially commercial projects	Development Pending	Mineral Resources	Identified Resources <\$ 130/Kg* <\$50/lb U3O8	Prospective	2	2.1	1,2,3
	Development on Hold	Discovered not economic*			2	2.2	1,2,3
Non-commercial projects	Development Unclearified		Identified Resources >\$130/KgU* >\$ 50/lbU		3.2	2.3	1,2,3
	Development not Viable				3.3	4	1,2,3
Exploration Projects			Prognosticated		3	3	4.1
		Exploration Data	Speculative Resources		3	3	4.2,4.3

Attempting alignment (2)

UNFC Class	Sub-class	E	F	G	Status	Description
Commercial Projects	On Production	1	1.1	1,2,3	Existing	Extraction taking place
	Approved for development	1	1.2	1,2,3	Committed	Funds committed and implementation under way
	Justified for development	1	1.3	1,2,3	Planned	Detailed feasibility studies completed
Potentially commercial projects	Development Pending	2	2.1	1,2,3	Prospective	Project activities ongoing to justify development in foreseeable future
	Development on hold	2	2.2	1,2,3		Project activities on hold; may be subject to significant delay
Non-commercial projects	Development Unclarified	3.2	2.2	1,2,3		Economic viability cannot be determined due to insufficient information
	Development not Viable	3.3	2.3	1,2,3		No reasonable prospects for economic extraction in foreseeable future
Exploration projects		3.2	3	4.1	Prognostic.	Based primarily on indirect data in well defined trends
		3.2	3	4.2	Speculative	Based primarily on indirect data

U resources in UNFC sub-classes

IAEA	Existing On Production	Committed Approved for Development	Planned Justified for Development	Prospective		Development Unclassified	Development not Viable	Exploration Projects
UNFC	1/1.1/1,2,3	1/1.2/1,2,3	1/1.3/1,2,3	Development Pending	Development on Hold	3.2/2.2/1,2,3	3.3/2.3/1,2,3	3.2/3/4
Code	1/1.1/1,2,3	1/1.2/1,2,3	1/1.3/1,2,3	2/2.1/1,2,3	2/2.2/1,2,3	3.2/2.2/1,2,3	3.3/2.3/1,2,3	3.2/3/4
Argentina			?	?				
Australia	238993		66500	???				
Botswana					82195			
Brazil	10700	76100						800000
Canada	151200	81000	76900	???				850000
Czech Rep	1463							
Finland		8700						
Greenland					134654			
Jordan					12720		59360	65000
Kazakhstan	581803	24616						800000
Malawi	12321				17086			
Mexico					3758		8000000	13000
Mongolia			40852					1411000
Namibia	151000		300900					
Niger	111000	279000						649000
Peru					23546		4057	39700
Poland								20000
Portugal							7000	1500
Russia	115370	31119	282750					963800
Slovakia					10049			
South Africa	256200							1223200
Spain					14000			
Sweden							13490	
Tanzania					66260			
Turkey					9129			
Ukraine	71684		89885		48120			397500
Zambia					19452			

Uranium resources of Peru*

No	Deposit	Operator	Deposit Type	Resources (tU)	Average Grade (%U)	UNFC Class	UNFC Sub Class	E	F	G
1	Colibri 2-3	Macusani Yellowcake	Volcanic	7916	0.019	Potentially commercial project	Development Pending	2	2.1	2+3
2	Corachapi	Macusani Yellowcake	Volcanic	2656	0.017	Potentially commercial project	Development Pending	2	2.1	1+2+3
3	Isivilla	Vena	Volcanic	3049	0.033	Potentially commercial project	Development Pending	2	2.1	1+2+3
4	Nuevo Corani	Vena	Volcanic	1594	0.017	Potentially commercial project	Development Pending	2	2.1	1+2+3
5	Tantamaco	Vena	Volcanic	8331	0.0186	Potentially commercial project	Development Pending	2	2.1	1+2+3
6	Turmalina	-	Volcanic	500	0.3	Non-commercial project	Development un-clarified	3.2	2.2	2+3
7	Tuturumani	Vena	Volcanic	467	0.0085	Non-commercial project	Development un-clarified	3.2	2.2	2+3
8	Calvario Real	Vena	Volcanic	300	0.0233	Non-commercial project	Development un-clarified	3.2	2.2	3
9	Macusani District	Fission Energy	Volcanic	1790	0.1	Non-commercial project	Development un-clarified	3.2	2.2	2+3
10	Vilacabamba	-	Volcanic	500	3	Non-commercial project	Development un-clarified	3.2	2.2	3
11	Colquijirca	-	Volcanic	500	0.2	Non-commercial project	Development un-clarified	3.2	2.2	3
12	Bayovar	Vale/IPEN 2012	Phosphate	16000	0.006	Exploration project	[Prognosticated]	3.2	3	4.1
13	Various Locations	IPEN	Other (Cu-Pb-Zn-Ag-W-Ni)	5600	-	Exploration project	[Prognosticated]	3.2	3	4.1
14	Corongo	IPEN 2012	Granite - related	-	-	Exploration Project	[Speculative]	3.2	3	4.2+4.3
15	San Ramón	IPEN 2012	Granite - related	-	-	Exploration Project	[Speculative]	3.2	3	4.2+4.3
16	Coasa	IPEN 2012	Granite - related	-	-	Exploration Project	[Speculative]	3.2	3	4.2+4.3

**IAEA is happy to collaborate with
a working group if formed...**

Through its participation in UNFC
(classification and reporting) and
through Ux EWG (methodology)

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