Uranium and thorium resources: Evaluation and reporting issues

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IAEA
International Atomic Energy Agency

The "Atoms for Peace" Agency

- *World centre of cooperation in the nuclear field*
- *Promotes safe, secure and peaceful nuclear technologies*
- *Three pillars (**3S**) of IAEA*
  - ***Safety** and Security*
  - ***Science** and Technology*
  - ***Safeguards** and Verification*

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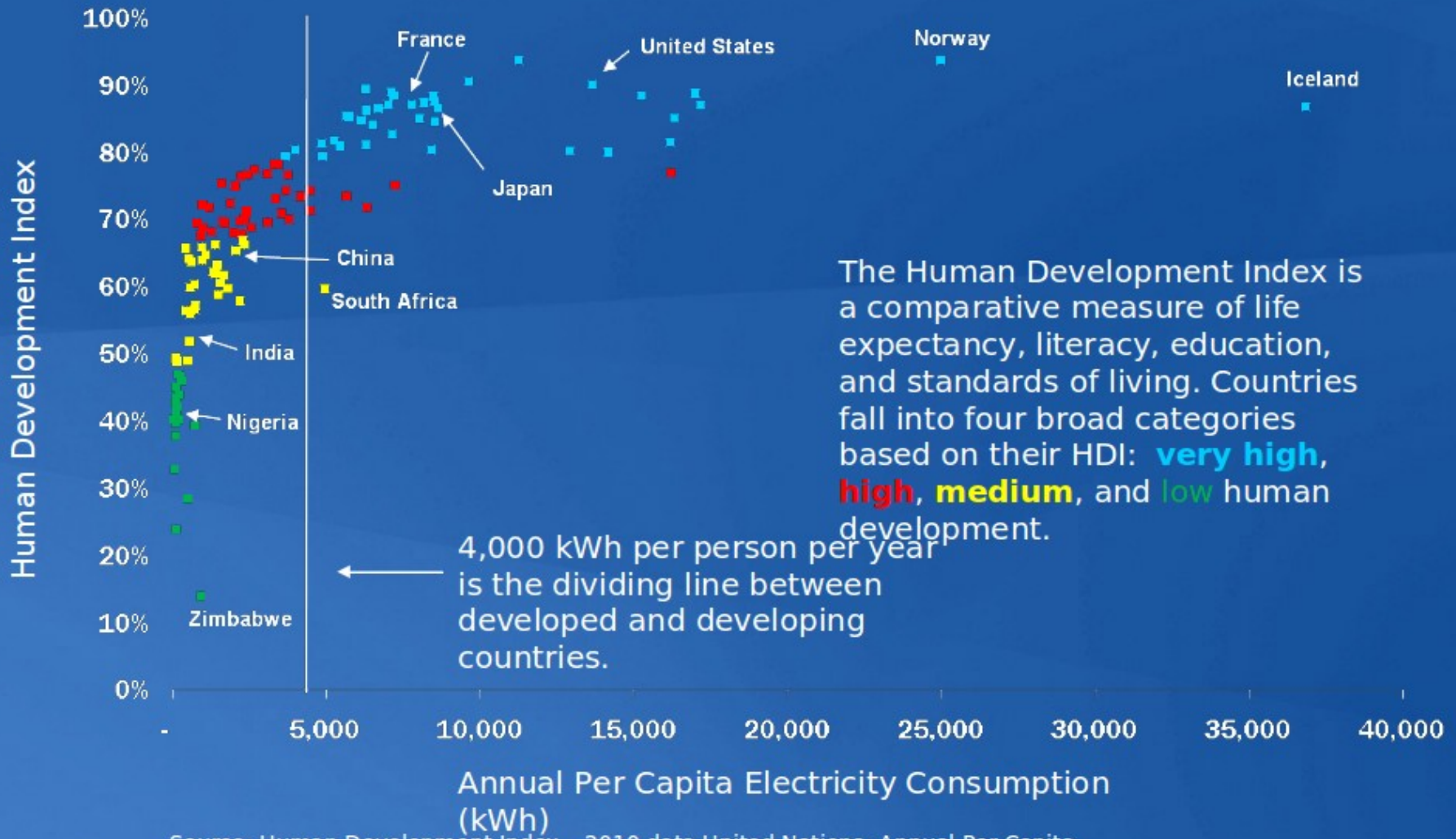
Developed Vs Developing economies

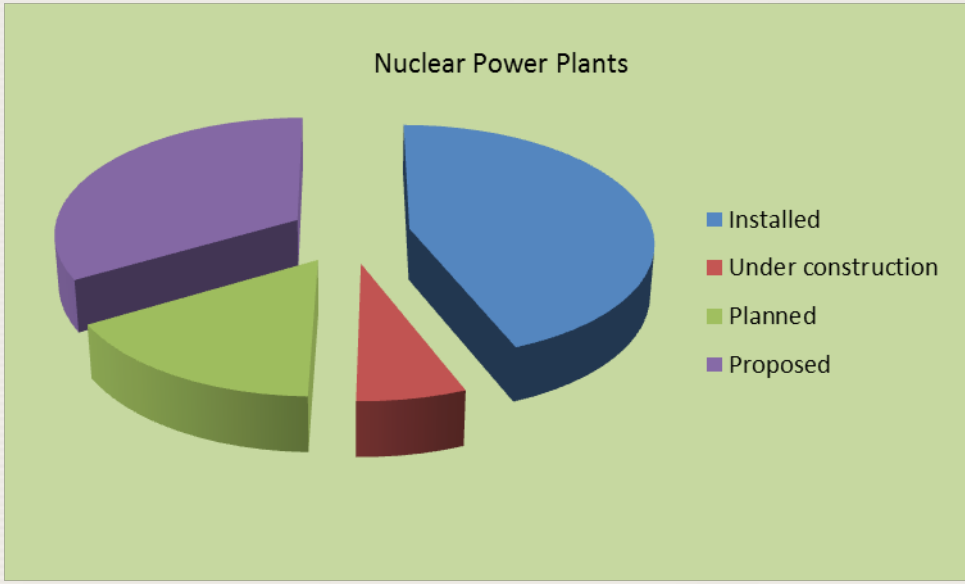


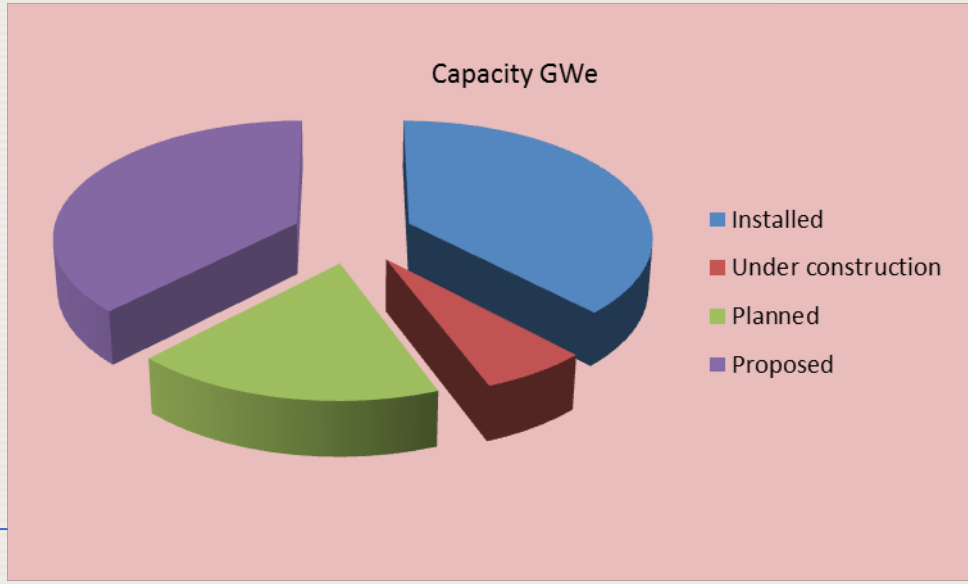
Source: Human Development Index – 2010 data United Nations; Annual Per Capita Electricity Consumption (kWh) - 2007 data World Bank

Updated: 4/11

Nuclear share

- ✓ *2515 billion kWh annually*
- ✓ *14 % share*
- ✓ *433 NPPs - 372 Gwe Installed Capacity*
- ✓ *63 NPPs - 62 GWe - under construction*
- ✓ *160 NPPs – 178 GWe On order / Planned*
- ✓ *329 NPPs – 370 GWe Proposed*





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Stated nuclear energy policy

Belgium	Slovenia	Turkey	Argentina	Tunisia
Bulgaria	Spain	Ukraine	Brazil	Uganda
Czech Rep	Sweden	Belarus	Bolivia	Cambodia
Finland	UK	India	Cuba	Indonesia
France	Canada	Iran	South Africa	Malaysia
Germany	Mexico	Pakistan	Algeria	Thailand
Hungary	USA	UAE	Egypt	Iraq
Italy	China	Bangladesh	Ghana	Kazakhstan
Lithuania	Japan	Jordan	Kenya	Oman
Netherlands	S Korea	Mongolia	Morocco	Nigeria
Poland	Armenia	Vietnam	Namibia	Phase-out
Romania	Russia	Qatar	Niger	Increase
Slovak Rep	Switzerland	Saudi Arabia	Syria	Maintain
Bahrain	Israel	Kuwait	Yemen	New

IAEA Scenario September 2011

Country Group	2010			2020 (a)			2030 (a)			2050 (a)(b)		
	Total Elect. GW(e)	Nuclear		Total Elect. GW(e)	Nuclear		Total Elect. GW(e)	Nuclear		Total Elect. GW(e)	Nuclear	
		GW(e)	%		GW(e)	%		GW(e)	%		GW(e)	%
North America	1165	113.8	9.8	1273 1310	119 126	9.4 9.6	1346 1526	111 149	8.3 9.7	1475	120 200	8.1 13.6
Latin America	313	4.1	1.3	457 587	6.4 6.4	1.4 1.1	982 1403	9 18	0.9 1.3	1990	15 60	0.8 3.0
Western Europe	843	122.9	14.6	1007 1058	93 126	9.2 11.9	1132 1389	83 141	7.4 10.1	1586	60 170	3.8 10.7
Eastern Europe	465	47.4	10.2	661 661	66 80	10.0 12.1	723 914	82 108	11.3 11.8	1031	80 140	7.8 13.6
Africa	130	1.8	1.4	383 422	1.8 1.8	0.5 0.4	781 1093	5 16	0.6 1.5	2630	10 48	0.4 1.8
Middle East and South Asia	418	4.6	1.1	538 954	13 22	2.4 2.3	1414 1885	30 53	2.1 2.8	5223	50 140	1.0 2.7
South East Asia and the Pacific	173			293 312			473 526	0 6	0.0 1.1	1242	5 20	0.4 1.6
Far East	1564	80.6	5.2	2222 2407	130 164	5.8 6.8	2818 3381	180 255	6.4 7.5	5215	220 450	4.2 8.6
World Total Low Estimate	5071	375.3	7.4	6835	429	6.3	9669	501	5.2	20391	560	2.7
World Total High Estimate				7711	525	6.8	12118	746	6.2		1228	6.0

~ 215 000 tU/year by 2050 – high case

~98 000 tU/year by 2050 – low case

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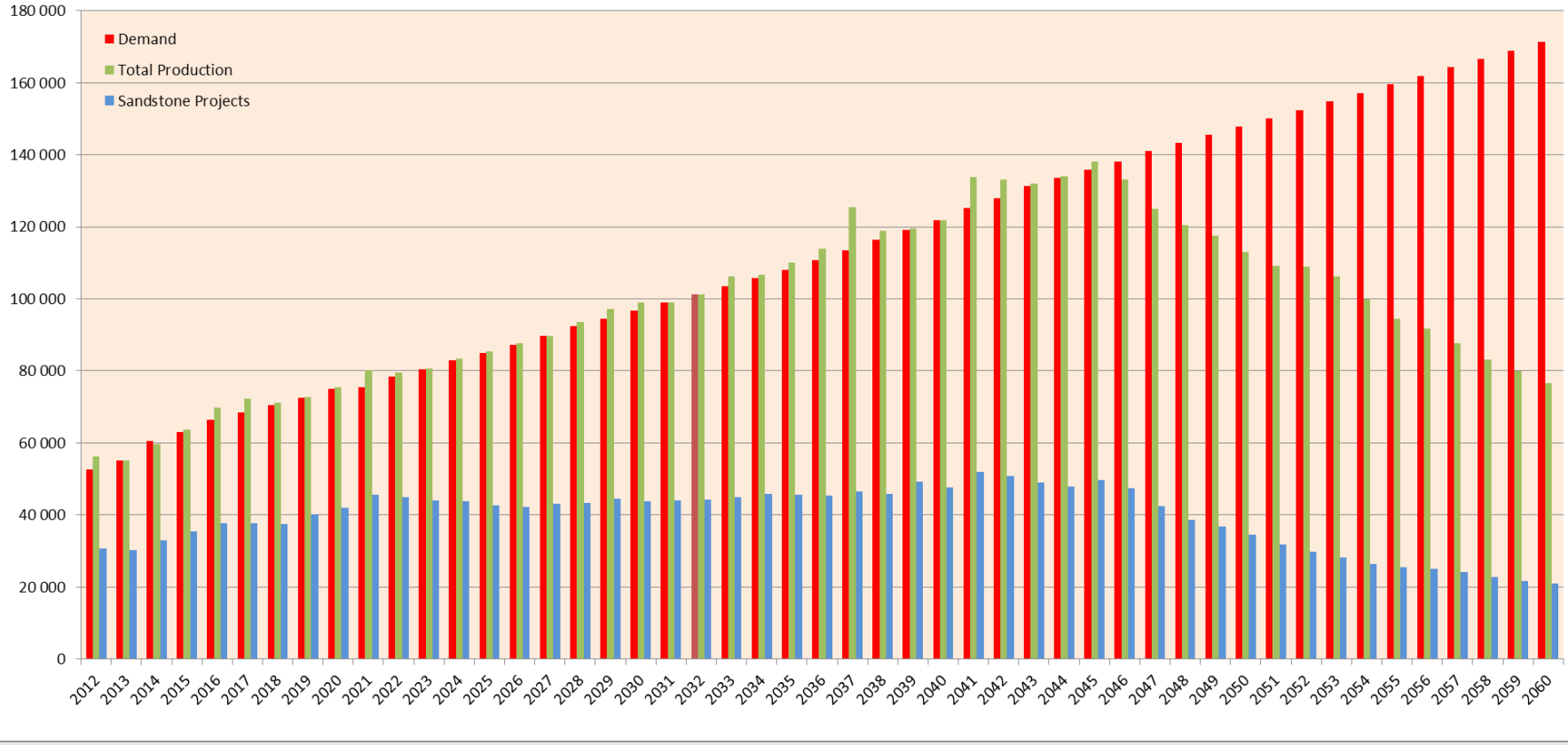
U 2060 study – supply reference case



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IAEA activities

Assessment of uranium resources, production and demand

- *IAEA/NEA Red Book*
- *Uranium 2060*
- *Database of Uranium Deposits* ***(http://infcis.iaea.org)***
- *Standardization of resource classification*

Supporting good practices in the uranium production cycle

- *Uranium Production Site Assessment Team*
- *Optimization of mining technologies*
- *Development of low grade ores*
- *Unconventional resources – Phosphates*
- *Thorium resources (By-product of REE)*
- *Support training activities*

Technical Cooperation *18 national projects and 2 regional projects*

- *Inter-regional project – 2012-13*

Mission

To collect and share knowledge of uranium resources and support the development of a sustainable uranium production cycle in Member States.

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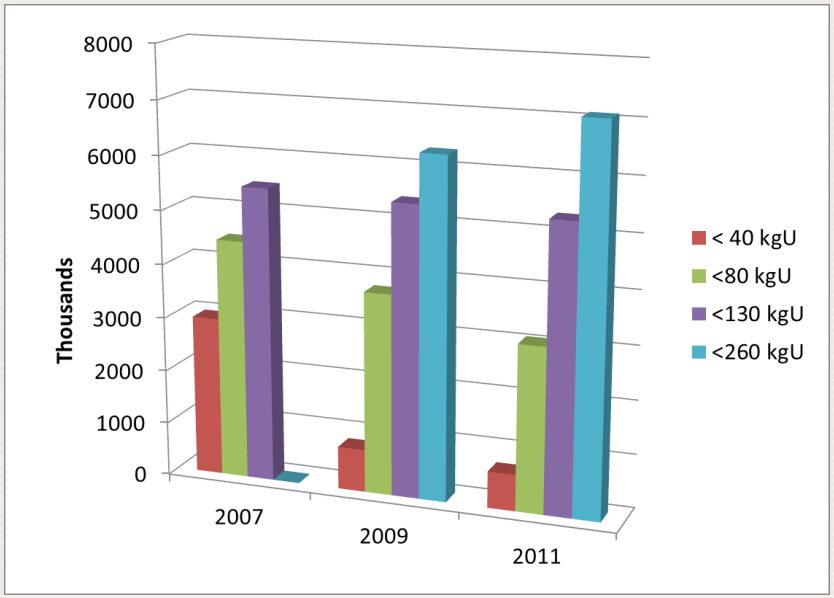
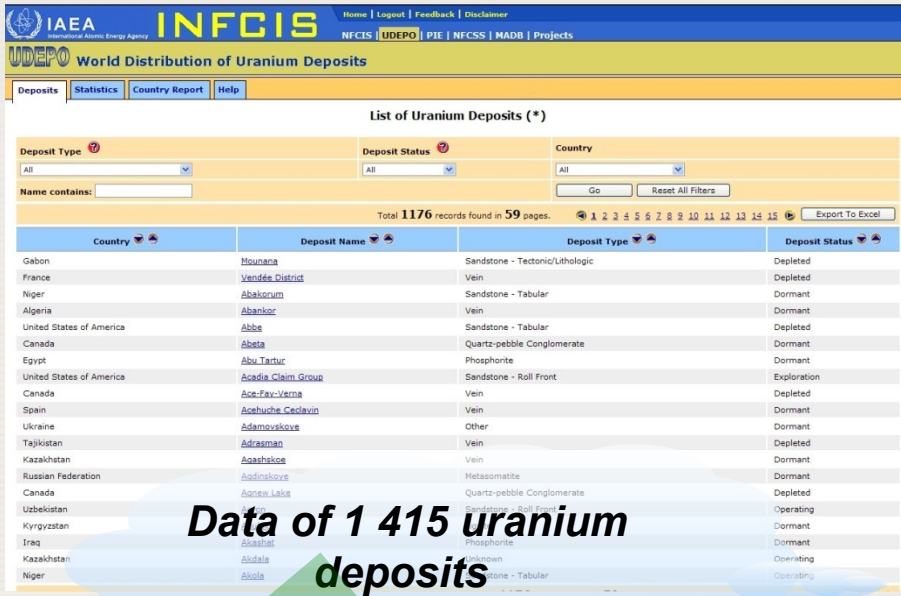
Uranium resources

Red Book 2011



iNFCIS - UDEPO



Data of 1 415 uranium deposits from 75 countries

Total Resources

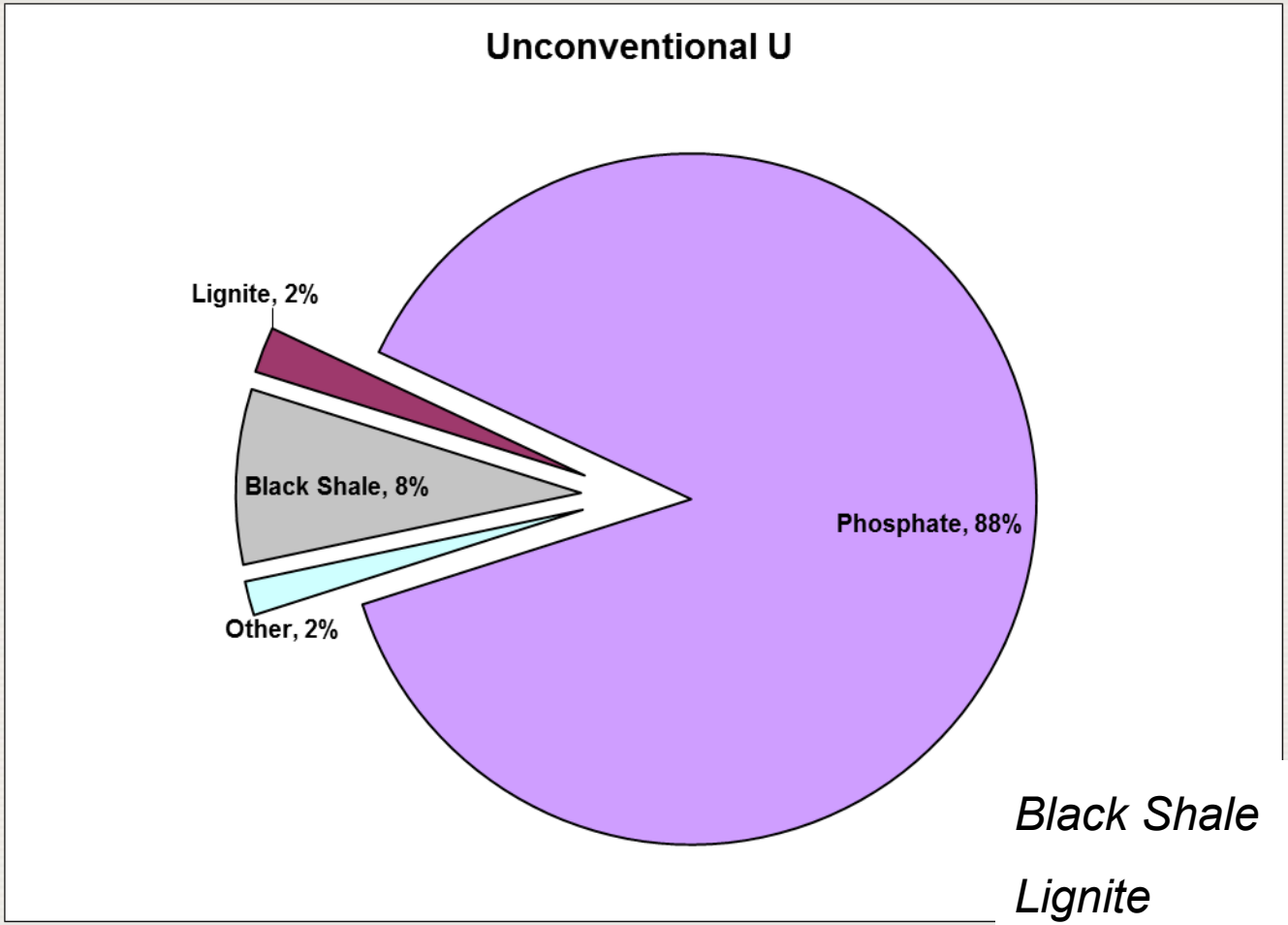
Total 26 802 989 tU

Undiscovered Resources: 10 400 000 tU

IAEA /OECD NEA Uranium 2011: Resources, Production and Demand

http://infcis.iaea.org

Unconventional Resources



UDEPO, 2012

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

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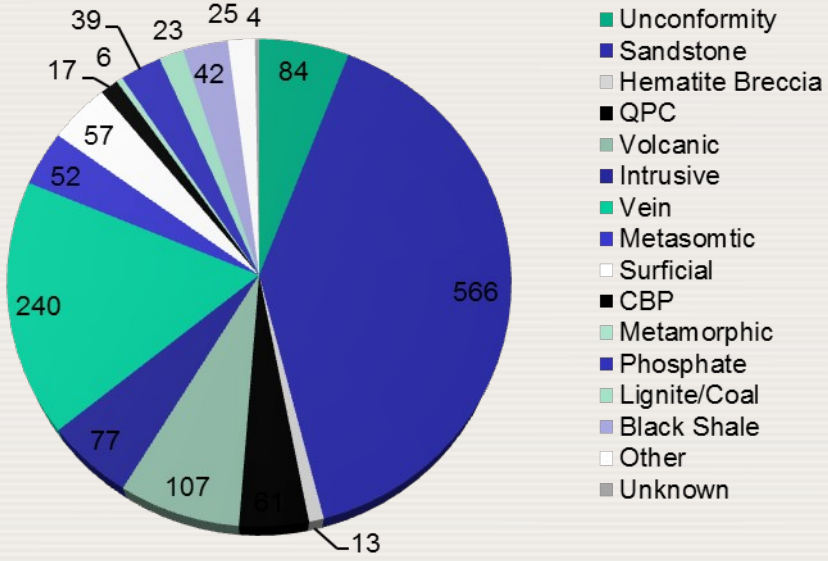
Growing uranium inventory



Type	# of deposits	tU*
Unconformity	84	1 235 381
Sandstone	566	3 872 095
Hematite Breccia	13	2 223 497
QPC	61	1 005 692
Volcanic	107	549 658
Intrusive	77	1 077 134
Vein	240	845 620
Metasomtic	52	957 676
Surficial	57	382 154
CBP	17	15 970
Metamorphic	6	21 439
Phosphate	39	12 894 830
Lignite/Coal	23	305 285
Black Shale	42	1 199 086
Other	25	232 993
Unknown	4	6 658
Total	1413	26825168

*Total (geological) resources

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Total 26 825 168 tU from ~75 countries

Uranium mining – Conventional

Rossing, Namibia

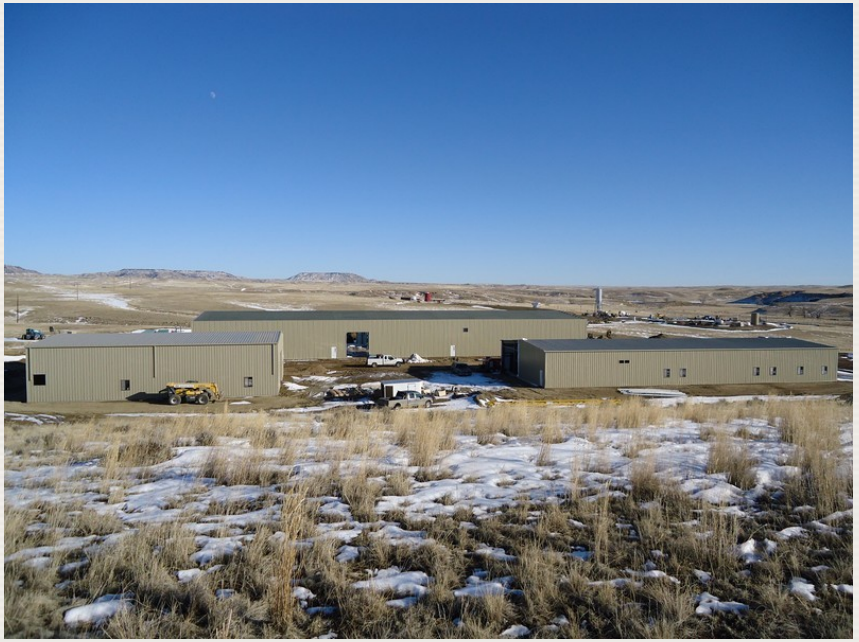
McArthur River, Canada

Total Conventional mine production - 25327 tU / year – 47%

Uranium recovery - ISL

Honeymoon, Australia

Nichols Ranch, USA



Total ISL production - 24,180 tU / year – 45%

Uranium recovery – By-product

Olympic Dam, Australia

Talvivaara, Finland

Total by-product production - 3987 tU / year – 7%

Thorium – Future of energy 1/2

Country	tTh
Turkey	744000 - 880000
Norway	320000
Greenland	86000 - 93000
Finland	60000
Russia	>155000
Sweden	50000
France	1000
Brazil	606000 -1300000
US	434000
Venezuela	300000
Canada	172000

Country	tTh
Peru	30000
Uruguay	3000
Argentina	1000
Egypt	380000
South Africa	148000
Morocco	30000
Nigeria	29000
Madagascar	22000
Angola	10000-20000
Mozambique	10000
Malawi	9000

Thorium – Future of energy 2/2

Country	tTh
Kenya	8000
Zaire	2500
CIS excl Russia	1500000
Kazakhstan est	>50000
Uzbekistan	5000-10000
India	846500
China est	>109000*
Iran	30000
Malaysia	18000
Bangaladesh est	17000
Thailand est	10000

Country	tTh
Vietnam est	5000 - 10000
Korea Rep	4500-7500
Sri Lanka	4000
Australia	474000
Total	**6566000-7421000**

* Includes Chinese Taipei 9000 tTh

Energy Basins (1)

Dominant fuels coal, oil & gas and uranium are to a large extent supplied from giant sedimentary basins.

There could a linkage between the presence of coal / oil & gas and uranium, which is not well understood yet in terms its genesis or total 'energy flows' in the basin.

Some examples:

- *oil & gas and adjoining uranium in sedimentary basins of Kazakhstan;*
- *oil & gas, coal and uranium in sedimentary basins in north China;*
- *coal and possibly uranium in Gondwana basins of India;*
- *coal and uranium; uranium and oil & gas in sedimentary basins of Texas;*
- *uranium, chromium, vanadium, nickel and hydrocarbons in Bakken Shales, Canada;*
- *uranium and oil & gas in sedimentary basins of Argentina;*
- *the Karoo basin of Africa, which is a source of coal and uranium etc.*

All the energy basins will have potential of various renewables energy sources

At times large resources of minerals like phosphates are also seen to occur in such basins, close to oil & gas occurrences and the genetic link remains to be established.

Energy Basins (2)

Unified and holistic approach to understand such 'energy basins' will greatly aid the exploration and discovery of multiple energy sources in many basins.

Holistic approach in developing such energy basins to extract multiple energy fuels like oil & gas, coal and uranium and renewables will aid the optimal and sustainable local development and conservation of all useful materials.

For example

uranium from deep levels in a basin, which could be uneconomic to mine conventionally, could be extracted economically with oil & gas;

uranium could extracted from coal with suitable modifications to coal to liquid technology; and

co-extraction of uranium, valuable elements and oil & gas from gas shales;

co-extraction of uranium and hydrocarbons from off-shore basins etc.

… and combined with harnessing the power of sun, wind, tides and other renewable energy sources

If properly understood and developed 'energy basins' could be supply 'plentiful energy' to meet the growing global demand, the supply of which is at present is based on a conventional compartmentalized developmental paradigm.

Need for petroleum, uranium, coal, phosphate and renewable experts to talk to each other.

Ultimately, energy basins can act as waste disposal repositories

Why uranium and thorium are special?

- Only fuel / metal globally reported by **an inter-governmental agency**.
- Need to keep an **inventory for 100 years of more.**
- Need to keep track of thorium, which has no market today – but can be used for 1000s of years in to future.
- In many countries uranium and thorium are **reported separately.**
- In many countries uranium mining is **regulated separately.**
- In some **'energy basins'** U seen to occur with other energy fuels. Use of common classification systems can help in energy studies.
- There has to be some **commodity specific issues,** while an unified classification system, the UNFC is applied.

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Thank you