IAEA Activities on Uranium Resources & Production and Databases for the Nuclear Fuel Cycle

C. Ganguly and J. Slezak

Nuclear Fuel Cycle & Materials Section
Division of Nuclear Fuel Cycle & Waste Technology
Department of Nuclear Energy

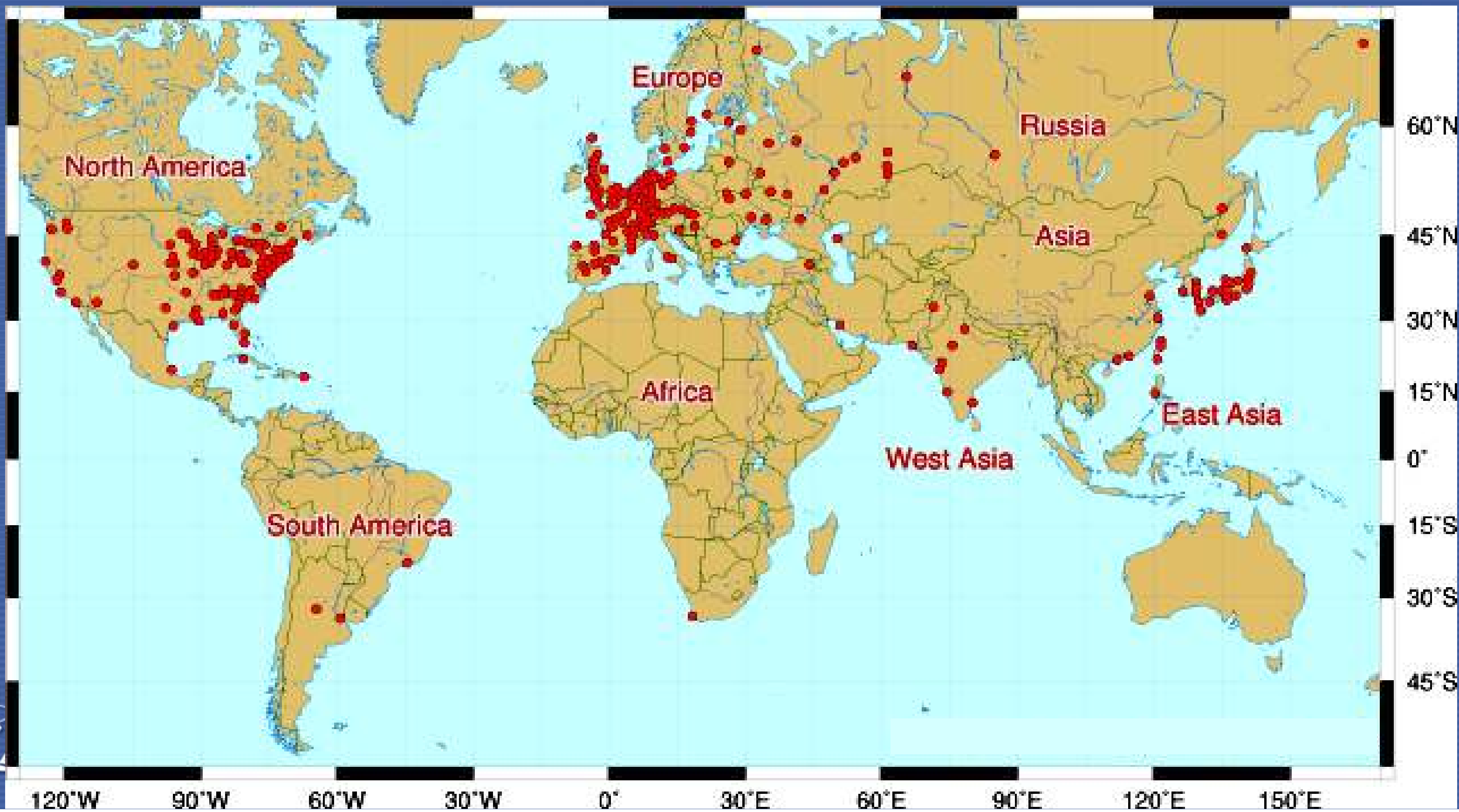
URAM 2009, 22-26 June 2009, Vienna

IAEA
International Atomic Energy Agency

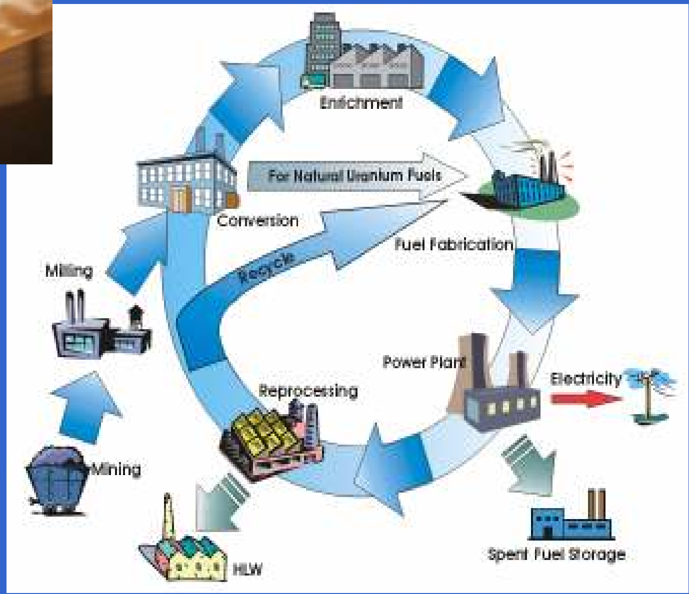
Nuclear Power Reactors Worldwide (June 2009)

436 Nuclear Power Reactors are in operation in 30 Countries : ~370GWe, ~ 14.% global electricity;
44 reactors are under construction
(In 2001: 438 reactors, 360 GWe generating 16% global electricity)

IAEA Nuclear Power Projection in 2030 :
low : 473 GWe
high : 748 GWe



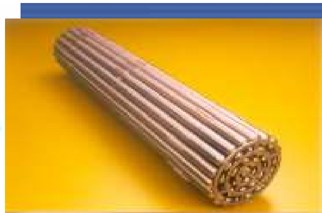
Nuclear Power Reactor & Nuclear Fuel Cycle Go Hand in Hand



Raw Materials for Nuclear Fuels :Nat. U (99.3 % U238 – fertile + 0.7 % U235 - fissile)

Nat. Th (100 % Th232 - fertile)

Nuclear Fuel Cycle



IAEA

Typical Fuels for Operating Nuclear Power Reactors in the World

UO_2 or $(U, Pu)O_2$ Fuel Pellets

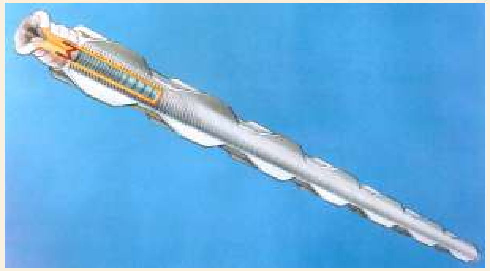
PHWR

37 Fuel elements
Zircaloy clad
Natural UO_2

LMFR

SS clad
$(U,Pu)O_2$

MAGNOX



Magnesium Alloy Clad
Natural Uranium Metal Pin

PWR

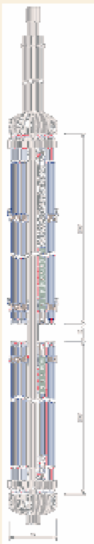
17x17 Fuel Elements

BWR

9x9 Fuel Elements

Zircaloy clad
Enriched UO_2
(<5%U -235)

RBMK



VVER

312 Fuel Elements

Zr-1%Nb clad
(<5%U -235)UO_2

AGR

SS Clad
Enriched UO_2
(<5%U -235)

Natural Uranium :

99.3% U^{238} (fertile)+

0. 7% U^{235}(fissile)

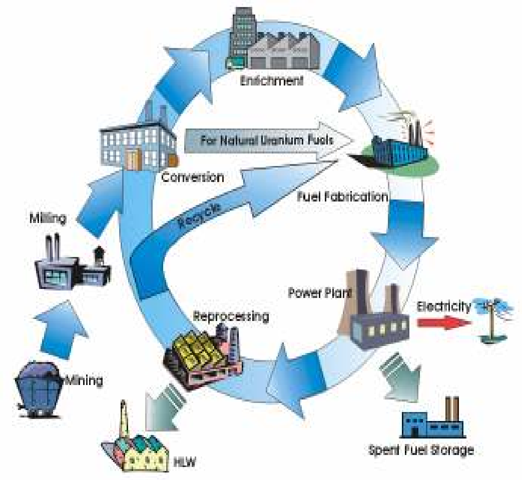
U^{238} → Reactor → Pu^{239} (fissile)

~ 30% nuclear energy is from in-situ fission of Pu^{239} in reactor

LWRs & PHWRs account for more than 90% of operating nuclear power reactors. They use low enriched uranium (<5% U^{235}) and natural uranium respectively as fuel in the form of uranium oxide pellets encapsulated in zirconium alloy cladding tubes

IAEA Major Programme 1.2: "Nuclear Fuel Cycle & Materials Technologies"

Mission Statement



To facilitate development of nuclear power reactor fuel cycle options that are : i) economically viable
ii) for efficient utilization of natural uranium and thorium resources ii) safe and environment-friendly,
iii)) proliferation-resistant and iv) sustainable.

To promote information exchange on

1. exploration, mining and processing of uranium and thorium ores
2. design, manufacturing, and performance of nuclear fuels
3. management of spent fuel, including storage & treatment of spent fuel & recycling of plutonium, uranium ,thorium and Minor Actinides (MA: Np,Am & Cm)

Through:

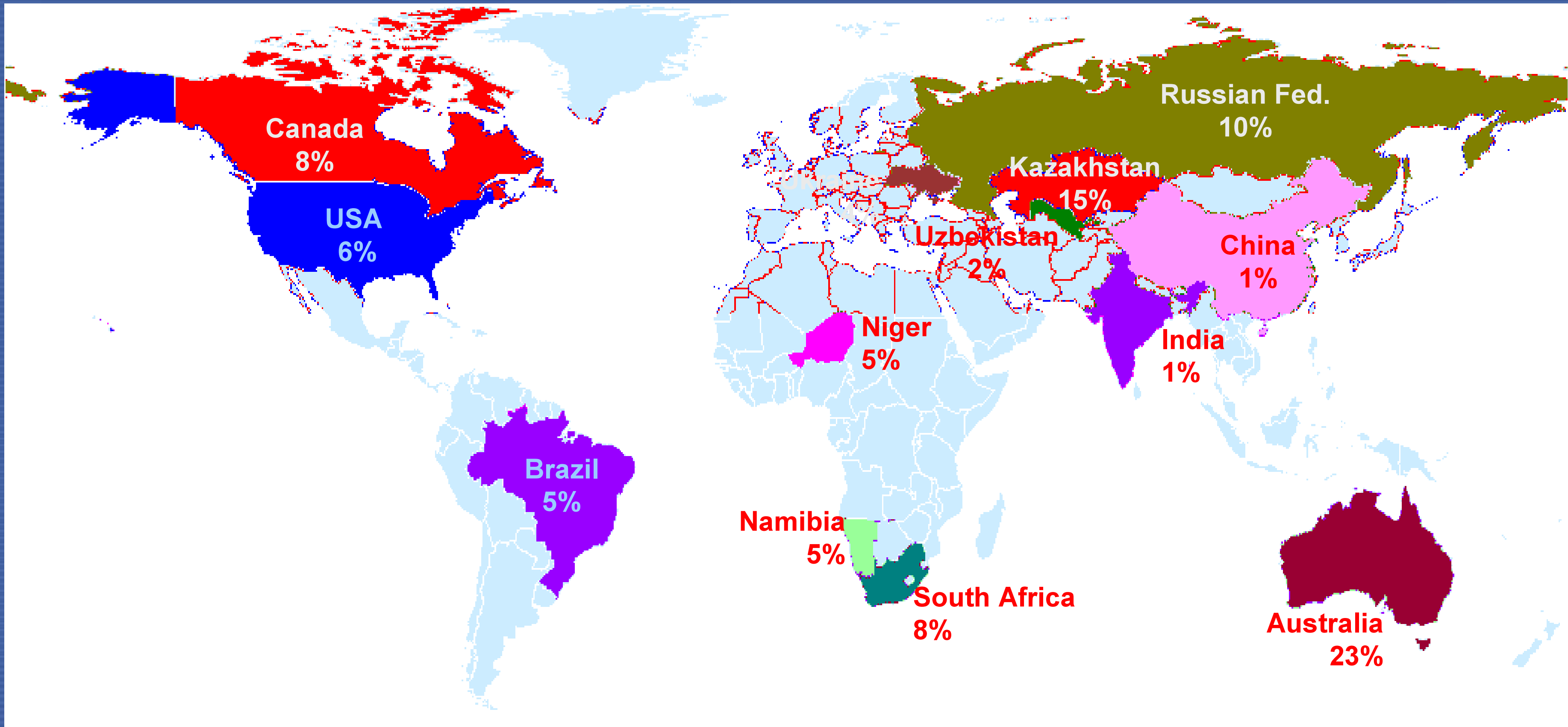
1. technical co-operation
2. organizing technical meetings, symposia and coordinated research projects
3. preparation of state -of -the art technical documents
4. maintaining & updating databases on nuclear fuels and fuel cycles

IAEA

Distribution of Identified Uranium Resources Worldwide

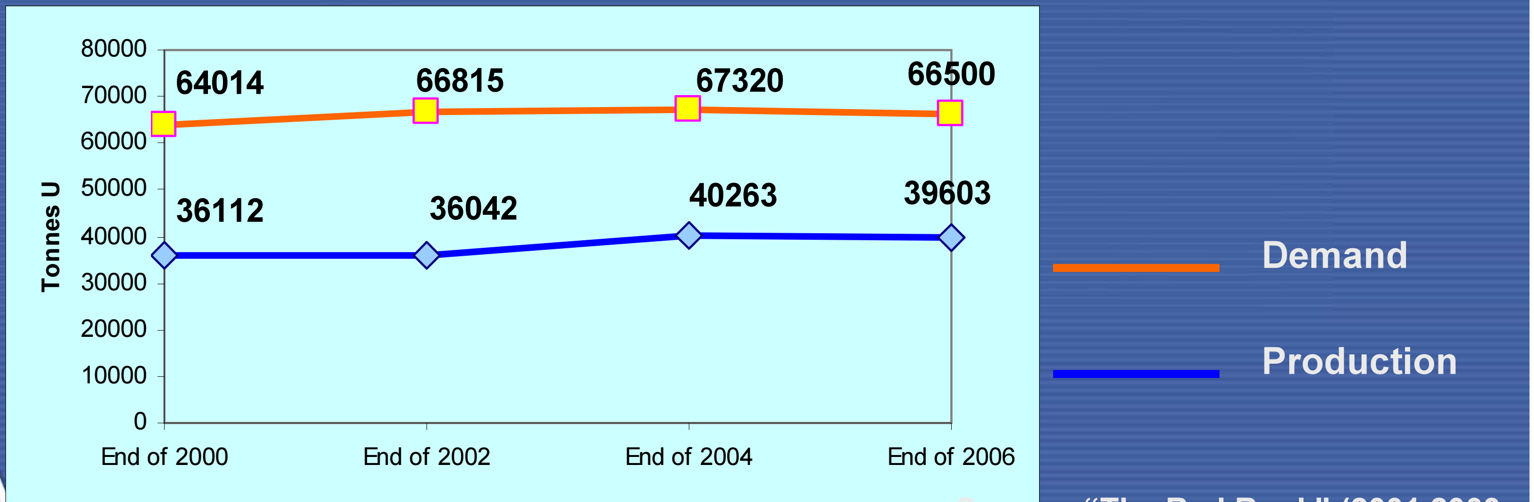
Total Identified Resources (< 130US$/kg U) : 5.47 Mt (Red Book 2007)

Is the supply secure?



IAEA

Uranium Resources, Demand & Production



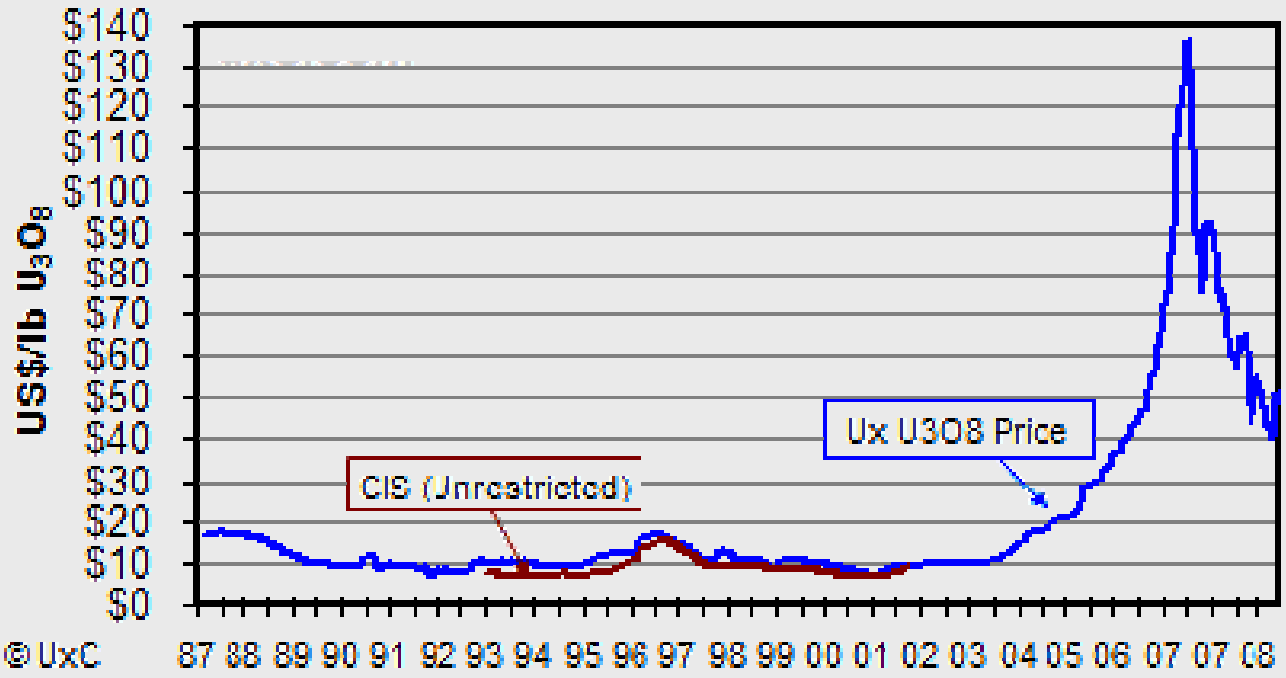
Source: "The Red Book" (2001,2003, 2005 & 2007 editions)

Countries with major Uranium Resources and Nuclear Power Reactors

Country	Uranium Resources (tonnes U)	% of World Uranium resources	No of nuclear power reactors (% total electricity)
Major Uranium Producers but without any Nuclear Power Plant			
Australia	1,243,000	23	NIL
Kazakhstan	817,300	15	
Namibia	275,000	5	
Niger	274,000	5	
Major Uranium Producers with Nuclear Power Plants			
USA	339,000	6	104 (20%)
Canada	423,200	8	18 (15%)
South Africa	435,100	8	2 (5%)
Russia	545,600	10	31 (17%)
Brazil	278,400	5	2 (3%)
China	67,900	1	11 (2%)
India	72,900	1	17 (2%)
Major Nuclear Electricity Producing Countries without Uranium Resources			
France	NIL		59 (76%)
Germany			17 (28%)
Japan			53 (25%)
Republic of Korea			20 (36%)
United Kingdom			19 (13%)
Sweden			10 (42%)

Ref Red Book 2007 & IAEA – PRIS, June 2009

Uranium Spot Price during the last two decades

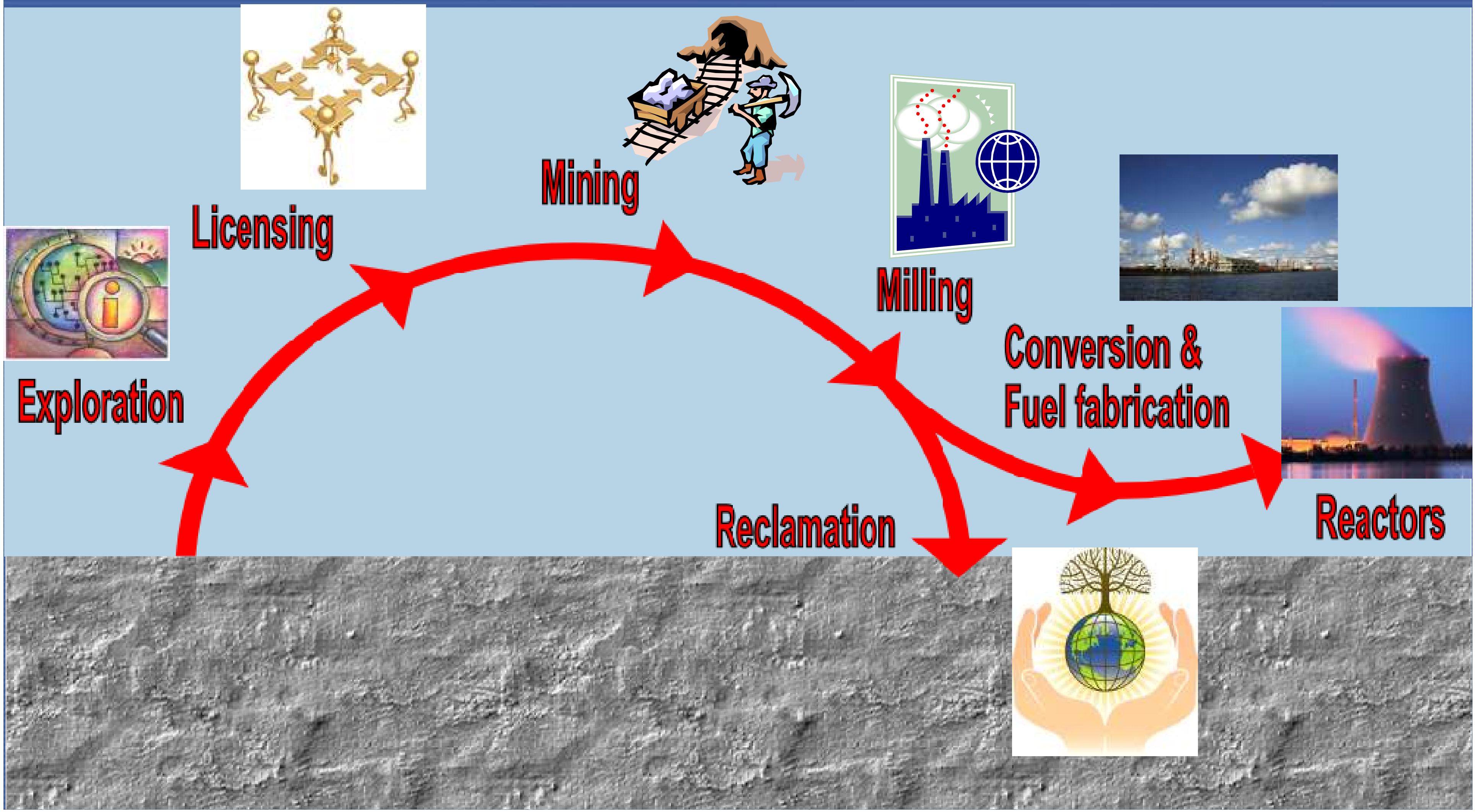


Uranium Spot Price on 15 June 2009: 53 US$/lb U_3O_8

IAEA

Uranium Production Cycle

Radiological safety and Mine & Mill remediation and reclamation are of great importance

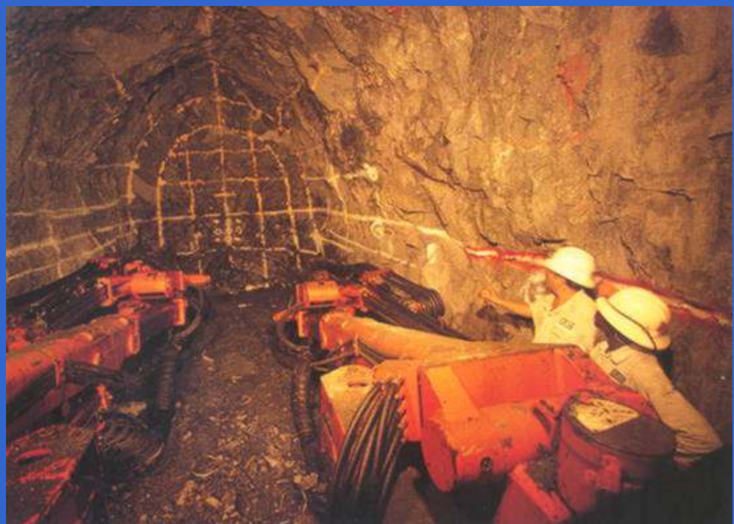


Uranium Mining Techniques

Open Pit Mining (24%)

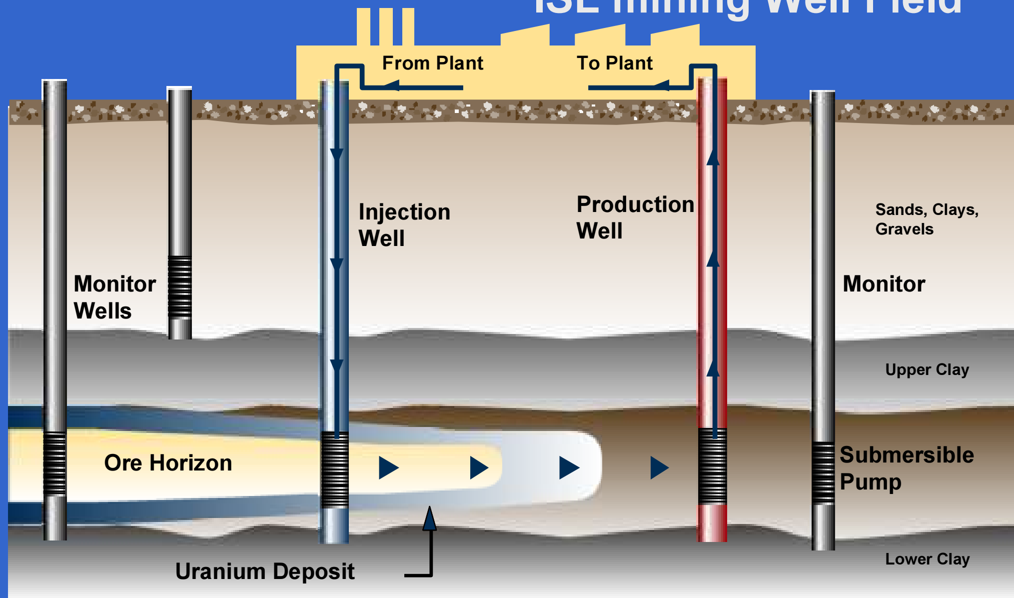
In Situ Leach (ISL) Mining (~28%)

Other techniques (~2%)

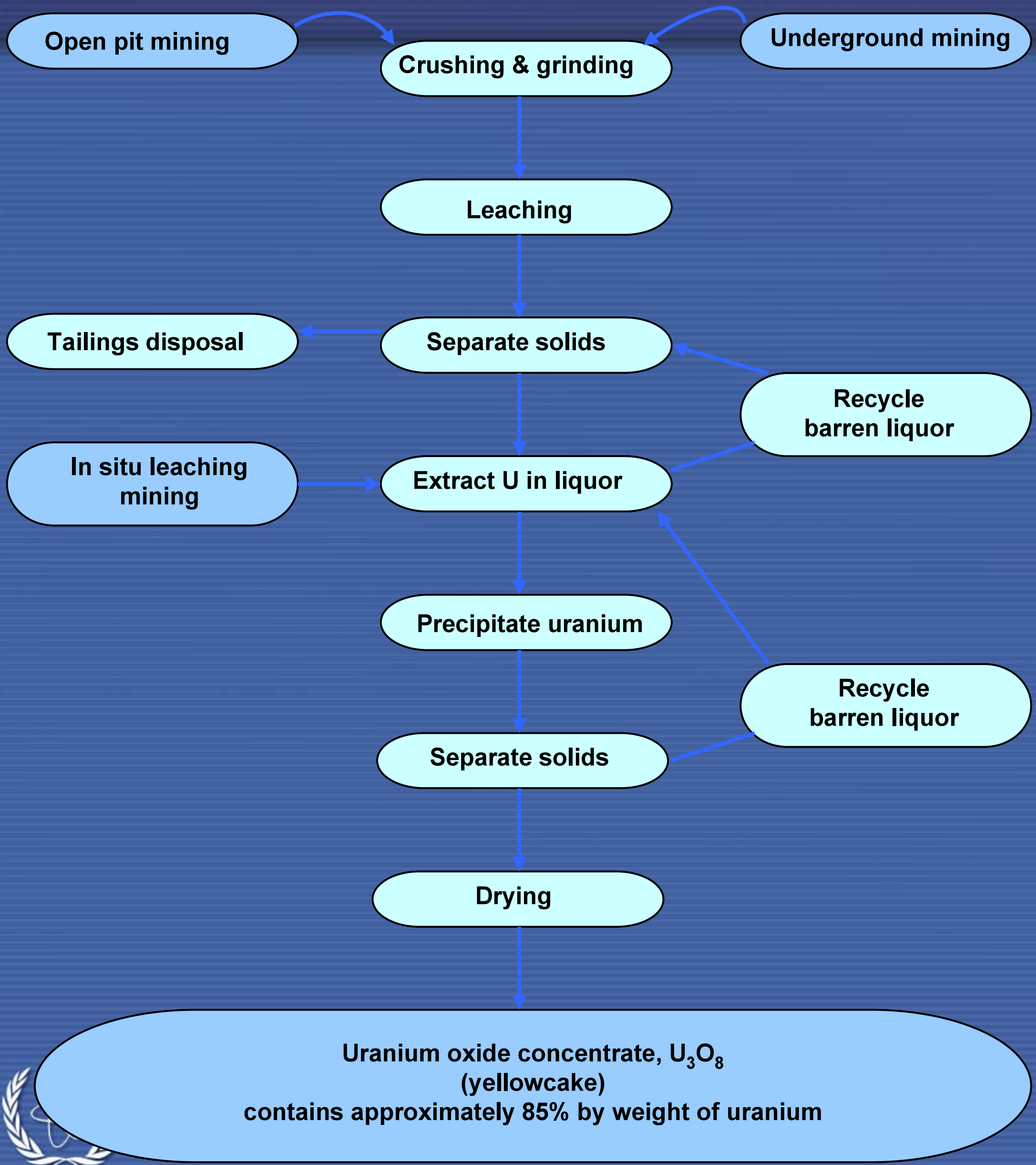


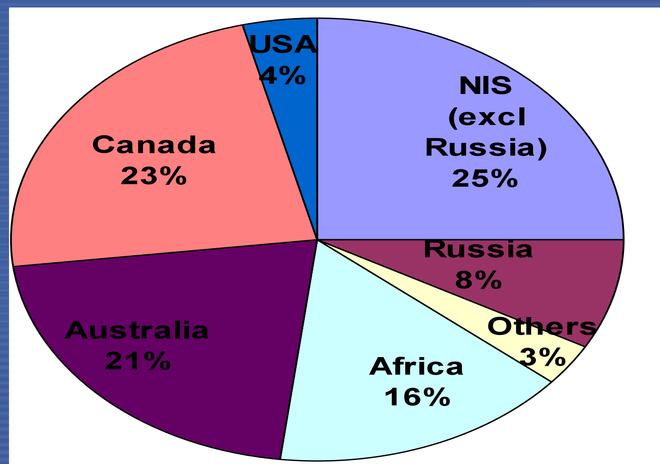
Underground Mining (~38%)

ISL mining Well Field



Process Flowsheet in Uranium Milling Plant & Statistics of World Uranium Production





World uranium production (41,279 Ut), 2007

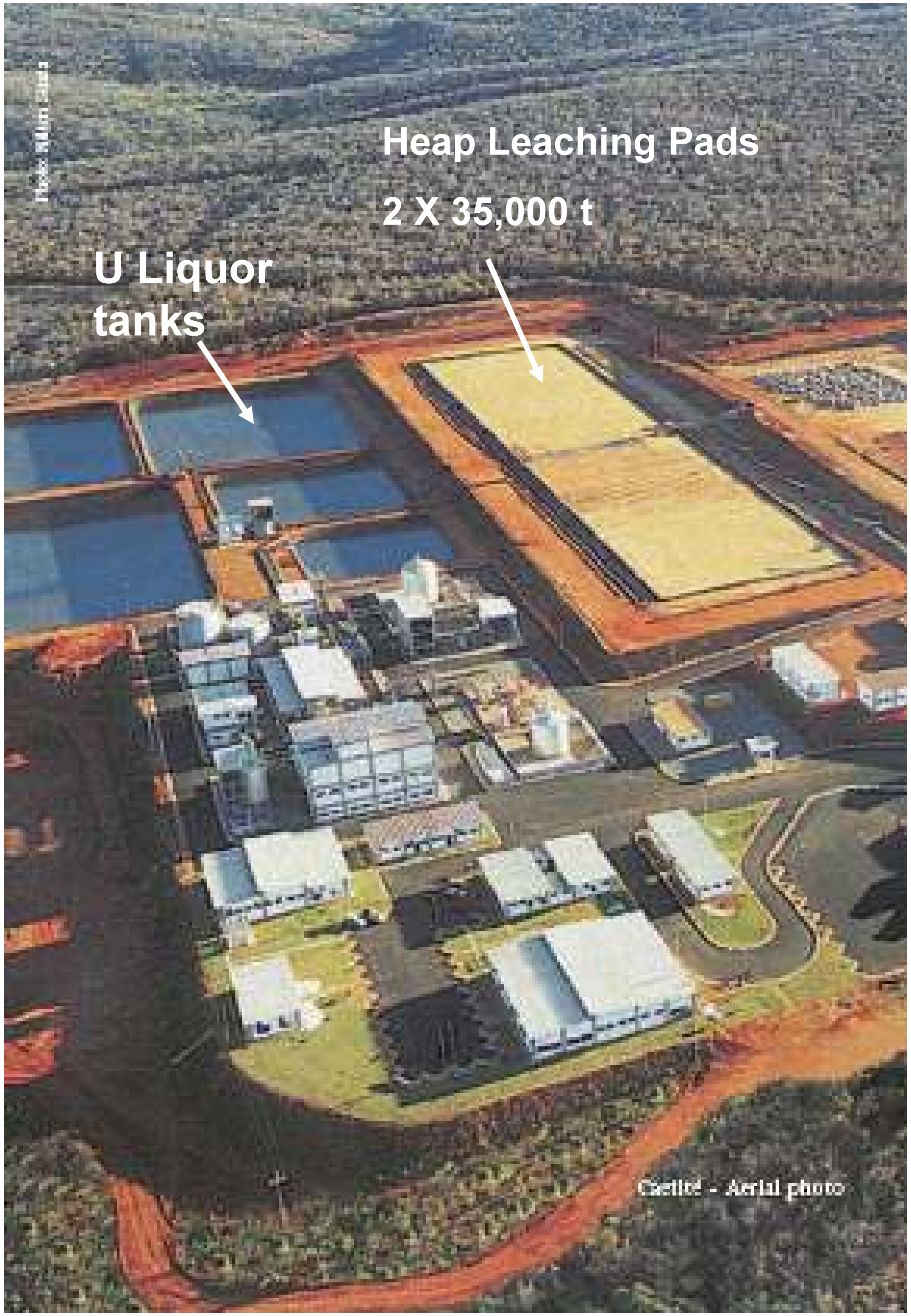
IAEA URANIUM PRODUCTION SITE APPRAISAL TEAM (UPSAT) – REVIVED IN 2008

UPSAT Guidelines — IAEA-TECDOC-878(1996)

The objective of IAEA Uranium Production Site Appraisal Team (UPSAT) is to assist to improve the Operation & Safety of Uranium Production Sites, in Member States(on request) by peer review involving international experts.

IAEA

Proposed IAEA - UPSAT mission at Uranium Mine and Mill site in Caetité, Brazil in the last quarter of 2009



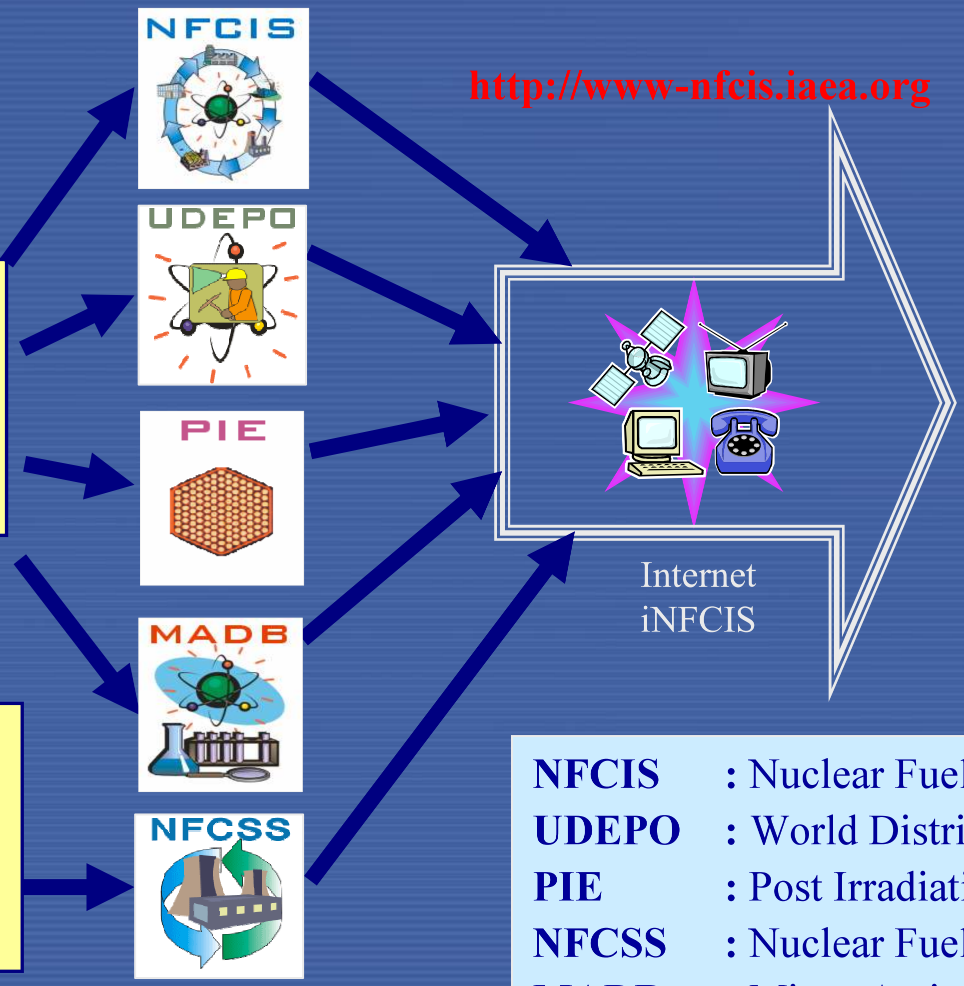
integrated Nuclear Fuel Cycle Information System (iNFCIS) – A database of IAEA related to the Nuclear Fuel Cycle

Information Sources

- Member States (Contact Points)
- Consultants
- IAEA Meetings
- Reliable Publications

Inputs

- Nuclear power projections
- Nuclear fuel cycle options
- Reactor physics calculations



- Navigation through facilities/deposits/records
- Search capabilities
- Summary reports for country specific or worldwide
- Country nuclear fuel cycle profiles
- Long term nuclear fuel cycle requirements for different scenarios

NFCIS	: Nuclear Fuel Cycle Information System
UDEPO	: World Distribution of Uranium Deposits
PIE	: Post Irradiation Examination Facilities Database
NFCSS	: Nuclear Fuel Cycle Simulation System
MADB	: Minor Actinide Property Database

IAEA

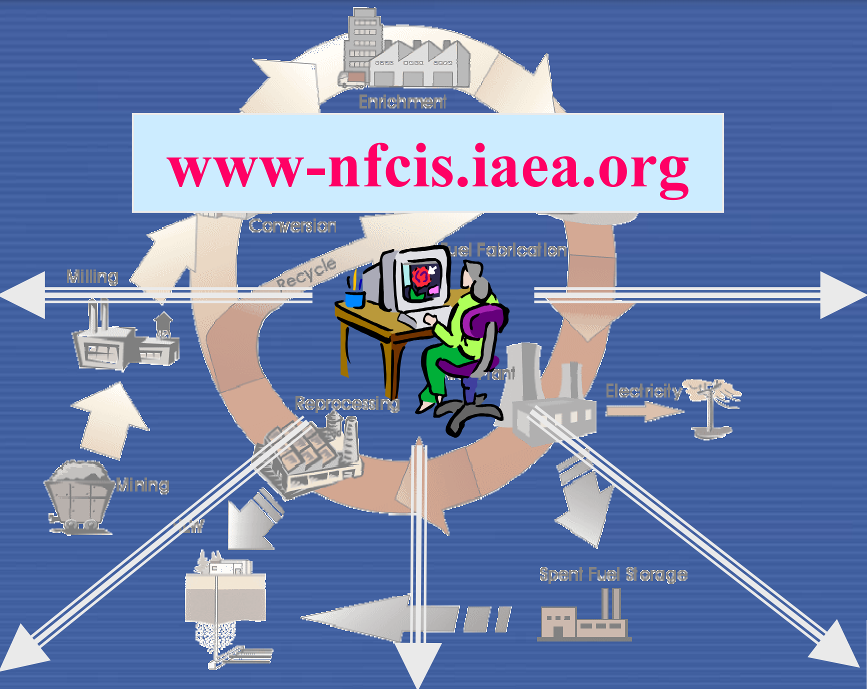
Integrated Nuclear Fuel Cycle Information Systems (iNFCIS)

IAEA

NFCIS

- Nuclear Fuel Cycle Information System
- Directory of Civilian Nuclear Fuel Cycle Facilities Worldwide
- Facilities from under planning stage to the decommissioned stage
- Facilities from uranium milling to reprocessing, spent fuel storage and heavy water production
- Available online since 2001
- 689 facilities in 55 countries (Apr 2009)
- TECDOC published in 2009 (TECDOC-1613)

www-nfcis.iaea.org



PIE

- Post Irradiation Examination Facilities Database
- Catalogue of PIE facilities worldwide
- General information about the facilities
- Technical capabilities of the facilities
- Available online since 2004
- 45 facilities in 21 countries (Apr 2009)

NFCSS

Nuclear Fuel Cycle Simulation System

- Scenario based simulation system
- Estimates nuclear fuel cycle material and service requirements
- Calculates spent fuel arisings and actinide contents
- TECDOC Published in 2007 (TECDOC-1535)
- The simple web version is online since 2005
- Full web version is available since June 2008.

UDEPO

- World Distribution of Uranium Deposits
- Technical and geological information on uranium deposits
- Country level maps of the deposits will be displayed on the web site
- Available online since 2004
- Currently 1107 deposits in 67 countries (Apr 2009)
- TECDOC to be published in 2009

ThDEPO to be started

MADB

- Minor Actinide Property Database
- Bibliographical database on physico-chemical properties of materials containing minor actinides
- Carbides, Nitrides, Alloys, Oxides, Halides, Elements and other forms are covered
- More than 1000 data records from 159 publications (Apr 2009)
- Online since May 2009

Properties of LMFR fuel and fuel assembly structurals

Challenges ahead

1. How to reduce the "GAP" between demand and supply of natural uranium ?

a) Reducing demand:

i. Increasing fuel burnup by optimizing fuel design and micro structure
ii. Reprocessing spent LWR & PHWR fuels - mono-recycling plutonium in LWRs / PHWRs and re-enriching and reusing reprocessed uranium
iii. Direct Utilization of spent PWR fuel In CANDU reactors - DUPIC process
iv. Reprocessing of spent fuel and multiple recycling of plutonium in combination with depleted uranium in fast reactors
v. Lowering "tail assay" in enrichment plant

b) Increasing Supply from conventional and unconventional sources:

i. Augmenting capacity of operating mines and mills and improving recovery
ii. Opening new mines and mills
iii. Developing economically viable process flow sheets for recovering uranium as by-product from unconventional sources (eg: phosphate rocks, coal ash, monazite, seawater etc)

IAEA

Challenges ahead

2. How to reduce the 'GAP' between uranium in ground and Yellow Cake in can?

   a) By increasing uranium resource base by adapting advanced geophysical and geochemical methods
   b) By prioritizing uranium mine and mill licensing process thereby reducing the time needed for licensing
   c) By improving uranium recovery from mine and mill through improved mining methods, leaching techniques and purification process
   d) By adapting In situ leach mining, mainly for porous sandstone type deposits

IAEA

Challenges ahead

3. Issues related to radiological and mine safety and environmental protection and adapting leading practices in uranium production cycle (encouraging UPSAT)
4. Issues related to “Social Licensing”
5. Issues related to ageing and retiring human resource and shortage of experts

Thank You…

IAEA