The Nuclear Dilemma

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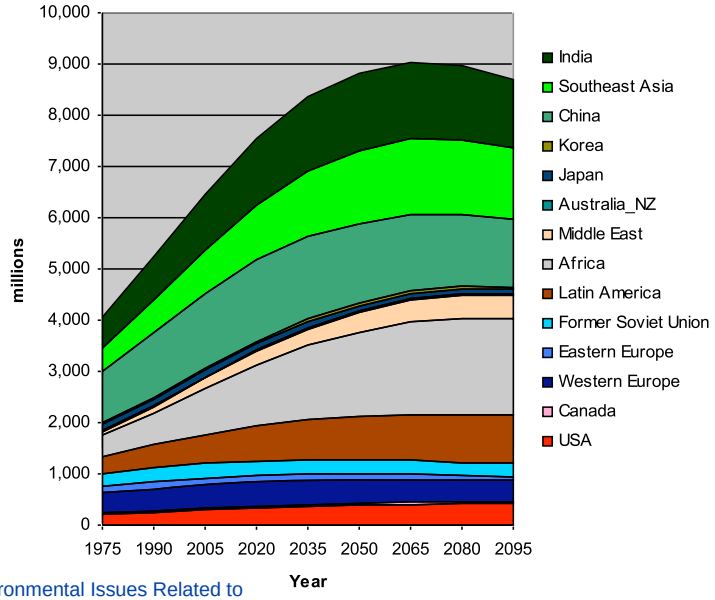
main topics

- energy and development
- nuclear technology
- nuclear watchdogs

Demographics

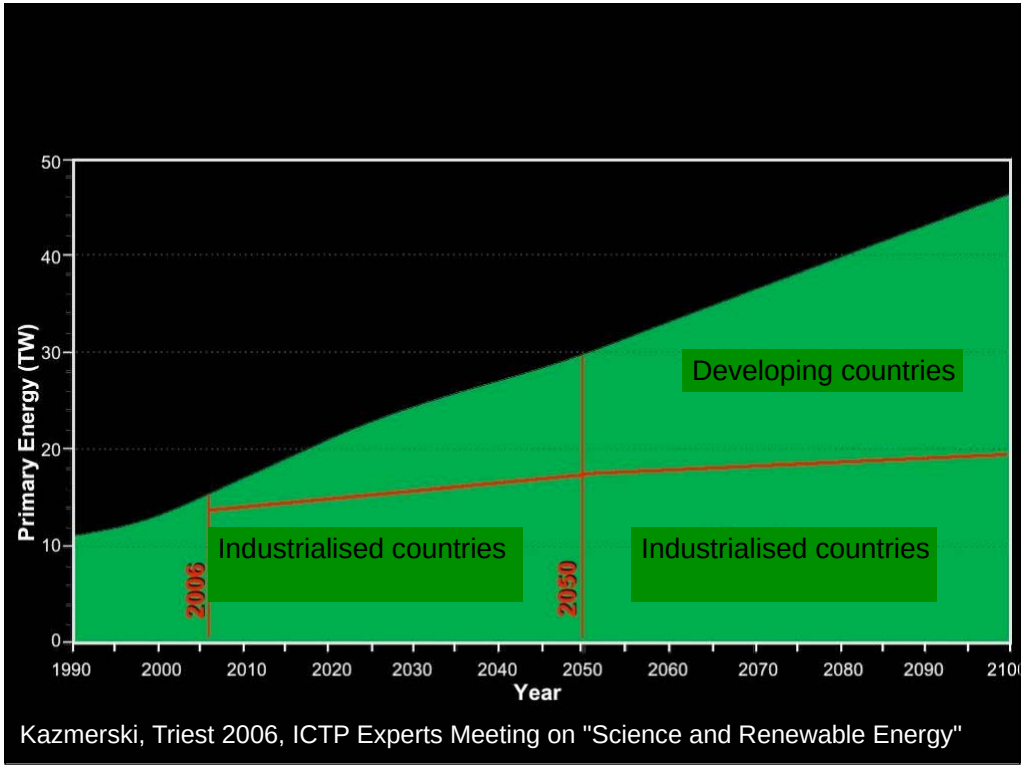


Sonny Kim & Jae Edmonds
Triest, 2008

Joint ICTP-IAEA Meeting on Environmental Issues Related to Geological Storage of Carbon Dioxide and Nuclear Wastes

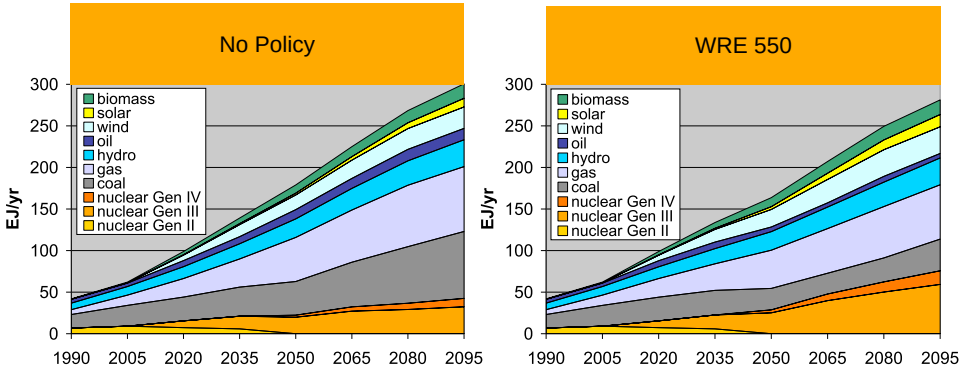
During this lecture about 10’000 new people will enter the world, at the rate of 3/sec, most of them in **developing countries**.

They need energy to survive decently.



Kazmerski, Triest 2006, ICTP Experts Meeting on "Science and Renewable Energy"

Global Electricity Generation



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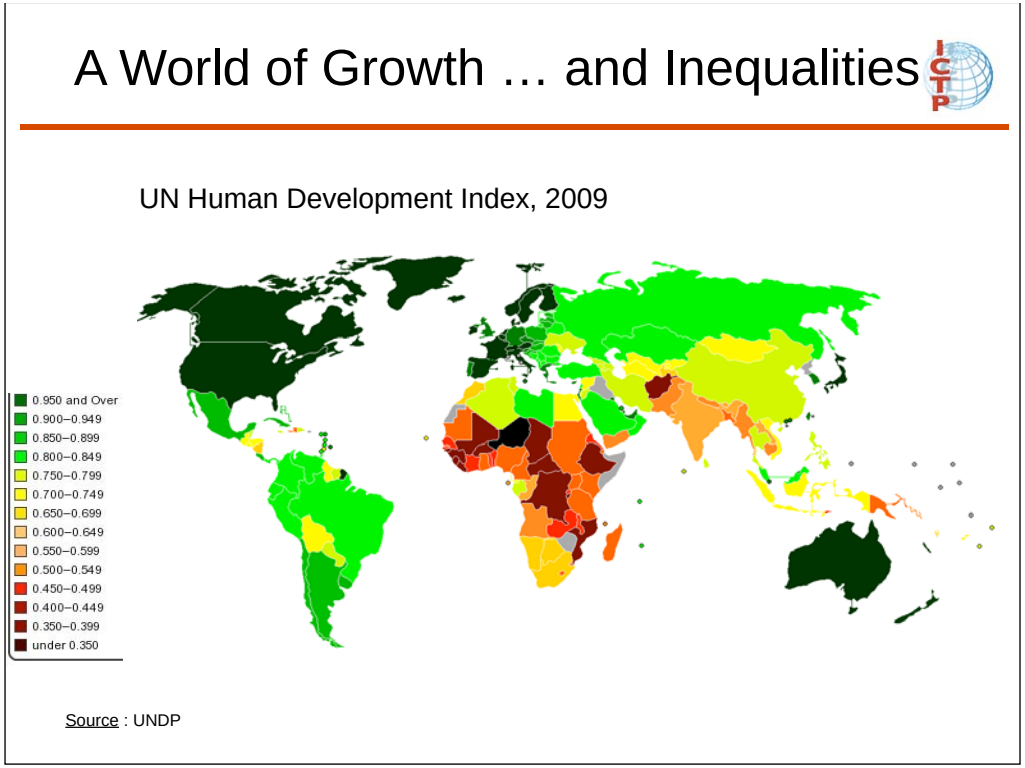
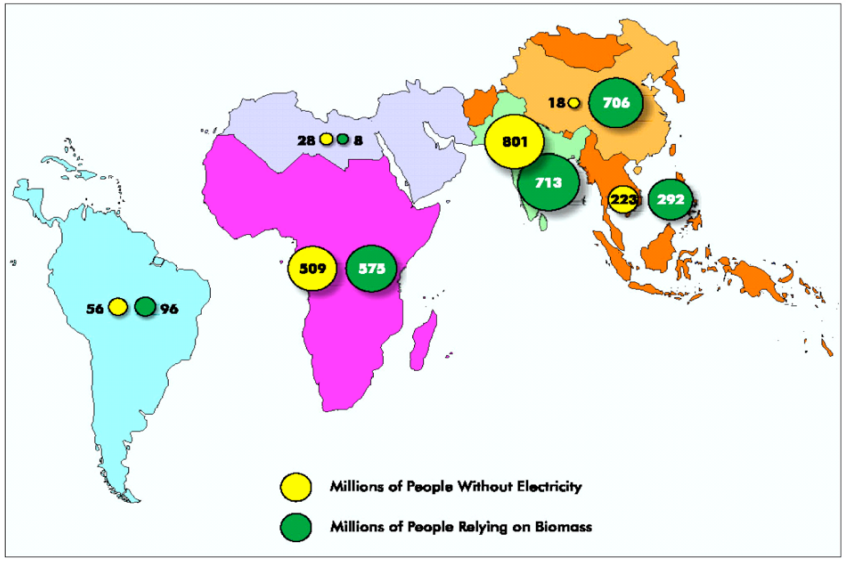


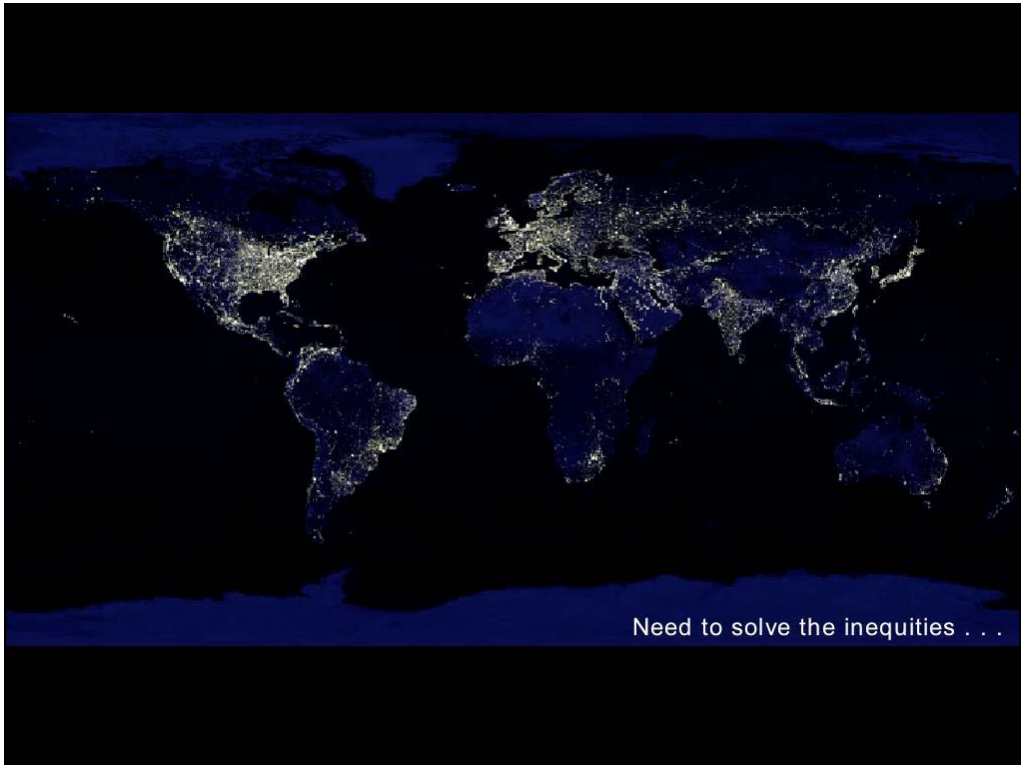
Les enthousiastes qui mettent l'accent sur les aspects positifs de la globalisation se laissent parfois emporter ", note avec ironie le rapport du programme des Nations unies pour le développement (PNUD) dans son édition 2006. Depuis 1990, le PNUD publie chaque année un indicateur de développement humain (IDH) composite mêlant à la mesure du pouvoir d'achat celle de l'espérance de vie et de la scolarisation à différents niveaux d'éducation.

A cette aune, l'accroissement sans précédent de richesses et de bien-être qu'a connu en moyenne la planète ces dernières décennies apparaît toujours aussi mal partagé. Surtout, les écarts se sont accrus, en particulier avec l'Afrique subsaharienne, dont l'indicateur stagne depuis 1990 à moins de 0,5 point, quand celui des pays de l'OCDE est passé de 0,90 à 0,95. Si les pays d'Amérique latine, d'Asie de l'Est et du Sud ont connu une nette amélioration de leurs performances, les écarts de bien-être entre les différentes régions du monde sont restés à peu près stables depuis seize ans.

Without electricity



Source: IEA analysis.


Need to solve the inequities . . .

"More than 60 countries – mostly in the developing word – have informed the Agency that they might be interested in launching nuclear power programmes

IAEA, Annual Report, 2009

- Joint ICTP-IAEA School of Nuclear Energy Management, Trieste, November, 2010
- Joint ICTP-IAEA School of Nuclear Knowledge Management, Trieste, August 2010

TABLE 1. NUCLEAR POWER REACTORS IN OPERATION AND UNDER CONSTRUCTION IN THE WORLD (AS OF 1 JANUARY 2010)[a]

Country	Reactors in operation		Reactors under construction		Nuclear electricity supplied in 2008		Total operating experience through 2009	
	No. of units	Total MW(e)	No. of units	Total MW(e)	TW·h	% of total	Years	Months
Argentina	2	935	1	692	6.9	6.2	62	7
Armenia	1	376			2.3	39.4	35	8
Belgium	7	5863			43.4	53.8	233	7
Brazil	2	1766			13.2	3.1	37	3
Bulgaria	2	1906	2	1906	14.7	32.9	147	3
Canada	18	12577			88.3	14.8	582	2
China	11	8438	20	19920	65.3	2.2	99	3
Czech Republic	6	3678			25.0	32.5	110	10
Finland	4	2696	1	1600	22.1	29.7	123	4
France	59	63260	1	1600	419.8	76.2	1700	2
Germany	17	20470			140.9	28.8	751	5
Hungary	4	1859			13.9	37.2	98	2
India	18	3984	5	2708	13.2	2.0	318	4
Iran, Islamic Republic of			1	915				
Japan	54	46823	1	1325	241.3	24.9	1439	5
Korea, Republic of	20	17647	6	6520	144.3	35.6	339	8
Mexico	2	1300			9.4	4.0	35	11
Netherlands	1	482			3.9	3.8	65	0
Pakistan	2	425	1	300	1.7	1.9	47	10
Romania	2	1300			10.3	17.5	15	11
Russian Federation	31	21743	9	6894	152.1	16.9	994	4
Slovakia	4	1711	2	810	15.5	56.4	132	7
Slovenia	1	666			6.0	41.7	28	3
South Africa	2	1800			12.8	5.3	50	3
Spain	8	7450			56.5	18.3	269	6
Sweden	10	8958			61.3	42.0	372	6
Switzerland	5	3238			26.3	39.2	173	10
Ukraine	15	13107	2	1900	84.5	47.4	368	6
United Kingdom	19	10097			48.2	13.5	1457	8
United States of America	104	100683	1	1165	806.7	19.7	3499	9
Total[b,c]	437	370187	55	50855	2597.8	14	13911	3

Construction of water cooled reactors (2x 917 Mwe) at Kundankulam, in India

+ United Arab Emirates

IAEA, Annual Report, 2009

Issues for the future of NP

- Nuclear community has been relying on nuclear technology developed in the 1950s, with roots in **military** applications
  - Not inherently safe
  - Not proliferation-free, etc
- Expansion of NP depends on active safety systems, institutional measures to reduce accident and proliferation risks, etc: **not competitive**

Need

Innovative approaches to address concerns about economic **competitiveness**, **safety**, **security**, **waste** and potential **proliferation** risks

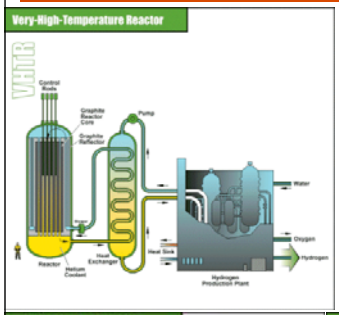
- At the national level, work is proceeding in several IAEA Member States
- International level
  - OECD /IEA, OECD/NEA and the IAEA are co-operating
  - Generation IV International Forum (GIF)

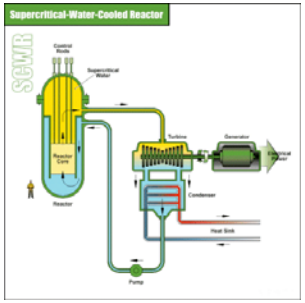
Innovative NP

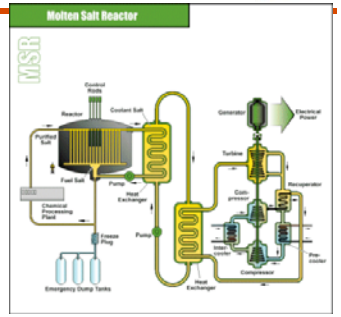
- Small modular reactors with **once-through** fuel cycles
- **Fast** reactor and **closed** fuel cycle concepts
- **Accelerator** driven systems
- **Thorium** based reactor and fuel cycle systems

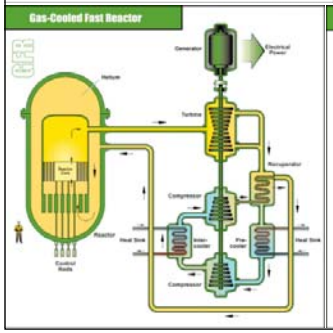
- Joint ICTP-IAEA Workshop on Nuclear Reaction Data for Advanced Reactor Technologies, Trieste, 2008
- Joint ICTP-IAEA Workshop on Technology and Applications of Accelerator Driven Systems, Trieste, 2005
- IAEA International Project on Innovative Reactors and Fuel Cycles - (INPRO) Workshop on Crosscutting Issues, Trieste 2001

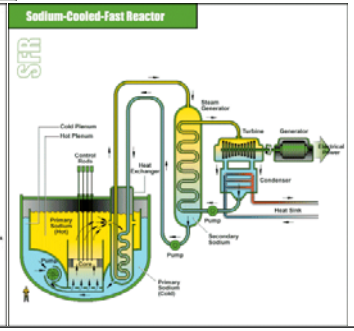
Generation IV Nuclear Reactors

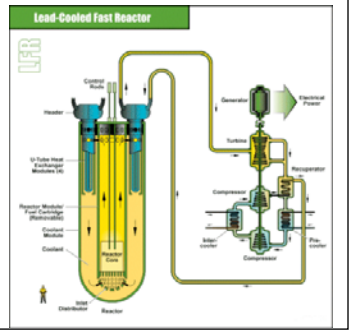












Nuclear power evolution

In 60 years, nuclear energy has grown from a novel scientific development to a **major part of the energy mix** in several of the 30 countries using nuclear power;

NP can help countries to obtain **energy independence**, **reduce emission** of GHGs;

NP can contribute to long-term global **sustainable** energy mix;

- BUT .....

Challenges

Political opposition to NP

- Safety
- Non-proliferation
- Nuclear waste

Electricity market deregulation

- gas-fired power generation

Safety

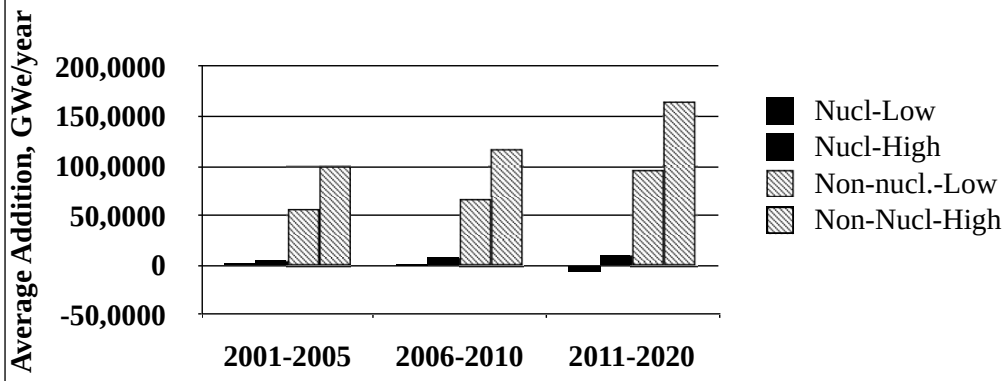
Public remains wary of nuclear power due to Chernobyl and Three Mile Island accidents

Nuclear plants vulnerable to terrorist attacks

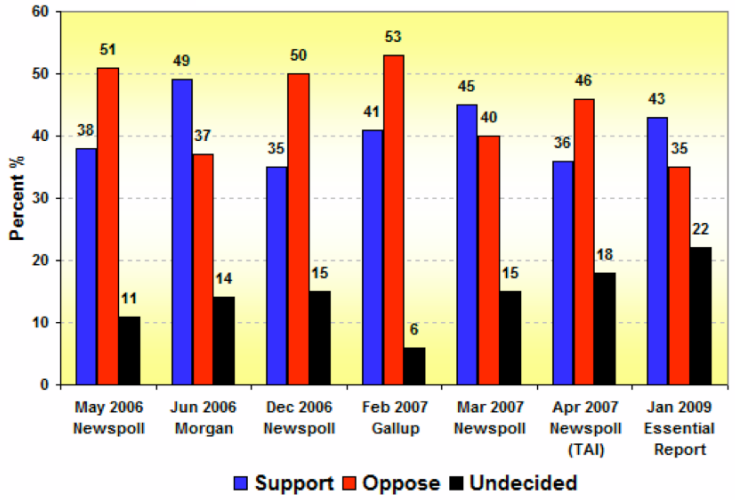
Safer, more efficient, and more secure plants planned for the future

Chernobyl

World Electricity Capacity Additions: IAEA Projections



Nuclear power in Australia



The new IAEA

Inspectors from ‘accountants’ to ‘detectives’

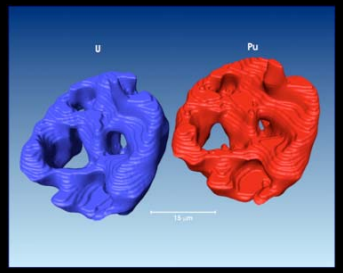
➡ Inspections without notice

➡ Environmental sampling

Swipe sample analysis

analysis of individual particles – multiple analyses from one swipe

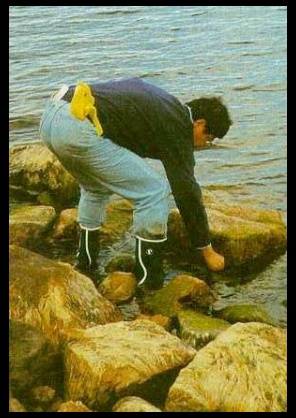
bulk analysis – higher sensitivity but loss of information for heterogeneous samples



Wide Area Environmental Sampling

Environmental media sampled as collectors of radionuclides

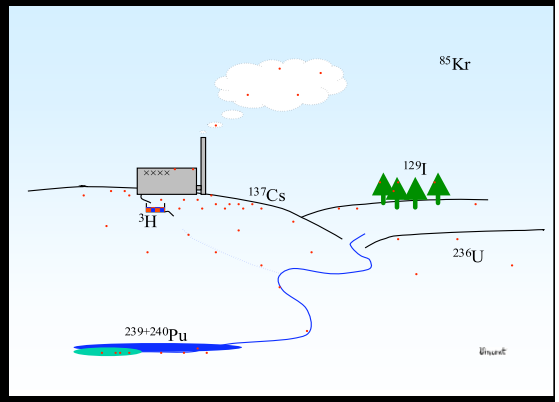
- Soil
- Water
- Sediment

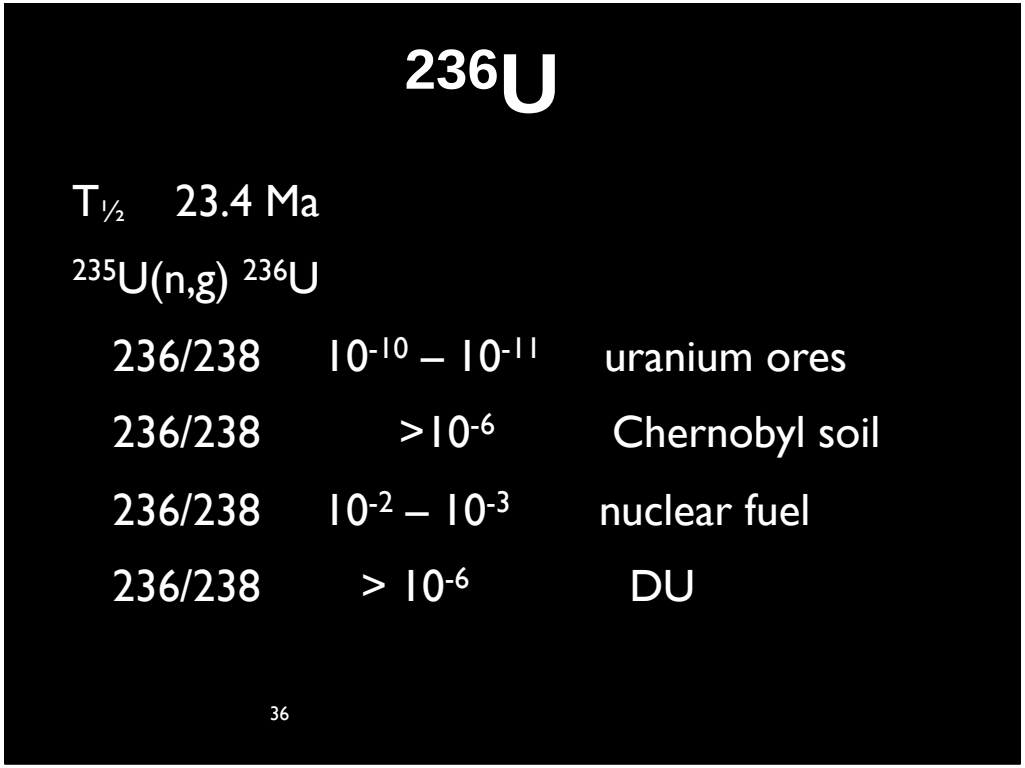


Wide Area Environmental Sampling

Useful indicators:

- ➡ difficult to contain
- ➡ deposited locally
- ➡ long-lived
- ➡ detectable at background levels





Mainly produced bu thermal neutron capture on 235U, cross-section = 1/5 fission cross-section.

236U in nuclear fuel gives poisoning effect which is the factor limiting the recicling of uranium fuels.

The cotrast in ratios between natural and irradiated uranium provides a wide dynamic range for the detection of traces of irradiated material in environmental samples containing natural uranium.

ANTARES, Sydney, 236U, 239Pu, 129I

ICTP/IAEA International School on Nuclear Security

Trieste, April 2011

Concluding Remarks

Today, nuclear power is at a **crossroads**. In some parts of the world, its future is in **doubt** while in other regions use of nuclear power is **expanding**;

The global energy market is expanding and nuclear energy has the potential to increase **market share** in electricity generation and heat applications;

The challenges to nuclear power require **scientific and technical research** to assure a very high level of nuclear **safety and security, proliferation-resistance, economic competitiveness** and accepatble level of **environmental impact.**