Status and Trends of the World Nuclear Industry

Update September 2008

(for text analysis see http://www.thebulletin.org/web-edition/reports/2008-world-nuclear-industry-status-report)

Mycle Schneider

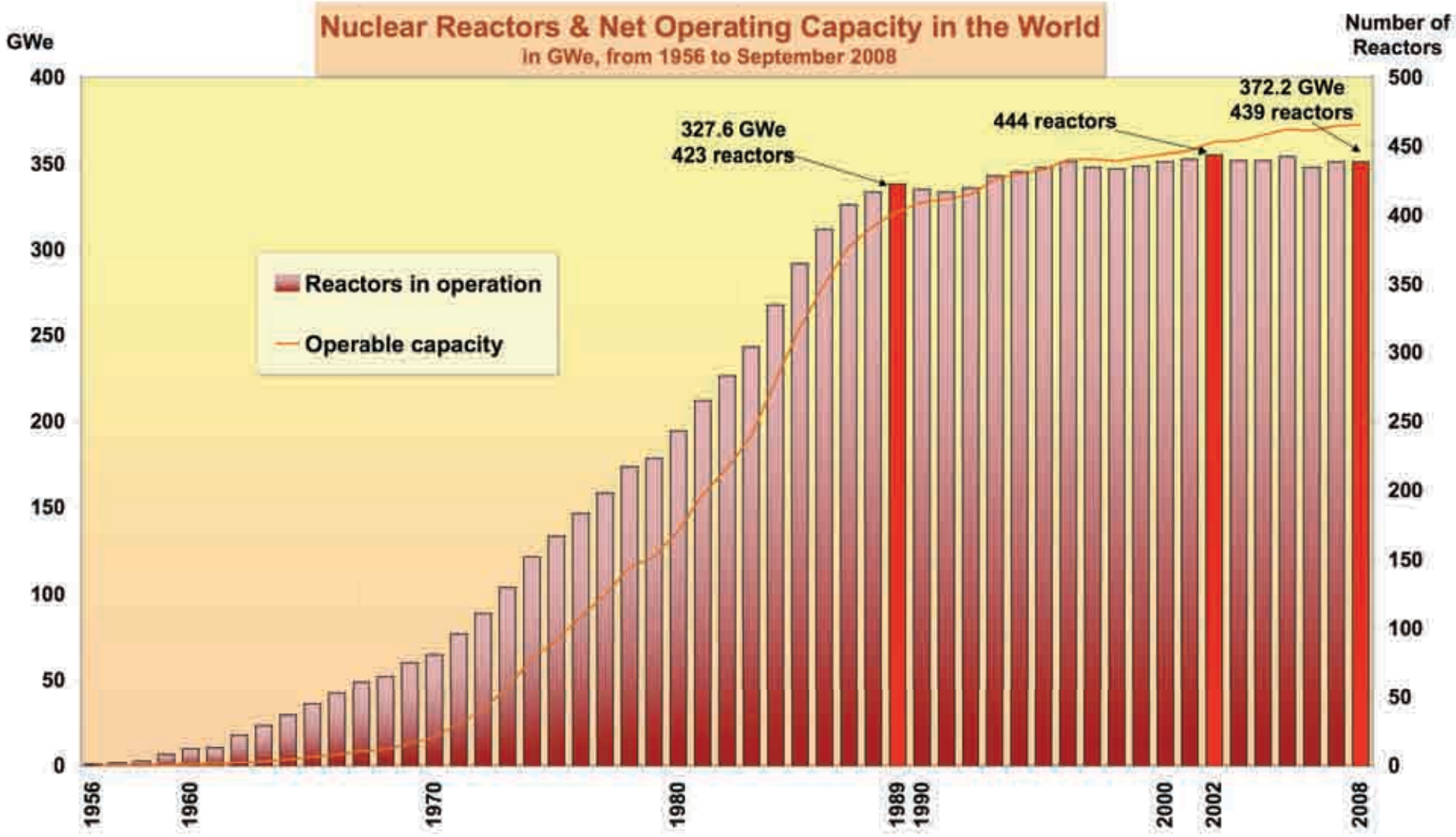
International Consultant on Energy and Nuclear Policy

ANA-Meeting, 13 September 2008

1. Status and Trends of the International Nuclear Industry
2. New build in EU, China
3. Key Barriers
    - Financial Risks
    - Workforce Problem
    - Public Opinion

« The IAEA has revised upwards its nuclear power generation projections to 2030, while at the same time it reported that nuclear's share of global electricity generation dropped another percentage point in 2007 to 14%. »

IAEA Press Release, 11 September 2008



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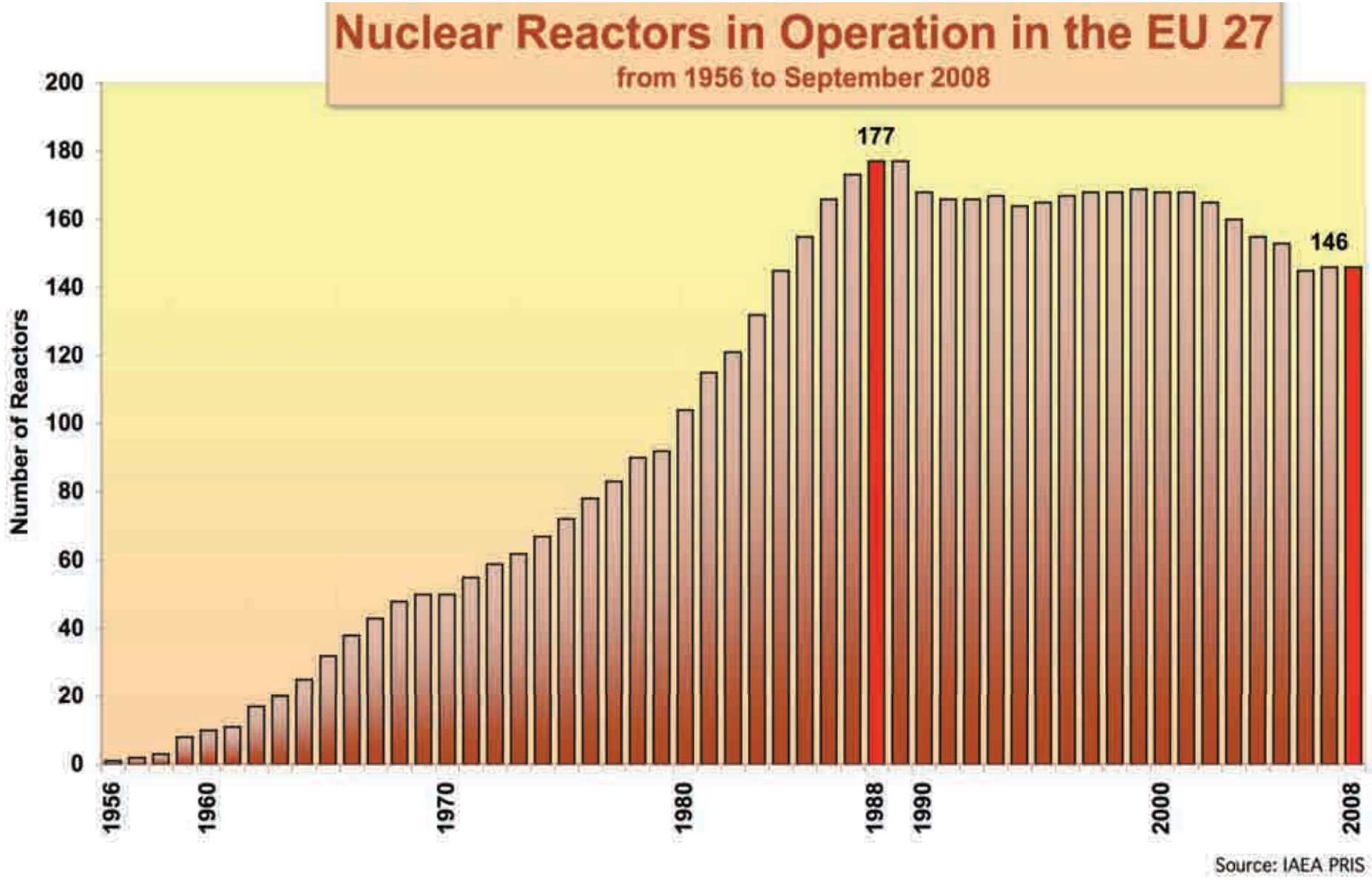
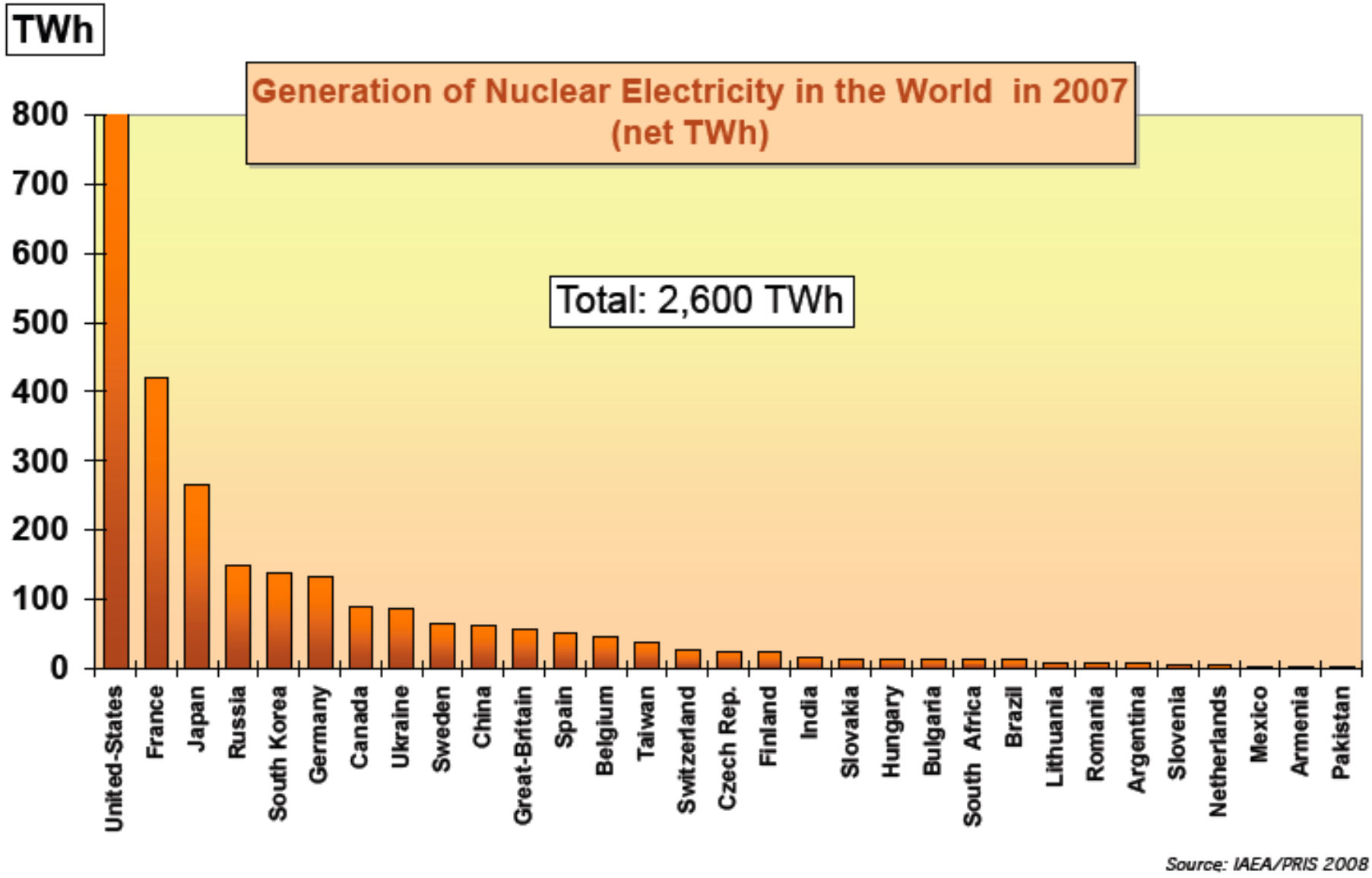
Source: IAEA-PRIS, 2008


Nuclear Reactors in Operation in the EU 27
from 1956 to September 2008
Number of Reactors
200
180
160
140
120
100
80
60
40
20
0
177
146
1956
1960
1970
1980
1988
1990
2000
2008
Source: IAEA PRIS


TWh
Generation of Nuclear Electricity in the World in 2007
(net TWh)
Total: 2,600 TWh
800
700
600
500
400
300
200
100
0
United-States
France
Japan
Russia
South Korea
Germany
Canada
Ukraine
Sweden
China
Great-Britain
Spain
Belgium
Taiwan
Switzerland
Czech Rep.
Finland
India
Slovakia
Hungary
Bulgaria
South Africa
Brazil
Lithuania
Romania
Argentina
Slovenia
Netherlands
Mexico
Armenia
Pakistan
Source: IAEA/PRIS 2008

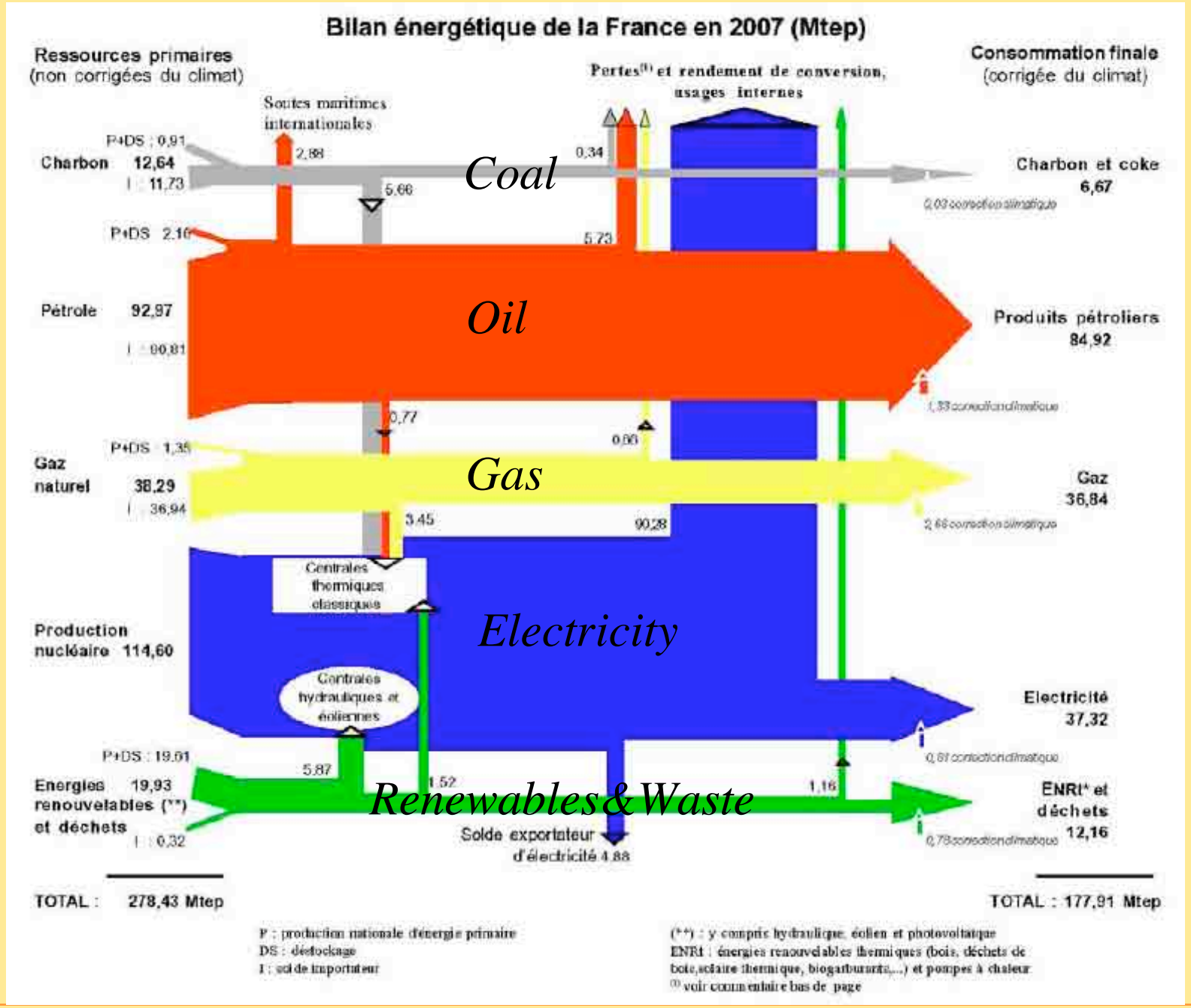
Nuclear Power in the World

By Country

(as of September 2008)

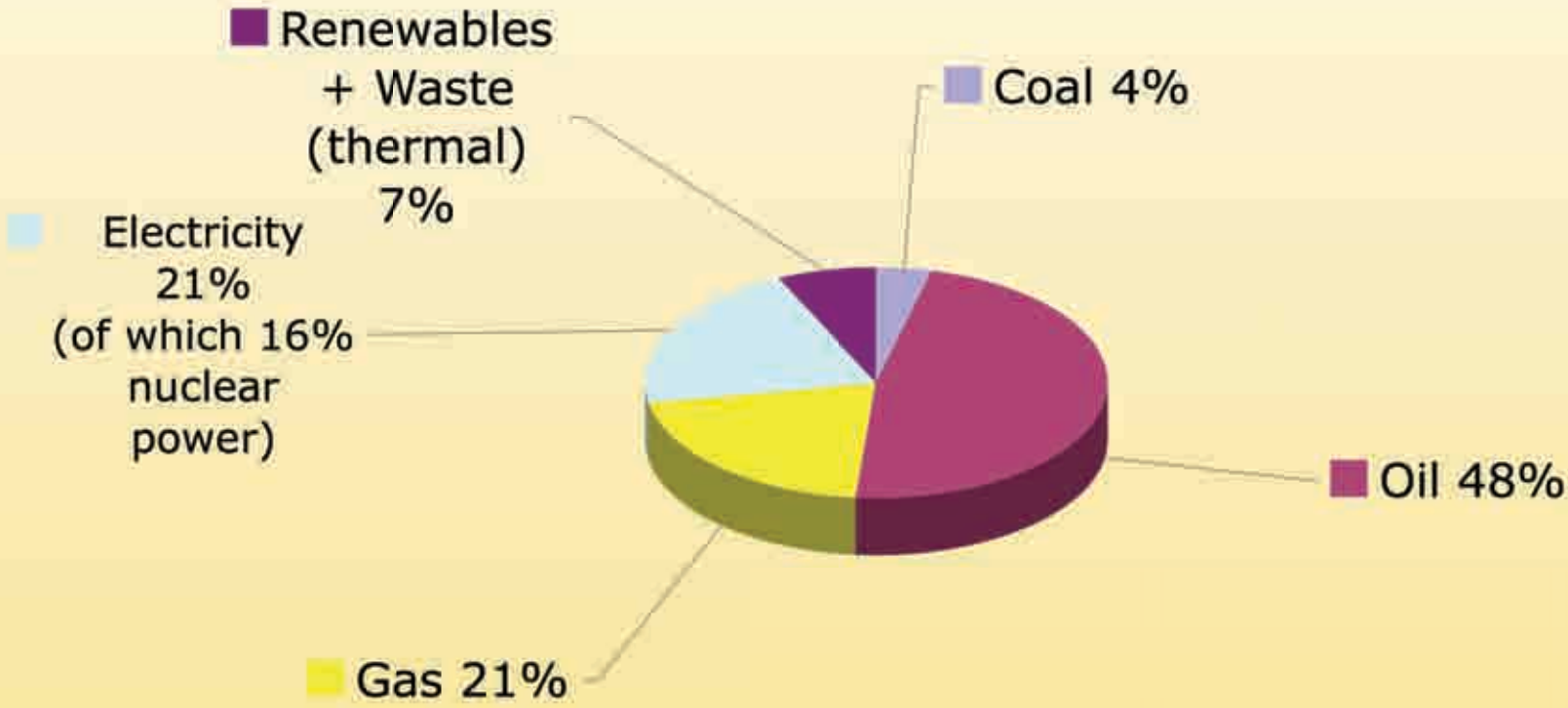
Countries	Nuclear Reactors[1]				Power[2]	Energy[3]
	Operate	Average Age	Under Construction[4]	Planned[5]	Share of Electricity[6]	Share of Commercial Primary Energy
Argentina	2	30	1	1	7%(=)	3%
Armenia	1	28	0	0	43%(+)	?%
Belgium	7	28	0	0	54%(=)	15%
Brazil	2	17	0	1	3%(=)	1%
Bulgaria	2	19	2	0	44%(=)	16%
Canada	18	24	0	3	15%(–)	7%
China	11	7	6	24	2%(=)	<1%
Czech Republic	6	17	0	0	30%(–)	14%
Finland	4	29	1	0	29%(=)	20%
France	59	24	1	0	77%(–)	39%
Germany	17	26	0	0	26%(–)[7]	10%
Hungary	4	23	0	0	37%(=)	14%
India	17	17	6	10	3%(=)	1%
Iran	0	0	1	2	0%(=)	0%
Japan	55	23	1	12	28%(–)	12%
Korea RO (South)	20	15	3	5	35%(–)	14%
Lithuania	1	21	0	0	64%(–)	25%
Mexico	2	17	0	0	5%(=)	2%
Netherlands	1	35	0	0	4%(=)	1%
Pakistan	2	23	1	2	2%(=)	<1%
Romania	2	7	0	2	9%(+)	4%
Russia	31	26	7	10	16%(=)	5%
Slovakia	5	20	0	2	54%(–)	20%
Slovenia	1	27	0	0	40%(+)	?%
South Africa	2	24	0	1	5%(+)	2%
Spain	8	25	0	0	17%(–)	8%
Sweden	10	29	0	0	46%(–)	30%
Switzerland	5	33	0	0	40%(+)	22%
Taiwan	6	27	2	0	19%(=)	8%
Ukraine	15	20	2	0	48%(=)	15%
United Kingdom	19	27	0	0	15%(–)	7%
USA	104	29	1	12	19%(=)	8%
EU27	146	25	4	4	28%(–)	12%
Total	439	24	35	87	14%(–)	<6%

Sources: IAEA-PRIS 2008, BP 2008, WNA 2008, MSC 2008



Source: DGEMP 2008

Final Energy Consumption in France in 2007
73% fossil fuels, 16% nuclear



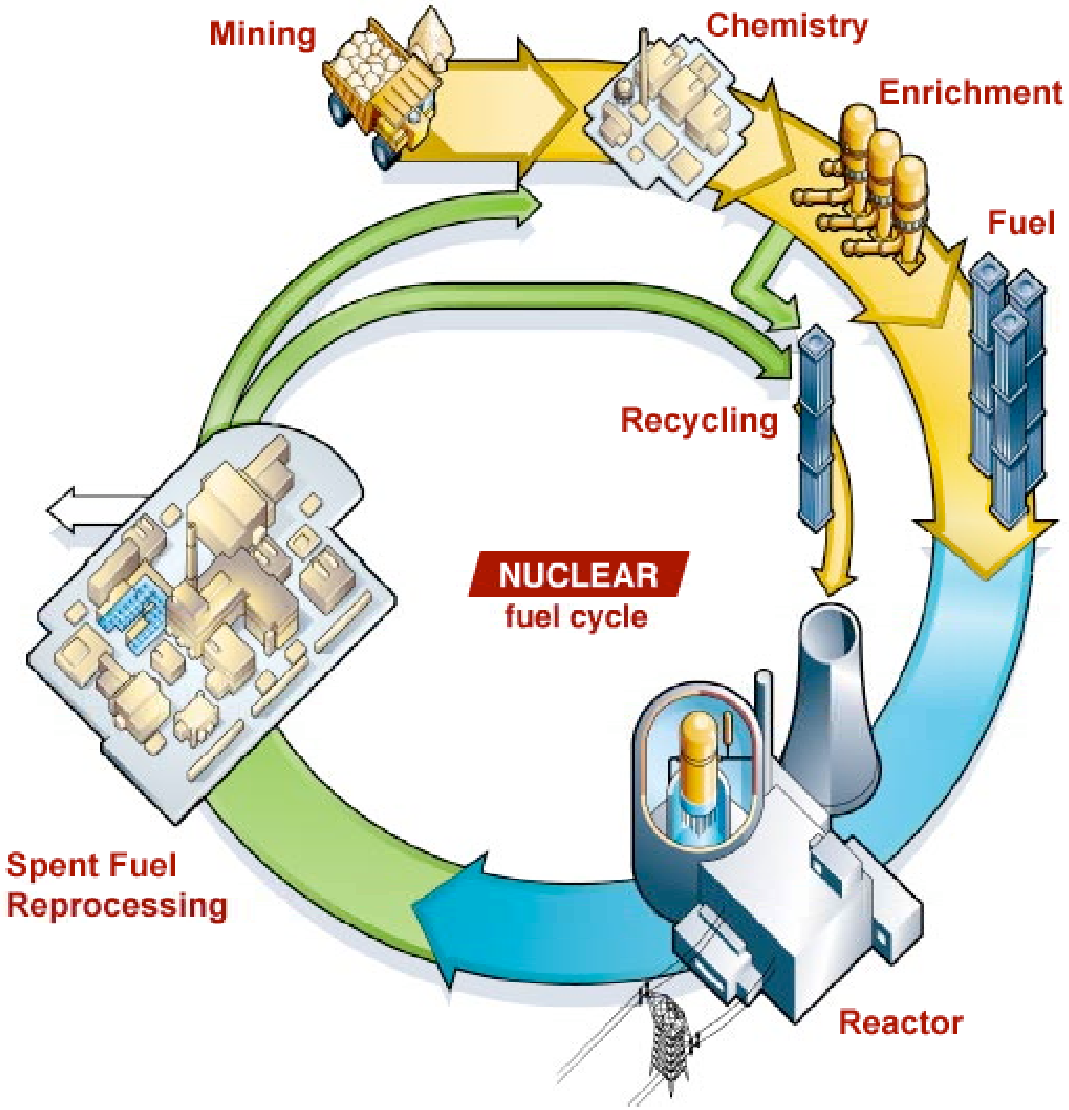
Source: French Ministry of Ecology, Energy and Sustainable Development, Bilan Energie 2007, 2008

Adjusted Level of French Energy Independence in 2007

	Mtoe	Level of Energy Independence
Nuclear Primary Energy Generation + other Primary Energies (Renewables, etc)	114.6 21.8	50.4%
a) Electricity exports 56.8 TWh	- 4.9	
b) Nuclear auto-consumption ca. 18 TWh	- 1.6	
Primary Energy Generation/Independence	129.9	48.0%
c) Nuclear final energy contribution + Renewables + Coal, oil, gas	28.7 11.9 2.0	
Final Energy Generation/Independence I	42.6	23.9%
d) - Uranium imports e) + Plutonium & reprocessed uranium credit	- 28.7 +1.3	
Final Energy Generation/Independence II	15.2	8.5%

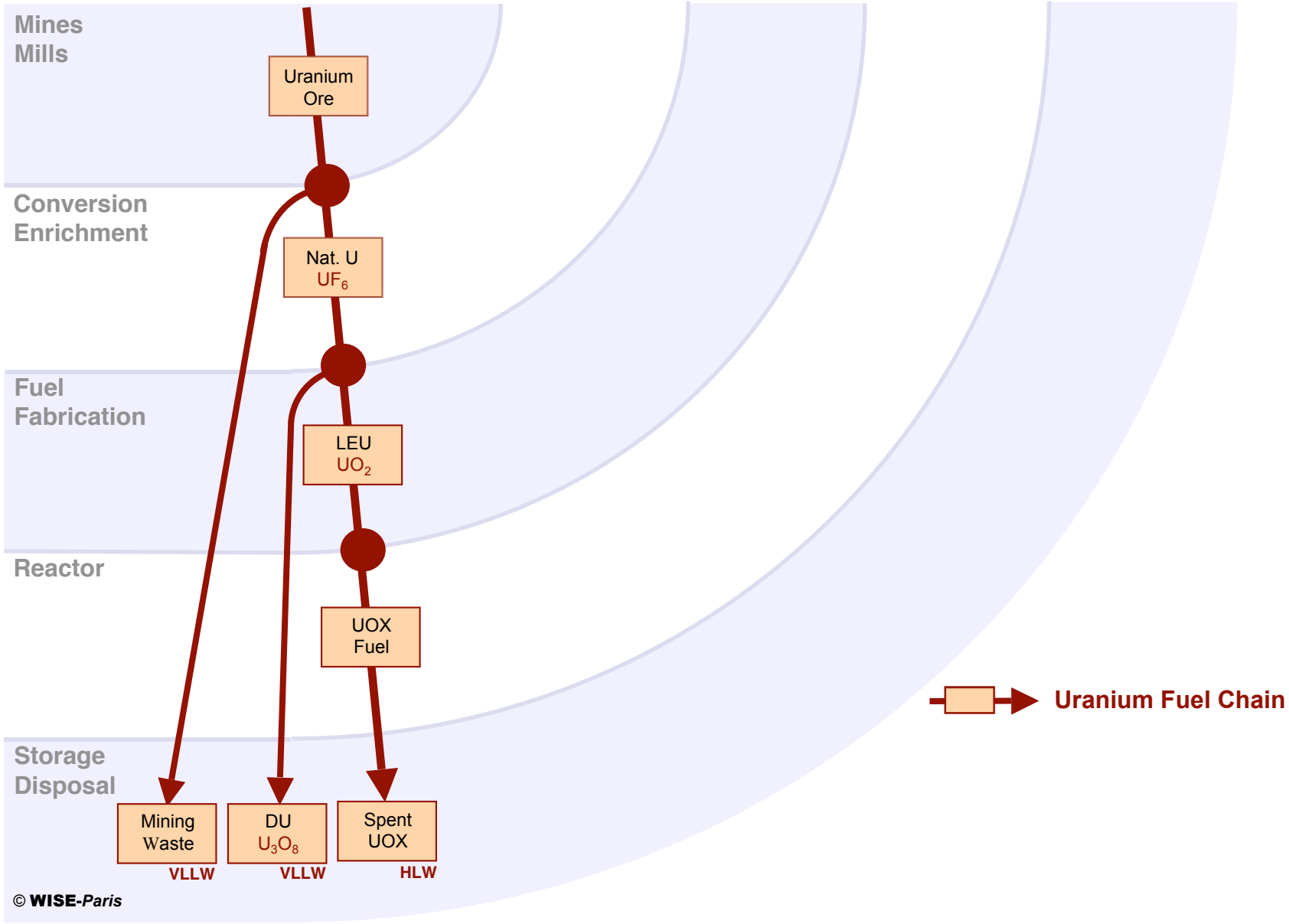
Source: Mycle Schneider Consulting

AREVA's Representation of the « Fuel Cycle »



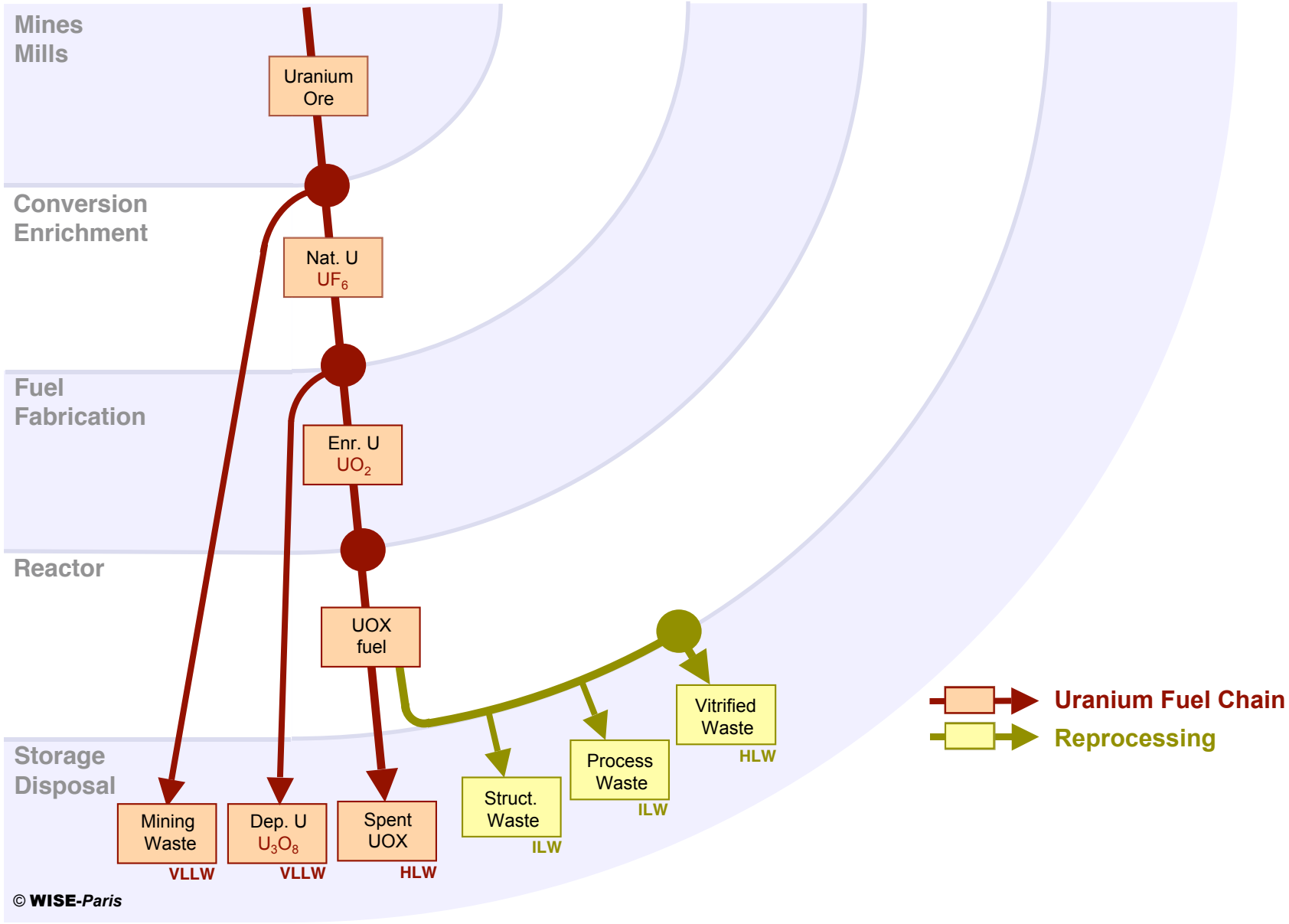
Source: www.areva.com

Wastes and Materials Generated in the Fuel Chain

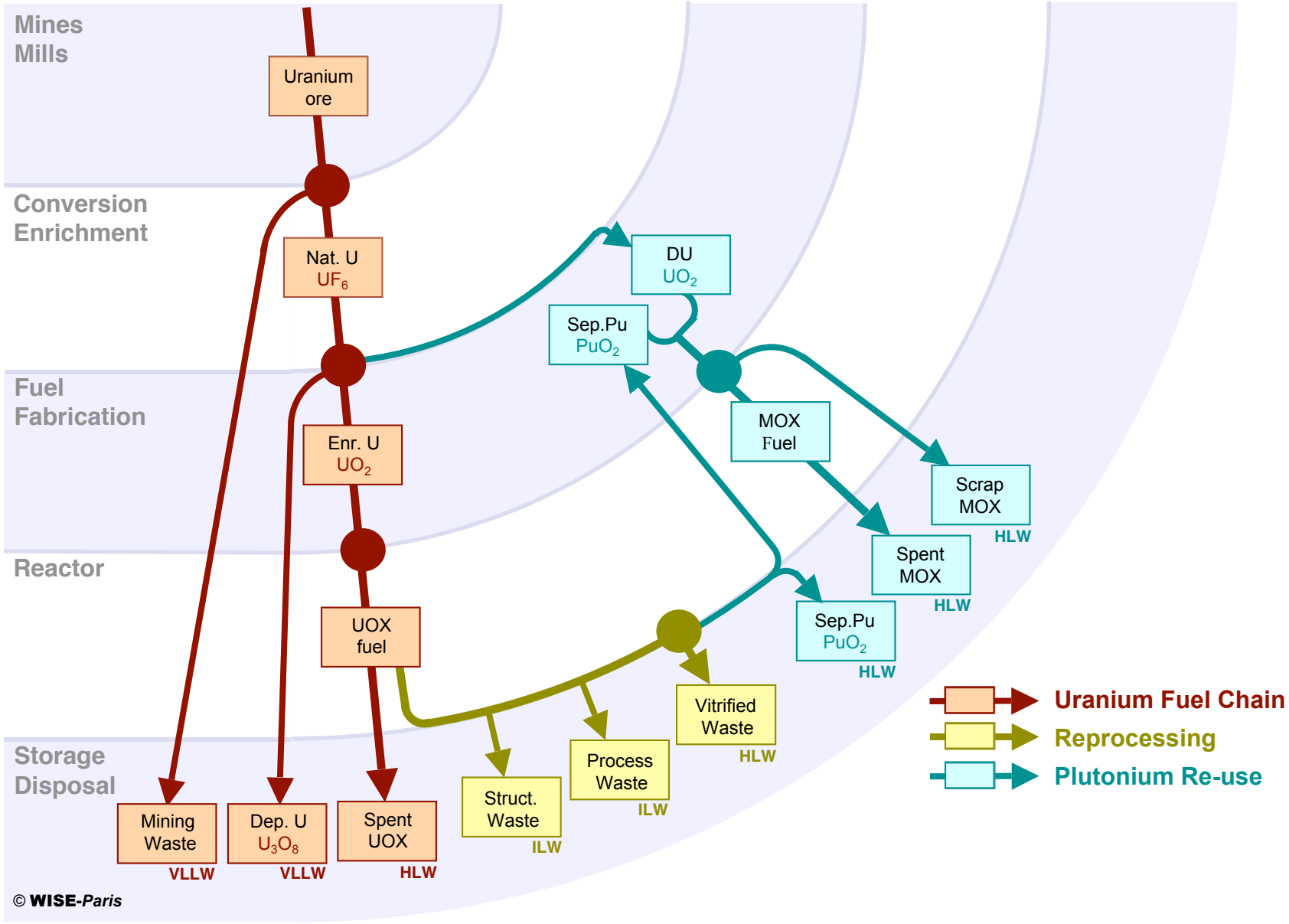


AREVA NC La Hague: 750 acres, 6,000 people

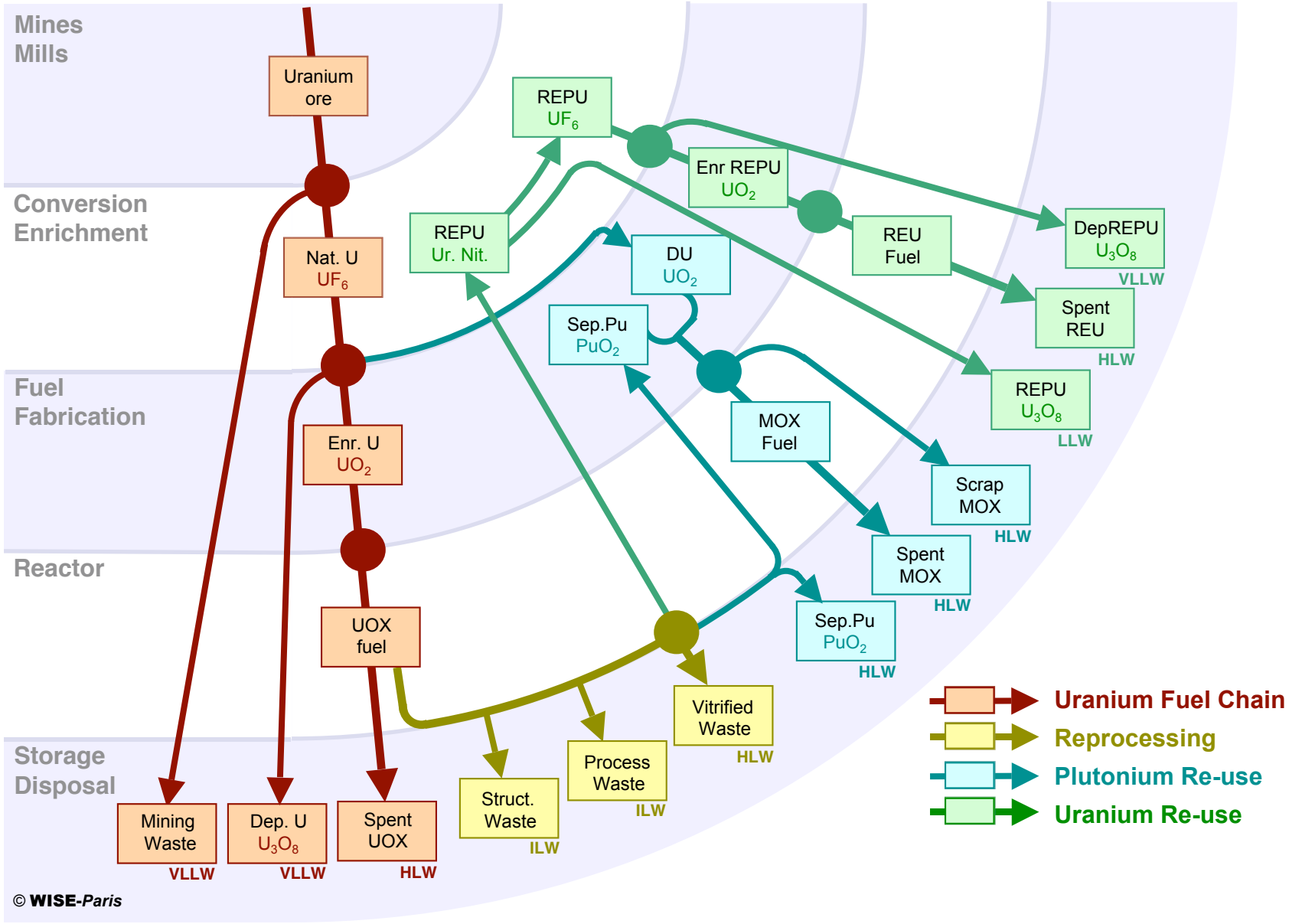
Wastes and Materials Generated in the Fuel Chain



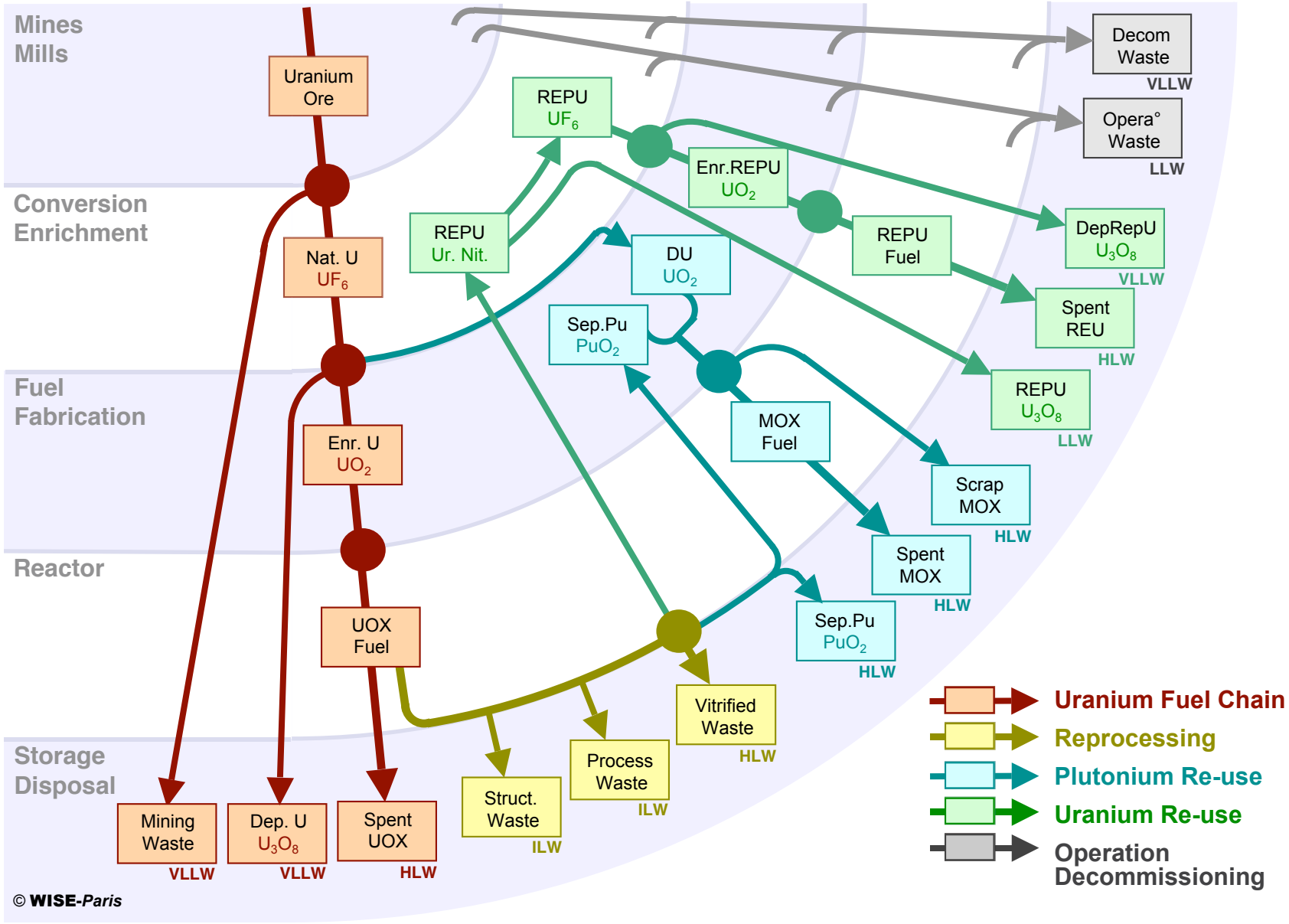
Wastes and Materials Generated in the Fuel Chain

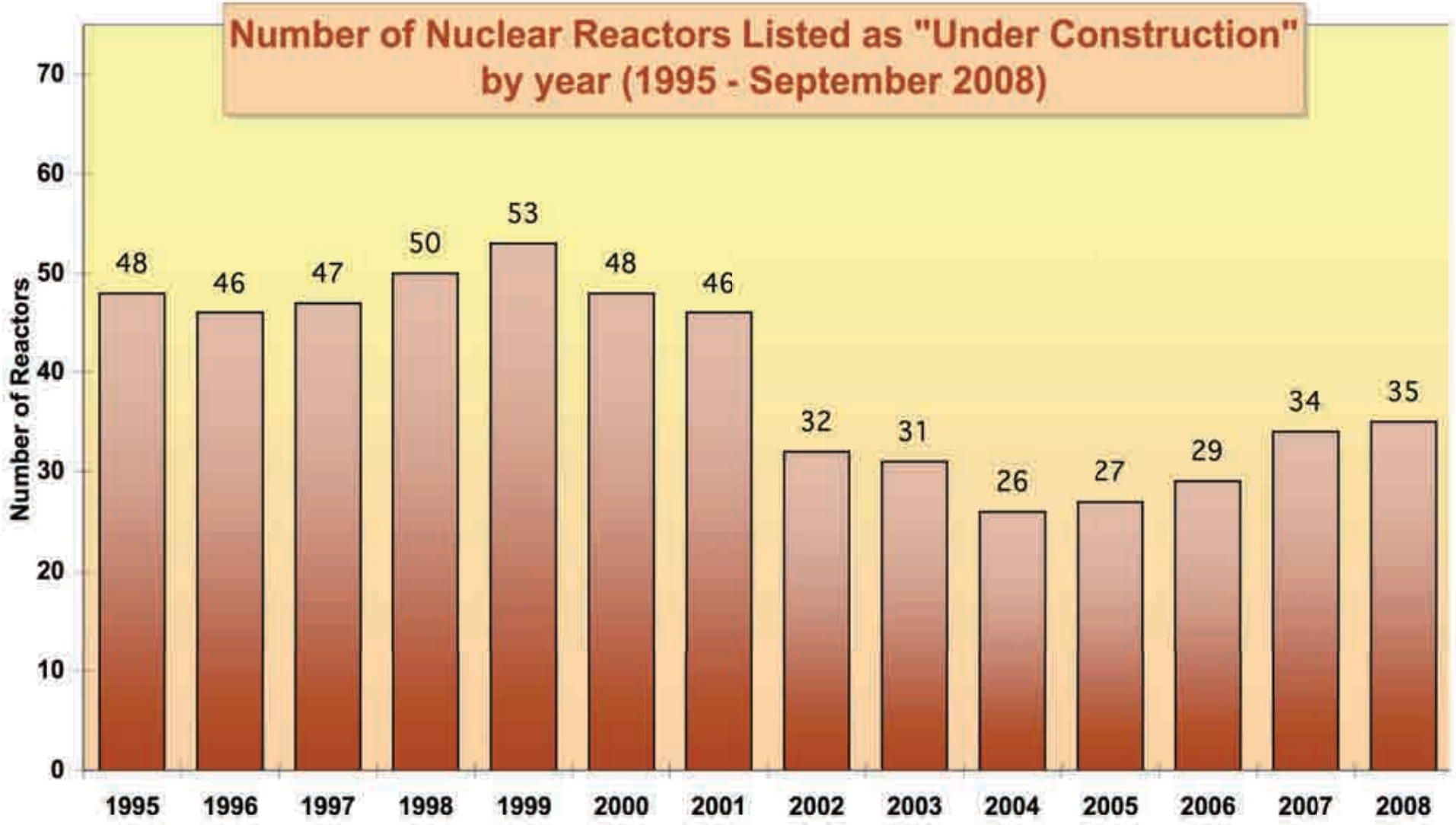


Wastes and Materials Generated in the Fuel Chain



Wastes and Materials Generated in the Fuel Chain




Number of Nuclear Reactors Listed as "Under Construction"
by year (1995 - September 2008)
Number of Reactors
0
10
20
30
40
50
60
70
48
46
47
50
53
48
46
32
31
26
27
29
34
35
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008

Nuclear Reactors Listed as "Under Construction" in the World

By Country

(as of September 2008)

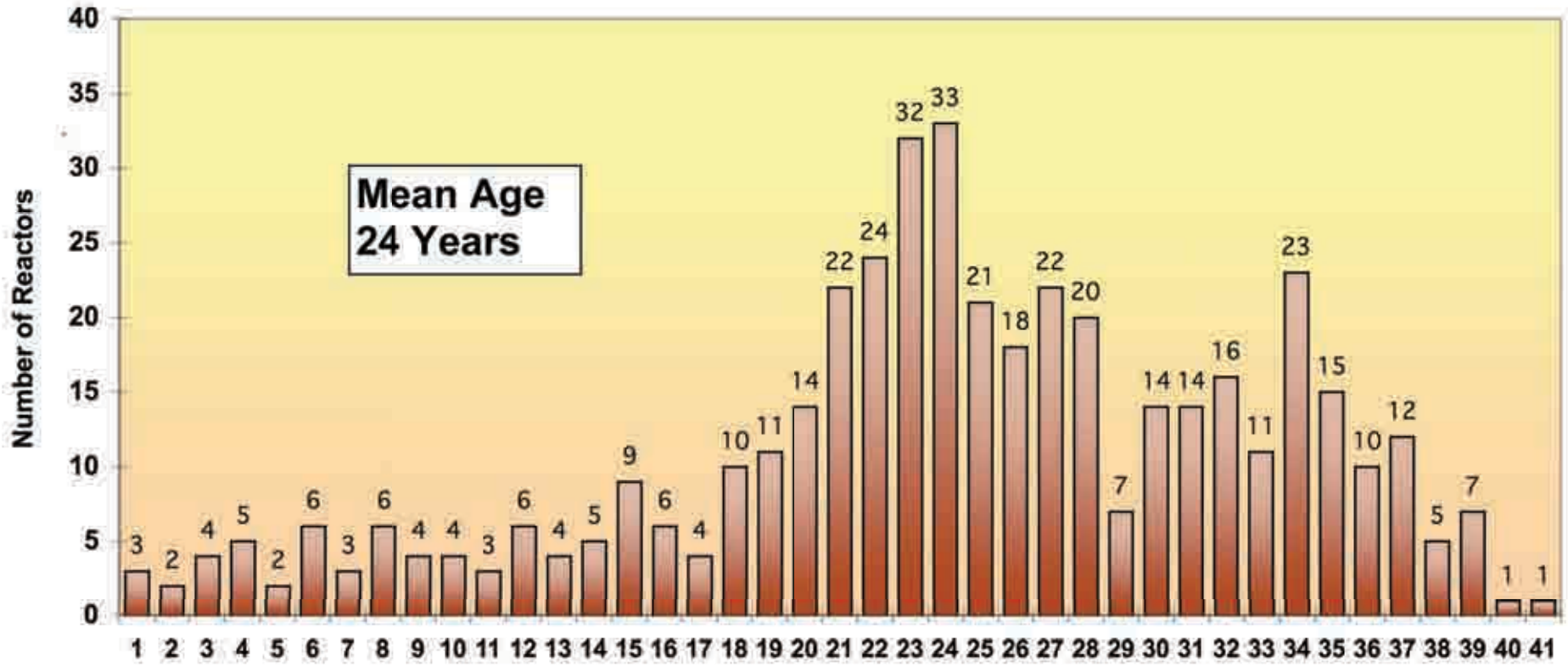
Country	Units	MWe (net)	Construction Start	Planned Grid Connection
ARGENTINA	1	692	1981/07/14	2010/10/01[1]
BULGARIA	2	1906		
Belene-1		*953*	1987/01/01	?
Belene-2		*953*	1987/03/31	?
CHINA	6	4220		
Hongyanhe		*1000?*	2007/08/18	?
Lingao-3		*1000*	2005/12/15	2010/08/31
Lingao-4		*1000*	2006/06/15	?
...Ningde-1		*1000*	2008/02/18	?
Qinshan-II-3		*610*	2006/03/28	2010/12/28
Qinshan-II-4		*610*	2007/01/28	2011/09/28
FINLAND	1	1600	2005/08/12	Summer 2011[2]
FRANCE	1	1600	2007/12/03	2012/05/01[3]
INDIA	6	2910		
...Kaiga-4		*202*	2002/05/10	2008/07/31[4]
...Kudankulam-1		*917*	2002/03/31	2009/01/31[5]
...Kudankulam-2		*917*	2002/07/04	2009/07/31[6]
...PFBR		*417*	2004/10/23	?
...Rajasthan-5		*202*	2002/09/18	2008/06/30[7]
...Rajasthan-6		*202*	2003/01/20	2008/12/01[8]
IRAN	1	915	1975/05/01	2009/08/01[9]
JAPAN	1	866	2004/11/18	?[10]
PAKISTAN	1	300	2005/12/28	2011/05/31
RUSSIA[11]	7	4720		
...Novovoronezh-2-1		*1085*	2008/06/24	?
...BN-800		*750*	1985[12]	?
...Kalinin-4		*950*	1986/08/01	?[13]
...Kursk-5		*925*	1985/12/01	?[14]
...Severodvinsk-1		*30*	2007/04/15	?
...Severodvinsk-2		*30*	2007/04/15	?
...Volgodonsk		*.950*	1983/05/01	?[15]
SOUTH KOREA	3	2880		
...Shin-Kori-1		*960*	2006/06/16	2010/08/01
...Shin-Kori-2		*960*	2007/06/05	2011/08/01
...Shin-Wolsong-1		*960*	2007/11/20	2011/05/28
TAIWAN[16]	2	2600		
...Lungmen-1		*1300*	1999	2010[17]
...Lungmen-2		*1300*	1999	2010[18]
UKRAINE	2	1900		
...Khmelnitski-3		*950*	1986/03/01	2015/01/01
...Khmelnitski-4		*950*	1987/02/01	2016/01/01
USA	1	1165	1972/12/01	?
Total:	**35**	**28274**		

Sources: various, MSC 2008

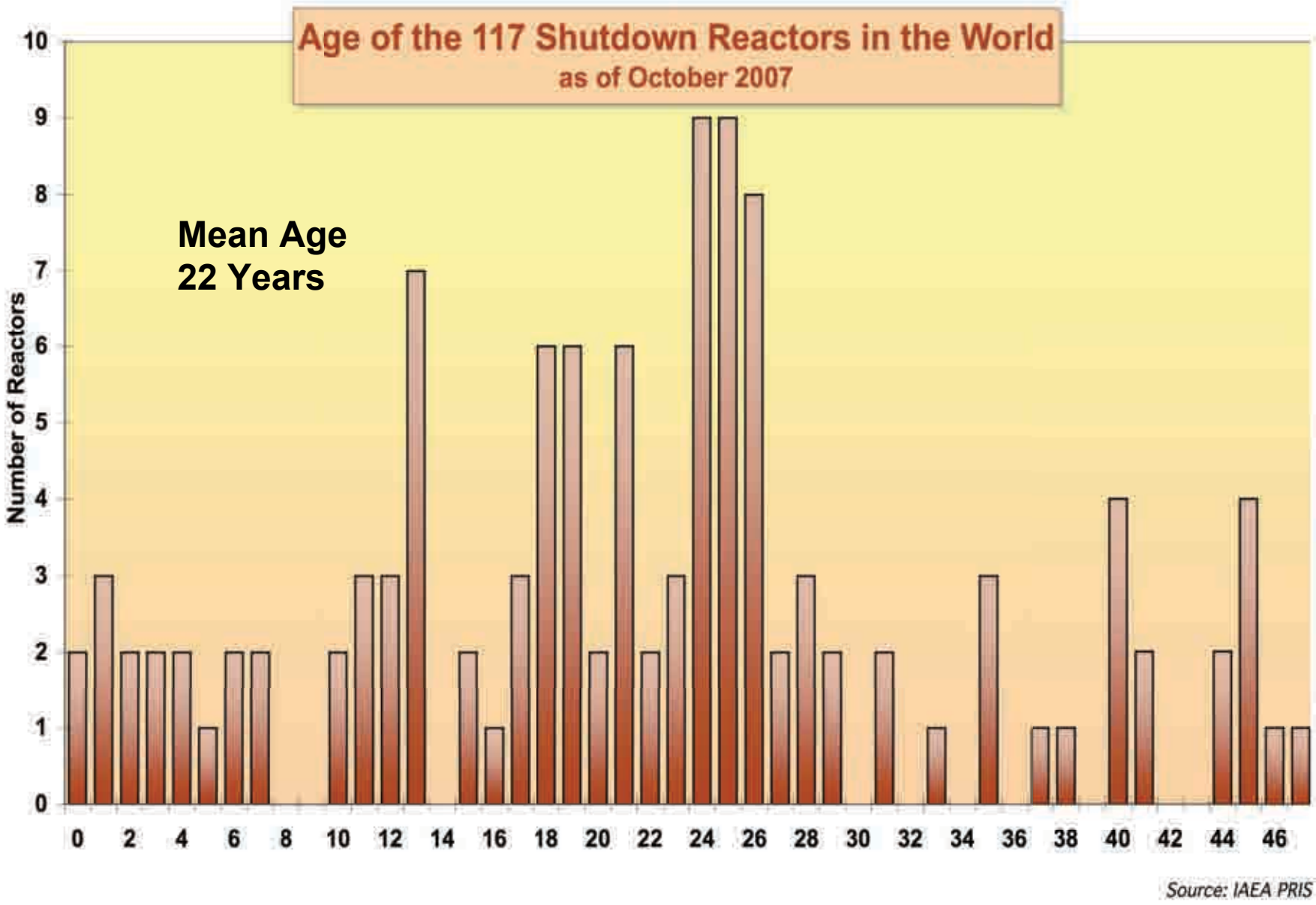
Notes pertaining to Table 2

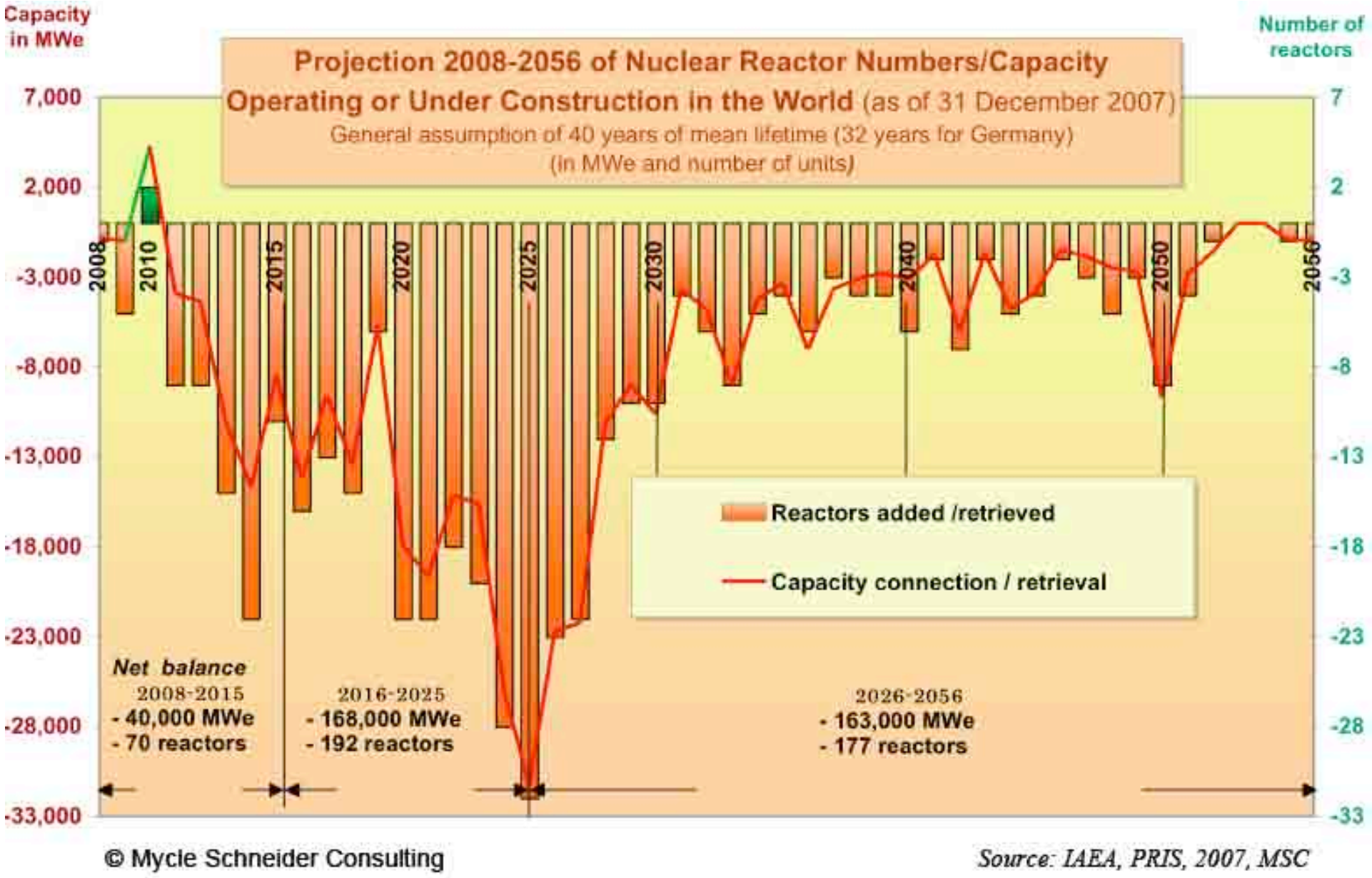
[1] Date published after January 2008
[2] This date refers to the new planned start-up of the plant. However, the plant owner TVO has so far reported dates for the "commercial operation" of the plant, that usually takes place several months after the initial start-up. It is possible that the new delays reported in December 2007 will postpone commercial operation to the end of 2011. (TVO, Press Release, 28 décembre 2007, see http://www.tvo.fi/1016.htm). Also, the plant experienced a significant fire at the construction site in August 2008, which is believed to delay the construction by an additional several months.
[3] Unofficially delayed by 9 months.
[4] Delayed again from planned start-up at 2007/07/31 as of the end of 2007 (sic)
[5] Delayed again from previous planned start-up in December 2007
[6] Delayed again from previous planned start-up in December 2008
[7] Delayed again from planned start-up at 2007/06/30 as of the end of 2007 (sic).
[8] Delayed again from planned start-up at 2007/12/31 as of the same date.
[9] Delayed again from planned start-up at 2007/11/01 as of January 2008
[10] Delayed from planned start-up at 2009/12/01 as of January 2008 without new planned start-up date.
[11] Balakovo-5 has been withdrawn from the list since the beginning of 2008.
[12] The IAEA Power Reactor Information System (PRIS) curiously provides a new construction start date as 2006/07/18. Until 2003, the French Atomic Energy Commission (CEA) listed the BN-800 as « under construction » with a construction start-up date « 1985 ». In subsequent editions of the CEA's annual publication *ELECNUC, Nuclear Power Plants in the World*, the BN-800 had disappeared.
[13] Delayed from planned start-up at 2010/12/31 as of end of 2007, no new date.
[14] Delayed from planned start-up at 2010/12/31 as of end of 2007, no new date.
[15] Delayed from planned start-up at 2008/12/31 as of end of 2007, no new date.
[16] Data on Taiwan from http://www.world-nuclear.org/info/inf115_taiwan.html
[17] Delayed from original start-up date of mid-2006
[18] Delayed from original start-up date of mid-2007

Age of the Reactors in Operation in the World
as of January 2008



Sources: IAEA-PRIS 2008


Age of the 117 Shutdown Reactors in the World
as of October 2007
Mean Age
22 Years
Number of Reactors
0
1
2
3
4
5
6
7
8
9
10
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46
Source: IAEA PRIS


Capacity in MWe
Number of reactors
Projection 2008-2056 of Nuclear Reactor Numbers/Capacity
Operating or Under Construction in the World (as of 31 December 2007)
General assumption of 40 years of mean lifetime (32 years for Germany)
(in MWe and number of units)
7,000
2,000
-3,000
-8,000
-13,000
-18,000
-23,000
-28,000
-33,000
7
2
-3
-8
-13
-18
-23
-28
-33
2008
2010
2015
2020
2025
2030
2040
2050
2056
Reactors added /retrieved
Capacity connection / retrieval
Net balance
2008-2015
- 40,000 MWe
- 70 reactors
2016-2025
- 168,000 MWe
- 192 reactors
2026-2056
- 163,000 MWe
- 177 reactors
© Mycle Schneider Consulting
Source: IAEA, PRIS, 2007, MSC

New Build Issues

- **European Union**
- **China**

Excessive Lead Times/Cost Overruns: Example Olkiluoto-3, Finland

1998-1999	TVO submits environmental impact assessment report.
2000	TVO submits application for decision-in-principle.
2001	Preliminary safety assessment. Public hearings.
2002	Government and Parliament approve decision.
2003	TVO selects its Olkiluoto site to build a third reactor.
2004	TVO applies for construction licence.
2005	MTI grants licence. First concrete in August.
2006	Project running 18 months late.
2007	Project running 24 months late.
2011	Expected start-up.

Lead Time: 12-13 years since EIA

Official Price: ca. €3 Billion (Guaranteed Fix Price)

Cost Overrun 2 Years after Construction Start: €1.5 Billion

Sources: OECD-IEA, WEO 2006; AREVA 2006, French Ministry of Finances 2006

Chinese Fantasies

Chinese Forecasting	Capacity Planned	Capacity Installed	Share Realised
in 1985 for 2000	20,000 MW	2,168 (in 15 Years)	11%
in 1996 for 2010	20,000 MW	max.10,282 (in 25 Years)	51%
in 2006 for 2020	40,000 MW to 60,000 MW	+30,000 to + 50,000? (in 10 Years?)	?

Source: Mycle Schneider Consulting

OECD Nuclear Energy Agency on Nuclear Competence Crisis in Finland, Germany, South Korea, UK, USA…

These national surveys show that employers require more engineers and scientists having a nuclear component to their education than those graduating.

Source: OECD NEA, *Nuclear Competence Building,* 2004

Nuclear Education Crisis in Germany

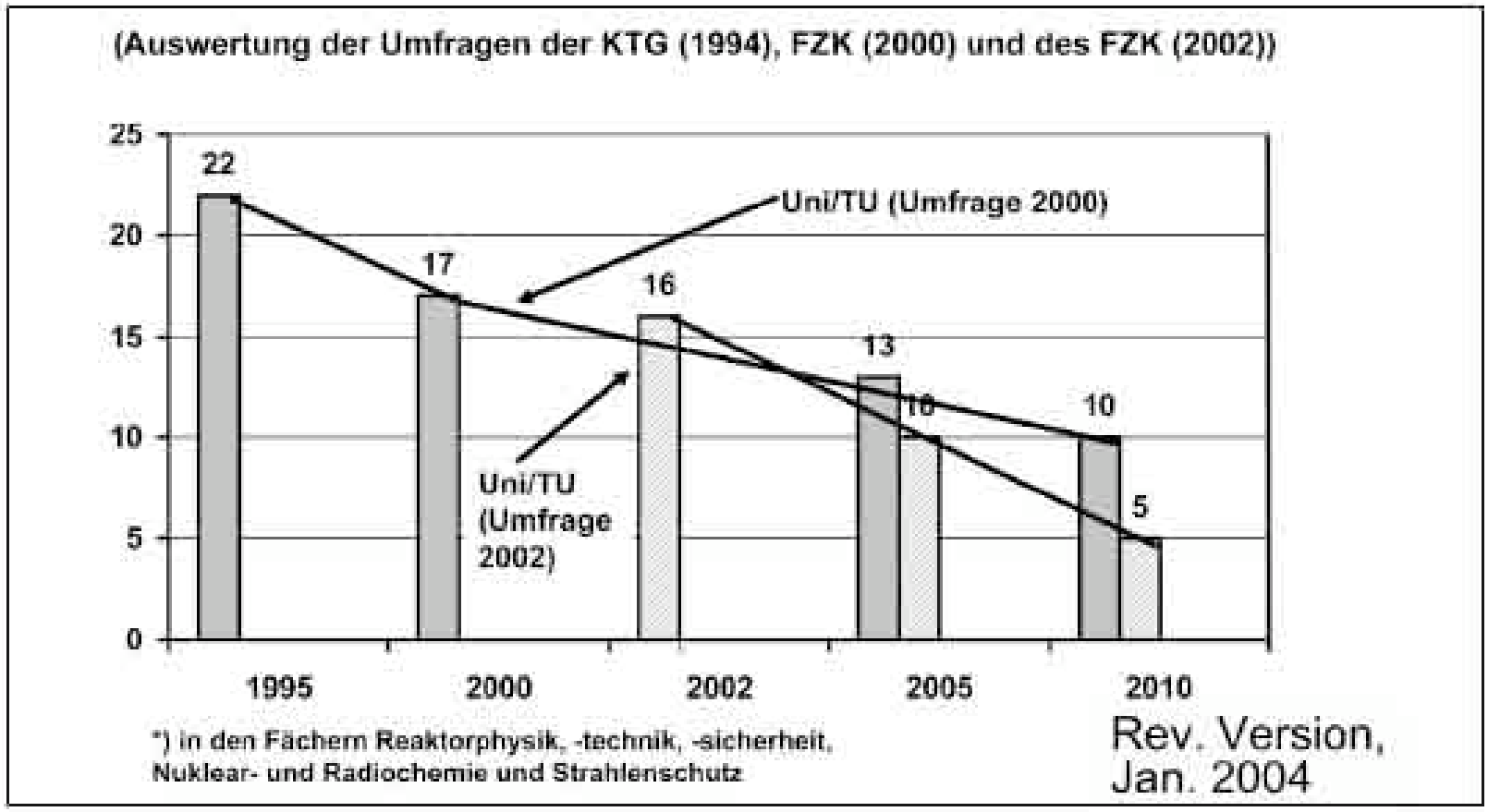


Abb. 6: Umfrageergebnisse zum Trend bei den kerntechnischen Lehrangeboten in den Fächern Reaktorphysik, -technik, -sicherheit, Nuklear- und Radiochemie und Strahlenschutz an deutschen Hochschulen (Uni, TU)

Source: Atomwirtschaft, 6/2004

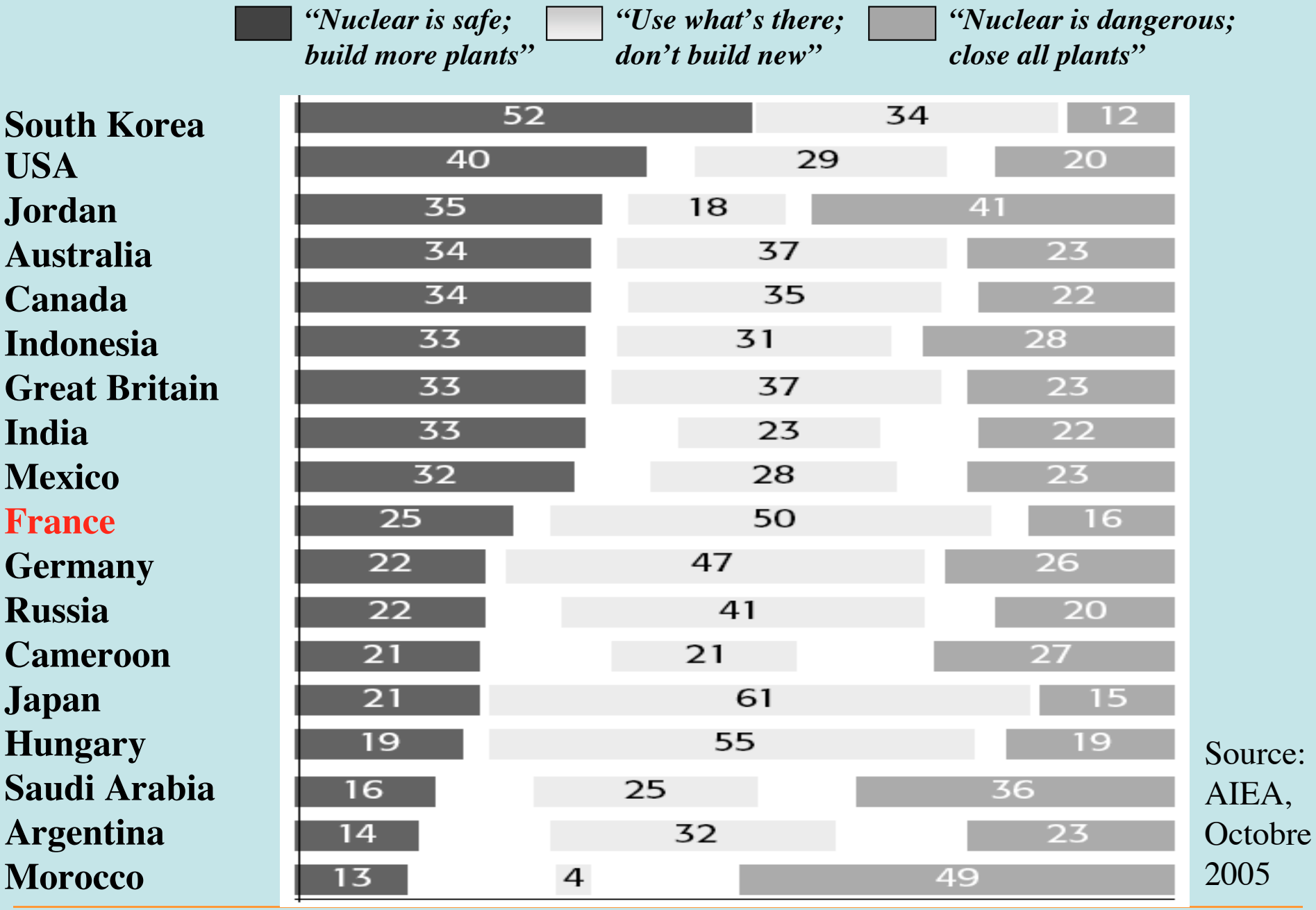
No Change in Sight

« The “aging workforce” issue is keeping countless CEOs awake at night. (…)

The U.S. Department of Labor indicates that a third of the workers in the nuclear industry are eligible to retire in the next five years. (…)

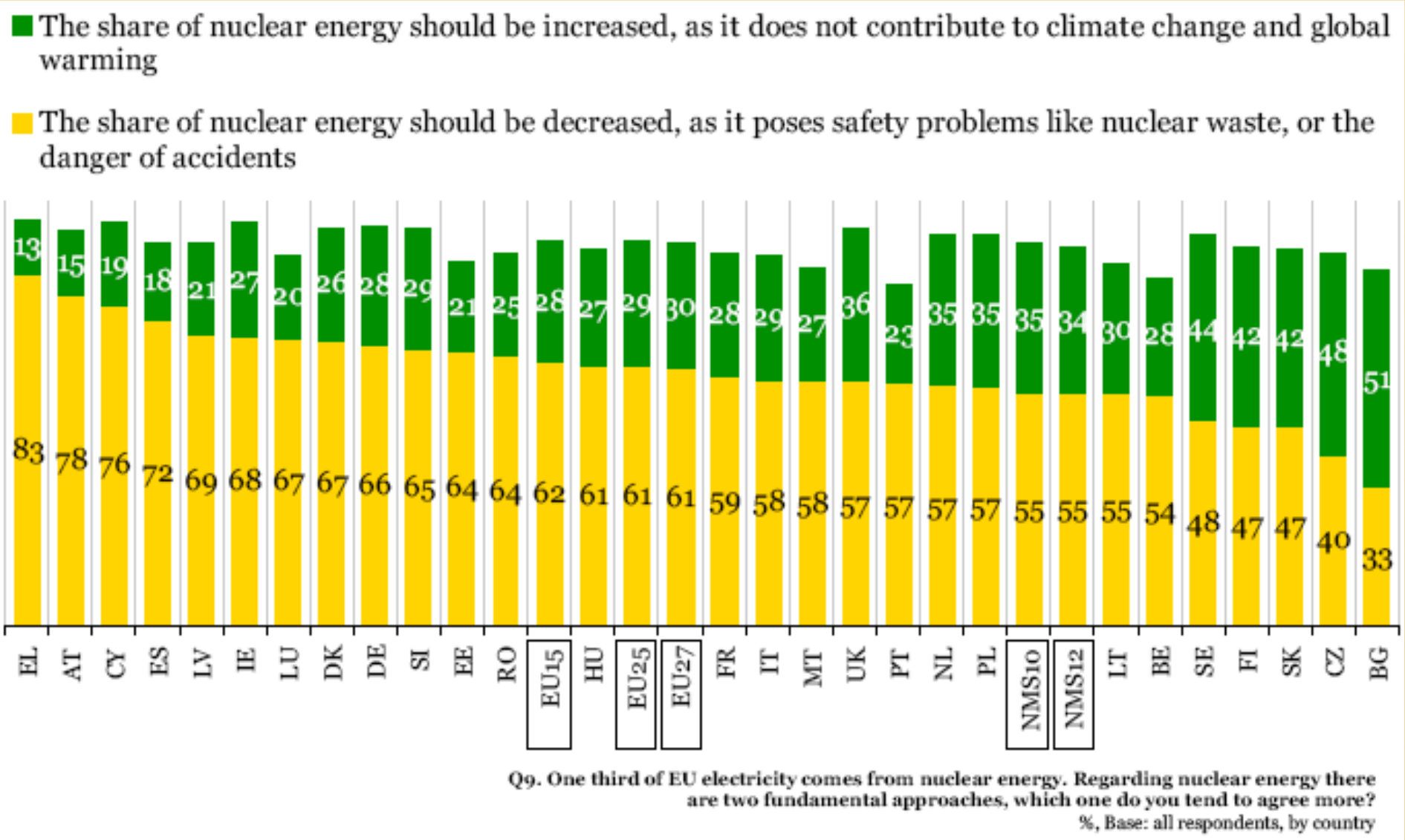
The U.S. nuclear power industry will need to attract about 26,000 new employees over the next 10 years for existing facilities. These estimates do not include additional resources necessary to support new plants. »

Source: Capgemini, « Preparing for the Nuclear Renaissance », March 2008



Source: AIEA, Octobre 2005

Public Opinion on Nuclear Power in the EU



Q9. One third of EU electricity comes from nuclear energy. Regarding nuclear energy there are two fundamental approaches, which one do you tend to agree more?
%, Base: all respondents, by country

Gallup, *Attitudes on issues related to EU Energy Policy,* European Commission, DG TREN, April 2007

"The European public is still strongly opposed to the use of nuclear power; those who are worried about climate change are even more fiercely opposed."

Gallup, *Attitudes on issues related to EU Energy Policy,* European Commission, DG TREN, April 2007

Conclusions

- Nuclear power plays a limited role. It is highly likely that it will further decline.
- The industry has a a long term workforce problem and will struggle to maintain competence levels for existing facilities.
- Public opinion in the EU remains critical towards nuclear power and has a strong preference for other energy forms.
- The nuclear industry has failed to deliver in the past. Large budget overruns, construction delays and excessive overall lead times. Much of this had to be covered by the tax-payer.
- Problems with recent new build projects indicate that there is no change to be expected.
- Nuclear energy will rather hinder than favour reliable, sustainable energy policies.

Finally,

- one more serious nuclear accident
- one event involving a dirty bomb
- one major attack on a nuclear facility or shipment
- one credible threat with a nuclear explosive device

and what is now perceived by some as contributing to "energy security" will turn into a nightmare of ball and chain.

The Future Will Be Energy Intelligent or Will Not Be

Thank you for your attention!

mycle@orange.fr