The World Nuclear Industry Status Report and Future Trends

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Presented at the Workshop on Energy Scenarios with focus on two issues

Hamburg 11-12 September 2008

About Presentation

- World Nuclear Industry Status Report
- Lead Author: Mycle Schneider
  - http://www.greens-efa.org/cms/topics/dokbin/206/206749.pdf
- Antony Froggatt, co-author
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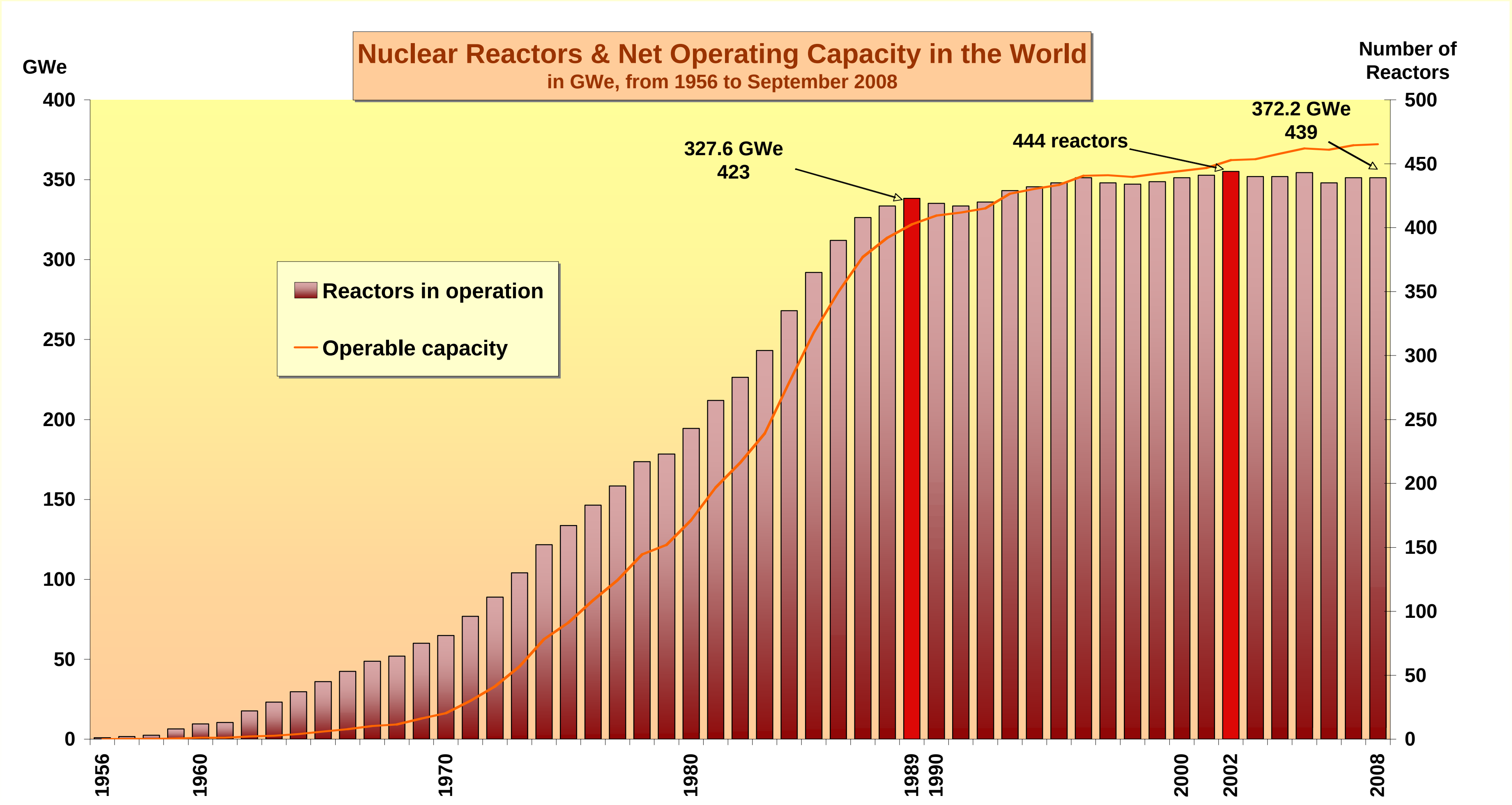
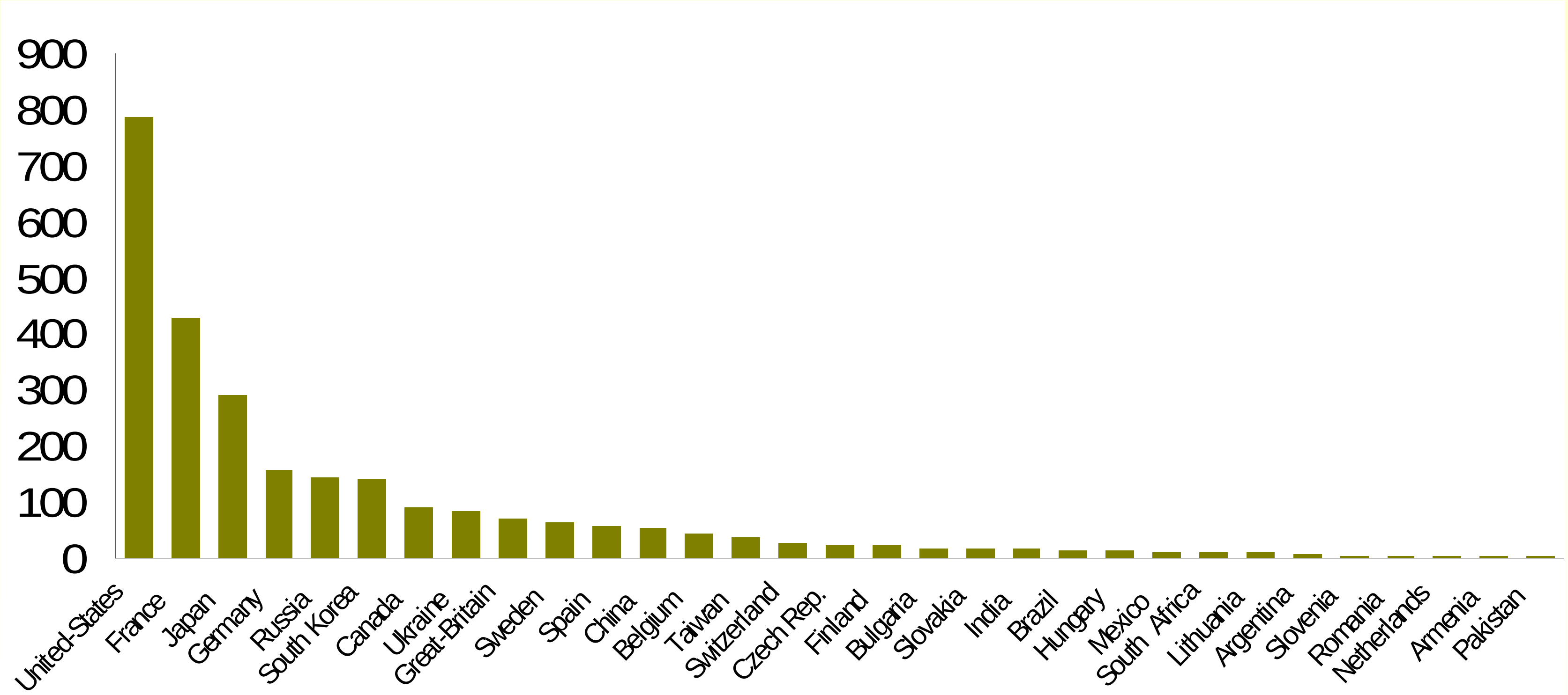
  - Senior Research Fellow Chatham House, UK

Growth in use of Nuclear Power



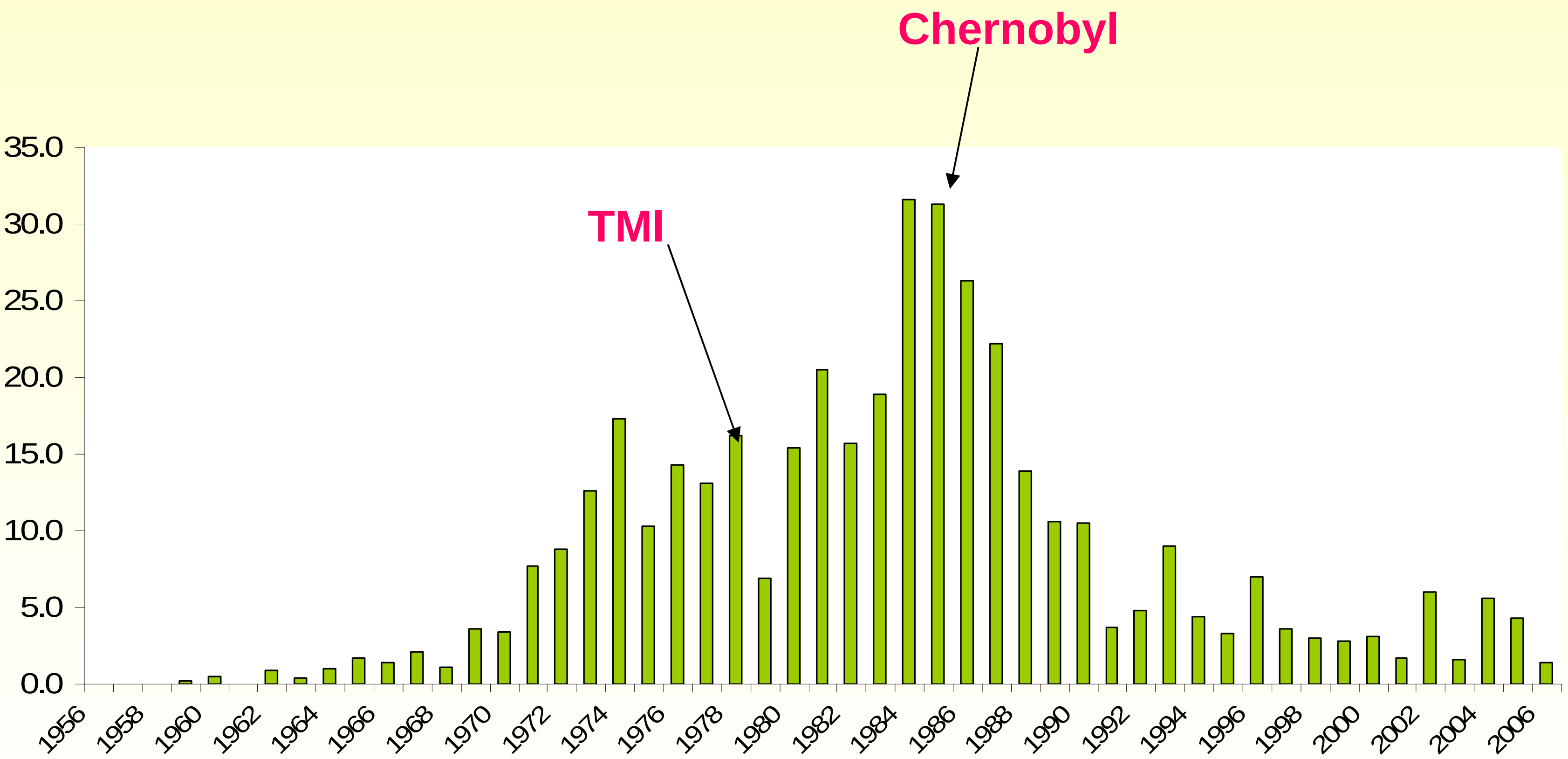
Source: Mycle Schneider

Global Nuclear Electricity Production (TWh) in 2007



Source: WISE- *Paris* / Mycle Schneider Consulting

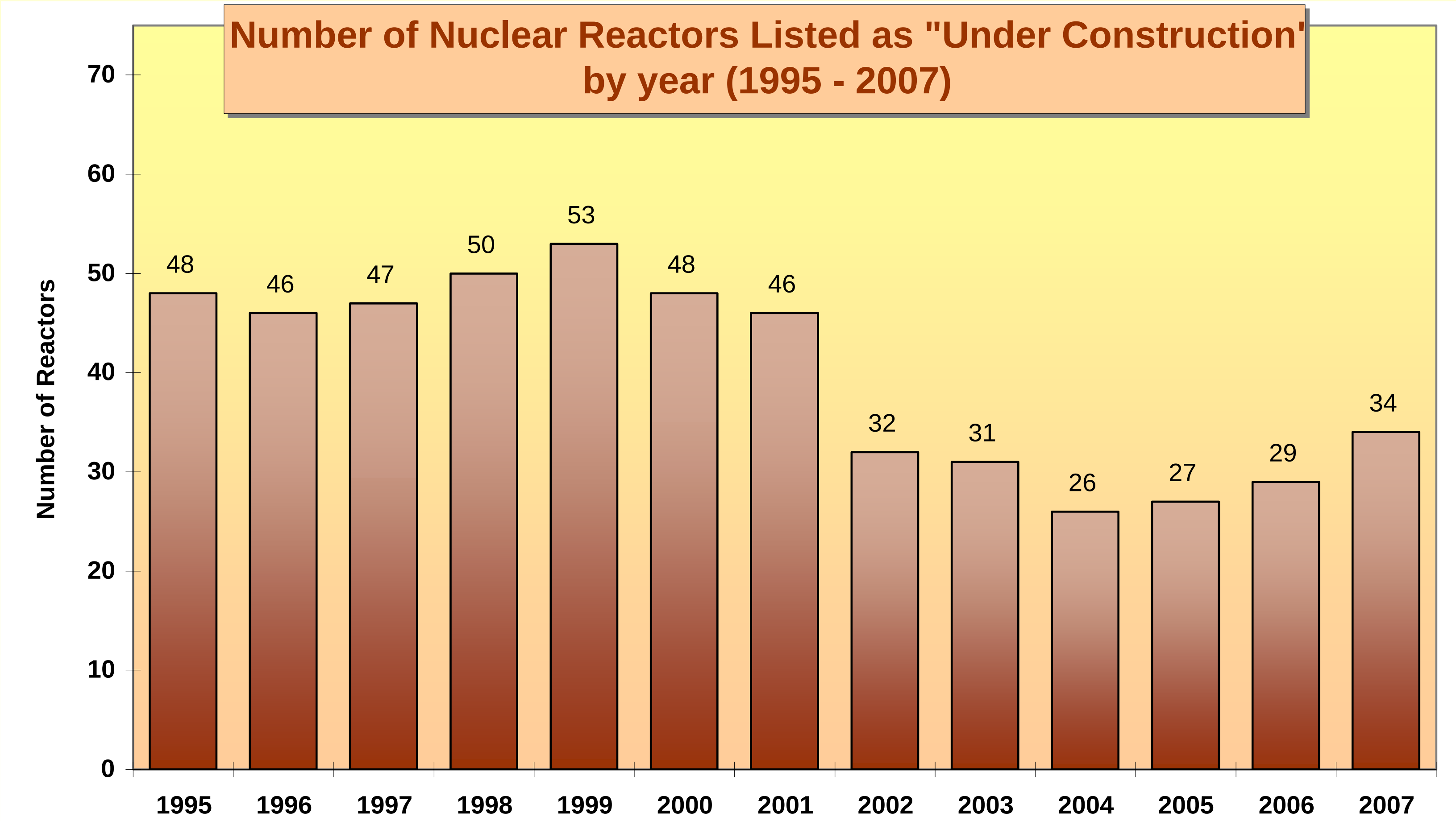
Global Start-ups Nuclear Reactors (GW)



Countries	*Nuclear Reactors*				*Power*	*Energy*
	Operate	Avera ge Age	Under Constructio n	Planne d	Share of Electricity	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**	**78%(–)**	**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%

Reactors Under Construction



Reactors Under Construction

Country	Units	MWe (net)	Construction Start	Planned Grid Connection
ARGENTINA	1	692	1981/07/14	2010/10/01
BULGARIA *Belene-1* *Belene-2*	2	1906 *953* *953*	 1987/01/01 1987/03/31	 ? ?
CHINA *Hongyanhe* *Lingao-3* *Lingao-4* …*Ningde-1* *Qinshan-II-3* *Qinshan-II-4*	6	4220 *1000?* *1000* *1000* *1000* *610* *610*	 2007/08/18 2005/12/15 2006/06/15 2008/02/18 2006/03/28 2007/01/28	 ? 2010/08/31 ? ? 2010/12/28 2011/09/28
FINLAND	1	1600	2005/08/12	Summer 2011
FRANCE	1	1600	2007/12/03	2012/05/01
INDIA …*Kaiga-4* …*Kudankulam-1* …*Kudankulam-2* …*PFBR* …*Rajasthan-5* …*Rajasthan-6*	6	2910 *202* *917* *917* *417* *202* *202*	 2002/05/10 2002/03/31 2002/07/04 2004/10/23 2002/09/18 2003/01/20	 2008/07/31 2009/01/31 2009/07/31 ? 2008/06/30 2008/12/01
IRAN	1	915	1975/05/01	2009/08/01
JAPAN	1	866	2004/11/18	?

PAKISTAN	1	300	2005/12/28	2011/05/31
RUSSIA *…Novovoronezh-2-1* *…BN-800* *…Kalinin-4* *…Kursk-5* *…Severodvinsk-1* *…Severodvinsk-2* *…Volgodonsk*	7	4720 *1085* *750* *950* *925* *30* *30* *.950*	 2008/06/24 1985 1986/08/01 1985/12/01 2007/04/15 2007/04/15 1983/05/01	 ? ? ? ? ? ? ?
SOUTH KOREA …Shin-Kori-1 …Shin-Kori-2	3	2880 *960* *960*	 2006/06/16 2007/06/05	 2010/08/01 2011/08/01
…Shin-Wolsong-1		*960*	2007/11/20	2011/05/28
TAIWAN *…Lungmen-1* *…Lungmen-2*	2	2600 *1300* *1300*	 1999 1999	 2010 2010
UKRAINE *…Khmelnitski-3* *…Khmelnitski-4*	2	1900 *950* *950*	 1986/03/01 1987/02/01	 2015/01/01 2016/01/01
USA	1	1165	1972/12/01	?
Total:	**35**	**28274**		

Example Countries/Regions

- US
- EU
- China/Asia

US

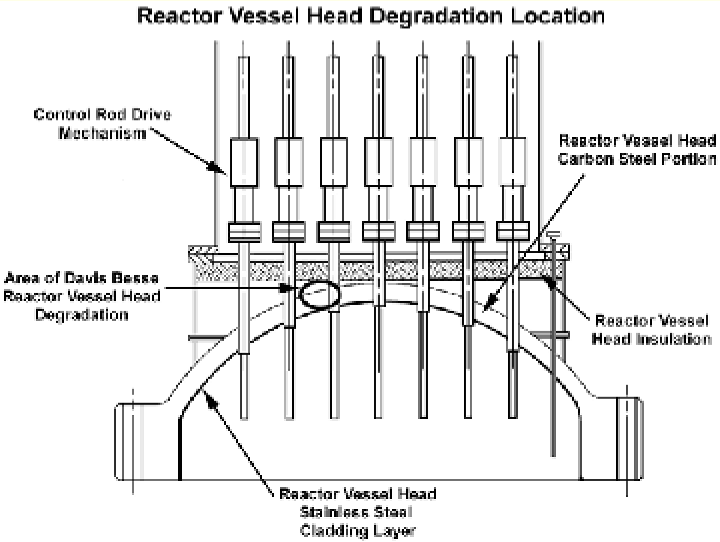
- More operating nuclear power plants than any other country in the world, with 104 commercial reactors providing.
- Although there are a large number of operating reactors in the U.S., the number of cancelled projects – 138 units – is even larger.
- An assessment of 75 of the country’s reactors showed predicted construction costs to have been US$45 billion but the actual costs were US$145 billion
- It is now 34 years since a new order has been placed that has not subsequently been cancelled (October 1973).
- In 2007 for the first time in three decades, utilities have requested a license to build a nuclear plant.
- The U.S. Nuclear Regulatory Commission expects a total of 21 applications for 31 units until 2009. However, this is no guarantee of actual construction.

US Support Program

- Production Tax Credits: 1.8 cent tax credit for each kWh from new reactors for 8 years for six reactors: cost to US treasury $5.7 billion.
- Loan Guarantees for first 6-8 reactors (worth upto $18.5 billion)
- A support framework against regulatory or judicial delays, worth up to $500 million for the first two reactors and $250 million for the next four.
- Further research and development funding worth $850 million.
- Assistance with historic decommissioning costs (up to $1.3 billion)
- December 2007, Christopher Crane, President of Exelon Generation, one of the utilities that has stated an intention to build new nuclear plants stated: *'If the loan guarantee program is not in place by 2009, we will not go forward'*

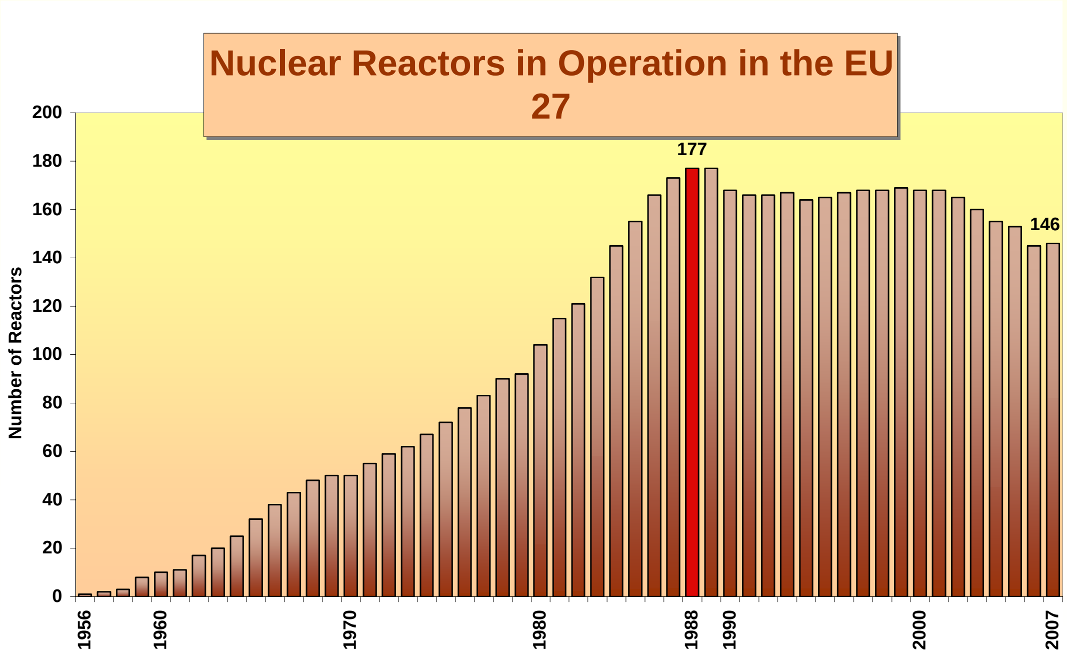
Reactor Aging

- Large Life Extension and upgrading programme
- NRC approved 110 uprates since 1977
- 20 year life extensions
- 4.7 GW of upgraded power



EU

- 15 of the 27 countries in the enlarged European Union (EU27) operated 146 reactors, about one third of the units in the world.
- The vast majority of the facilities, 125 are located in eight of the western EU15 countries.
- 21 are in the seven new Member States with nuclear power.
- In other words, almost nine out of ten operating EU27 nuclear reactors are in the West. Nevertheless, especially when it comes to safety issues, a large part of the public and political attention seems to be directed towards the East.
- Moreover, almost half (45%) of the nuclear electricity in the EU27 has been generated by one country only: France



Europe’s Most Advance Reactor under Construction Olkiluoto 3

- EPR, being built by Areva
- Financing:
  - Government Backing: €710 million in ECA guarantees from France and Sweden
  - Enabling €1.95 billion loan at 2.6% from German state Bank
  - Subject of European Commission State Aid compliant investigation
- Construction started in 2005

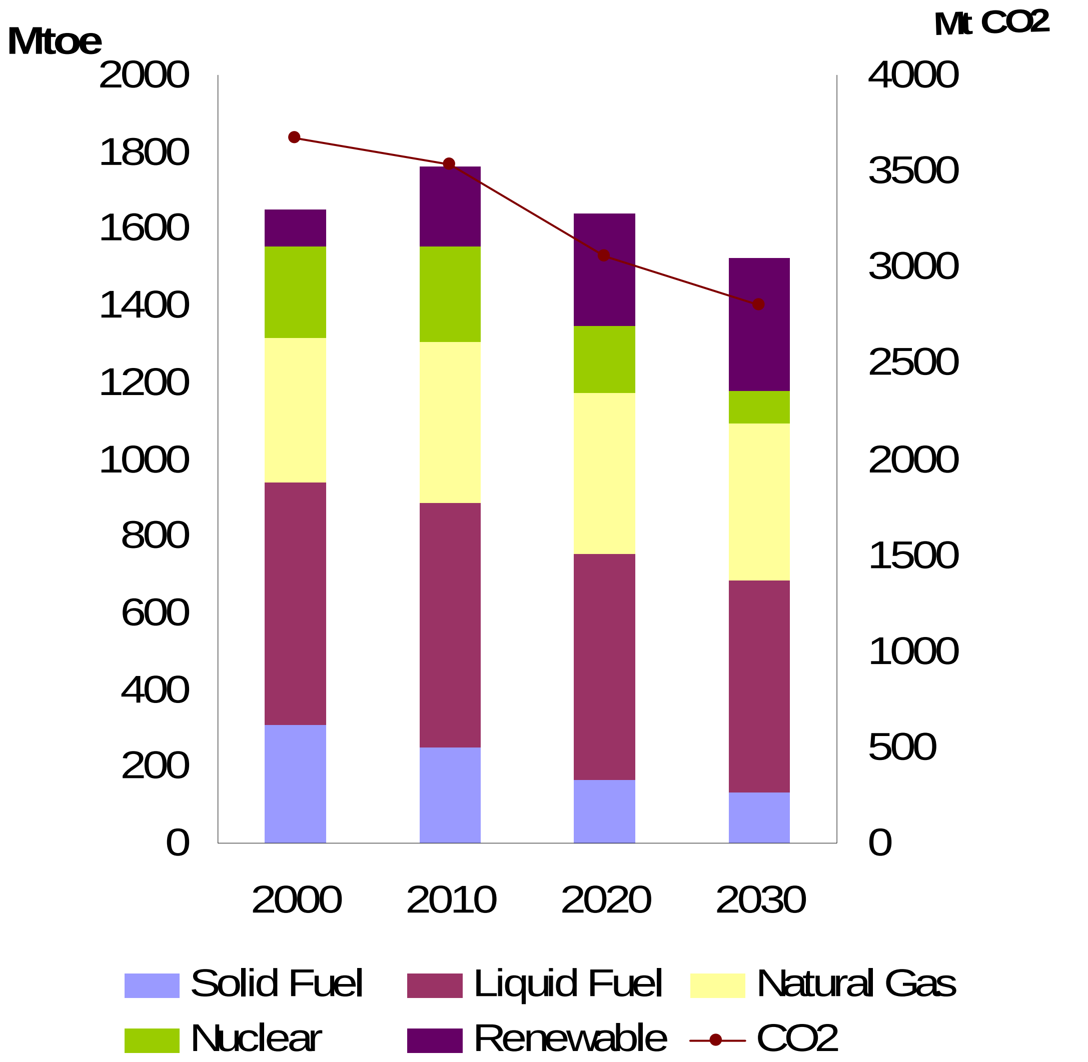
Technical Problems

- Finish Safety Agency Report, released in 2006 highlighted a number of problems, including.
  - ‘The tight cost frame is also a problem in selecting and supervising subcontractors. They have very often chosen a sub-contractor who has given the lowest tender’
  - ‘The time and amount of work needed for the detailed design of the unit was clearly underestimated when the overall schedule was agreed on’
  - ‘was not sufficiently familiar with the Finnish practices at the beginning of the project
- Project now an estimated 2 year behind schedule
- Cost over-runs may reach €1-2 billion, on a €3.2 billion project

UK

- "There will be no subsidies, direct or indirect. We are not in the business of subsidising nuclear energy. No cheques will be written, there will be no sweetheart deals," Malcolm Wicks, House of Commons trade and industry select committee, October 2006
- Companies:
  – EDF Energy (UK): ‘We have made it clear we are not asking for subsidies, all costs will be borne by us.
  – While E.ON ‘It also believes that there is no requirement for either government subsidies or for a guaranteed long-term cost of carbon to make new nuclear power stations economic.

EU 20:20:20 Target



Source: European Commission 2006

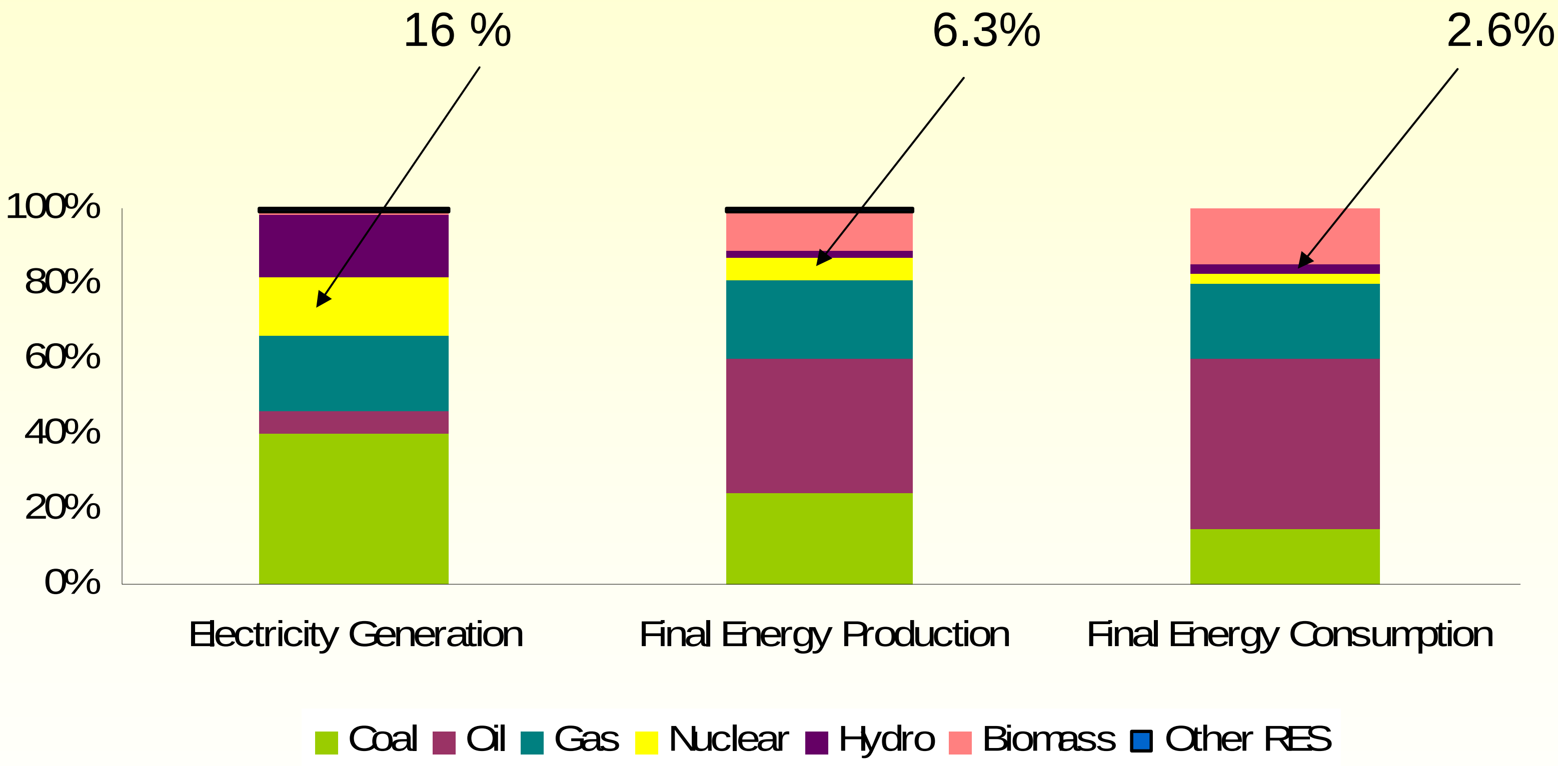
China/Asia

- Over half reactors under construction are in Asia: 6 in China, 6 in India, Taiwan, South Korea and Japan
- In addition there are significant programmes to increase construction
- China: Currently nuclear currently provides 1.9% of electricity – 8.5GW (11 units). Plans suggest that by 2030 40 GW of nuclear capacity. While extremely ambitious, also not significantly change nuclear's role.
- India: 2.5% of electricity, 3.7 GW (17 units)

Scaling Up Nuclear to Address Climate Change

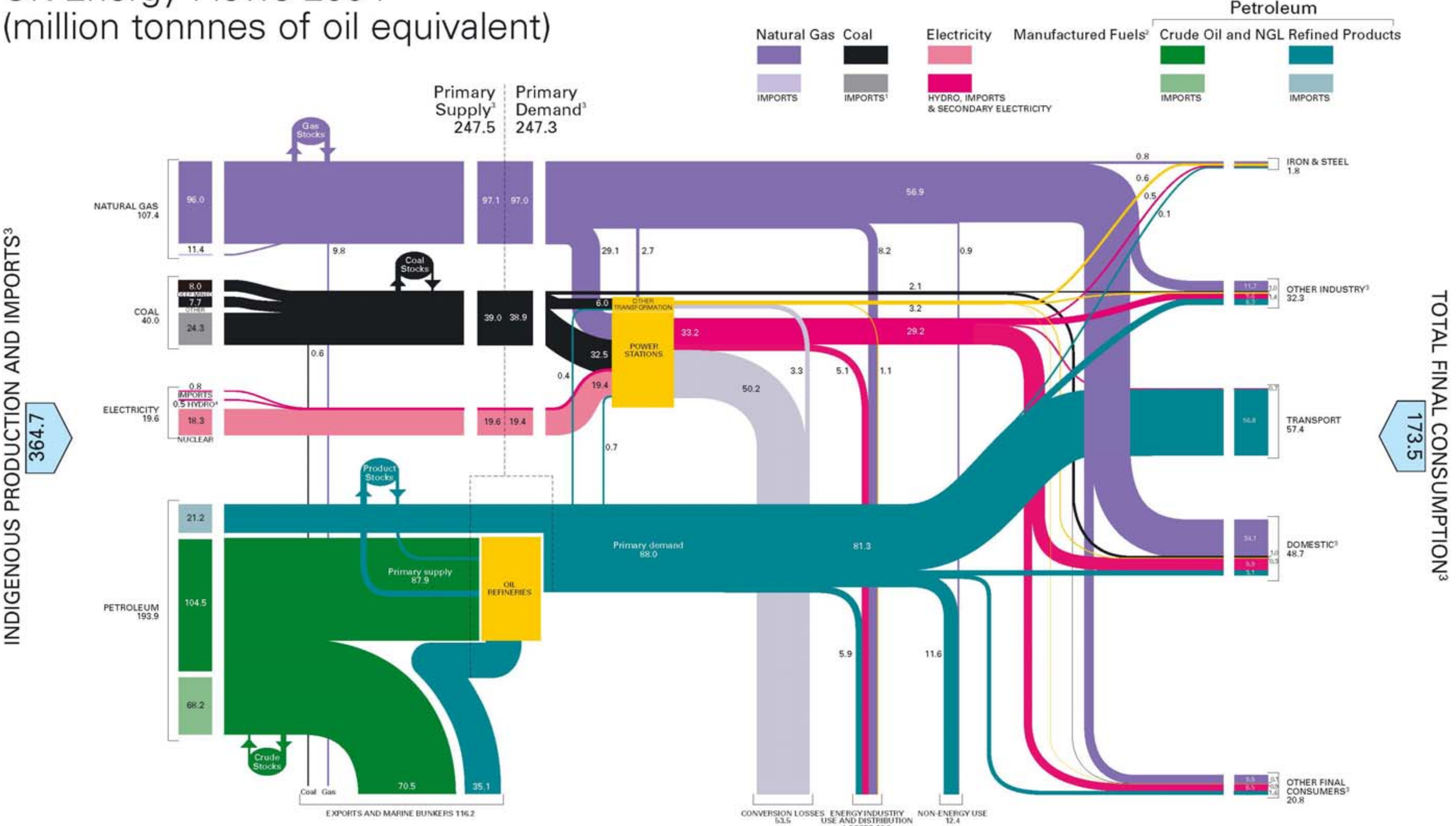
- Current Contribution
- Nuclear, one low carbon option
- Economics
- Waste costs
- Uranium resources
- Proliferation implications
- Staffing and infrastructure
- Timing

Nuclear Contribution to Global Energy Mix



Source: IEA 2006

UK Energy Flows 2004
(million tonnnes of oil equivalent)



FOOTNOTES:
1. Coal imports include imports of manufactured fuels, which accounted for 0.1 million tonnes of oil equivalent in 2004.
2. Includes heat sold.
3. Includes all renewables.
4. Includes wind, wave, geothermal and solar.
This flowchart has been produced using the style of balance and figures in the 2005 UK Digest of Energy Statistics, Table 1.1.

national STATISTICS

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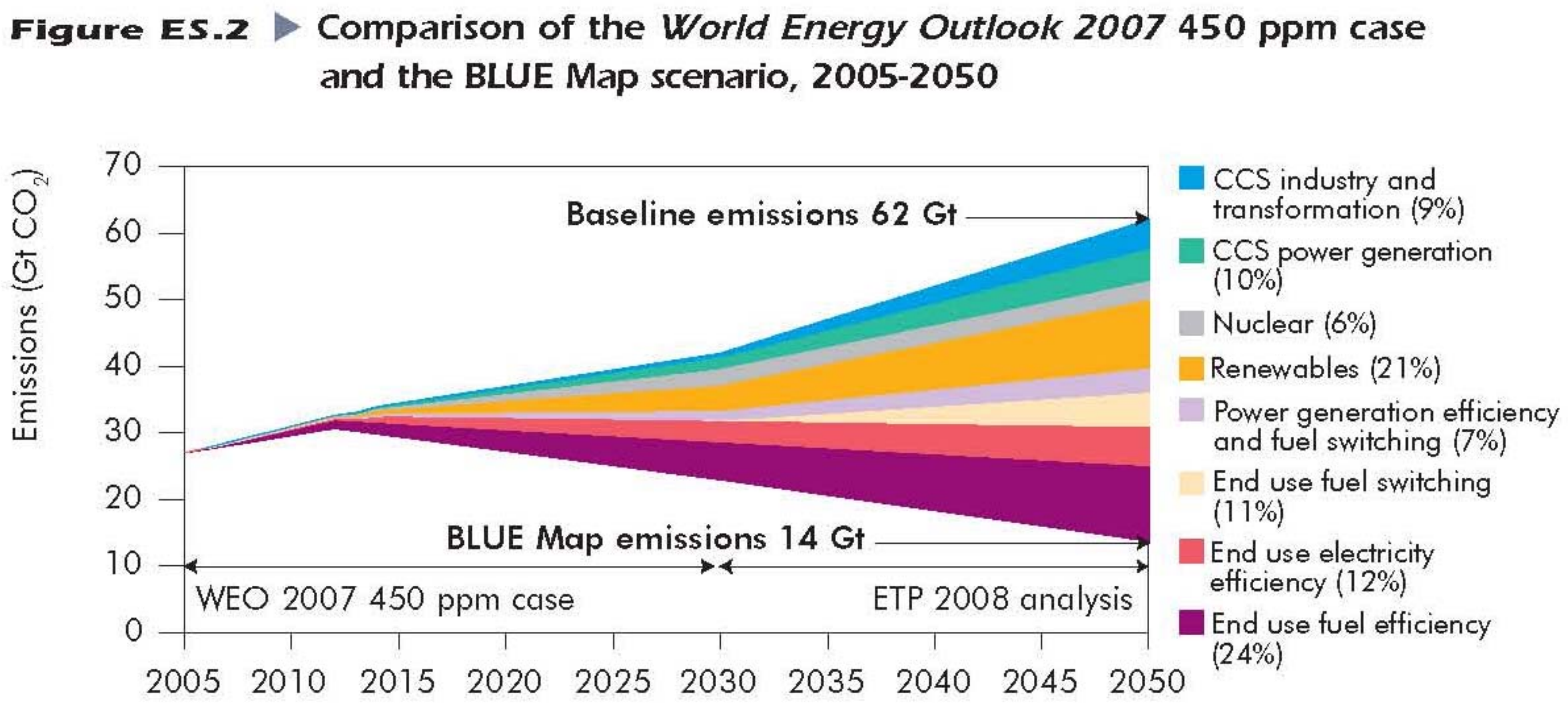
ENERGY FLOW CHART 2004

IEA BLUE MAP SCENARIO



Historical/Delays Cost Escalations

- Many historical examples of cost over-runs: The most recent UK reactor, a PWR at Sizewell B, experienced increases in capital costs from £1,691m to £3,700m.

Period of reference	Number of reactors	Average construction time (months)
1965-1970	48	60
1971-1976	112	66
1977-1982	109	80
1983-1988	151	98
1995-2000	28	116
2001-2005	18	82

Nuclear Learning Curves

- *"The costs of energy production and use from all technologies have fallen systematically with innovation and scale economies in manufacture and use, apart from nuclear power since the 1970s"* –background paper to Stern Report

Technology	**Period**	**Learning rate (%)**
Wind – OECD	1981-95	17
Solar – PV – World	1985-95	32
Gas Turbine Combined Cycle Power Plants – OECD	1984-94	34
Nuclear Power – OECD	1975-93	6

- The **UK Trade and Industry Committee** stated in its 2006 report that ‘*Even the most optimistic estimates for this [new construction] are in the region of five years’,* but that *‘Experience in the UK to date has shown it can take much longer, with an average construction period for existing nuclear power stations of almost 11 years.’*
- **Chair of the Sustainable Development Commission, Sir Jonathan Porrit***: “the evidence shows that, historically, cost estimates from the industry have been subject to massive underestimates—inaccuracy of an astonishing kind consistently over a 40, 50 year period*”

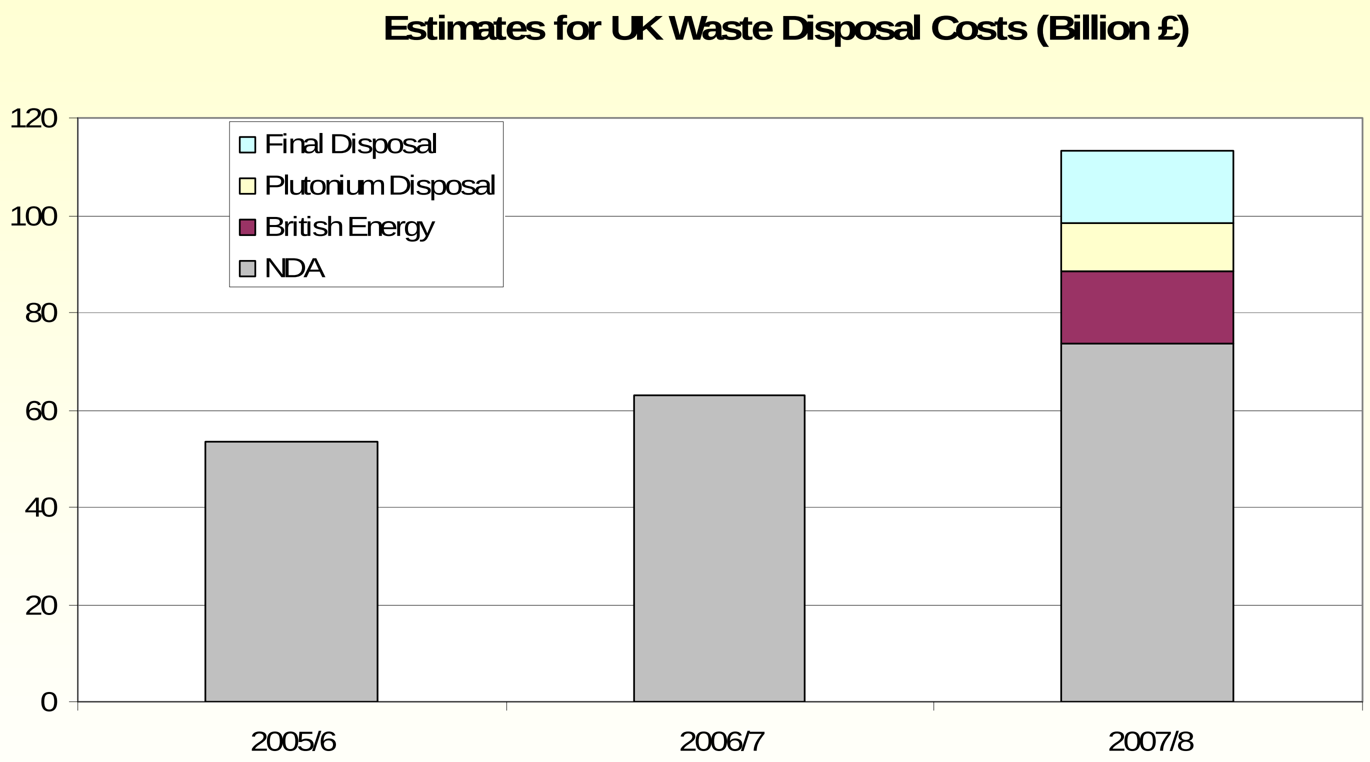
Subsidies or Not ?

- **UK Government:** *'There will be no subsidies, direct or indirect. We are not in the business of subsidising nuclear energy. No cheques will be written, there will be no sweetheart deals'.*
- **International Energy Agency: '***Nuclear power* ***will only*** *become more important if the governments of countries where nuclear power is acceptable play a stronger role in* ***facilitating private investment****, especially in liberalised markets'*

Industry Seeking Guarantees

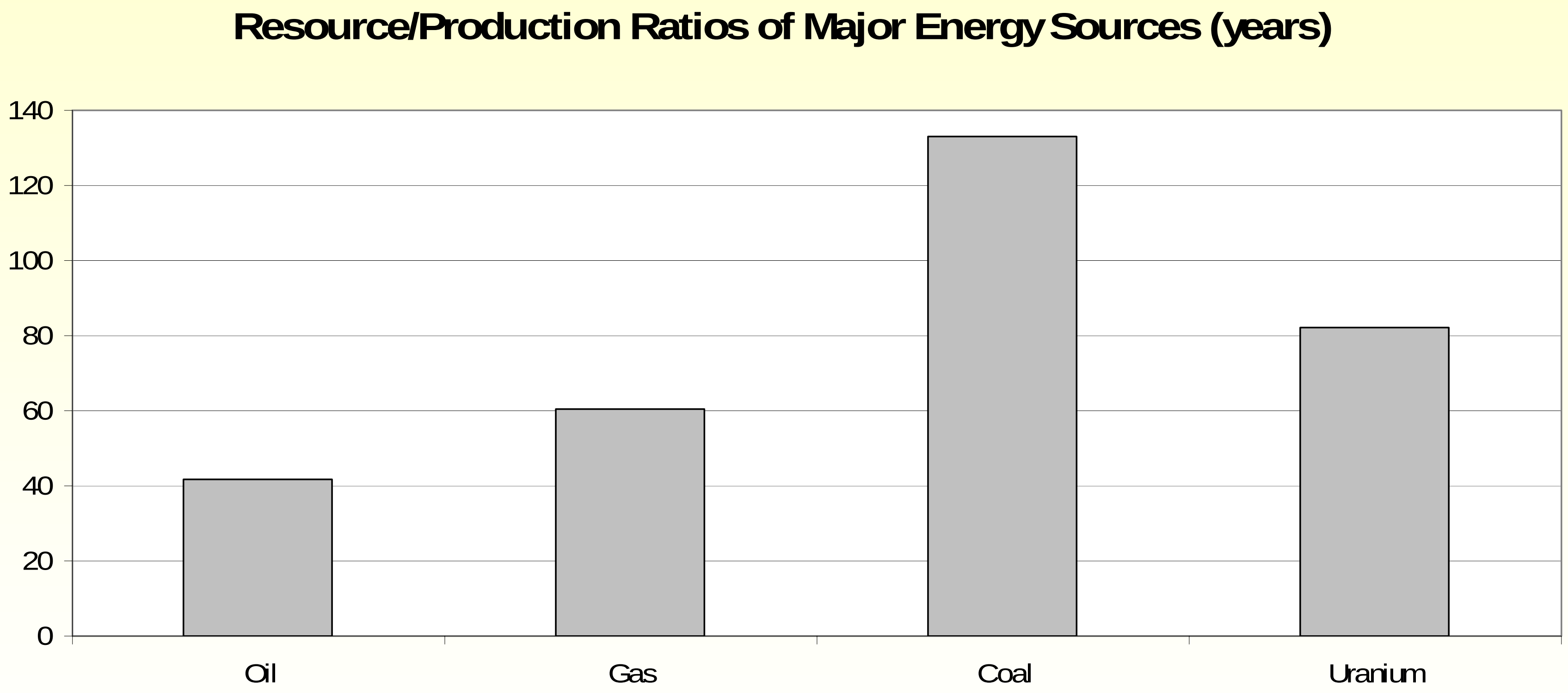
- Waste
- **Eon:** *Investors would need to be assured that a secure route will exist for the safe disposal of all radioactive waste and in particular that* ***Government will accept ownership and responsibility for spent fuel and intermediate level waste by the end of a plant's life****.*
- *Carbon price:*
- **Edf:** '*To make a commitment of billions of pounds to a project with a time-scale of half a century, investors above all need predictability about price. They must know the* ***value society will place on carbon reduction not just tomorrow, but 10, 20, 30, 40 years*** *from now'.*
- *Planning:*
- **British Energy:** *If the Government wishes the private sector to finance and construct new nuclear power stations, there will need to be a high level of confidence in the timescale* ***and outcome*** *of the consent process.*

Rising Waste Costs



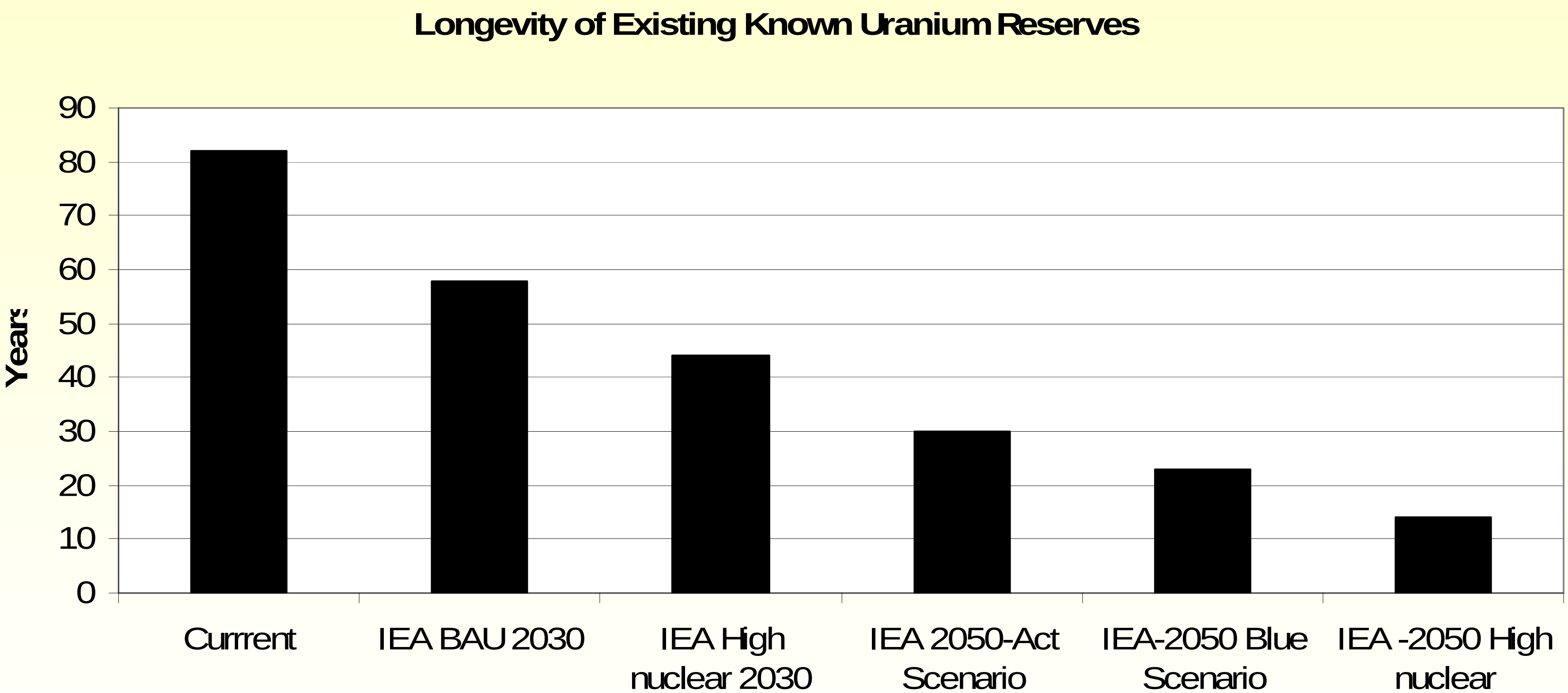
Sources: NDA/BE

Global Energy Resources



Source: BP/Nuclear Energy Agency

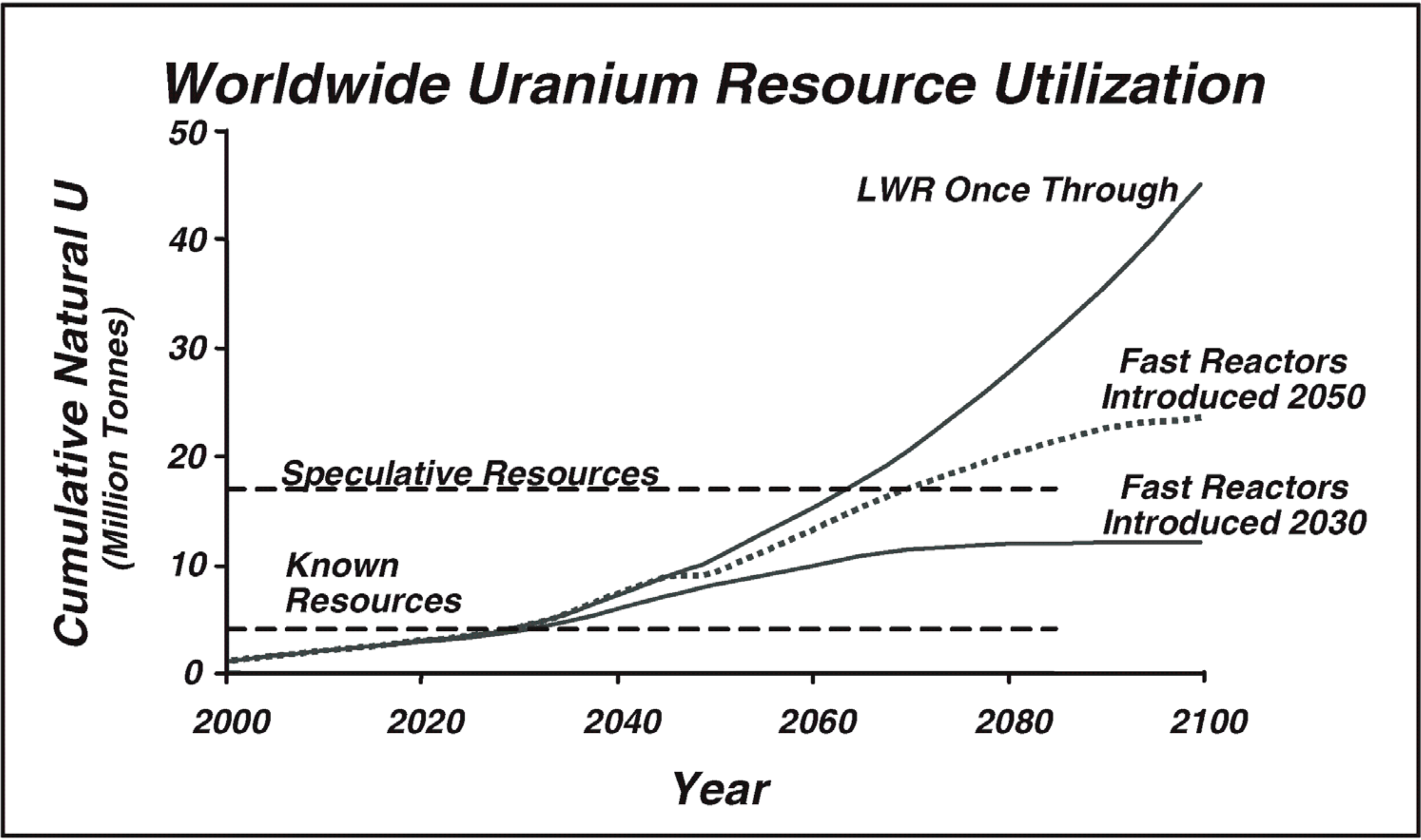
Uranium reserves



Regardless of the role that nuclear energy ultimately plays in meeting rising electricity demand, the uranium resource base described in this document is adequate to meet projected future requirements. The challenge is to develop mines and increase production in a timely fashion to bring these resources to the market. A continued strong market and sustained high prices will be necessary for resources to be developed within the timeframe required to meet future uranium demand.

Sources:

IEA/NEA



Source: A Technology Roadmap for Generation IV Nuclear Energy Systems (NERAC 2002)

Proliferation implications of Nuclear Scale up

- Large scale construction programme for nuclear promoted to reduce CO_2 emissions.
- 6500 GW of nuclear by 2100 would potentially reduce CO_2 emissions by one quarter.
- However, result in 600 tonnes/year of pu in conventional reactors and 4000 in pu fuelled reactors:
- Compared to150 global current military stockpile.

Staffing and Equipment

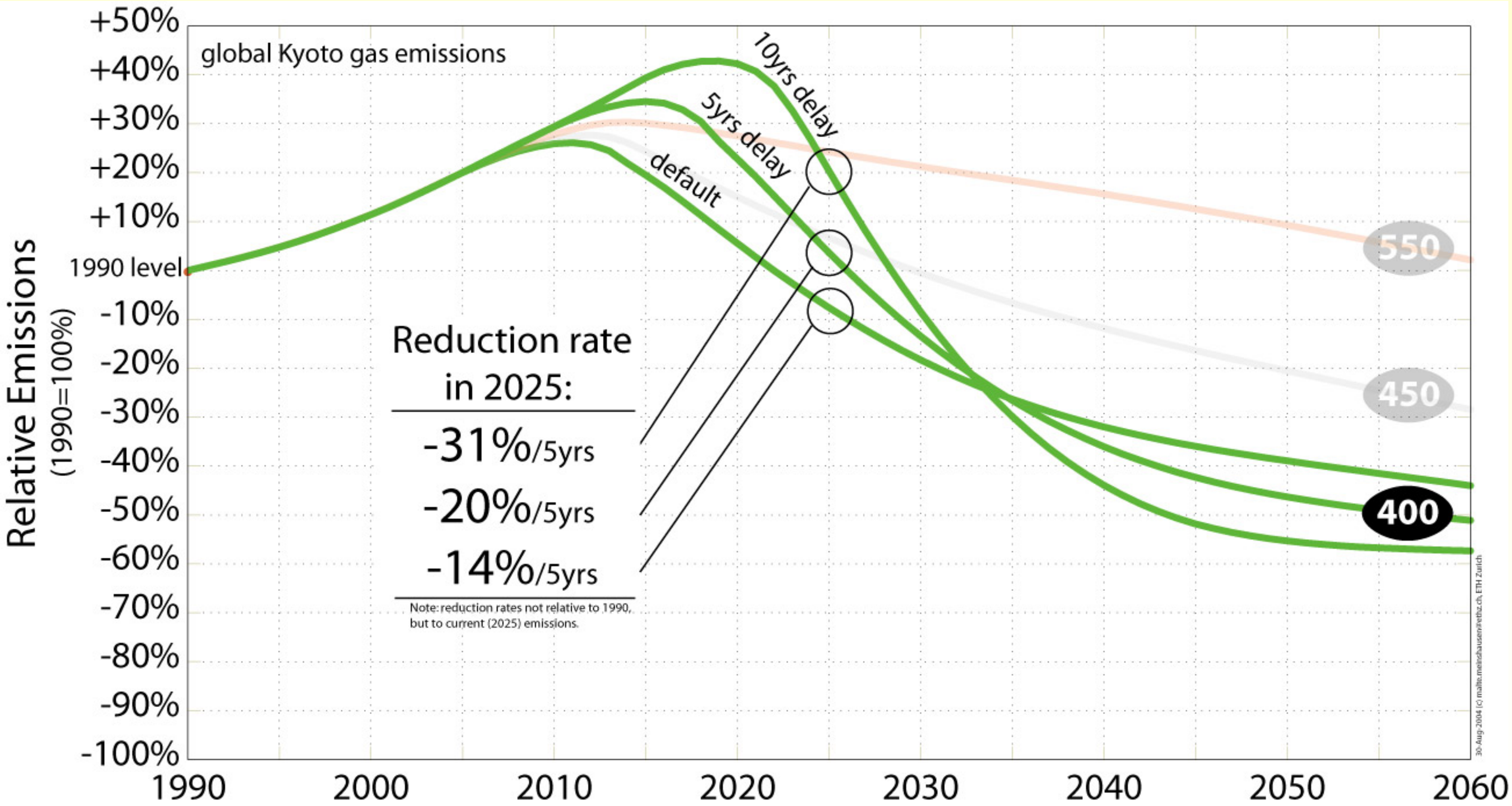
- Moving from a situation where on average 5 GW are commissioned annually (are of last 30 years) to 30+ GW requires scaling up of manufacturing infrastructure and staffing:
- Staffing:
  - Workforce is aging (26% of nuclear engineers in US can retire in next 5 years.
  - 8% of the US workforce is under 32.
  - 40% of EdF’s reactor staff are expected to retire by 2015.
  - In OECD ‘nuclear education had declined to the point that expertise and competence in core nuclear technologies was becoming increasingly difficult to sustain’.
  - In 1980s 65 nuclear engineering programmes in US, now 29
  - In Germany 22 higher education facilities in 2000 expected to be 5 in 2010.
  - Workforce also needed for decommissioning and waste.

- Equipment:
  - Only one forge – in Japan – for large pressure vessels – already has 3 year waiting list
  - Other pinch points on pumps, valves and heat exchanges

Targeting of Public Funds

- Analysis undertaken by Amory Lovins in US suggests:
  - Every $0.10 spent on a new nuclear kWh could have resulted in:
    - 1.2-1.7kWh of Wind power
    - 0.9-1.7 kWh of gas fired
    - 2.2-6.5 kWh of co-generation
    - Several to 10+kWh of energy efficiency.
- There is an opportunity cost of different support schemes.

Timescales Involved



Note: (a) The S550Ce, S450Ce, and S400Ce stabilization scenarios are based on the EQW multi-gas emission pathways method, which builds on the gas-to-gas correlations within the pool of 54 SRES and Post-SRES scenarios (Meinshausen et al. submitted).
(b) Landuse CO2 emissions are sharply decreasing in the default scenarios. If constant CO2 emissions from the landuse sector were assumed, the emission reductions of the Kyoto-gases (fossil CO2, Methane, N2O, HFCs, PFCs, SF6) have to be more pronounced. Alternatively, if emission allowances were given to avoided landuse emissions, overall emission allowances for the Kyoto-gases would have to be reduced accordingly (solid line).
(c) Delay profiles were calculated by assuming a 5 or 10 delay in global action. In the illustrative default scenarios, OECD and REF regions are assumed to enter stringent emission reductions by 2010, and ASIA and ALM by 2015.

Conclusions

- Despite media reports there is currently no 'nuclear renaissance' – nor could there be
- No increase in nuclear can be expected for 10 years (five year lead time; five year construction)
- Significantly scaling up of construction take two decades ?– to build manufacturing infrastructure/training etc
- Historic problems of industry – which halted last nuclear push in 1970s have yet to be resolved -
  - Public acceptance – but changing in favour of nuclear
  - Economics – will improve with energy scarity/carbon tax
  - Waste management
- New problems may arise/have greater prominence
  - Uranium availability
  - Proliferation concerns

Key Questions

- What type of energy system is needed to capture renewable and energy efficiency opportunities, is this compatible with requirements of nuclear?
- What are relative economics and opportunities of nuclear vs renewables how should they be measured?
- What role must fast reactors play in future and what are implications for global security ?
- How should political/public security of supply considerations be included in risk analysis?