Nuclear Fission Energy – today, in 2013 and thereafter?

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CERN Seminar

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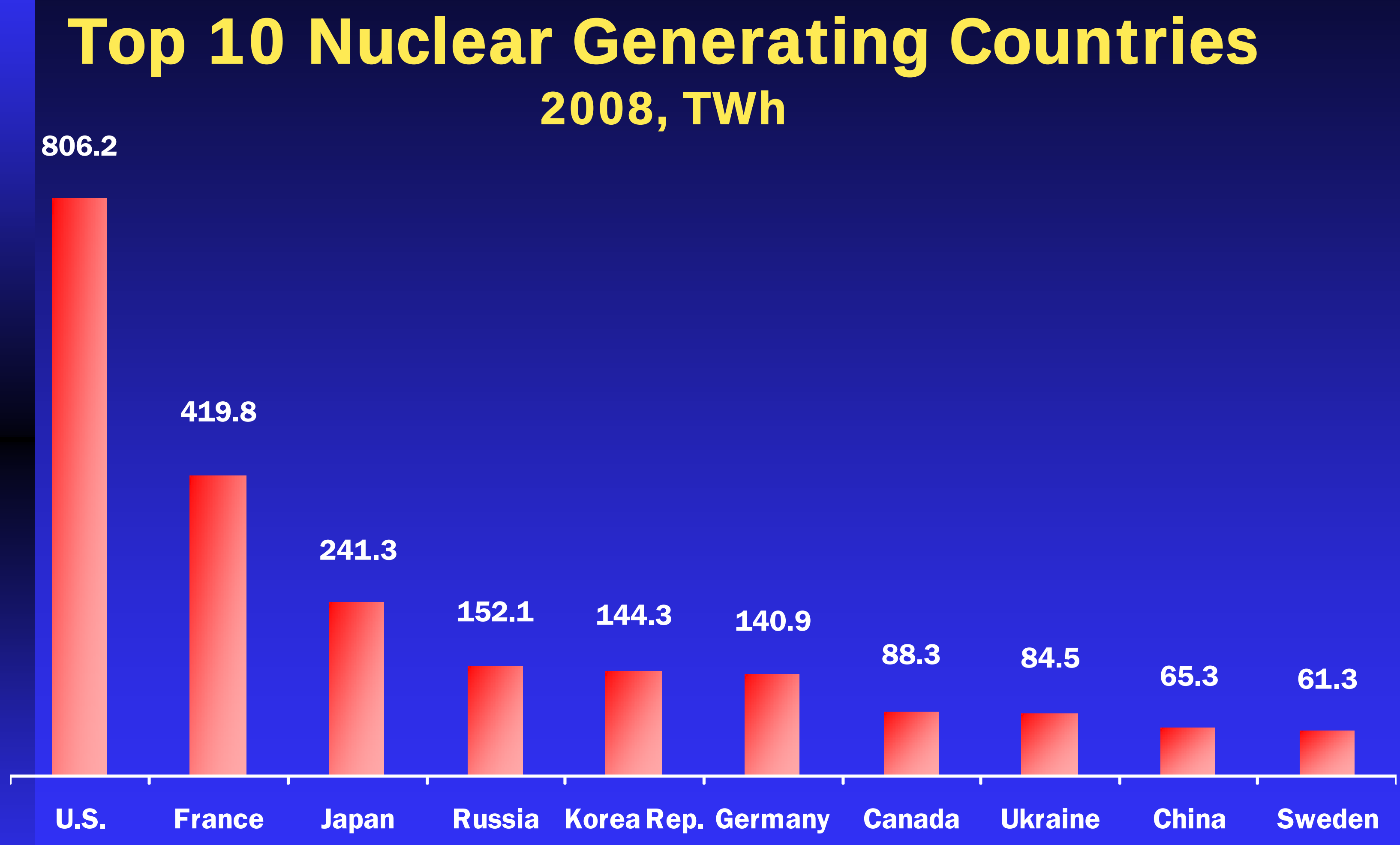
My articles:

http://www.after-oil.co.uk/articles.htm

Nuclear Fission in 2008



US IEA

Nuclear Fission in 2008

Switzerland	- 5 reactors	26 TWh	39%
France	- 58 reactors	418 TWh	76%
Germany	- 17 reactors	141 TWh	29%
UK	- 19 reactors	53 TWh	13%
World	- 435 reactors	2601 TWh	13%

World Primary Energy

Total primary energy 473 EJ (exajoules) of which nuclear provides 26 EJ or 5.5%

As electricity this is 9.4 EJ or 2.2%

Natural uranium required 65,405 t U

BP

Natural uranium requirements 2009

US – 18,887 t U (Equivalent)

France – 10,569 t U

Japan – 8,388 t U

Russia – 3,537 t U

S Korea – 3,444 t U

Germany – 3,398 t U

Totalling 74% of 65,405 t U

WNA

Natural uranium (equivalent) requirements 2013

By 2013 43 reactors to be commissioned

to provide additional 40, 000 MW capacity

Uranium extra needed is 8,000 t U

+ 3,000 t U initial core = 11,000 t U

65,000 + 11,000 = 76,000 t U in 2013

which is 33, 000 t U over 43,000 t U

from primary mining in 2008

WNA

Major component replacement

Davis-Besse reactor vessel head Ohio 2002

Large cavity 170 x 110 mm in 150 mm head

Pressure held by SS internal cladding

Stress corrosion cracking in penetration tube leaked

boric acid neutron absorber which attacked the ferritic shell

By 2005 93 RVHs and 83 SGs in PWRs and BWRs have been replaced

NRC

Reactors to be upgraded by 2013

- Some 43 reactors may be commissioned by 2013, but 31 (in the West) will be 40 years old
- Degree of upgrading depends on past history of replacements. In France 54 of the 58 reactor vessel heads have been replaced.
- Nuclear contribution to generation and uranium requirement uncertain

End of Megatons to Megawatts deal

Russian ex-weapons diluted HEU supplies half of the US reactors - equivalent to 10,000 t natural U

Western primary mining decline may continue.

It is unclear how much of secondary sources will be supplied after 2013.

Generation capacity boosted by commissioning, but reduced by upgrading and closures.

Level of nuclear generation in 2013 is uncertain.

New build

4 Areva EPRs under construction in Finland, France and China

2 Westinghouse AP1000s – Claimed to be on schedule

Prototype EPR at Olkiluoto delayed and overspent
Second EPR at Flamanville already delayed
2 EPRs in China tied to output of Trekkopje mine

Cost and delay implications

•Carbon tax on suppliers

•Few vessel manufacturers

•Inspectors demand control system modification

•Duplicate spent fuel ponds?

Capital costs per kW generated

2003	US$ 3,000/kW
2007-8	US$ 5,000/kW
2009	US$ 7,000 to 10,000/kW

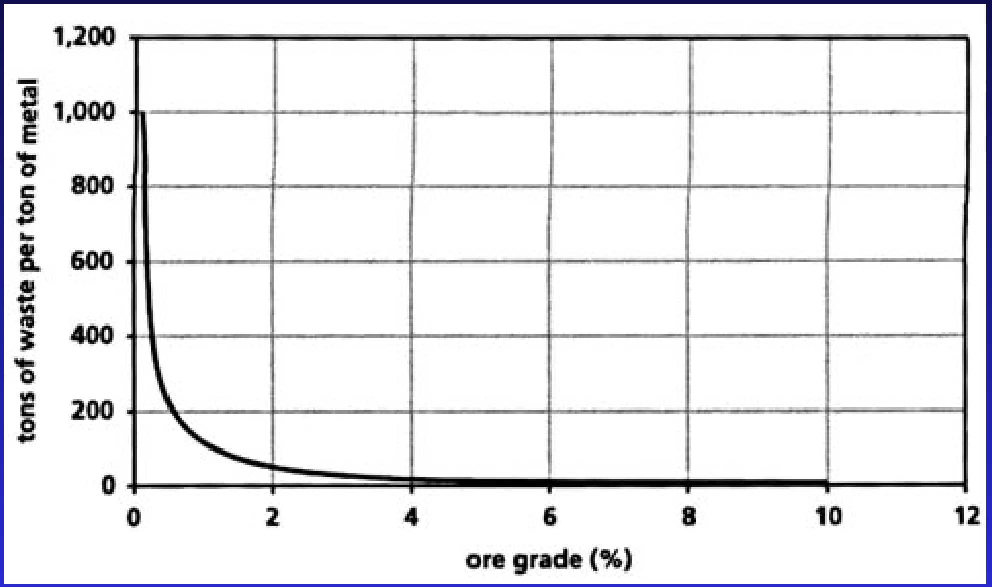
Fixed price contracts, but with escalation clause?

Construction delays reduce return on capital

State subsidy or re-nationalisation?

Ten new starts in 2008 and ten in 2009 were all state financed

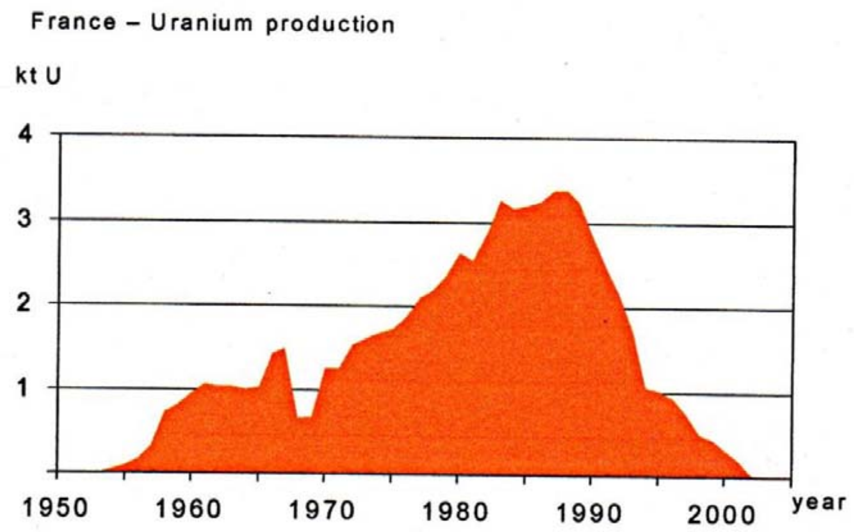
Lowering grades increase waste rock

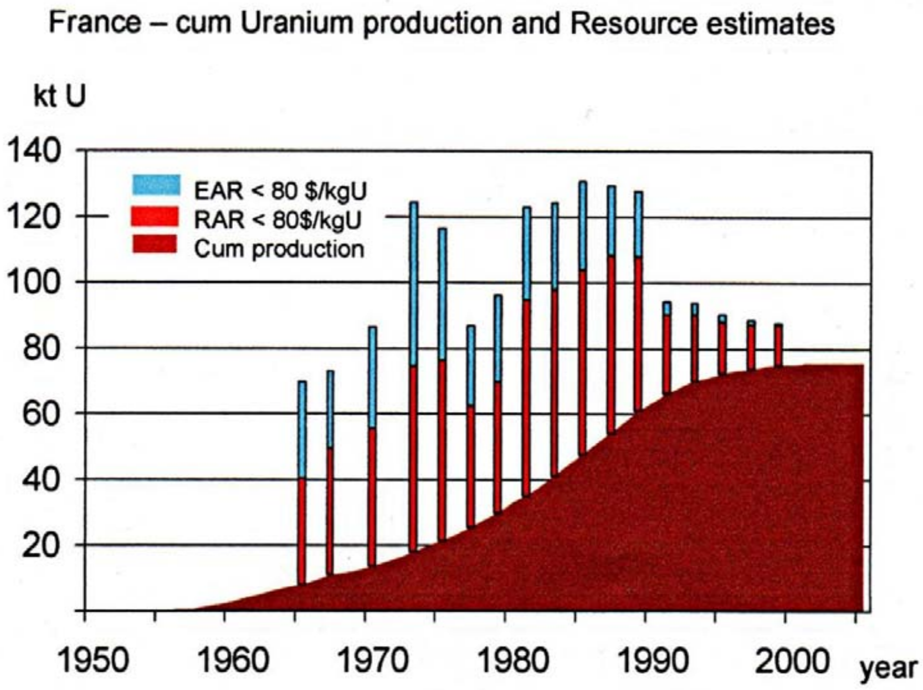


The Limits to Growth 30-year Update

Uranium

Production in France

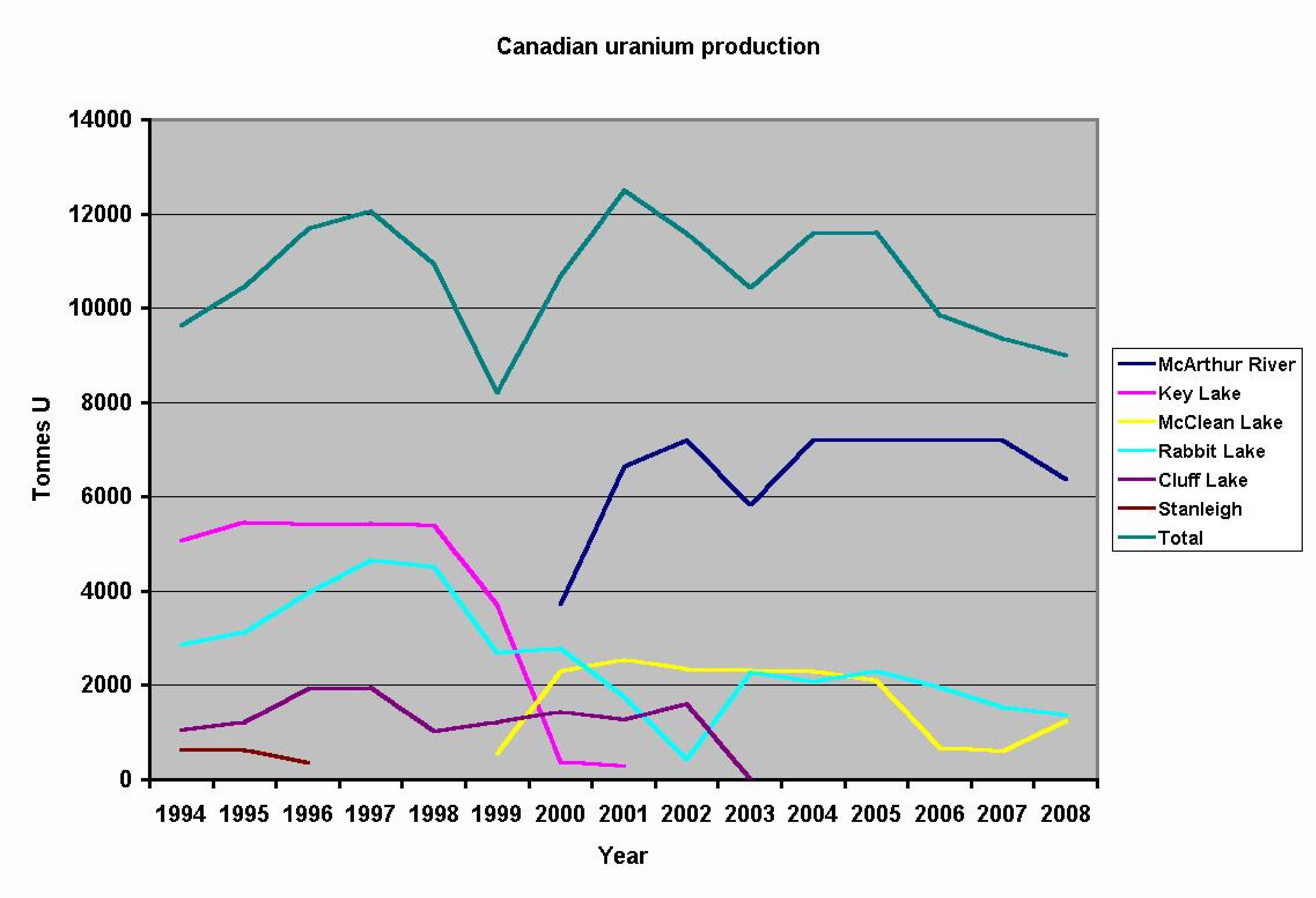




"Red Book" prognosis shrinks as mines exhaust

EWG

Uranium mining in Canada



"Red Book" claims

" … sufficient nuclear fuel resources exist to meet energy demands at current and increased demand well into the future" Not proven!

Uranium mining follows a Hubbert curve of a build up of production to a peak, followed by a decline.

This is shown in the production figures in France and in Canada. Cigar Lake delay has broken the series and overall production is declining.

Currently Kazakhstan is showing a rapid build up in production, but without a further series of new mines will exhibit a decline.

Fast breeder reactors

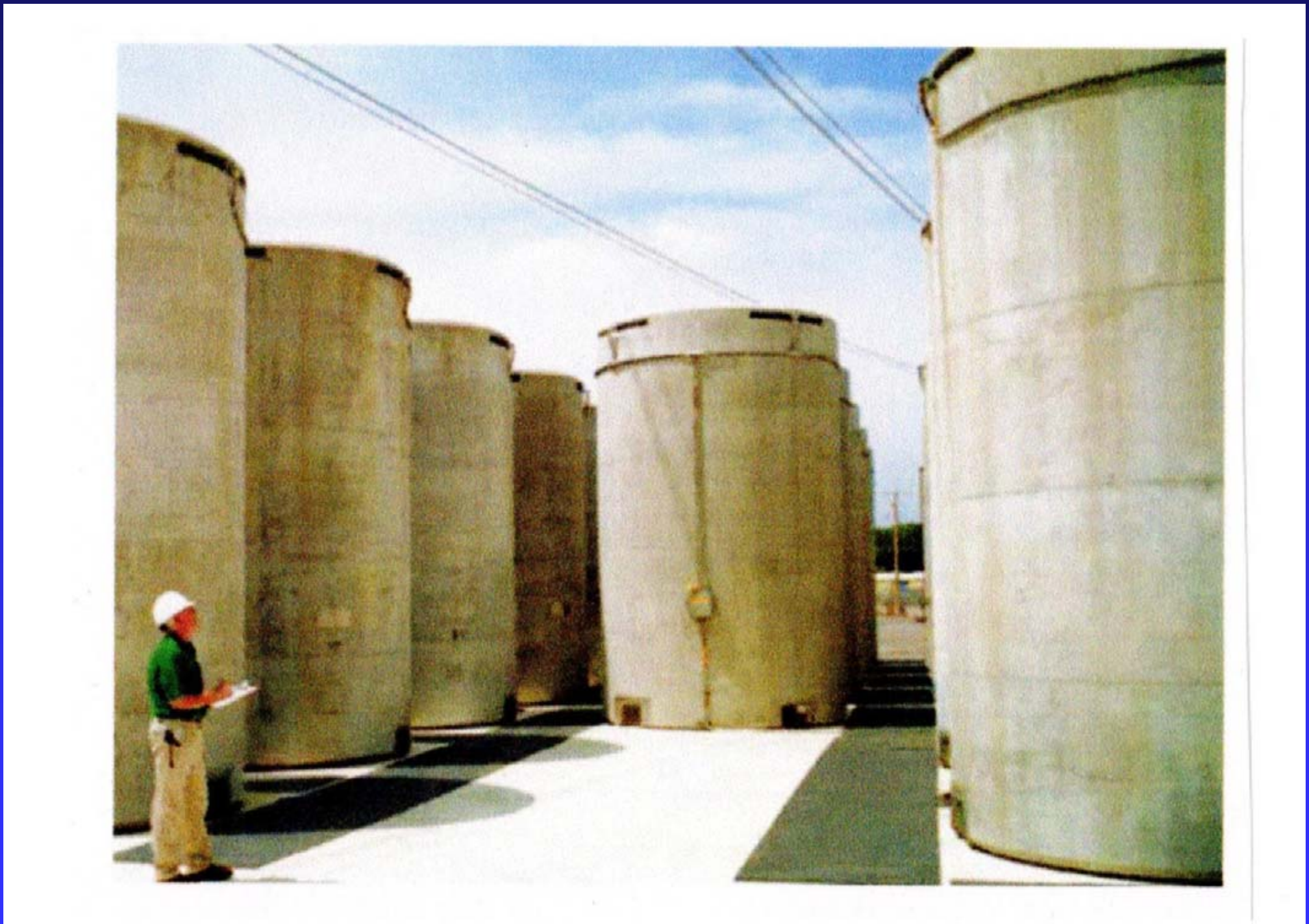
The "Red Book" claims:

"Moving to advanced technology reactors and recycling fuel could increase the long term availability of nuclear energy from hundreds to thousands of years"

Fast breeder reactors need to be part of three part cycle, of reprocessing spent fuel, separating Pu for fuel manufacture and the breeding, which at best needs 10 years to replace the original Pu.

The claim is not substantiated by mathematical modelling of the transition.

Dry casks



Low carbon?

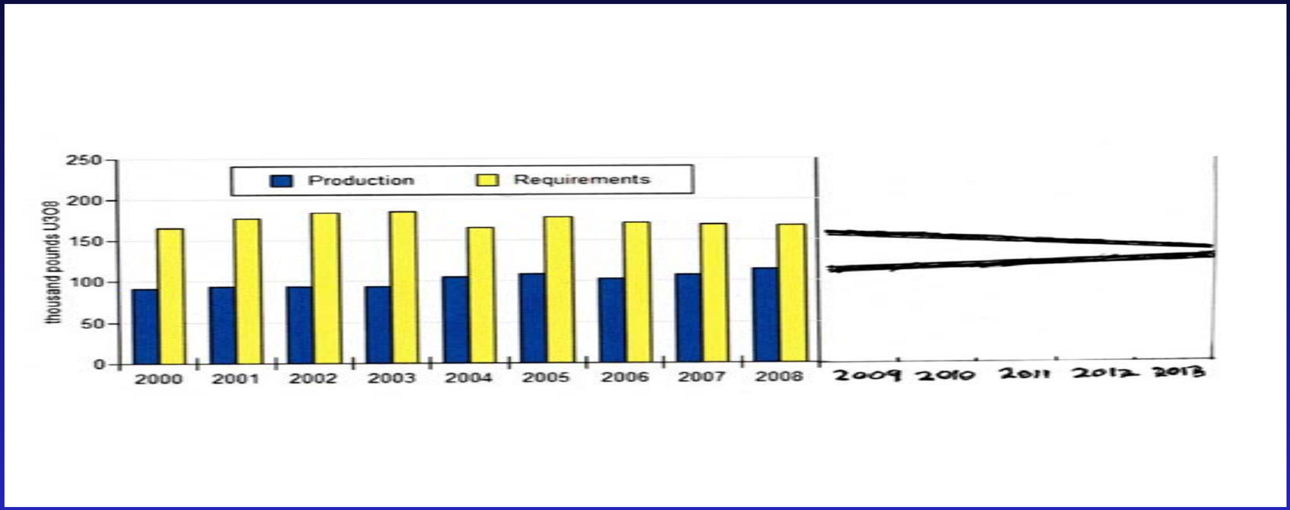
The low carbon property of nuclear power is based on the aggregate of the emissions over its life cycle.

Three main components

- Manufacture and construction
- Mining and fuel manufacture
- Spent fuel management

The first two components are up front before the fission produces electricity carbon free. With a progressive building programme, the carbon free operation never compensates for the initial two.

After 2013?



Taken from uranium trader TradeTech's plot, which shows a declining requirement, fulfilled by slowly rising primary and declining secondary production.

Extrapolating to 2013 gives 54,000 t U supporting 270 GW generation, cf. 370 GW.

Factors affecting prognosis

- Declining uranium production in Canada and Australia (Cigar Lake and Olympic Dam)
- West denied secondary sources
- Rising construction costs and lack of manufacturing capacity
- Delay in commissioning reactors under construction
- Depletion in fossil fuels needed for mining and construction

The “renaissance” will be stillborn

Summary

- Nuclear provides only 5.5% of the world's primary energy
- The West's supply of uranium is declining
- The secondary sources are in question after 2013
- The current reactor construction is funded by states
- The West's new build will need state subsidy
- There is insufficient fabrication capacity to support it
- The ageing of major components could remain a problem
- Spent fuel will remain in dry casks – no repository
- Peak oil, gas and coal will reduce economic activity
- There will be little spare energy to manage nuclear waste
- There will be insufficient revenue to maintain current generation
- Lack of diesel to mine low grade uranium ores
- Nuclear power is not an answer to emissions reduction or energy security
- Nuclear power will leave a difficult legacy for those generations surviving to the end of the century

Hydrogen

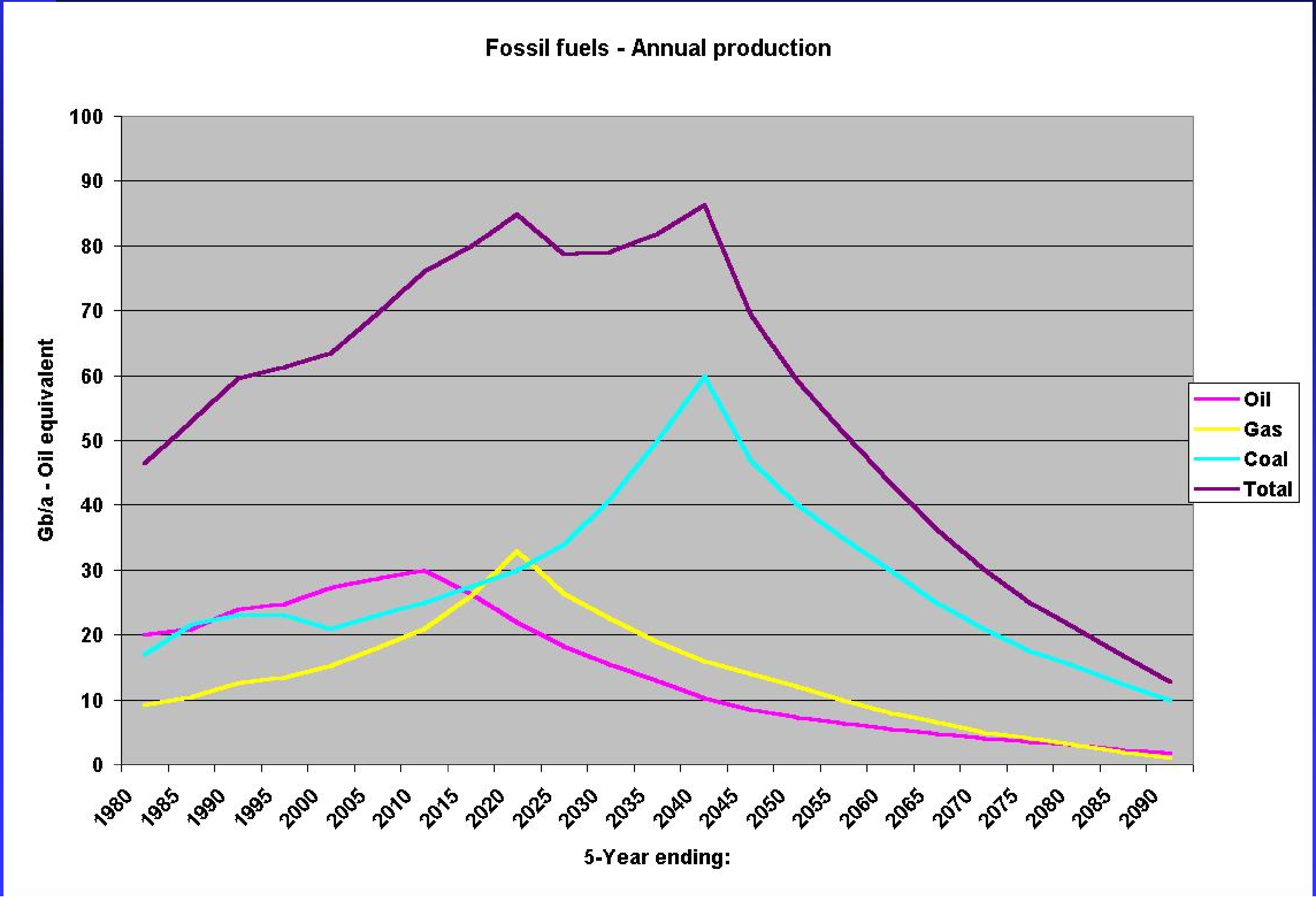
Taking mobile transport need as 40% of 473 EJ = 189 EJ

At 120 MJ/kg mobility energy is carried by
725 x 10^9 kg H_2 in liquid form.

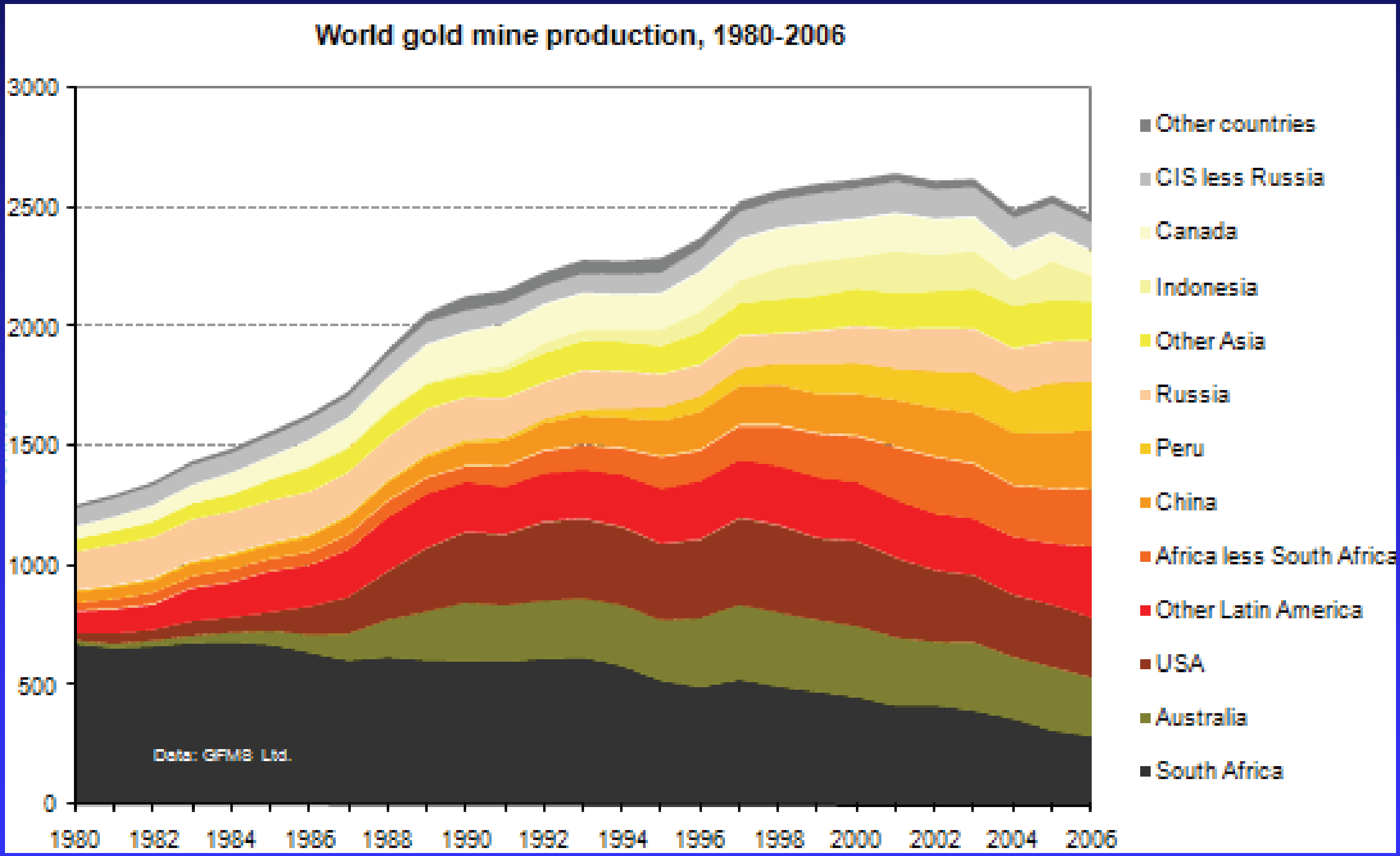
Electrolysis and liquefaction requires 75 kWh/kg
which for 54,400 TWh at 34% efficiency is
576 EJ of primary energy.

This is three times the primary energy supplied
by petroleum for mobile transport and would require
576 EJ/85 PJ = around 7,000 1 GW nuclear stations
and over 1million tonnes of natural uranium a year.

Oil, gas and coal peaks

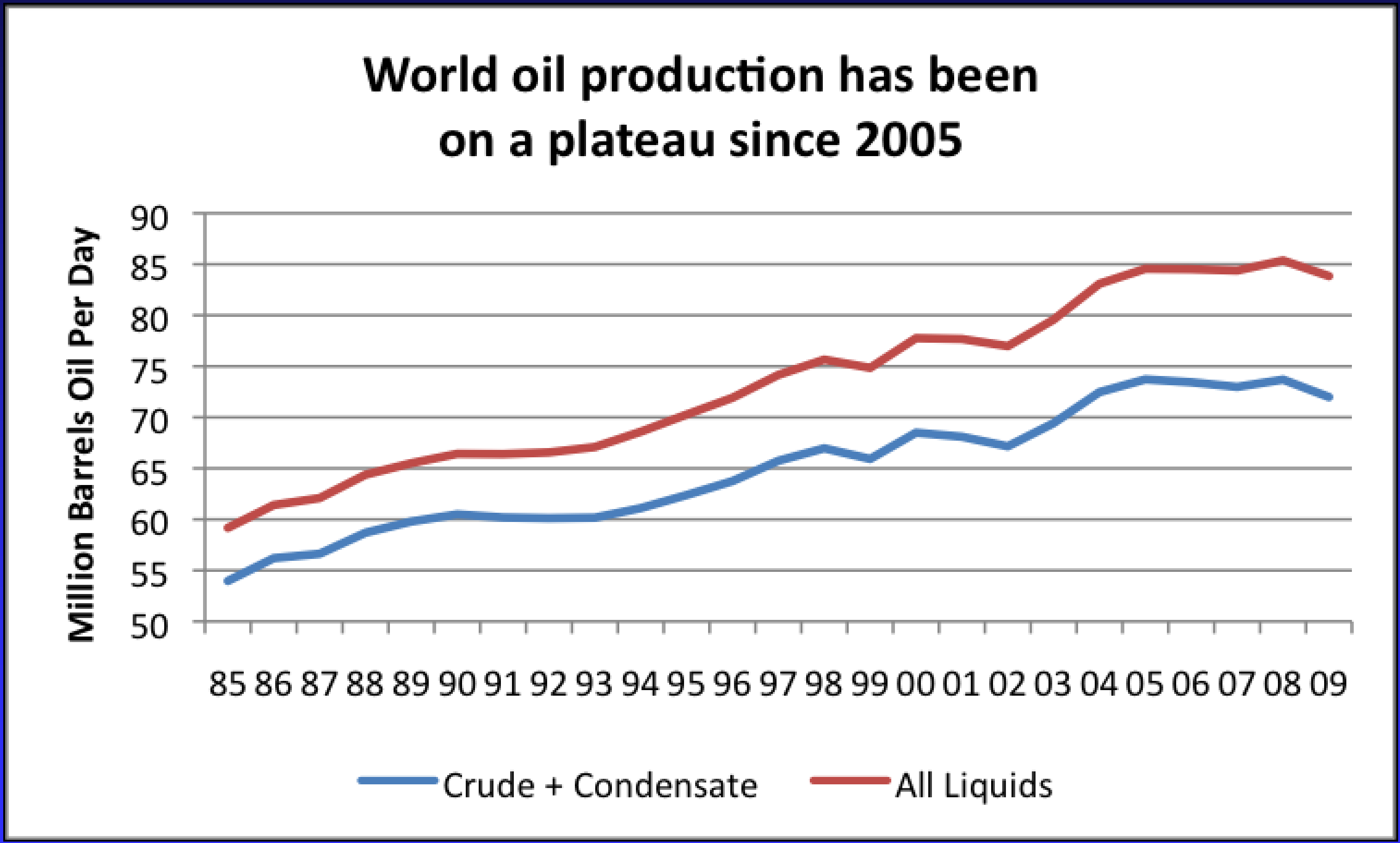


Gold production



www.gold.org

World oil production



The Oil Drum

Spent fuel and enrichment tails

Spent fuel pond

UF_6 cylinders

Nuclear fuel accessories

Gas centrifuges

Mixed oxide
flask (MOX)