Transition to RE – can it be made in time?

Bob Lloyd Otago University, Physics Dept

April 2010

Structure of the talk

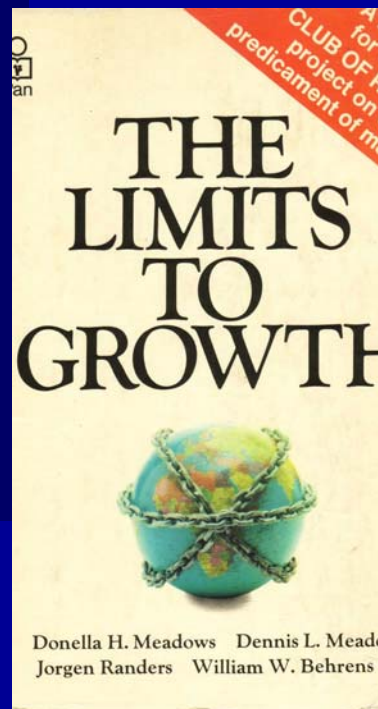
- Energy and society
- Fossil fuels: these will run out
- Possible replacements: nuclear,
- Renewables – biomass, wind, solar,
- World model for silicon pv transition
- Growth as the problem

Why the transition is needed ?

- Existing sources of energy such as fossil fuels and uranium are finite and so will eventually be depleted.
- If we want sustainable energy, the energy MUST come from renewable sources
- Our existing financial system is based upon continued economic growth
- And economic growth is based on a cheap and expanding energy supply

Hubbert on growth

- King Hubbert realised in 1949 that we needed to move from fossil fuels to renewable resources if mankind was to keep its high energy use intact and the population and our consumption etc
- It was perfectly evident then
- More so in the 1970s when “The Limits to growth” came out



SCIENCE

FEBRUARY 4, 1949

ENERGY FROM FOSSIL FUELS
M. KING HUBBERT

MICROCOMPOSITION OF BIOLOGICAL TISSUE ANALYZED BY INDUCED RADIOACTIVITY
CORNELIUS A. TOBIAS AND RAYBURN W. DUNN

TECHNICAL PAPERS

COMMENTS & COMMUNICATIONS

BOOK REVIEWS

ASSOCIATION AFFAIRS

NEWS AND NOTES

COMPLETE TABLE OF CONTENTS ON PAGE 3

VOLUME 109, NUMBER 2823

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Future scenarios in the original 1949 Hubbert paper

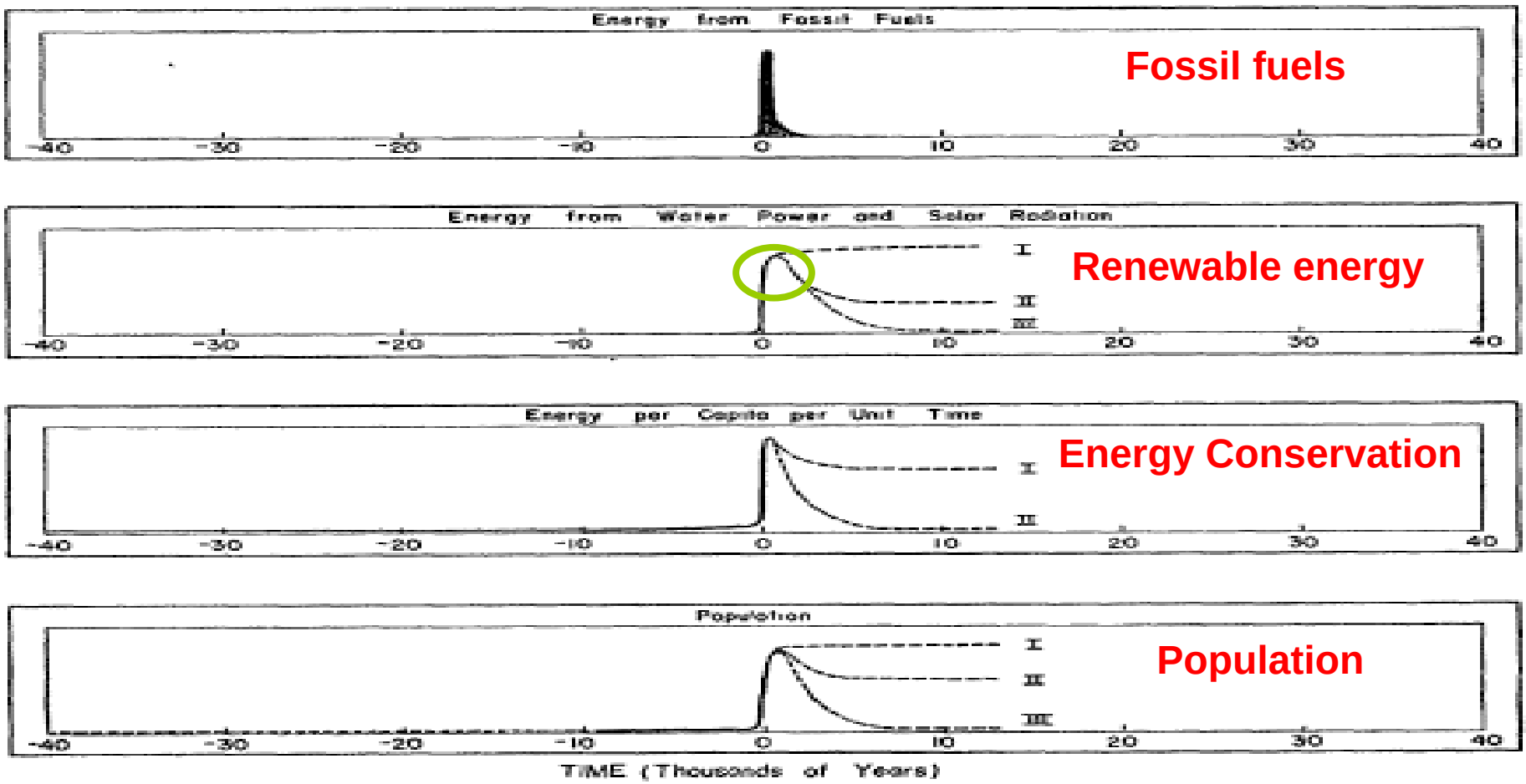


FIG. 8. Human affairs in time perspective.

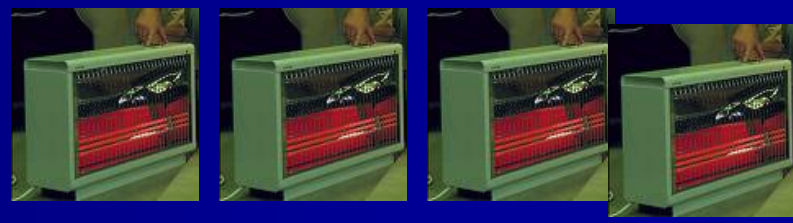
Energy and Civilisation

Every one agrees that energy is essential for civilisation

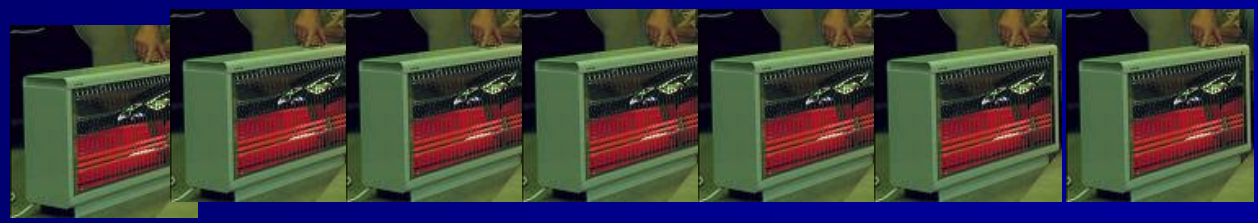
Pre industrial society used energy at around 500 Watts per capita

NZ now uses energy at around

8 kW per capita

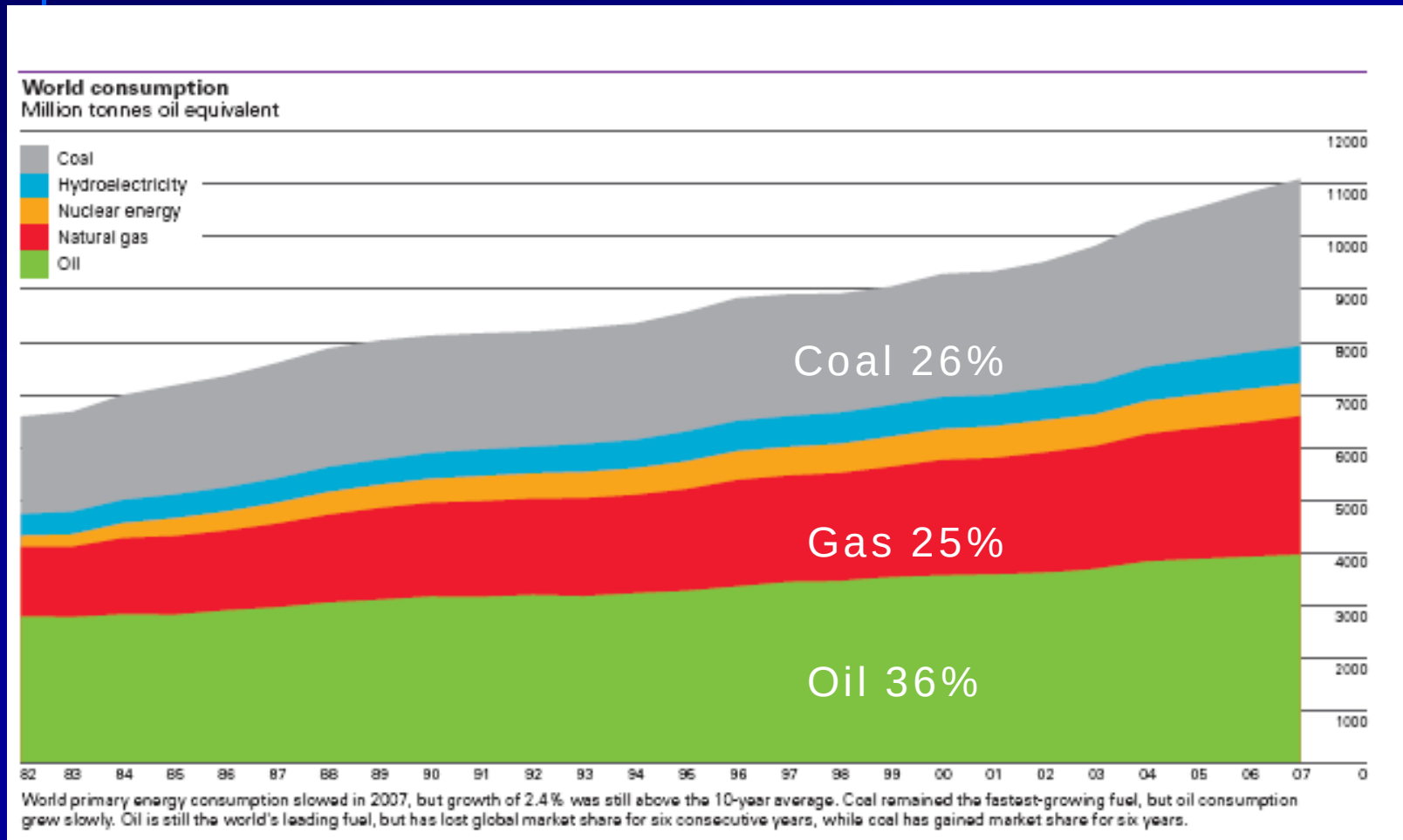


USA at around 14 kW per capita



The world average is around 2.4 kW per capita

This energy is mostly (87%) supplied by fossil fuels OIL GAS and COAL

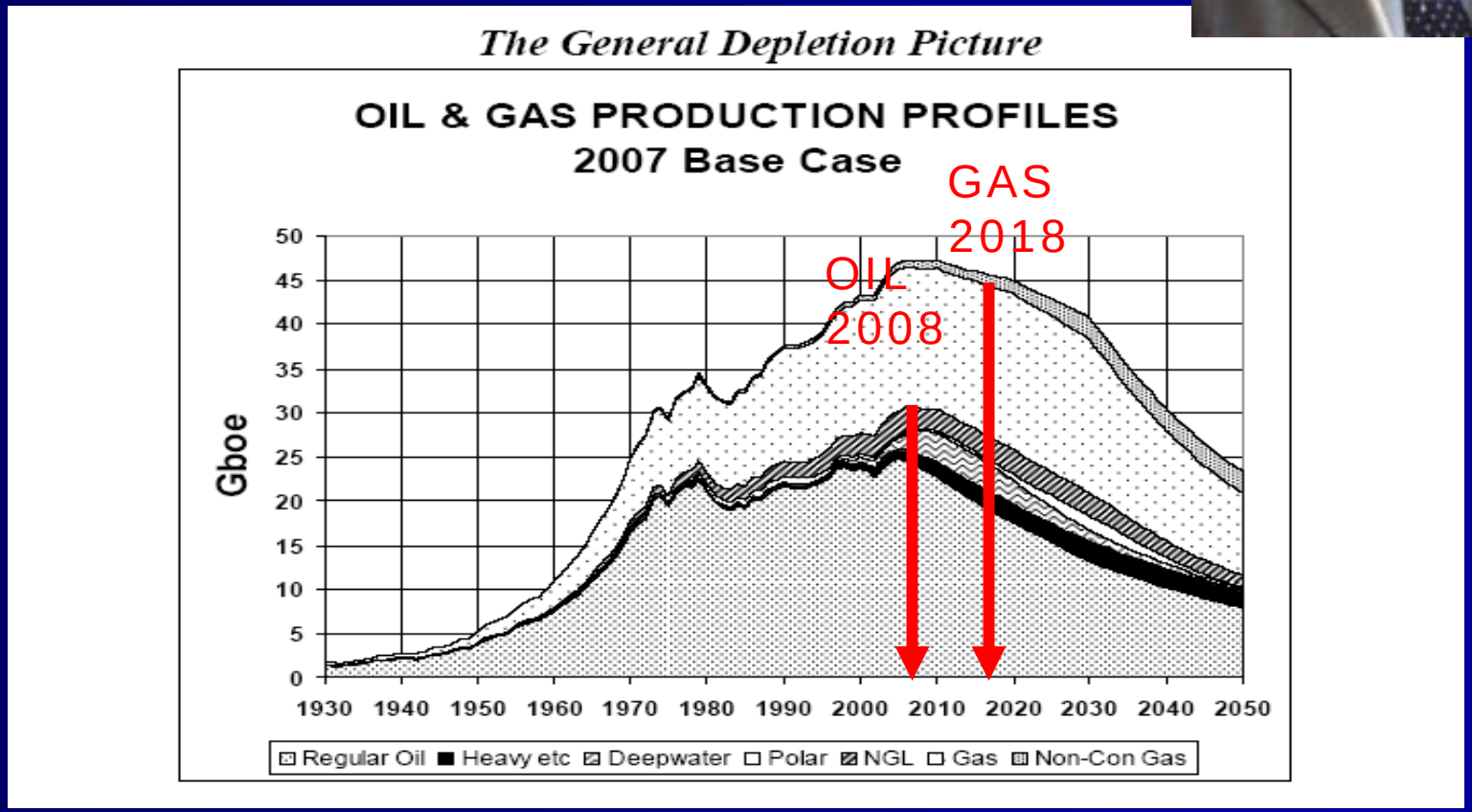


William Catton (Overshoot)

- Catton has suggested that present human society are detritovores using the detritus of previous biological life (fossil fuels)

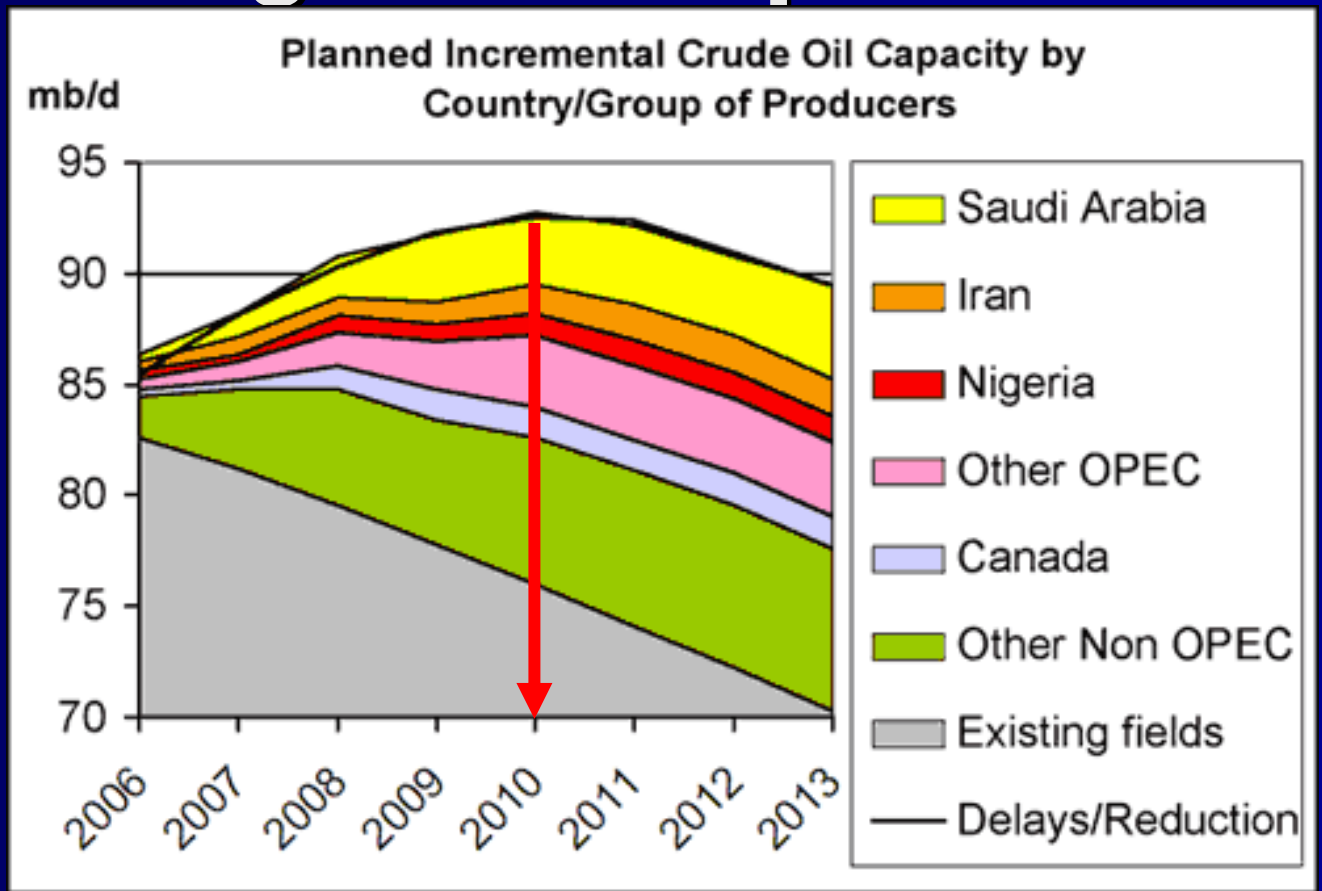
Lets look at the fossil fuels in turn

OIL - Colin Campbell's latest scenario puts peak oil (all liquids) at 2008: GAS a decade later in 2018

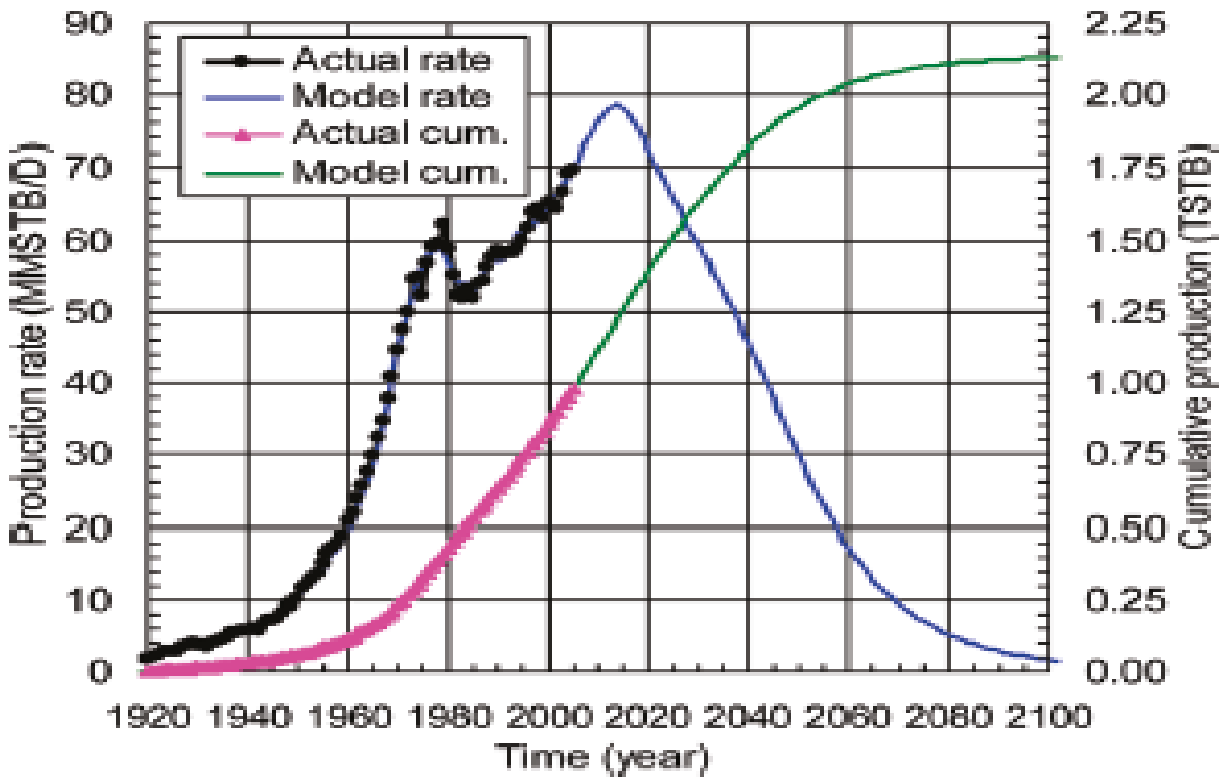


Colin's EUR for conventional oil = 1.9T bbls All liquids 2.5T bbls

Petroleum Review April 2006 includes mega projects in the pipeline gives the peak at 2010



Recent (Dec 2009) Kuwait study - 2014



Latest from EIA -March 2010 oil supplies could decline from 2012

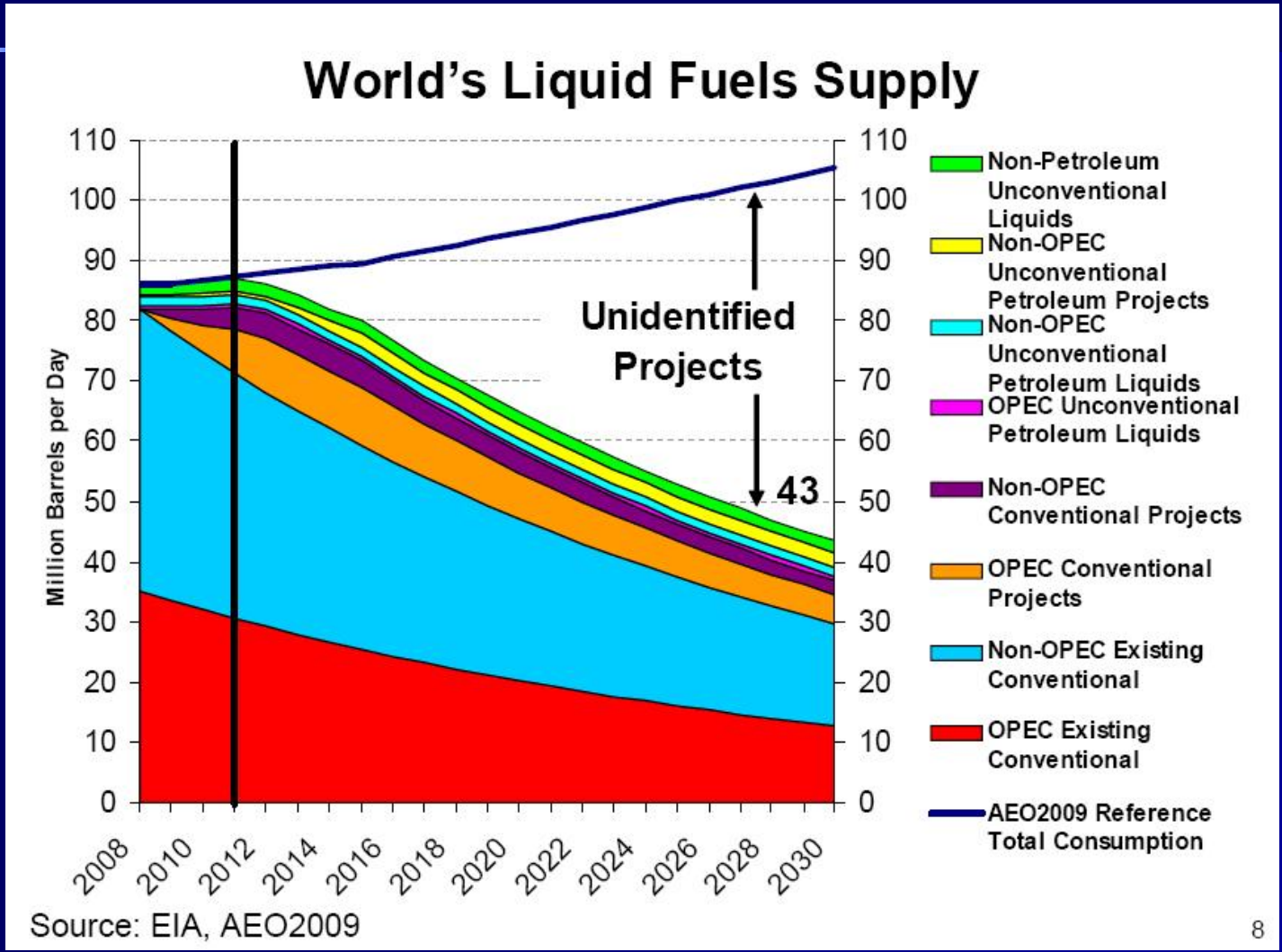
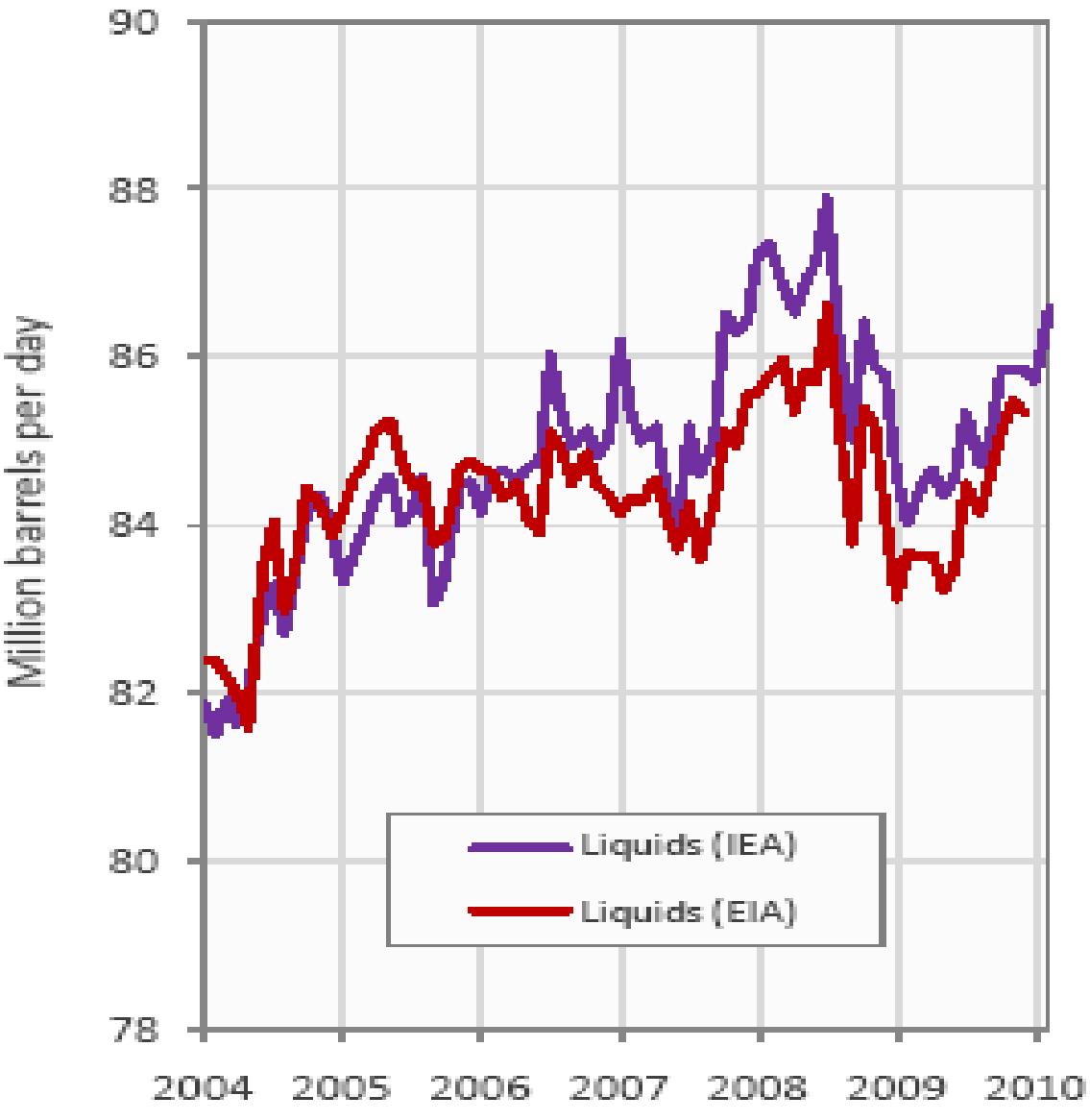


Chart 2: Liquids Production January 2004 - February 2010

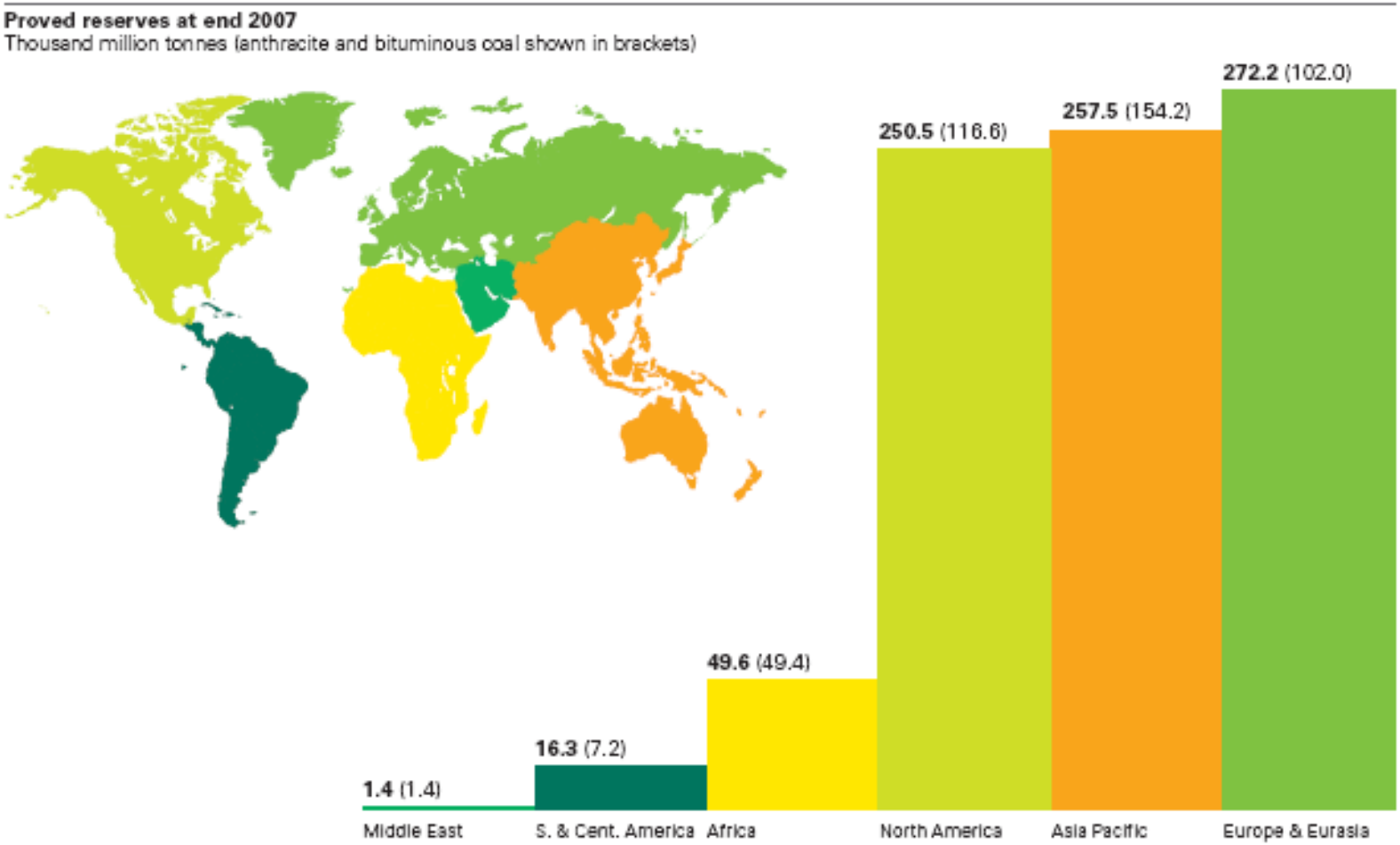


What about coal?

There must be lots of coal everyone says so !

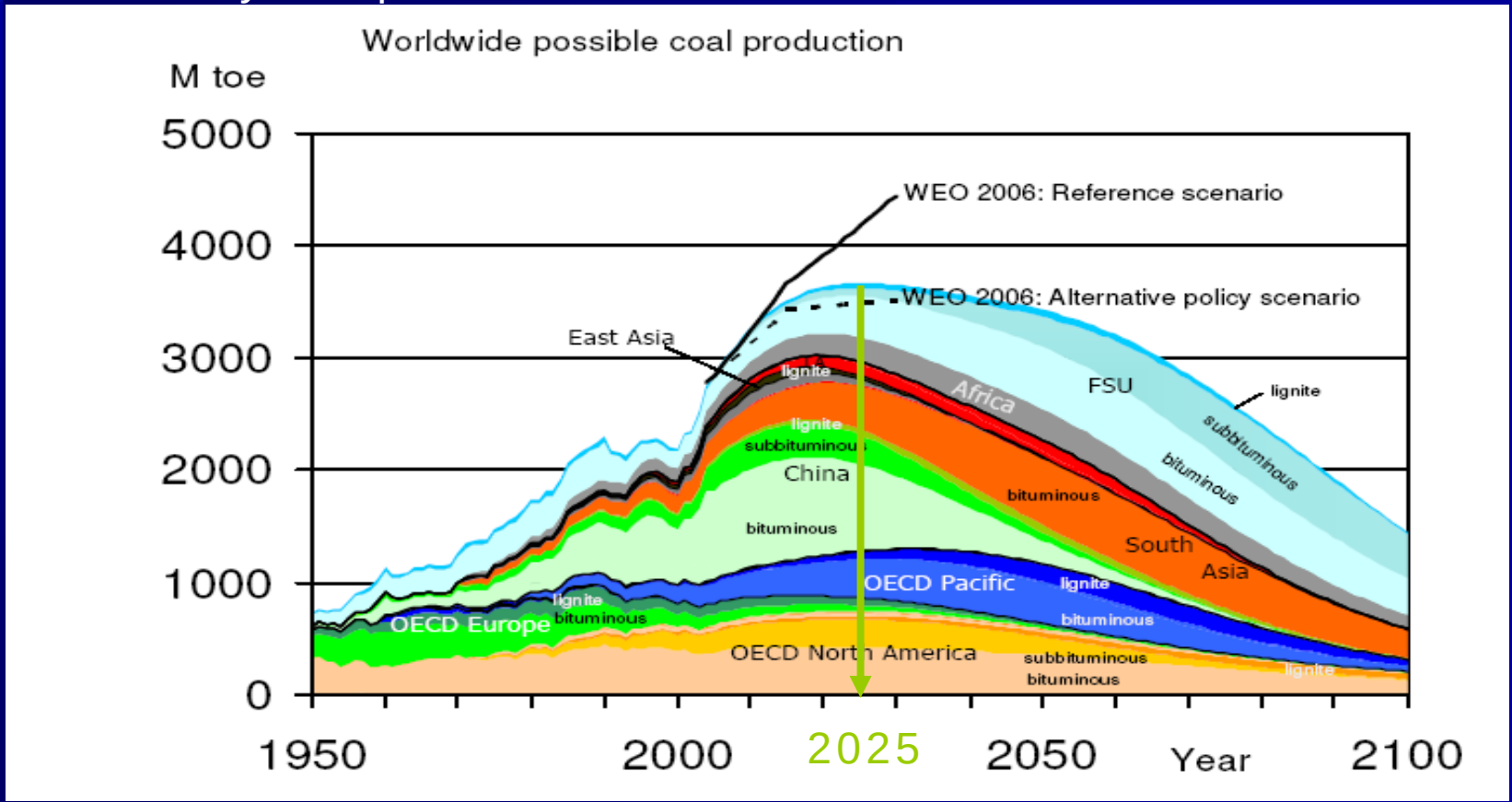
Proved coal reserves at end 2007

Total 847 billion tonnes



But coal reserve data is old and dated

A similar analysis to peak oil analysis was carried out by the German “Energy Watch Group” and they found peak coal could come as early as 2025 :albeit with a relatively flat plateau



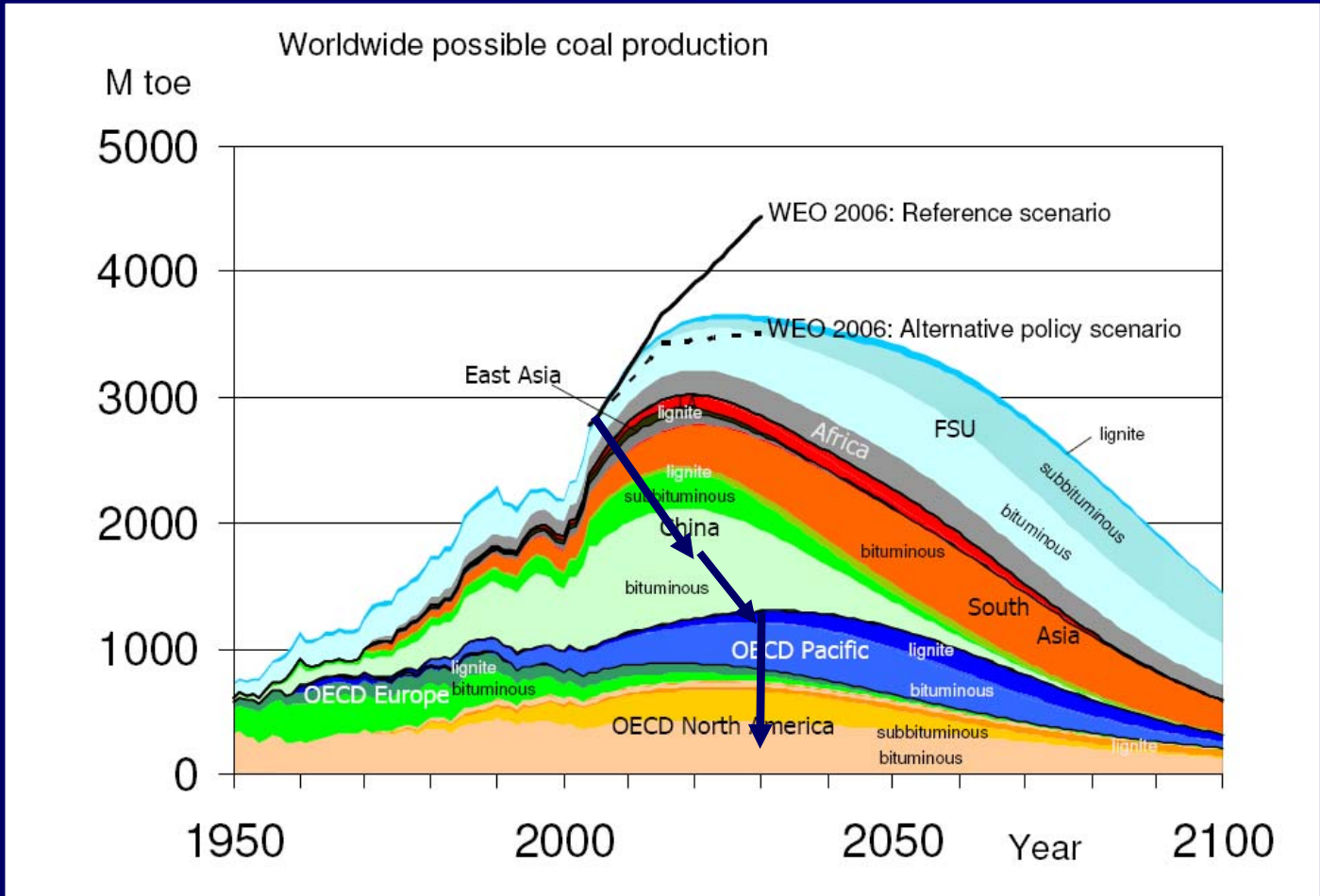
BUT Climate change

- We are coming to the realisation that we will not be able to rely on coal as a substitute energy source due to CO_2 emissions
- And that climate change will produce devastating climatic, ecological and economic consequences (Stern, Hanson, IPCC)

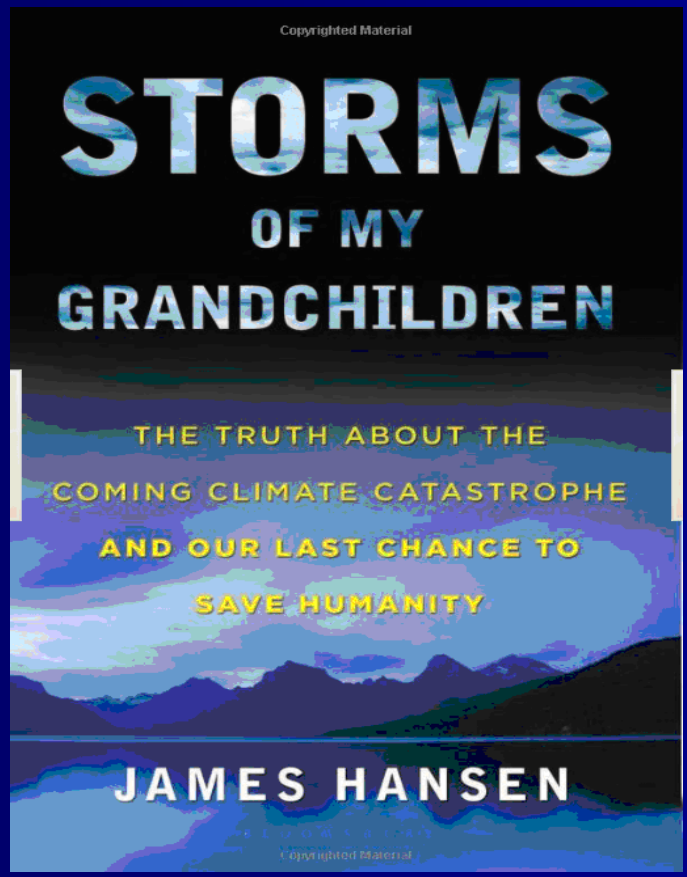
Jim Hanson's suggested strategy to avoid serious problems (To G8 2008)

- Developed nations to phase out all coal use by 2020 (except where CO_2 is captured)
- Developing countries to do same by 2030
- Only then CO_2 can be limited to 400-425 ppm
- Otherwise!!

If Jim Hanson's scenario is followed ie rich countries stop all coal fired power stations by 2020 and all countries by 2030



Read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THE TRUTH ABOUT THE
COMING CLIMATE CATASTROPHE
AND OUR LAST CHANCE TO
SAVE HUMANITY
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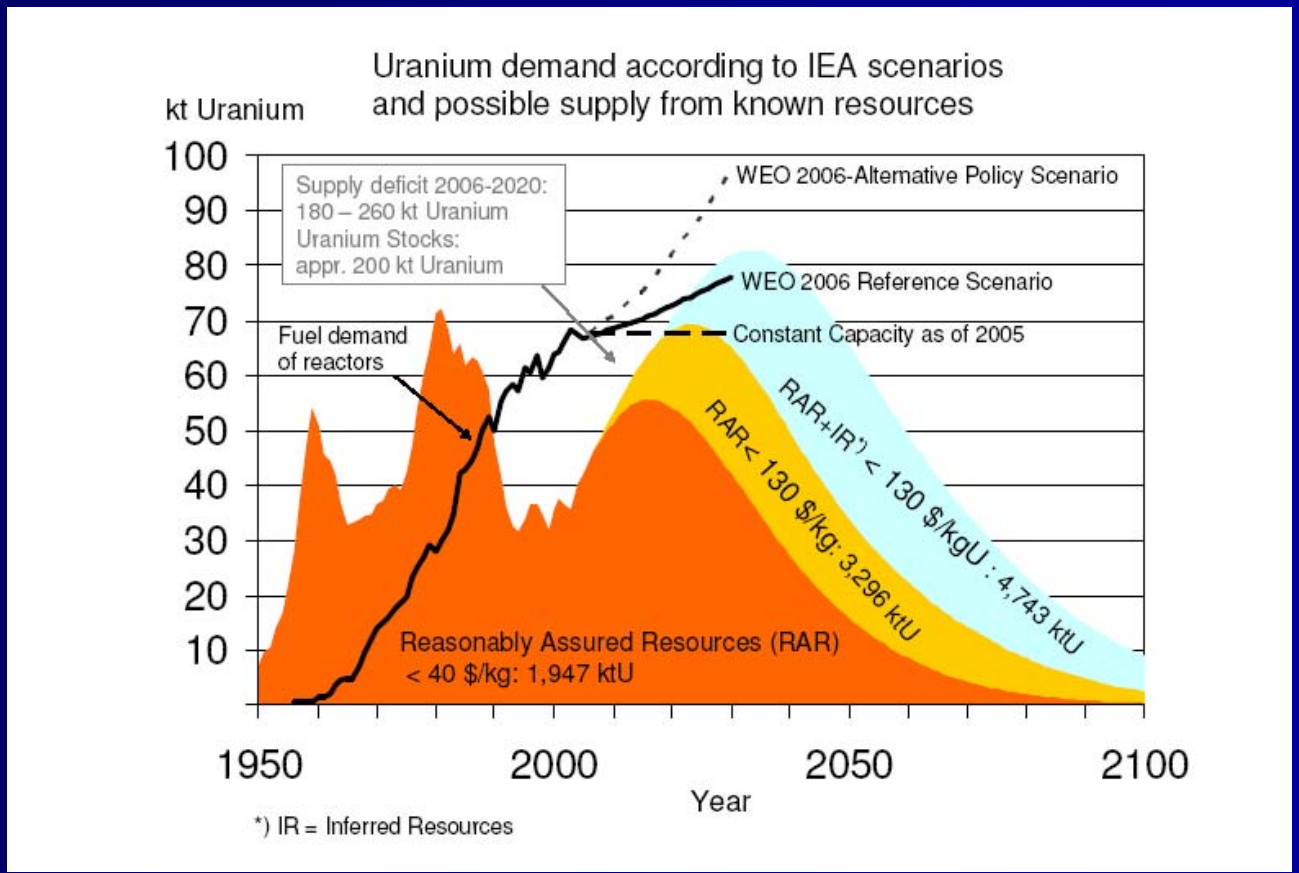
Finally Nuclear
How much Uranium?
(Presently 6 % of world energy supply from around 450 reactors)

Again an analysis by Energy Watch using IEA data



Can Renewables save us ?

Wind

Solar

Biomass

Marine

Energy Returned On Energy Invested

Technology	EROEI
Coal (mine mouth)	80:1 -- 30:1
Oil/Gas	100:1 -- 12:1
Oil world avg (2008)	35:1
Oil tar sands	4:1 – 2:1
Nuclear	15:1 (wide variation)
Hydro	100:1
Wind	18:1
Solar PV	20:1 -- 6:1
Biofuels	3:1 -- 0.8:1

Ref C Hall et al 2008

Can Biomass/Biofuels fill the gap?

Green Energy biomass power station in West Fife, Scotland.

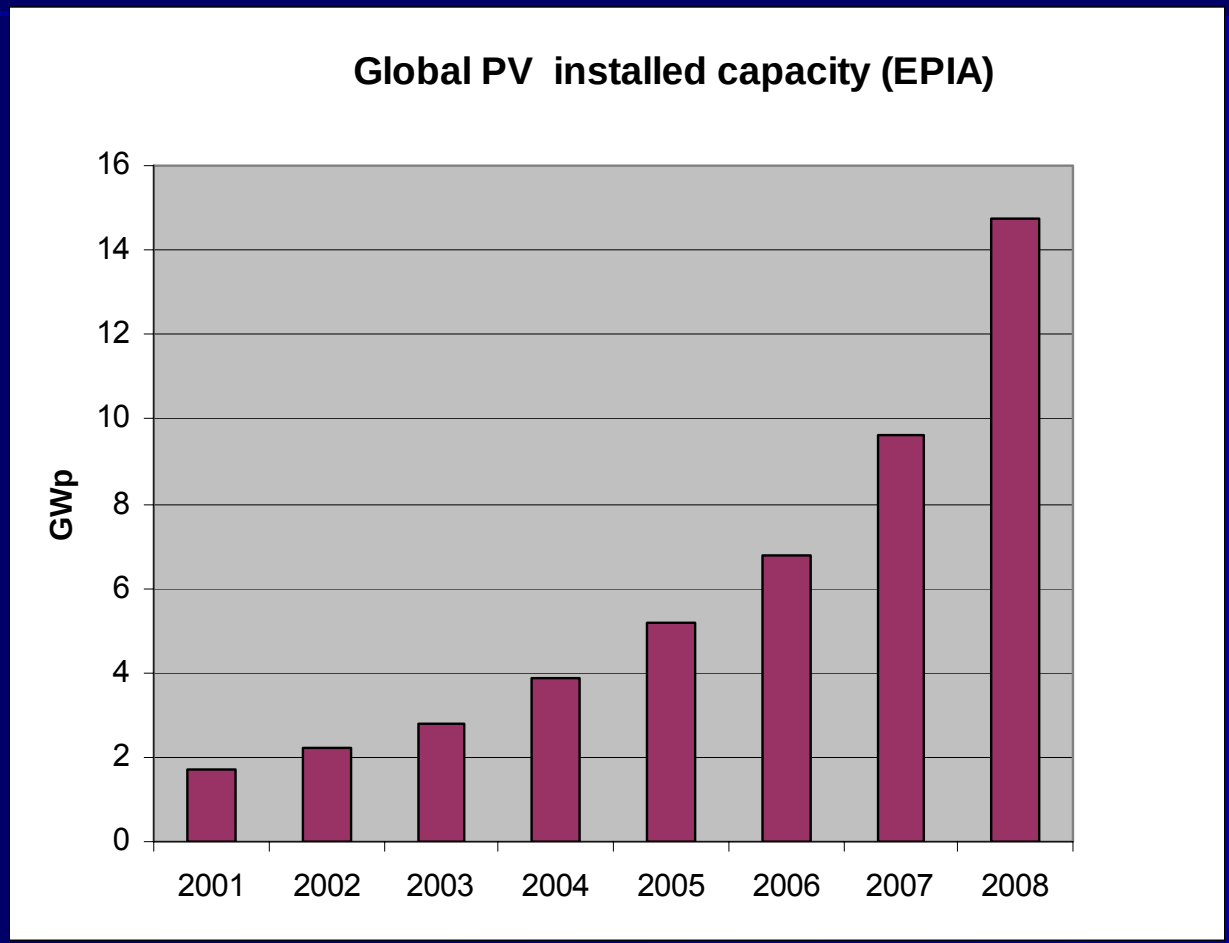
Can Biomass/Biofuels fill the gap?

Energy Source	Billion Tonnes of oil equivalent /annum (BTOE)
Coal	3.0 (2007)
Oil	4.4 (2007)
Gas	2.6 (2007)
Total fossil fuels	10 (2007) → 6.5 Carbon
Agriculture	Billion tonnes/annum
Food	5 (2004) (= 1 BTOE)
Wood (fuelwood)	1.6 (2006)
Wood (forestry output)	3.4 (2006)
Total agriculture/forestry	10 (= 3.4 BTOE)

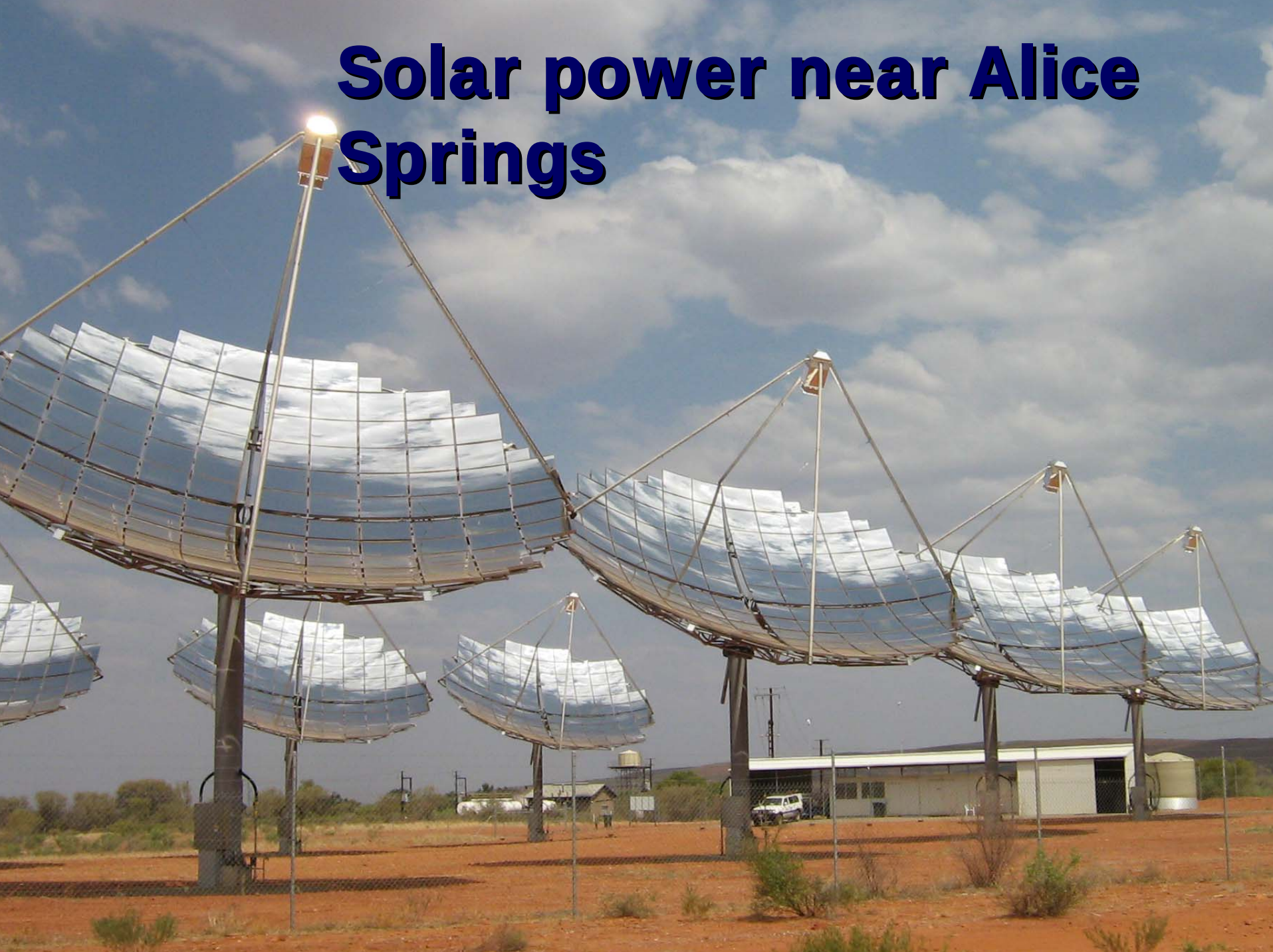
Thus we are left with wind and solar: but we need energy to make the energy converters

- Crystalline silicon PV has an energy payback time of around 2 years (EROEI of around 10)
- Plus storage and transmission --another 2 years
- That means that in the next 20 years we would have to spend 20% of current energy consumption PER ANNUM to produce RE systems to end up with 100% RE by 2030 or half this amount (10%) to end up with 50% RE
- If we allow growth at 3 % PA !!!

PV What a growth curve! doubling every 2 years !



Solar power near Alice Springs



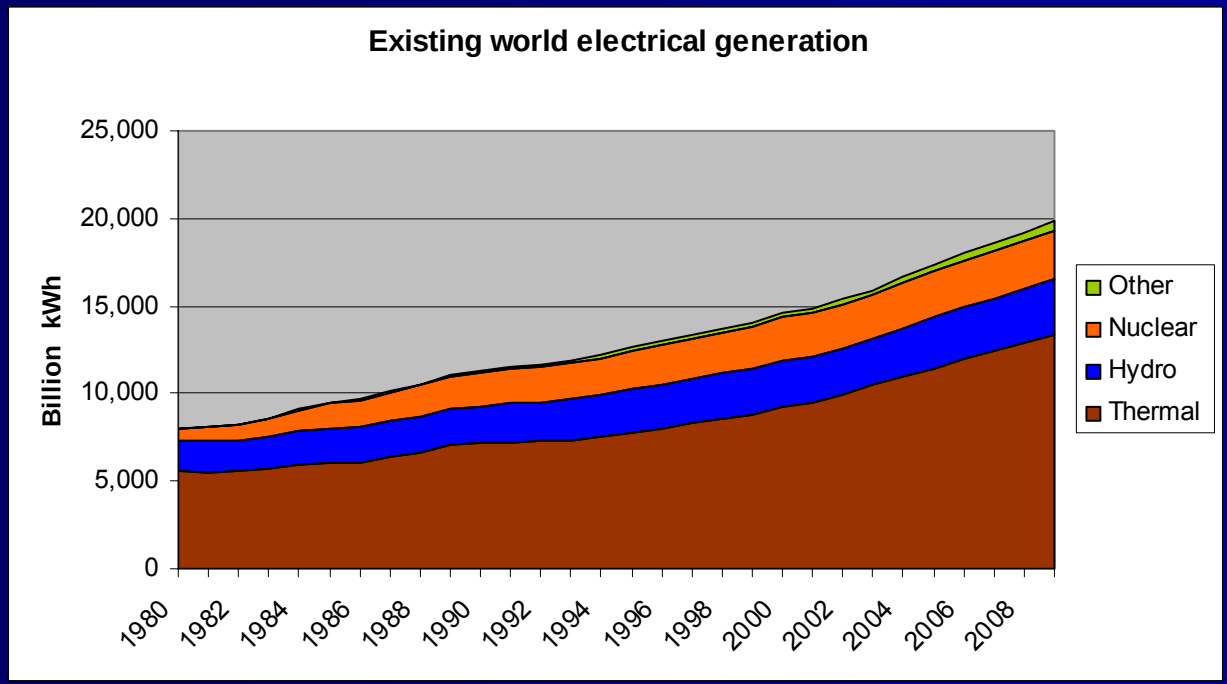
Existing (2009) Large Scale PV

- 60 MW Spain Olmedilla
- 50 MW Spain Puertollano
- 46 MW Portugal Marelaja
- 40 MW Germany Waldpolenz

World energy supply 10 billion toe of fossil fuel plus around 1 billion toe of other sources (mainly nuclear, hydro and biomass)

- 2/3 of this 11 billion toe goes to other uses including transport, industry buildings etc
- 1/3 goes to make electricity

Existing world electricity supply - around 5000 GW installed capacity of which renewables and nuclear account for 1000 Gw



PV transition model for world electricity supply

- Pessimistic and Optimistic embodied energy parameters for arrays ranging from 7000 MJ/m^2 to 1750 MJ/m^2
- Solar radiation either 1000 kWh/m^2/year or 1700 kWh/m^2/year
- Mineral resources needed cf world resources
- Costs ranging from $1/W to $4/W installed
- Limits of 10% of world electricity, flags % of resources
- Land area limit of 1% of world land area or 1.5 million km^2 cf area NZ 270,000 km^2
- Electricity growth rates ranging from BAU (2.4% pa) through steady state to collapse situations

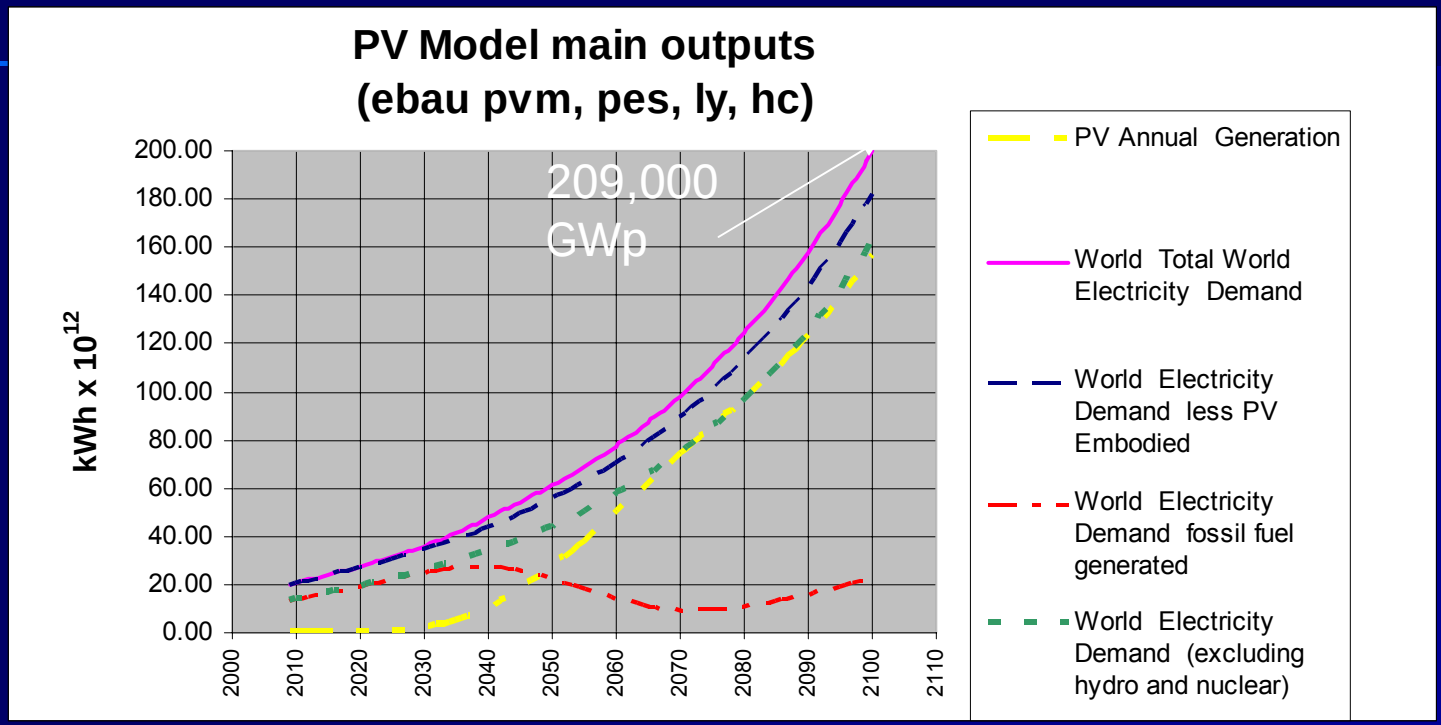
Resource requirements for PV arrays

Mineral	Aluminium	EVA	Water	Glass	Copper
Kg/m^2	3.66	1.0	21.2	10.0	1.11
Mineral	Silver	Lead	Steel	Nickel	Concrete
Kg/m^2	0.52	0.0031	1- 20	0.00016	0-240

Scenarios investigated

- BAU 2.4% electricity demand growth - -note historical demand growth has ben 3.2% pa
- Reduced growth rate 1% after 2050
- Peak Oil collapse
- Peak Oil fast track pv
- Climate change can the transition be met by 2030 ?
- No provision for storage or transmission , however!!

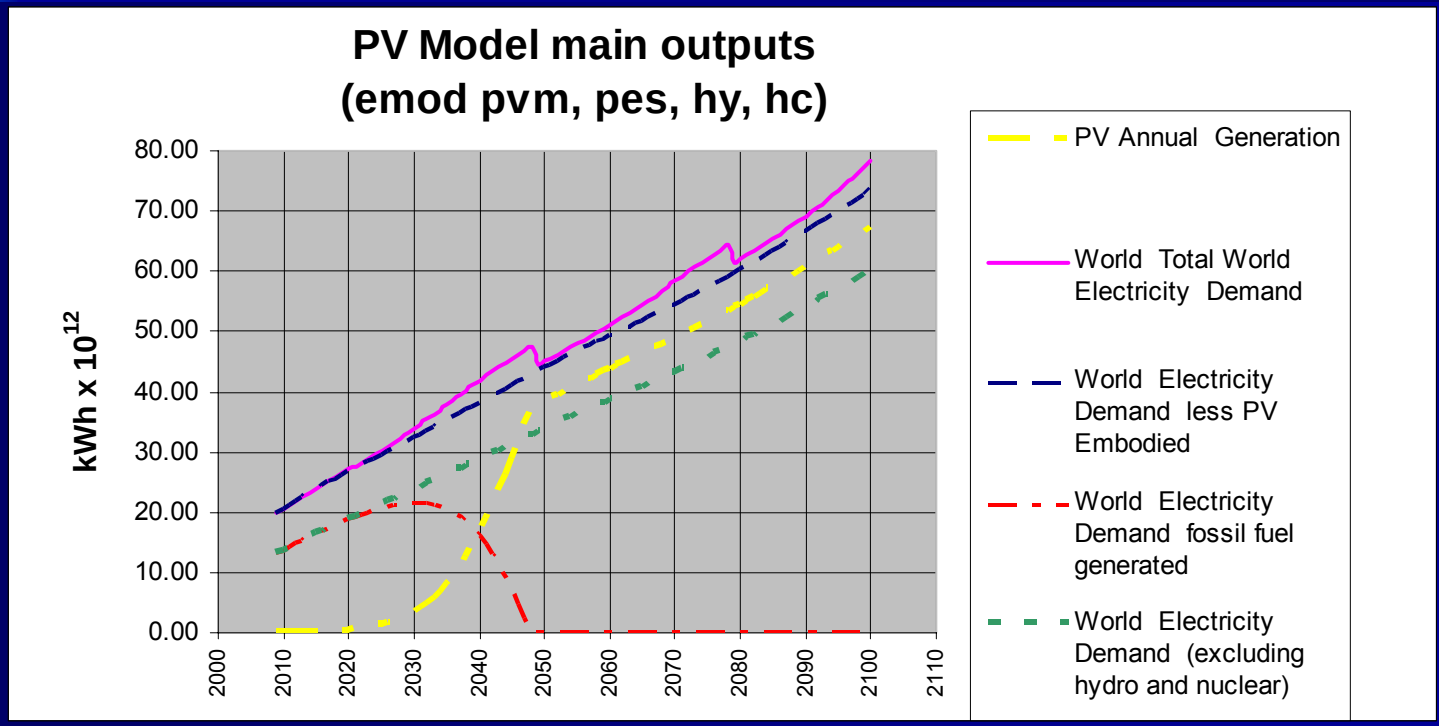
BAU 2.4% annual growth



The material constraints for BAU growth are very severe with silver demand for panel production reaching 10% of annual world demand by as early as 2012, Aluminum by 2025, Copper by 2027 and steel by 2037.

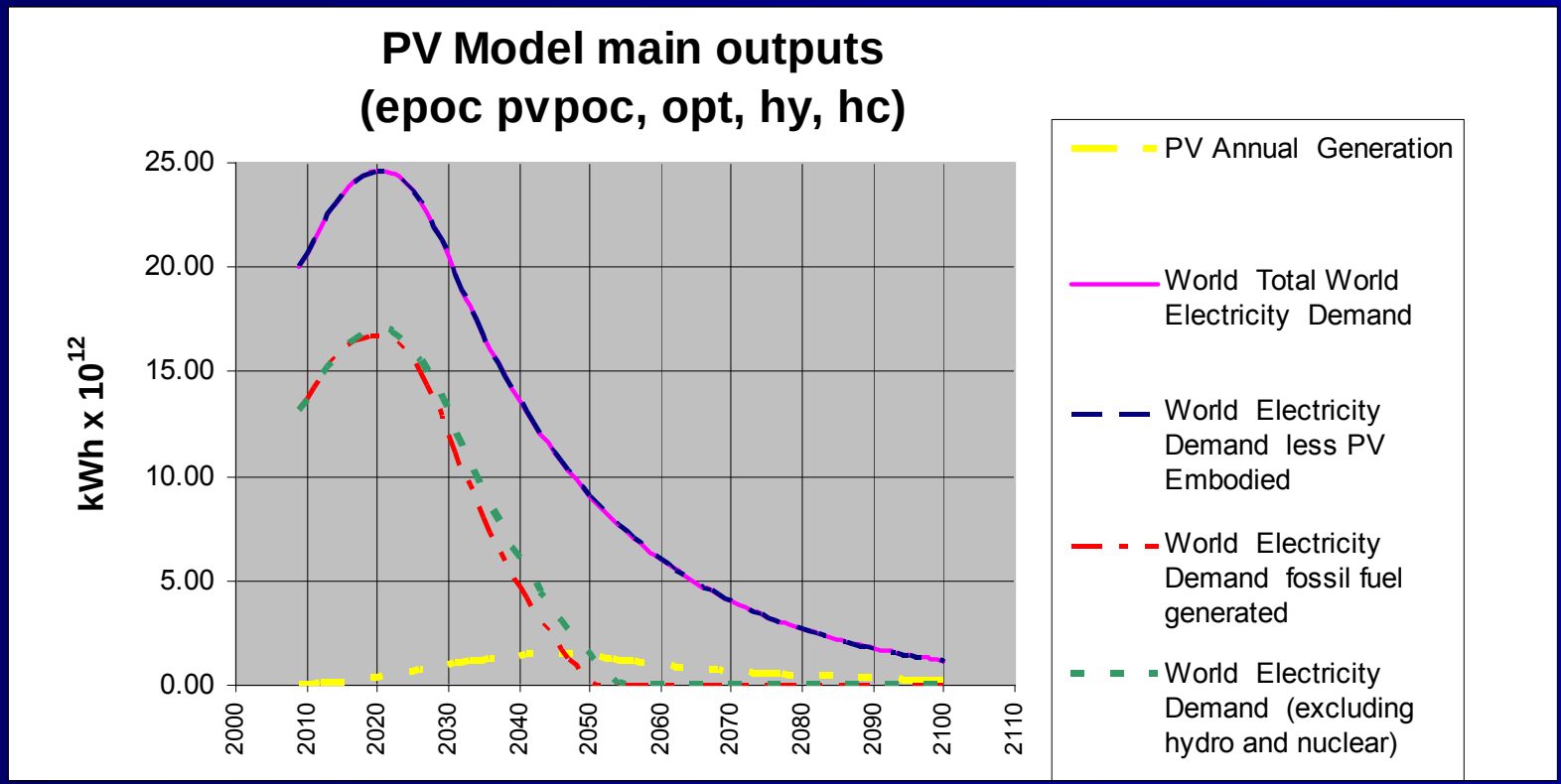
1.5 million km^2 would need to be covered by arrays 6 x NZ

Moderate growth in demand 1% pa after 2050

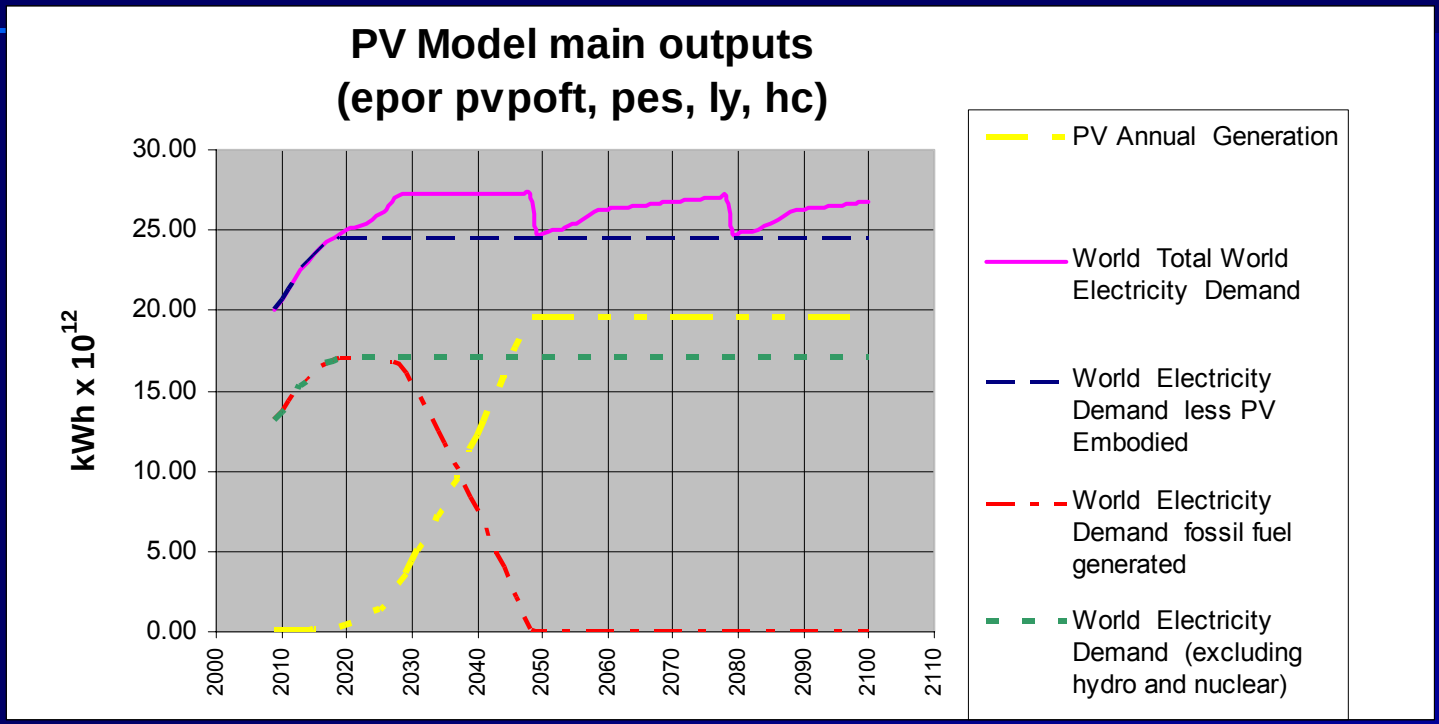


PV able to provide 100% of world demand by 2045- 2055
Between 86,000 GWp and 51,000 GWp of installed PV capacity being needed by 2100 The need for copper would reach 10% of world 2008 production by 2029 and steel by 2042

Peak Oil Collapse

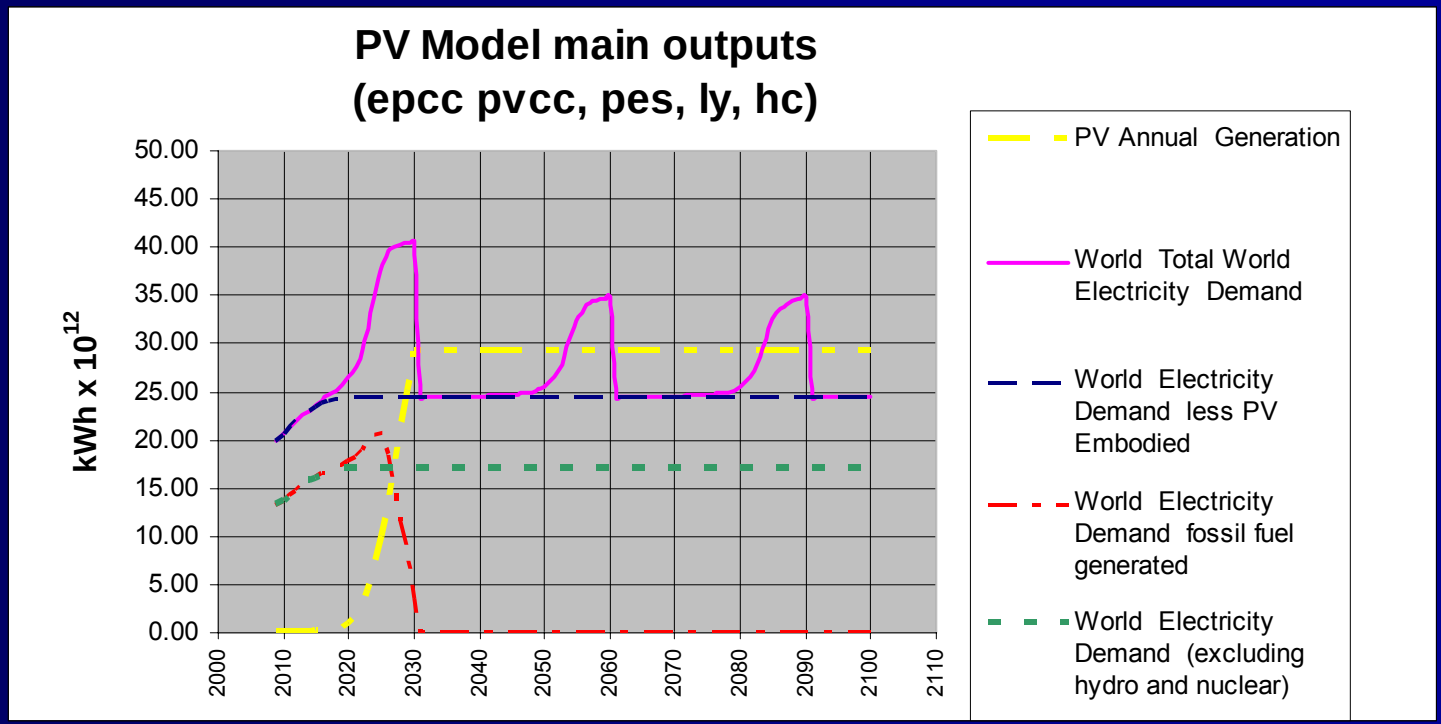


Peak oil steady state



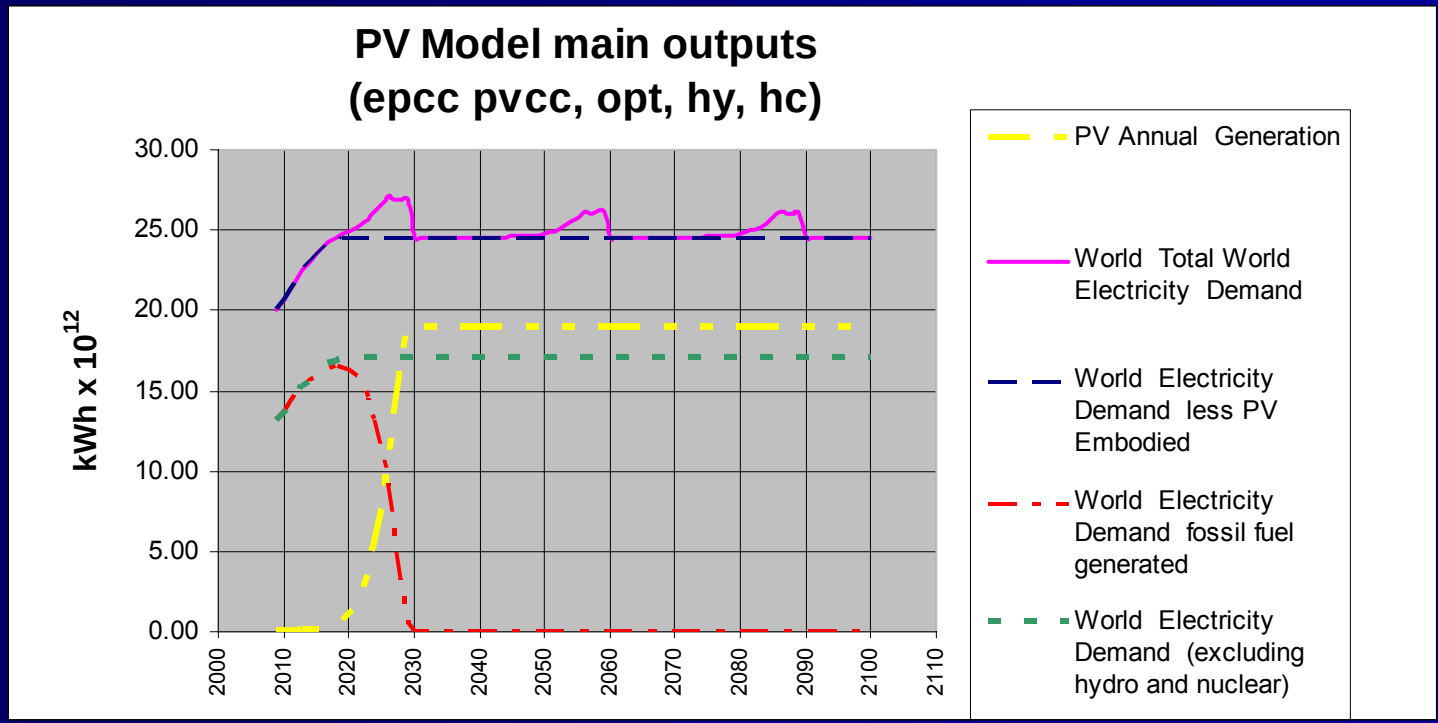
Fossil fuels could be eliminated by 2035 with PV installed capacity stabilizing at close to 14,000 GWp. This capacity would take up around 5% of the allowed land area or 68,000km^2 (Ireland) . In this case copper would not reach 10% of world (2008) demand until 2086 BUT see later for copper

Climate change pessimistic array parameters – can we make the 2030 deadline



Not really: Energy needs for PV construction would reach 60% of world capacity costing 30% of world GDP

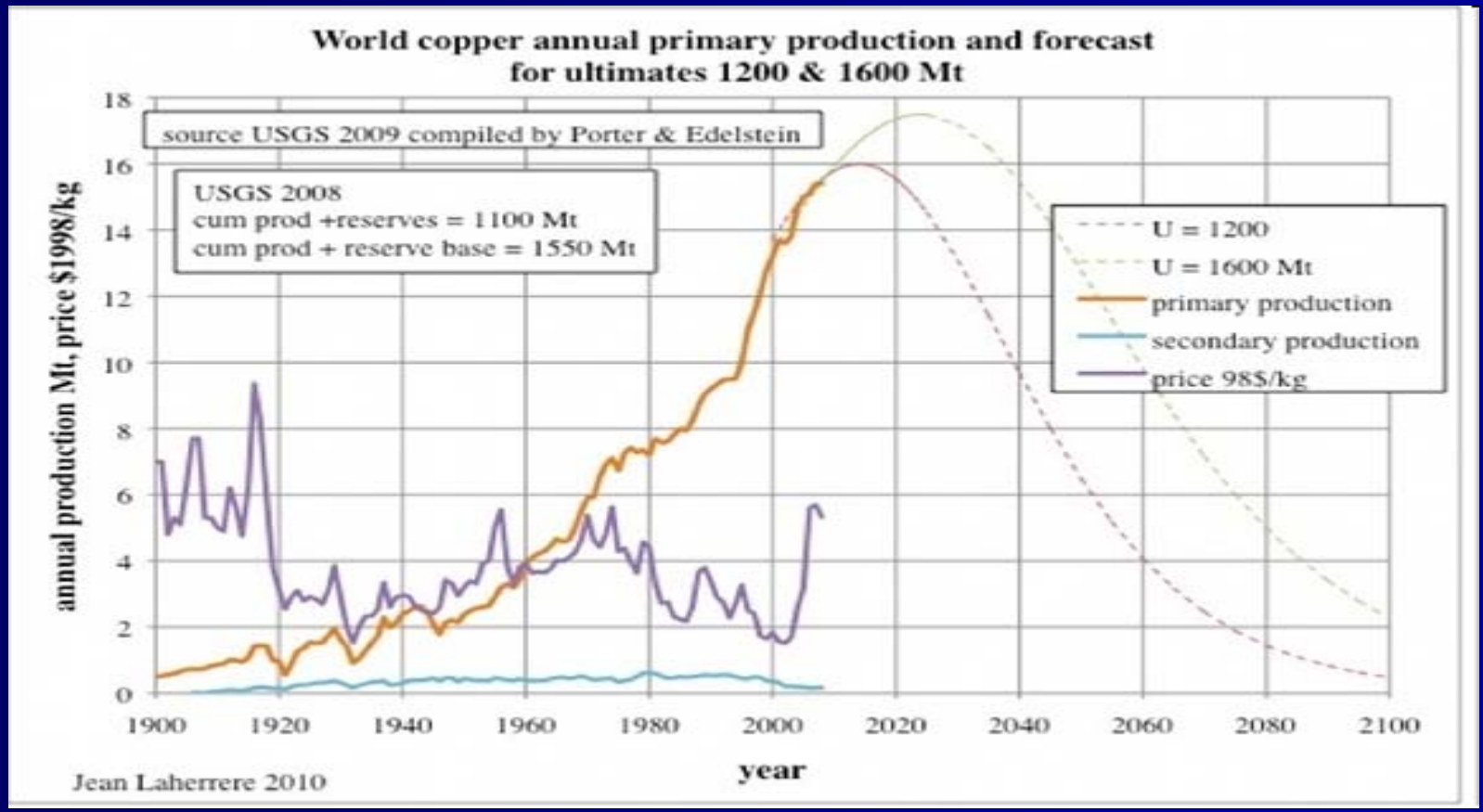
Climate Change optimistic array parameters, high yield locations



Can be done for around 10% of electricity production to make panels and costing between 6.5% and 13% of world GDP

Peak Copper!

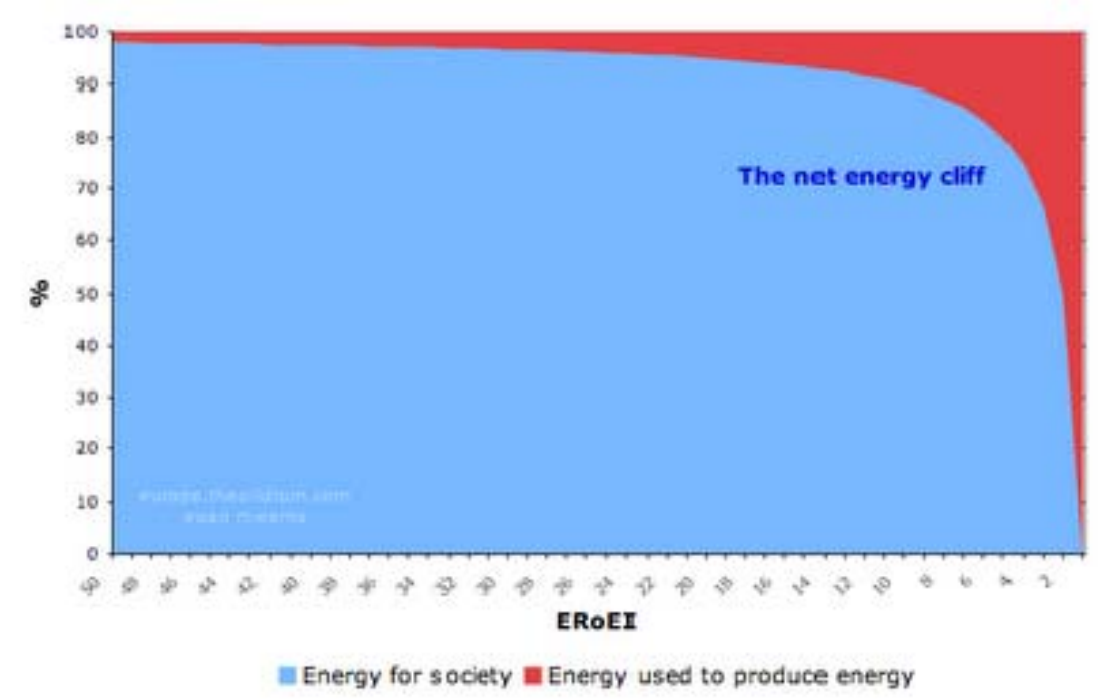
by Jean Laherrere: March 31 2010



Post in the Oil Drum

Net energy cliff

The difficulty will be that as we go down the renewable energy transition path we will have to cope with deteriorating embodied energy for all of the fossil fuels, plus climate change and the associated economic turmoil

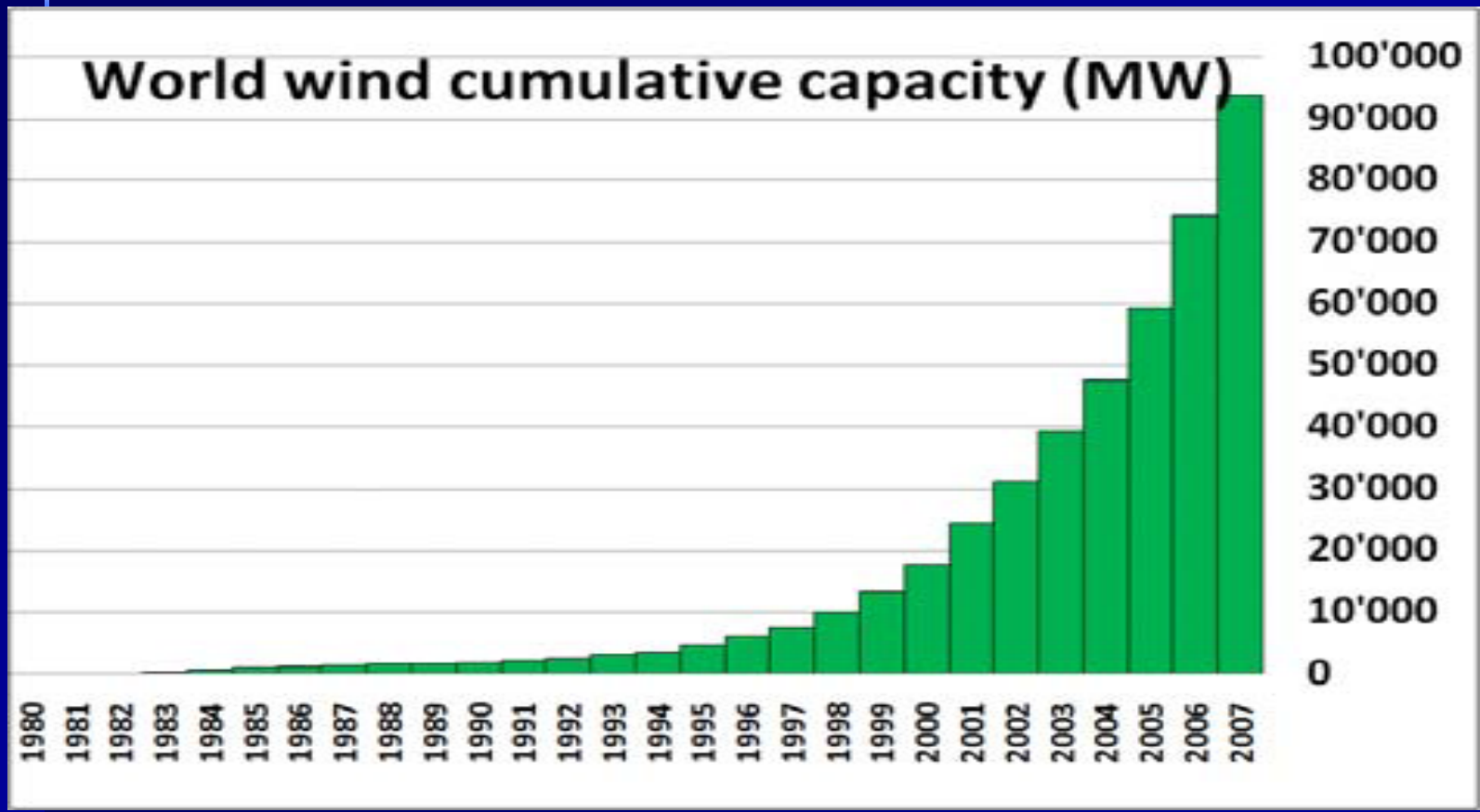


Kurt Cobb

What about wind energy

- Similar embodied energy would be required as for PV . Other resources?
- In terms of Wind Power: between one and five million wind turbines in the 5-MW range will be needed to convert the world electrical power system towards renewables needing around 2 million km^2

Success story wind doubling every 3 years can it keep this pace up?

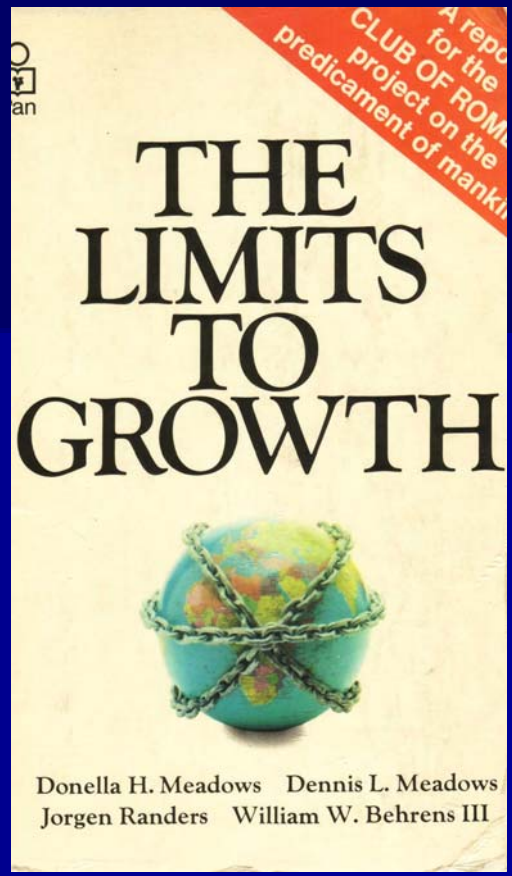


Conclusions from the model

- The transition to renewables of our present world electricity supply is technically feasible
- It would require considerable resources including around 10% of world electricity supply to make the devices and around 10% of world GDP
- Material constraints would eventually prevail, however, if we want growth beyond the middle of this century

Dennis Meadows

- Thirty-five years after he co-wrote the landmark study, Limits to Growth, Dennis Meadows told ASPO-5 that almost all of his original predictions of ecological collapse are coming true. "We have already overshot," Meadows said. "Collapse is not inevitable but it will very tough to avoid."
- He now thinks that his earlier 1972 report may be optimistic re the timing

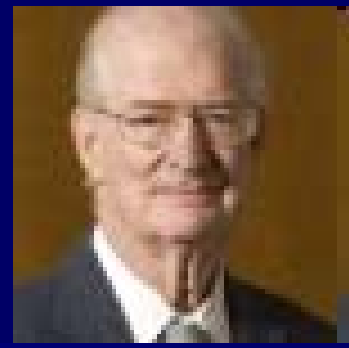


- Meadows also said peak oil is one of a number of limits that mankind is confronting. “Were facing a lot of peaks and oil is just one of them," “We are also drawing down our fertile soils, groundwater, and forest stocks.” Governments, he said, will be overwhelmed trying to deal with them.
- RE cannot save us in time
- Neither can energy efficiency
- Plus we will have Global Warming to contend with

Recently at Davos World Resources Forum Sept 2009

- Climate change, energy scarcity, these things are symptoms. Maybe we could solve them, maybe we won't. But even if we do, it doesn't eliminate the problem. The problem is physical growth, continued population expansion, continued increase in material standards of living, in a world that has finite limits.

Herman Daly



- **What Is a "Green Economy?"**
- A green economy is an economy that imitates green plants as far as possible. March 2010
- So the question is can society change from being detritovores to plants?
- What are the barriers to the transition?

Barriers

- Growth as an axiom (done elsewhere)
- Vested interests
- Politics
- Inertia

Detritus is profitable

- The 800 billion tones of coal in the ground is worth around US$ 40 trillion at US$ 50/tonne
- The remaining 800 billion barrels of oil is worth around US$ 64 trillion at US$80 per barrel.

The political barrier .

- Politicians if they want to get re- elected can never promise their electorate a reduction in living standards -which is interpreted as necessary if a reduction in consumption is required

Social Inertia

- Anti wind movement in NZ
- Consumer society
- Marketing industry
- Third world needs growth
- Others

Questions

MAJOR CRACKS ARE APPEARING IN EVERYTHING

Leunig