The Necessity of CCS

Ron Oxburgh

The 2009 Socio/economic Situation

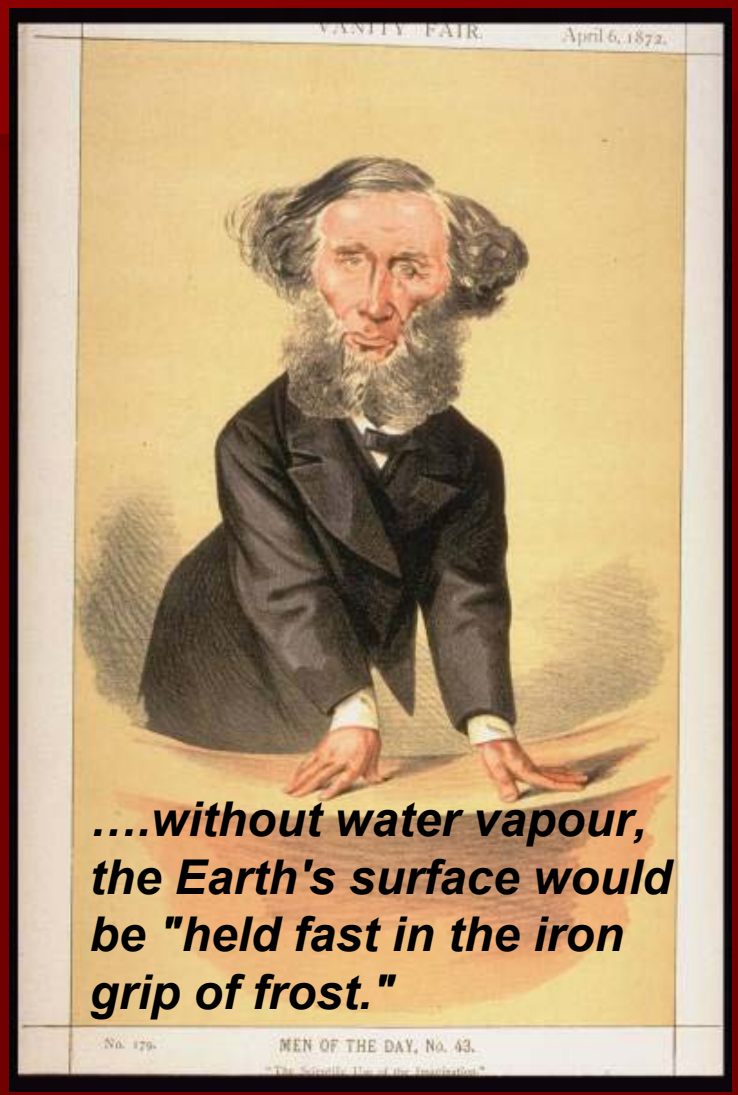
- Global decline in economic activity
  - Everyone feels poor
  - Oil price crash
  - Alternative energy relatively more expensive
  - Decline in energy use & emissions
- But previous imperatives don't vanish
  - Need to continue with fossil fuels for decades
  - Need to tackle emissions
- In reality the slow down is an opportunity to let the technology catch up!

We Know

- The Earth's climate is warming today
- The Earth's climate has warmed and cooled on a number of times in the past without human influence

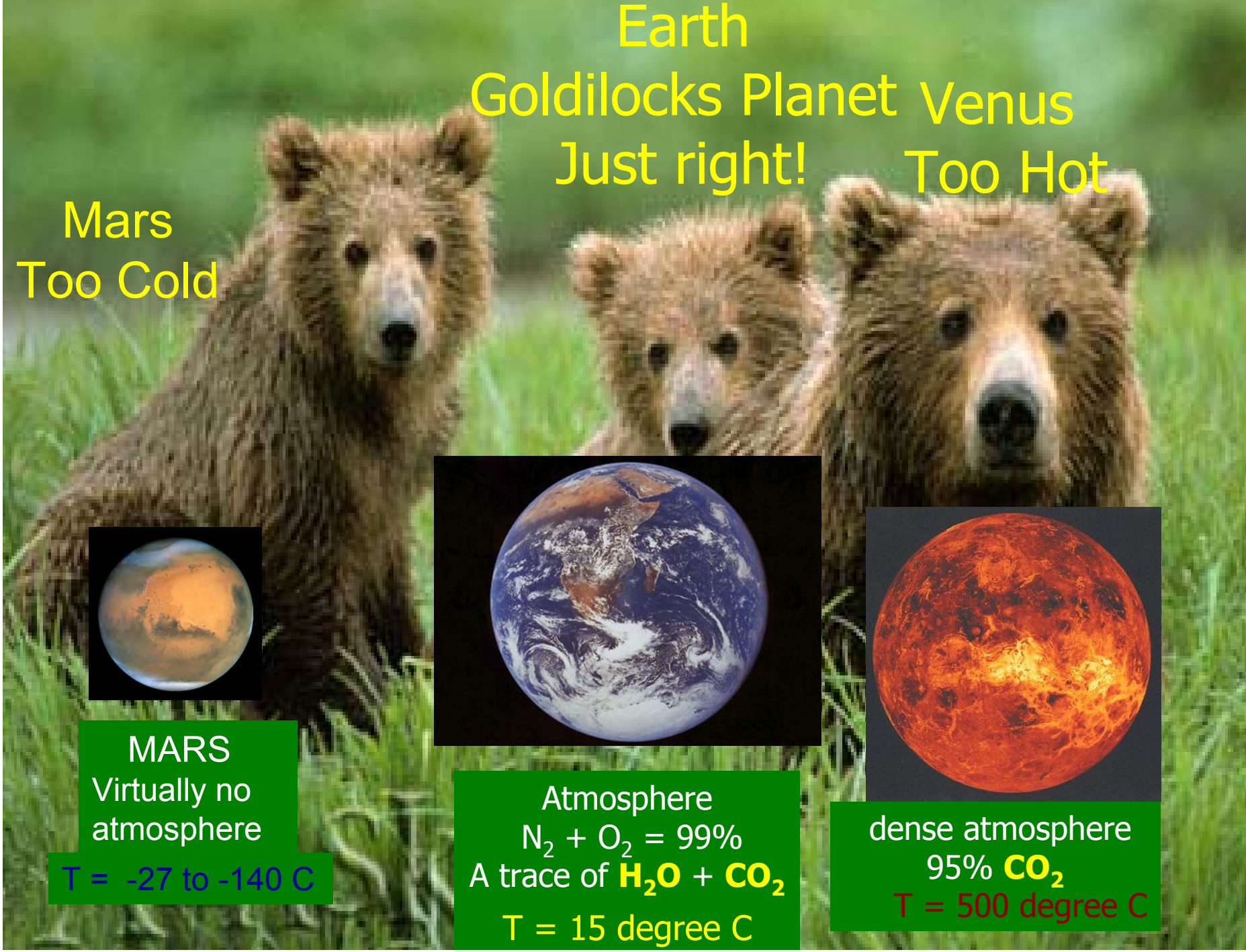
So what's all the fuss about?

John Tyndall (1820 - 93)

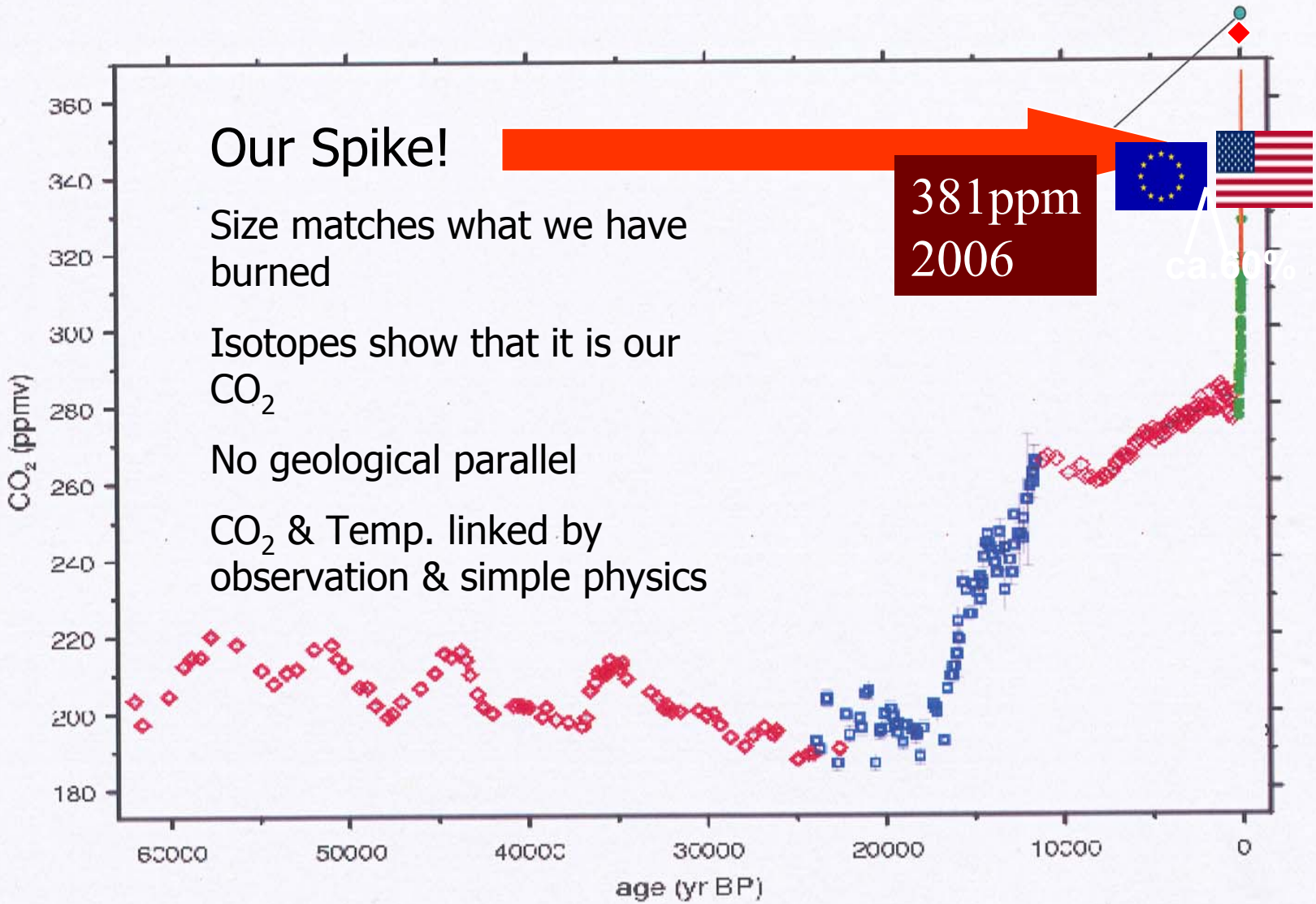


….without water vapour, the Earth's surface would be "held fast in the iron grip of frost."

Experiments at Royal Institution
Absorption of solar radiation by atmospheric gases
H_2O, C O_2 very potent


Earth
Goldilocks Planet
Just right!
Venus
Too Hot
Mars
Too Cold
MARS
Virtually no atmosphere
T = -27 to -140 C
Atmosphere
N_2 + O_2 = 99%
A trace of H_2O + CO_2
T = 15 degree C
dense atmosphere
95% CO_2
T = 500 degree C

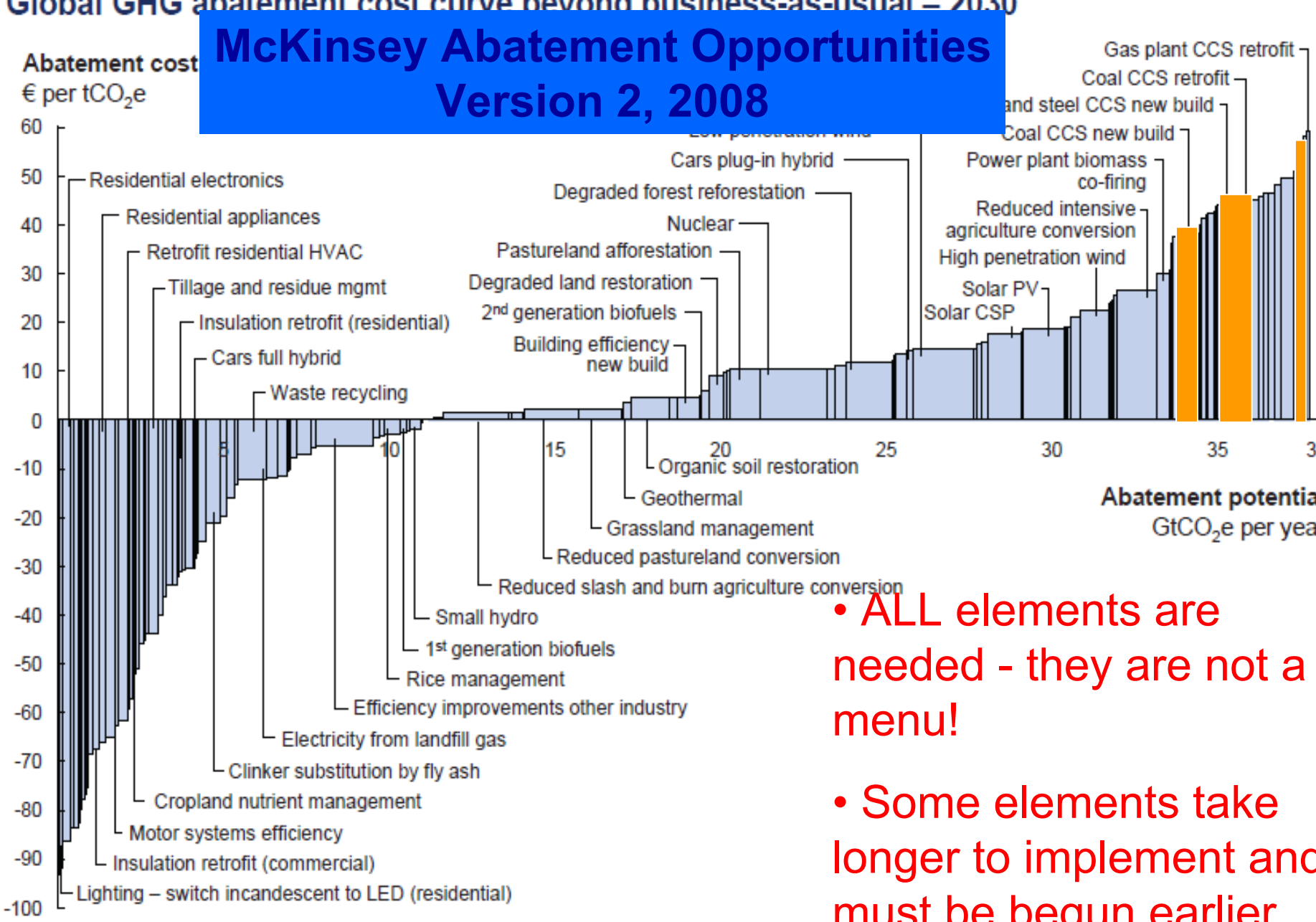
Carbon dioxide levels over the last 60,000 years



Global warming

- Does not mean that everywhere on Earth is warmer
- Warmer oceans do mean that the 'Earth System' operates much more violently:
  - Storms
  - Droughts
  - Floods
  - Sea level rise
  - ……and their consequences

McKinsey Abatement Opportunities Version 2, 2008

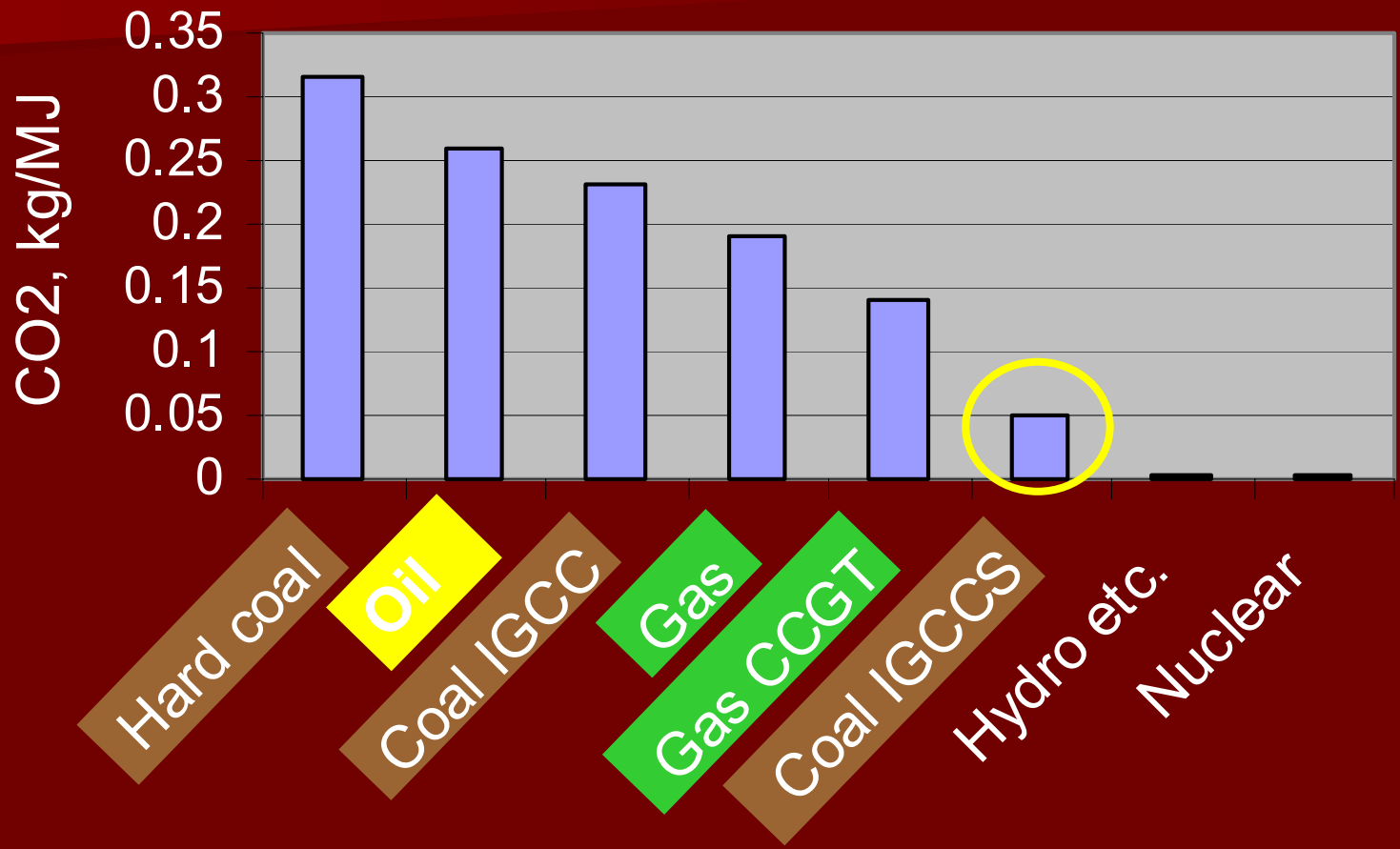


- ALL elements are needed - they are not a menu!
- Some elements take longer to implement and must be begun earlier

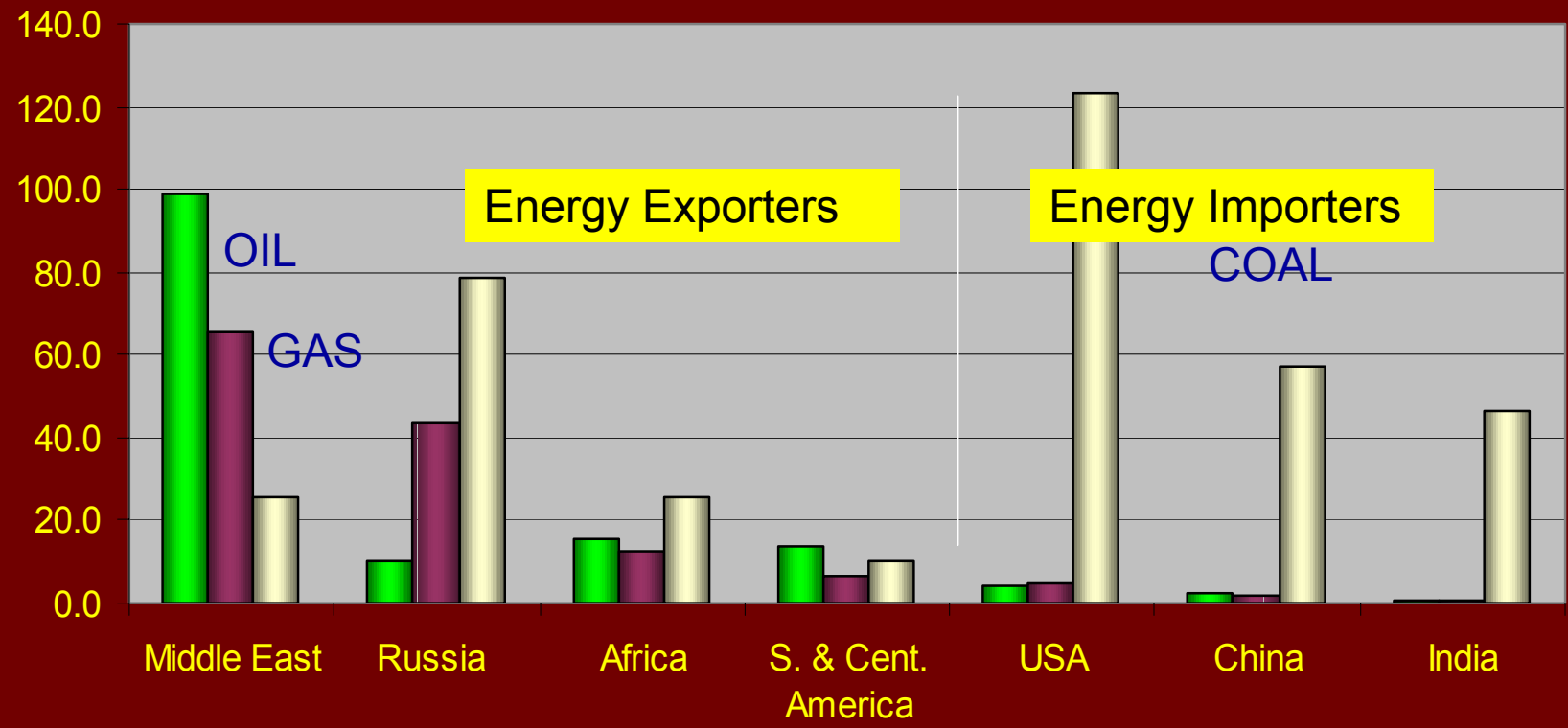
Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below €60 per tCO_2e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.

Source: Global GHG Abatement Cost Curve v2.0

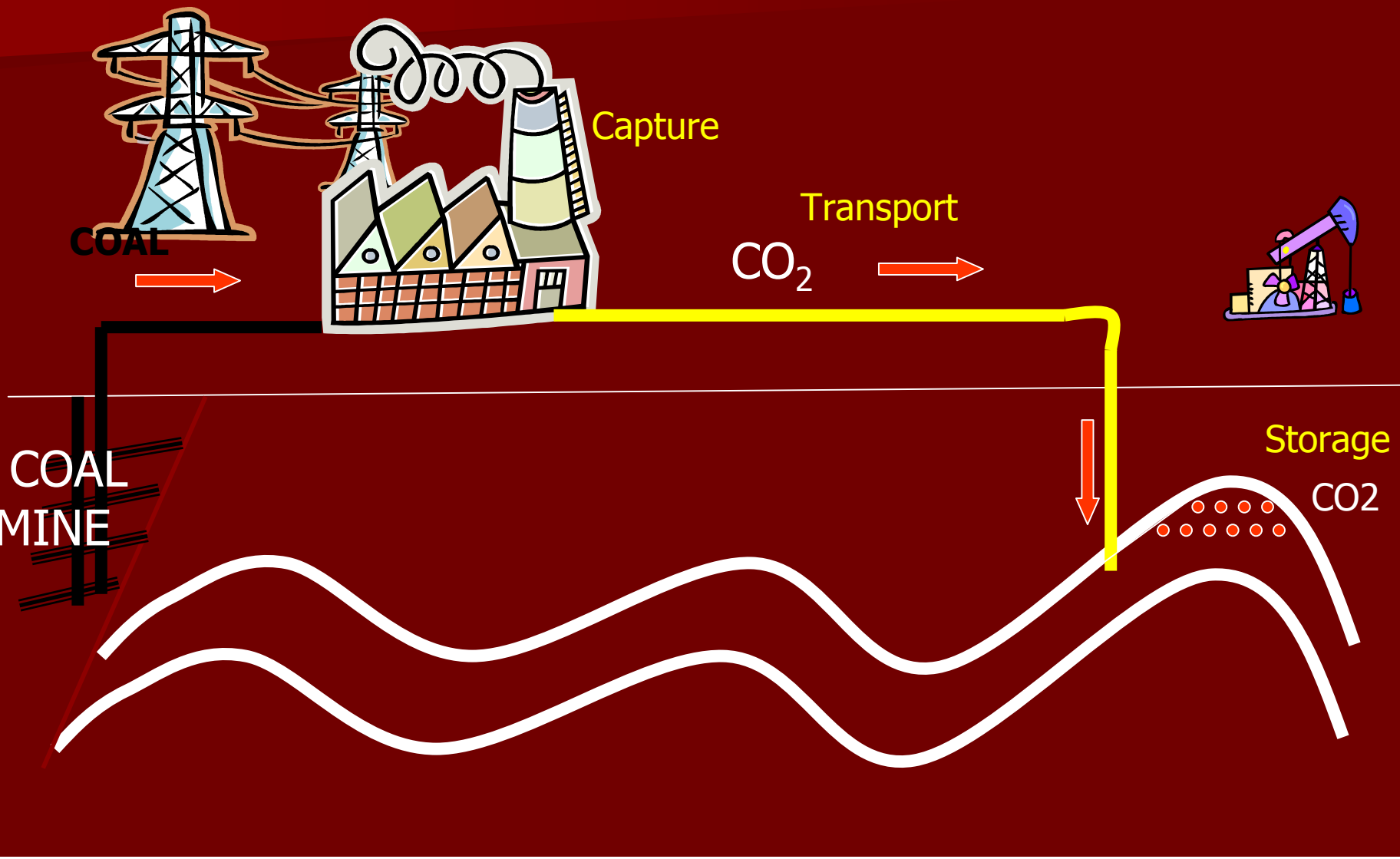
Emissions from Energy Production depend on fuel and combustion mode



Aspects of the World Reserves of Oil, Gas and Coal



Carbon Capture and Storage



Capture Technologies

- Most costly element in CCS - ? 2/3 CCS Capex?
- Capture – needs tech. development
  - Pre-combustion
    - IGCC & oxyburn – practical technologies
  - Post-combustion
    - solvent extraction of CO2
    - large footprint - retrofittable?
- At present all carry high efficiency losses
- ? $60/T when current technology mature
- Technology needs
  - New solvents?
  - Enzyme solution acceleration - Novozymes?
  - Physical rather than chemical extraction?

Early action vital – learn by doing

Transport & Storage

- Transport:
  - Problems largely logistic and regulatory
  - BUT pipelines may be rate limiting step for CCS systems
- Storage:
  - Underground storage – not difficult but requires focussed exploration and can't be rushed
  - Immobilisation in solids
  - Deep sea ponding – illegal at present

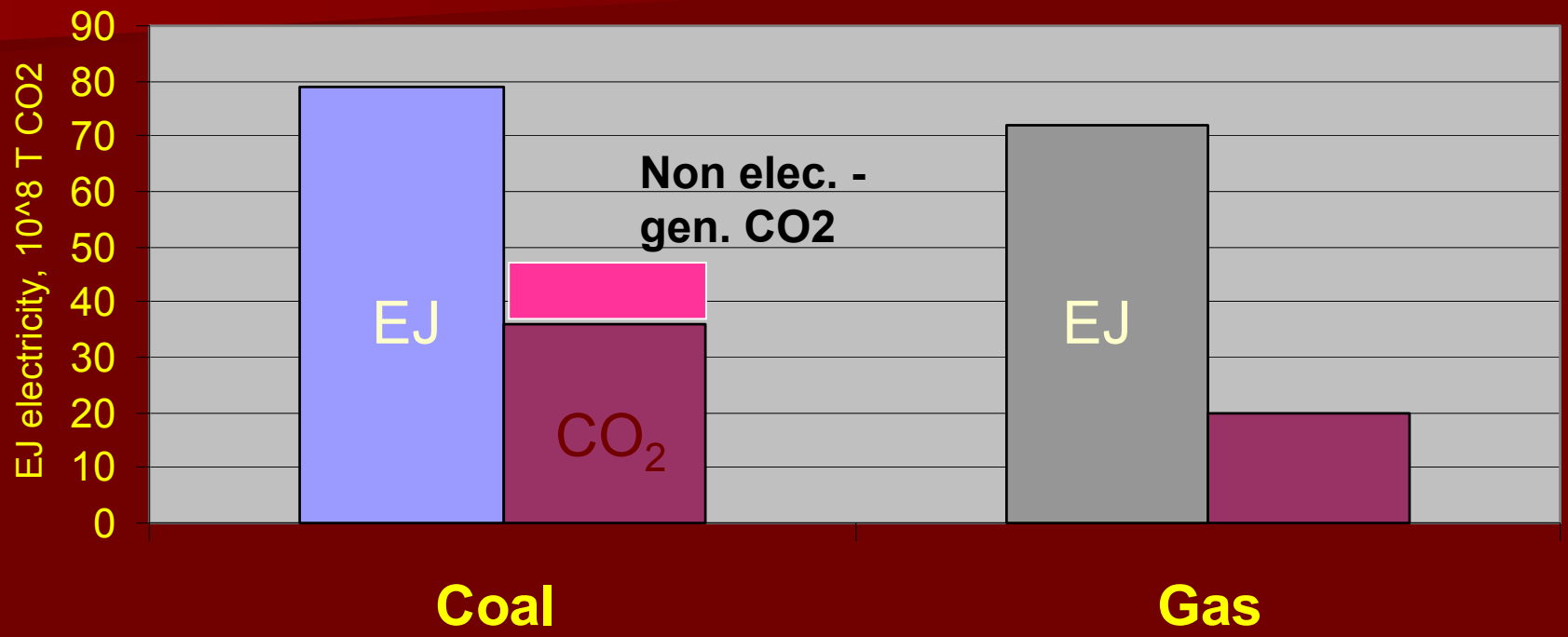
Paying for CCS – Carbon Trading

- Ideally it should cost emitters less to use CCS than to pay the carbon price
- Currently CCS relatively expensive & C price low
- Current technology implies 30% higher electricity cost
- For investment in CCS, stable high C-price needed ~ ? 60euro/T
- By the time this achieved, probably too late

Why Should Government Share Costs

- Time-scale – implementation slow – urgency – carbon price currently inadequate incentive
- Early movers carry risks
  - Technology risks
  - Stranded assets

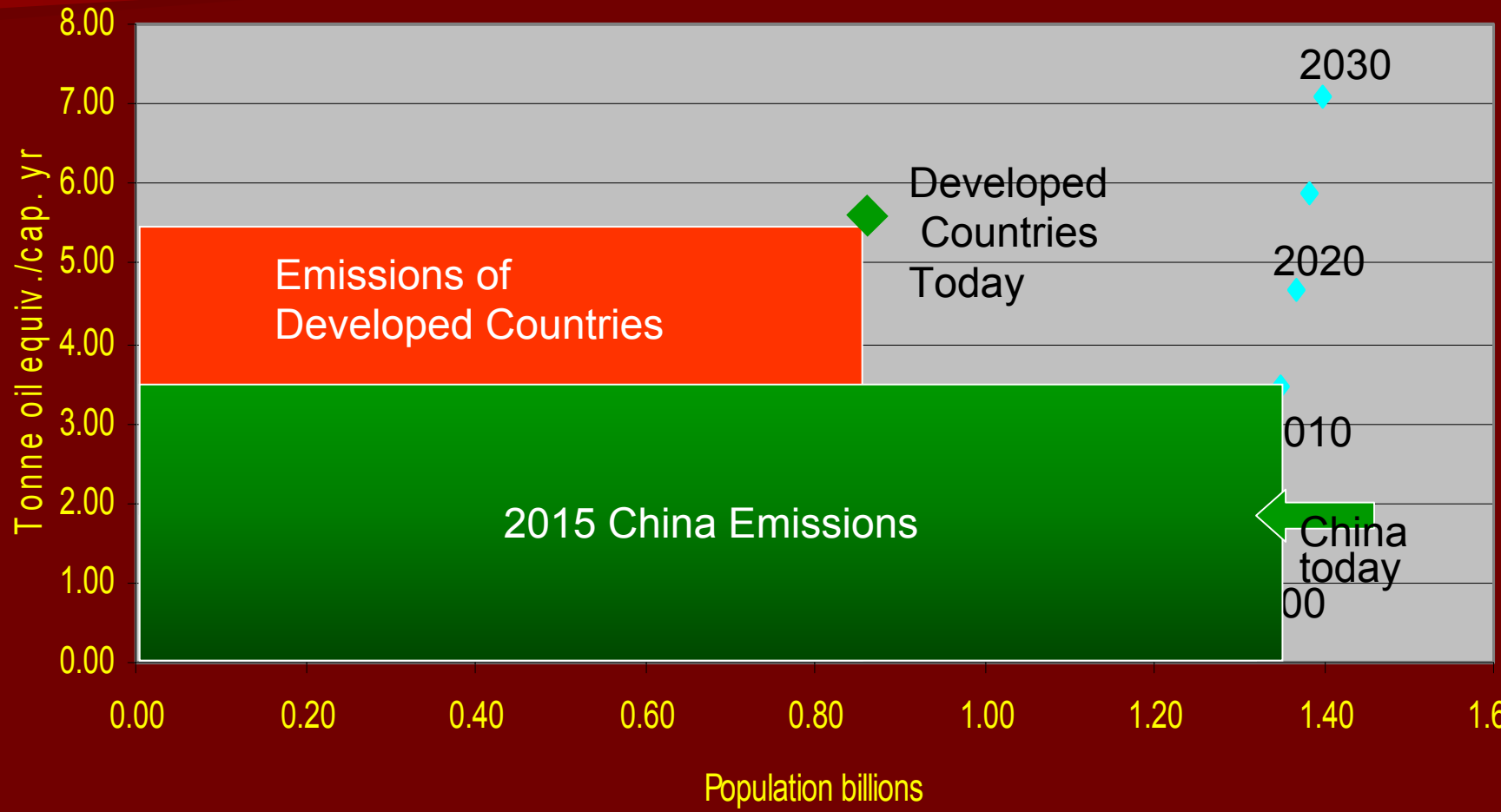
The Scale of CCS Electricity Generation & CO_2, 2004



5 x 10^9 T x $50 ≈ Future trillion $ business

Data IPCC 4th Assessment, Ch. 4

Energy & Emissions Developed Countries and China



Conclusions

- The case for emissions reduction will only become stronger – time not on our side
- Without CCS emissions targets unachievable
- Lead time for CCS is long and government kick-start & risk sharing essential
- Need to develop cheaper technology for world retrofit
- The present slow down should be an opportunity not threat
- The world CCS market could be massive