The International Context of CCS

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OSLO 29 January 2008

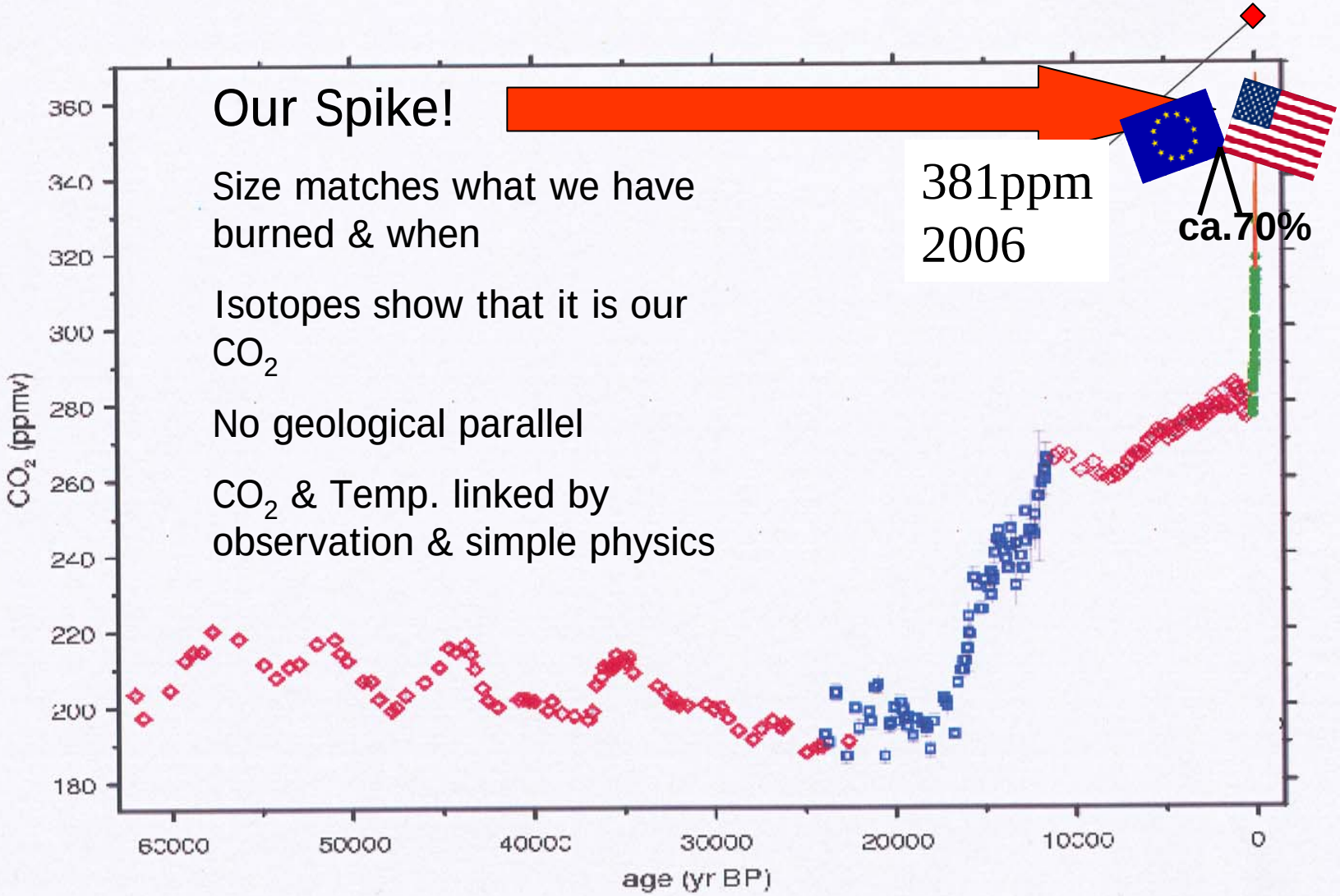
Looking Back

The Energy Problem in Context

Approach depends crucially on attitude to climate change

- ‘Permissive’ evidence
- ‘Compelling’ evidence

Carbon dioxide levels over the last 60,000 years

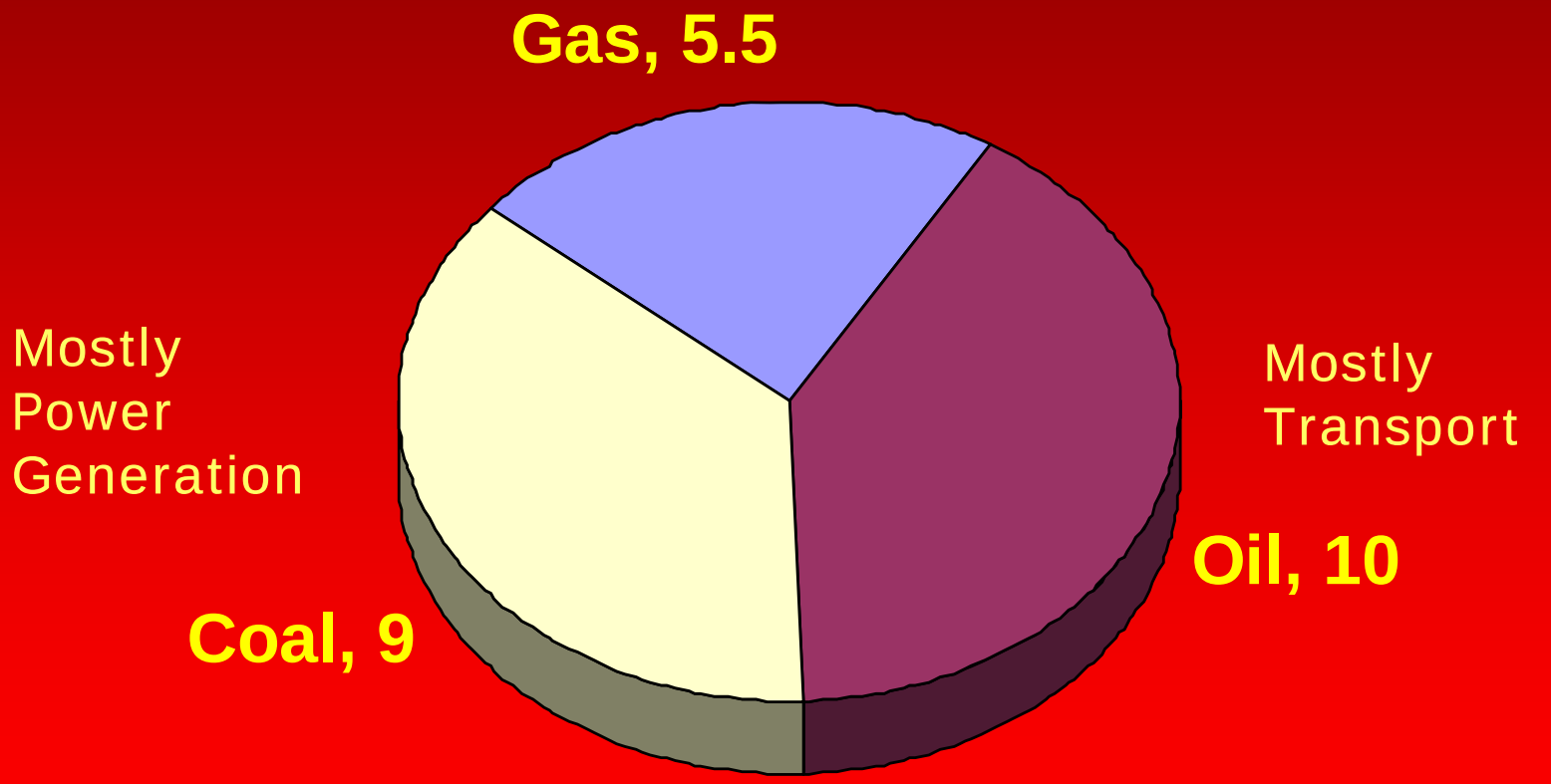


CO_2 legacy

- **Without a greenhouse effect Earth is uninhabitable**
- **‘Excess’ CO_2 added to the atmosphere over 150 years by burning fossil fuels**
- **CO_2 increased concentration almost certainly responsible for rapid global warming**
- **Different countries have contributed differently to the ‘legacy’ CO_2**
- **Climate change can be limited by reducing emissions**
- **The longer we take to reverse the spike the more severe the effects of climate change**

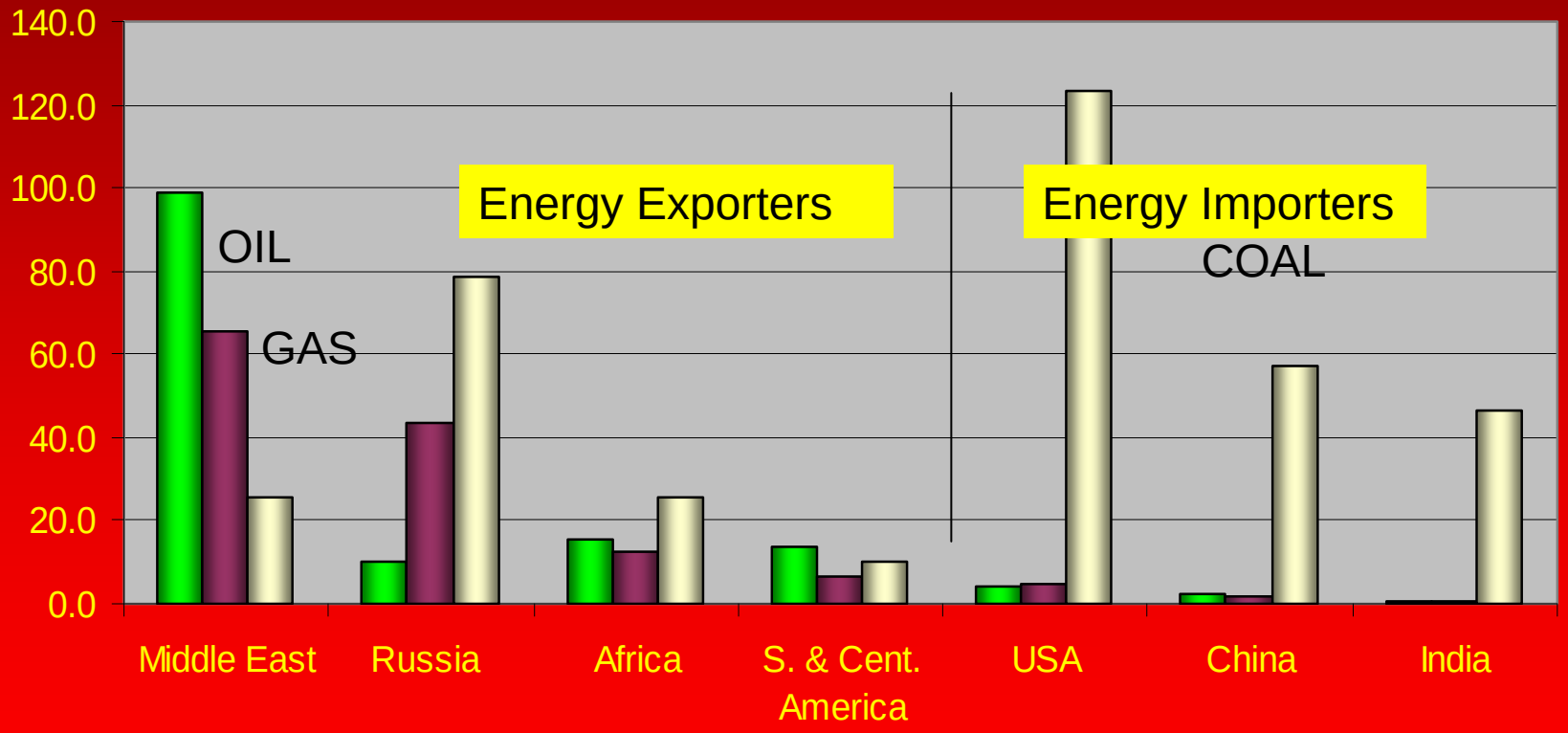
Looking Forward

World CO_2 Emissions from Fossil Fuels, MT, 2004

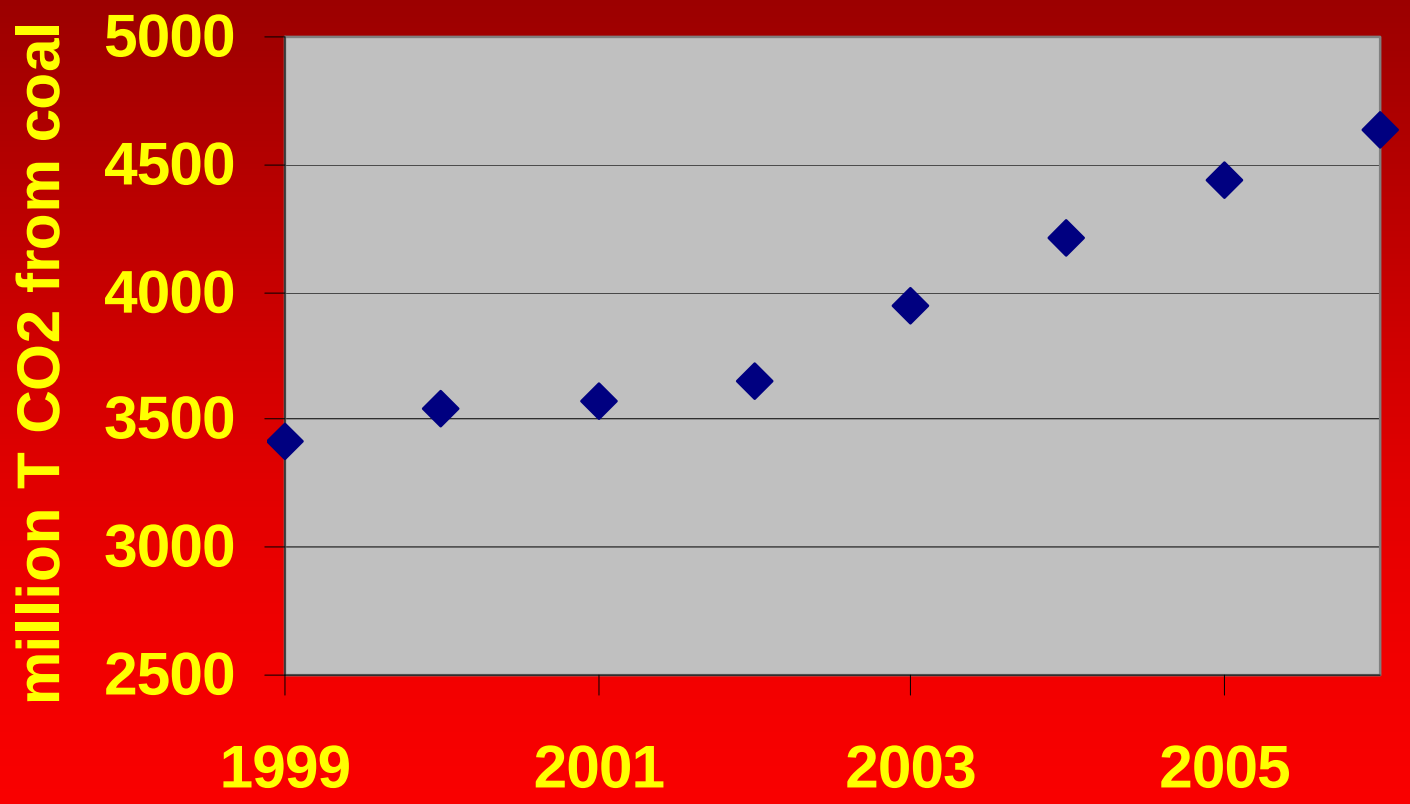


World Energy Outlook, 2005

Aspects of the World Reserves of Oil, Gas and Coal

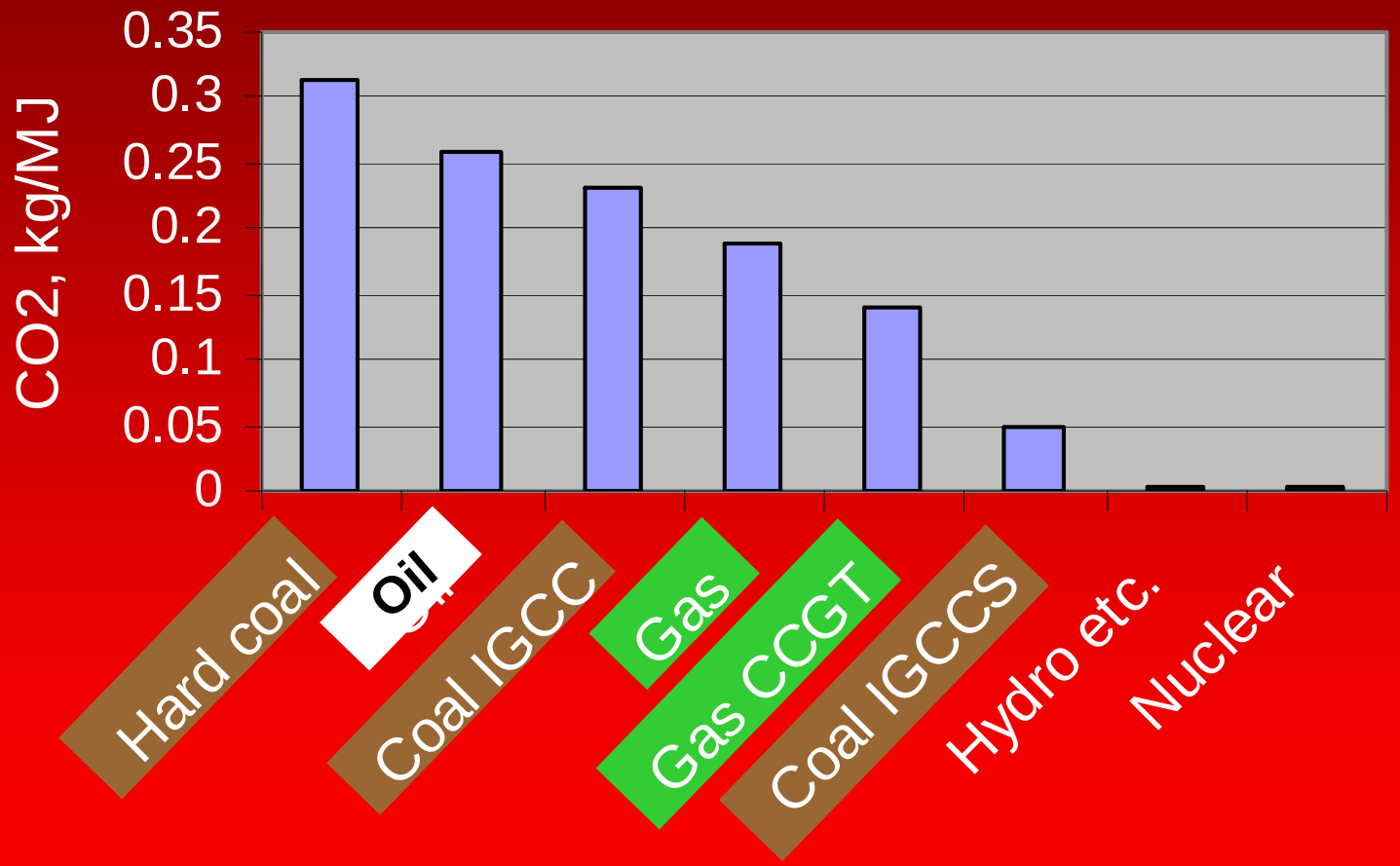


CO_2 from World Coal Consumption 1999 - 2006

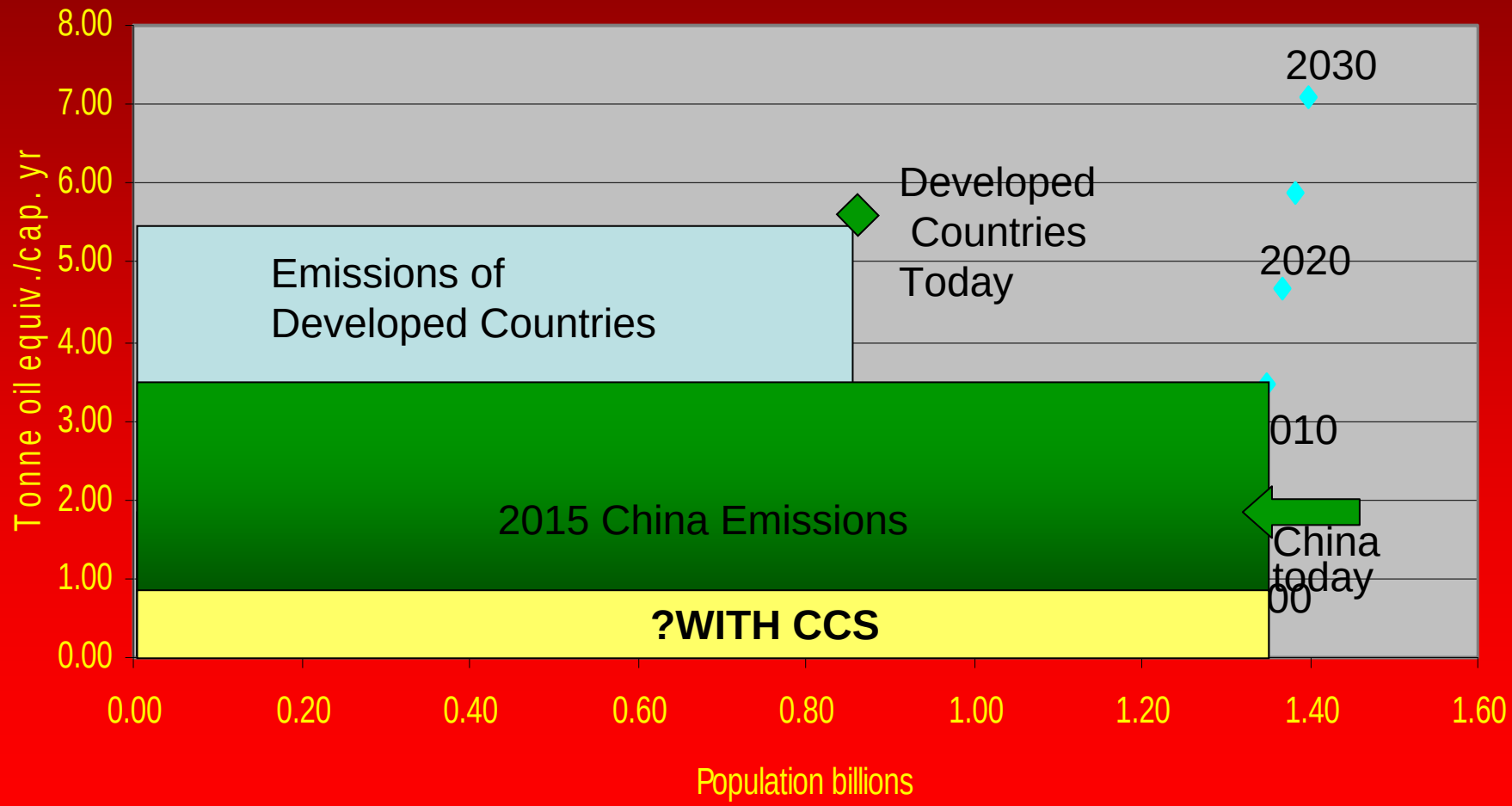


Data BP Statistical Tables, 2007

Emissions depend both on fuel and combustion mode



Energy & Emissions
China & Developed Countries



The International Context

- **CO_2 is a problem that is**
  - **Global**
  - **Dynamic**
  - **Urgent**
  - **Raises questions of**
    - **Fairness between nations**
    - **Business competitiveness**
- **Bali began to map the first steps towards a post-Kyoto agreement**
  - **Outcomes also depend on wider politico/economic Role of CCS?**

Post 2012 negotiations – ways of looking at CO_2

Tonnes CO_2/ cap yr	
India	0.98
China	2.39
Japan	9.06
United States	20.66
Australia	24

Total T CO_2/ yr	
Australia	472
India	1023.1
Japan	
Chi	
	5702.3

CO_2/ unit	
J	
	0.39
United States	0.64
China	0.67
Australia	1.00

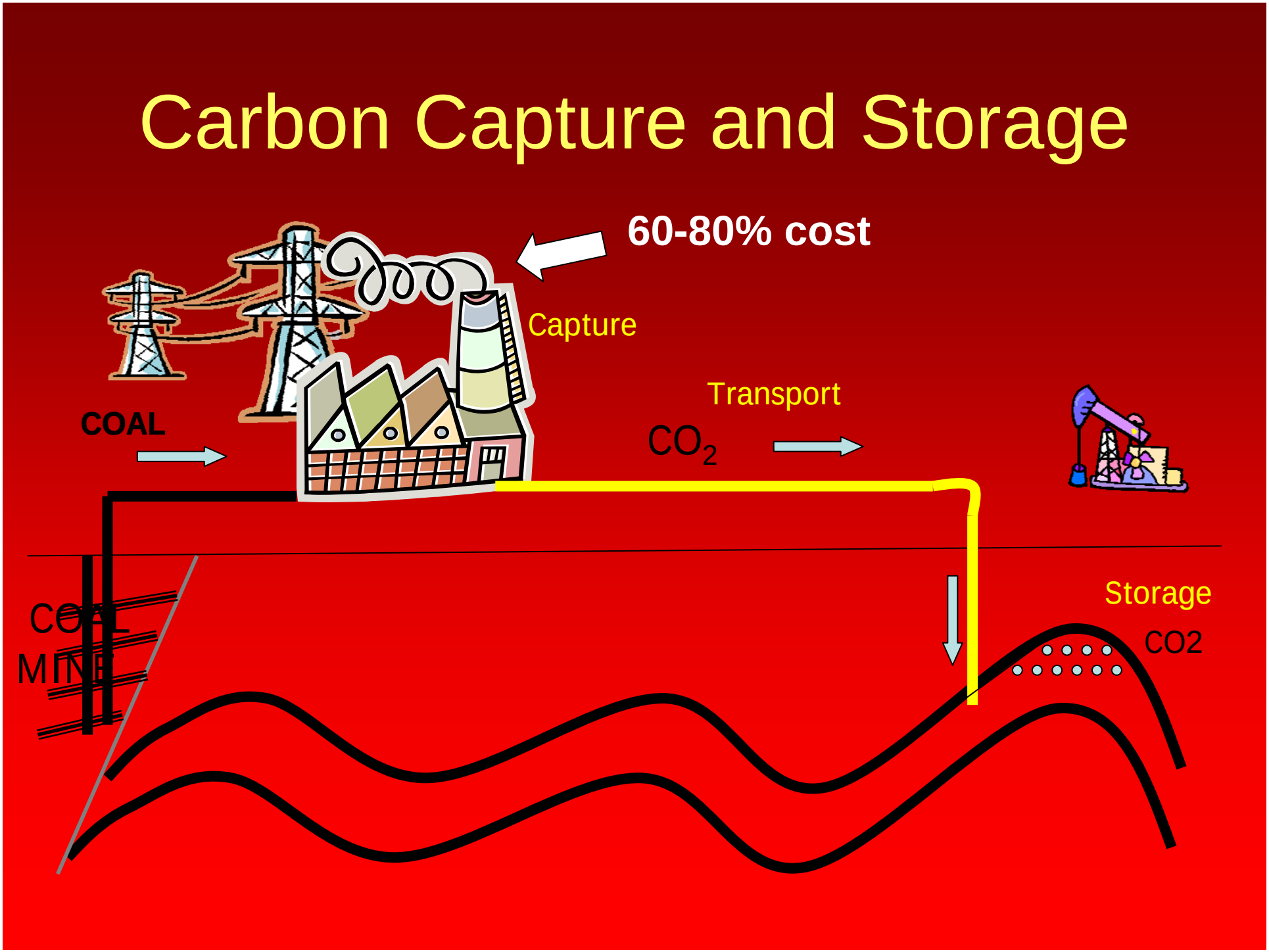
gCO_2/ kwh	
Japan	397
United States	572
China	753
Australia	817
India	959

These figures are six years old and need updating but the principle holds

Carbon Capture and Storage

- Current global infrastructure depends on cheap and abundant fossil fuel
- Transition to a low carbon economy will take > 50 years
- Fossil fuels for power generation will rise in the immediate future before declining - CCS essential for the transition

Carbon Capture and Storage



But…

- **CCS technology is immature**
- **Slow to implement - learn by doing - heavy engineering**
- **To have a major effect on emissions in ten years requires a major effort now**
- **There must be a retro-fit capability**
- **Post-combustion technology - large footprint**
- **‘Expensive’**

EU Carbon Capture Test facility

EU Carbon Capture test facility (2)

Cost shares of CCS Elements

- **Capture & Gas handling 60 – 80%**
- **Transport 5 – 15%**
- **Storage & reservoir identification and management 10 – 30%**

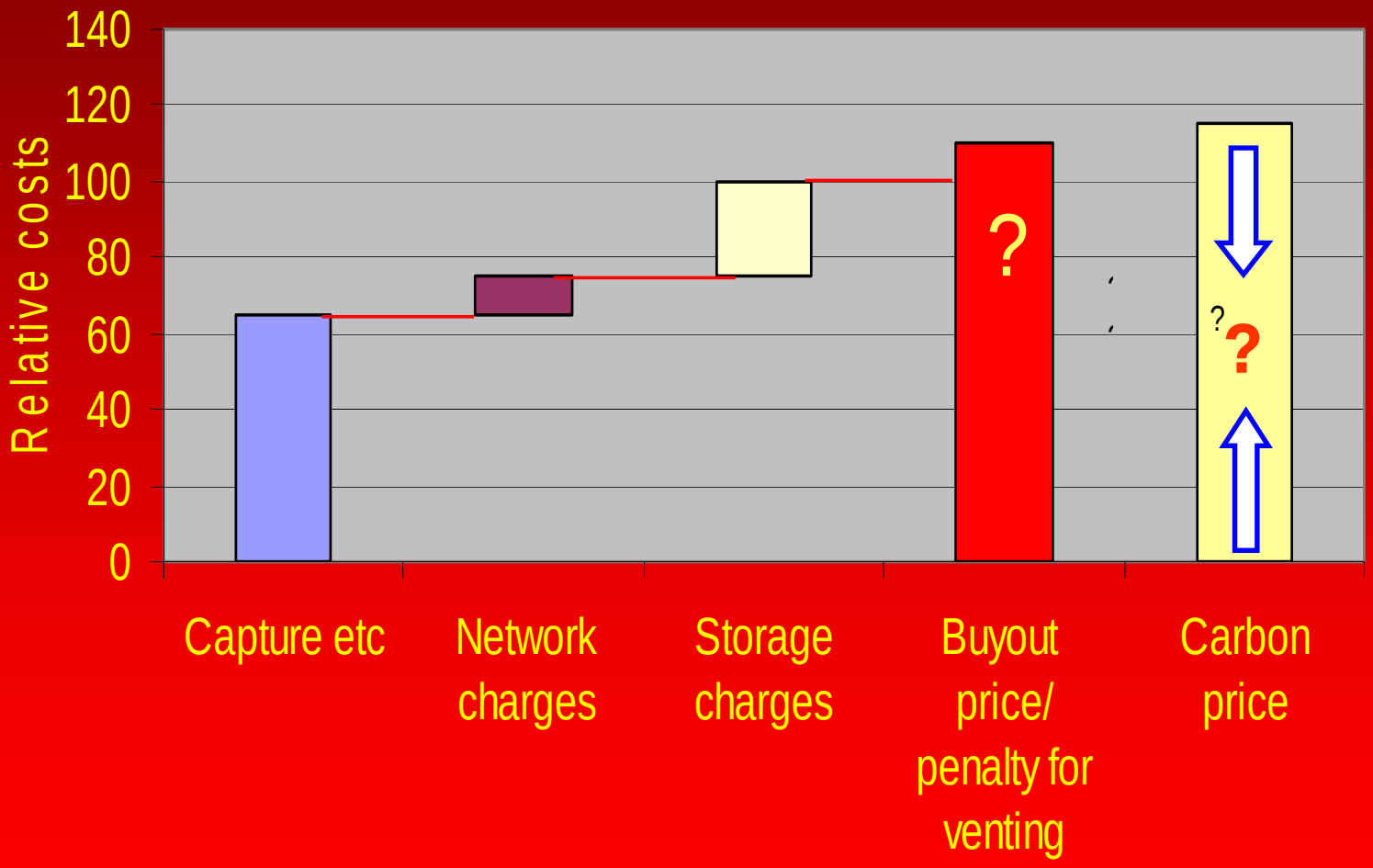
- **Power Plant Manu-facturers, Operators, & IOCs**
- **Pipe Line constructors, managers & IOCs**
- **Geological Surveys & IOCs**

Capture cost estimates from publicly available sources, by Climate Change Capital in support of EU flagship ZEP program

- Detailed study of published data shows
  - **Capex for capture + 20 – 50%**
  - **Opex for capture + 10 – 30%**
  - **Efficiency loss - 10 – 30%**
- Electricity cost + ca. 30%
- The developing world market will not open up until these figures are improved, especially for retrofit

www.climatechangecapital.com

CCS Cost Structure

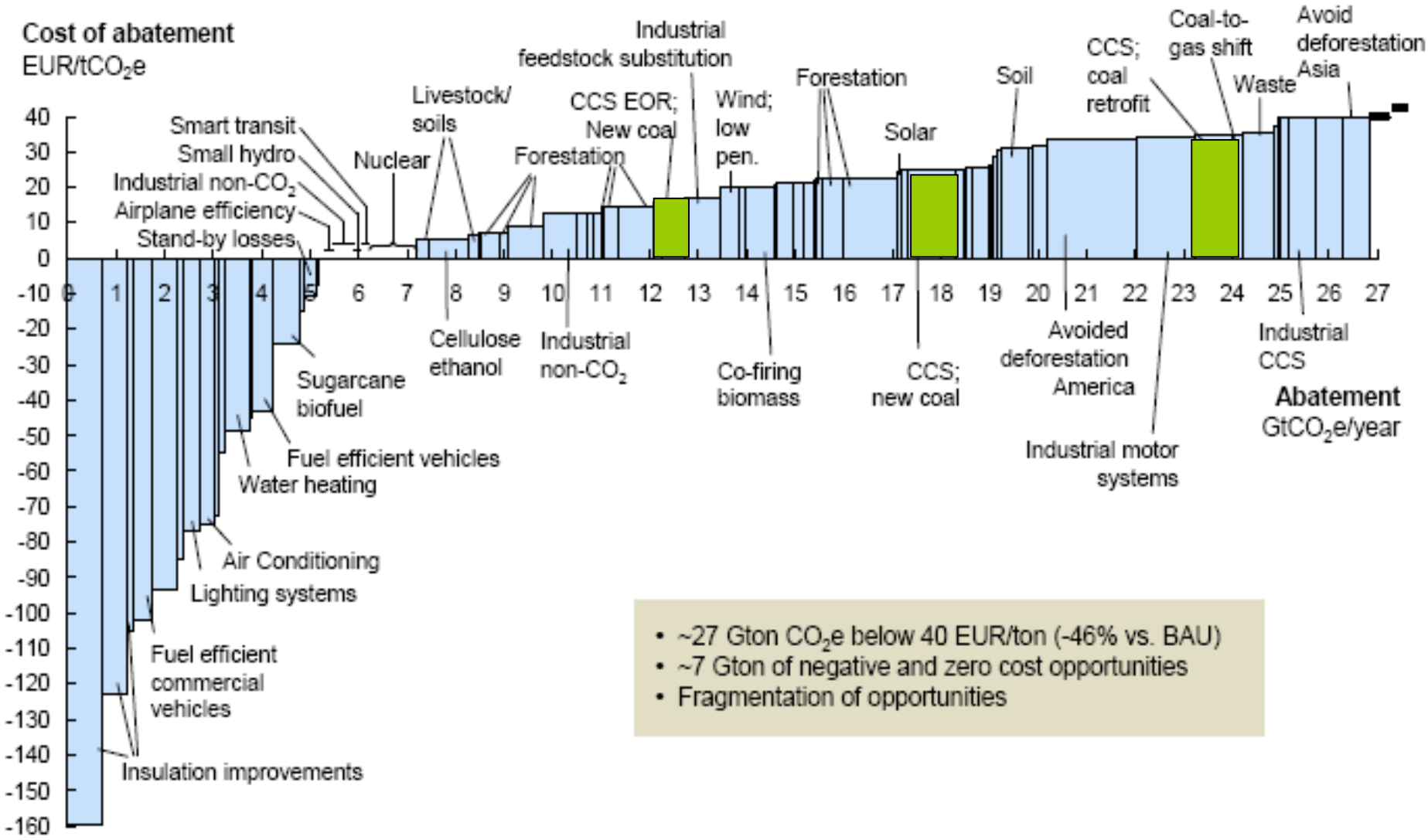


The Investment Requirements

- **A clear and stable regulatory/fiscal environment for Industry to invest in R&D & full scale plant:**
  - **Either a regulatory requirement e.g. a max permitted amount of CO_2/unit energy produced**
  - **Or a clear economic case for investment in CCS e.g. high Carbon penalty**
- **Also:**
  - **Level playing field for competition**
  - **Carbon market alone too low and too volatile – guaranteed floor?**
  - **Incentives to respond rapidly**
  - **Incentives to move on large scale**

Global cost curve of GHG abatement opportunities beyond business as usual

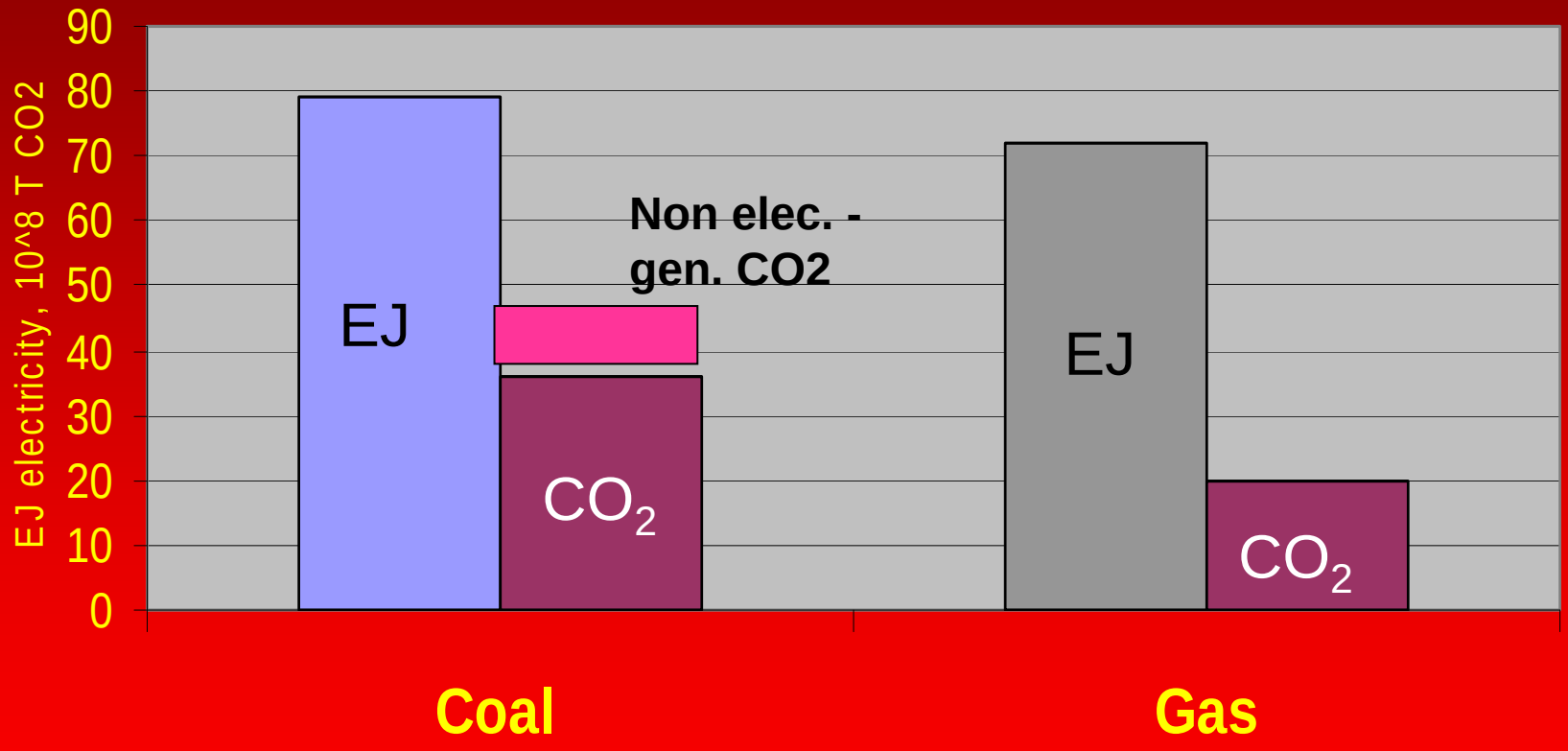
2030



- ~27 Gton CO_2e below 40 EUR/ton (-46% vs. BAU)
- ~7 Gton of negative and zero cost opportunities
- Fragmentation of opportunities

Source: McKinsey

Electricity Generation & CO_2, 2004

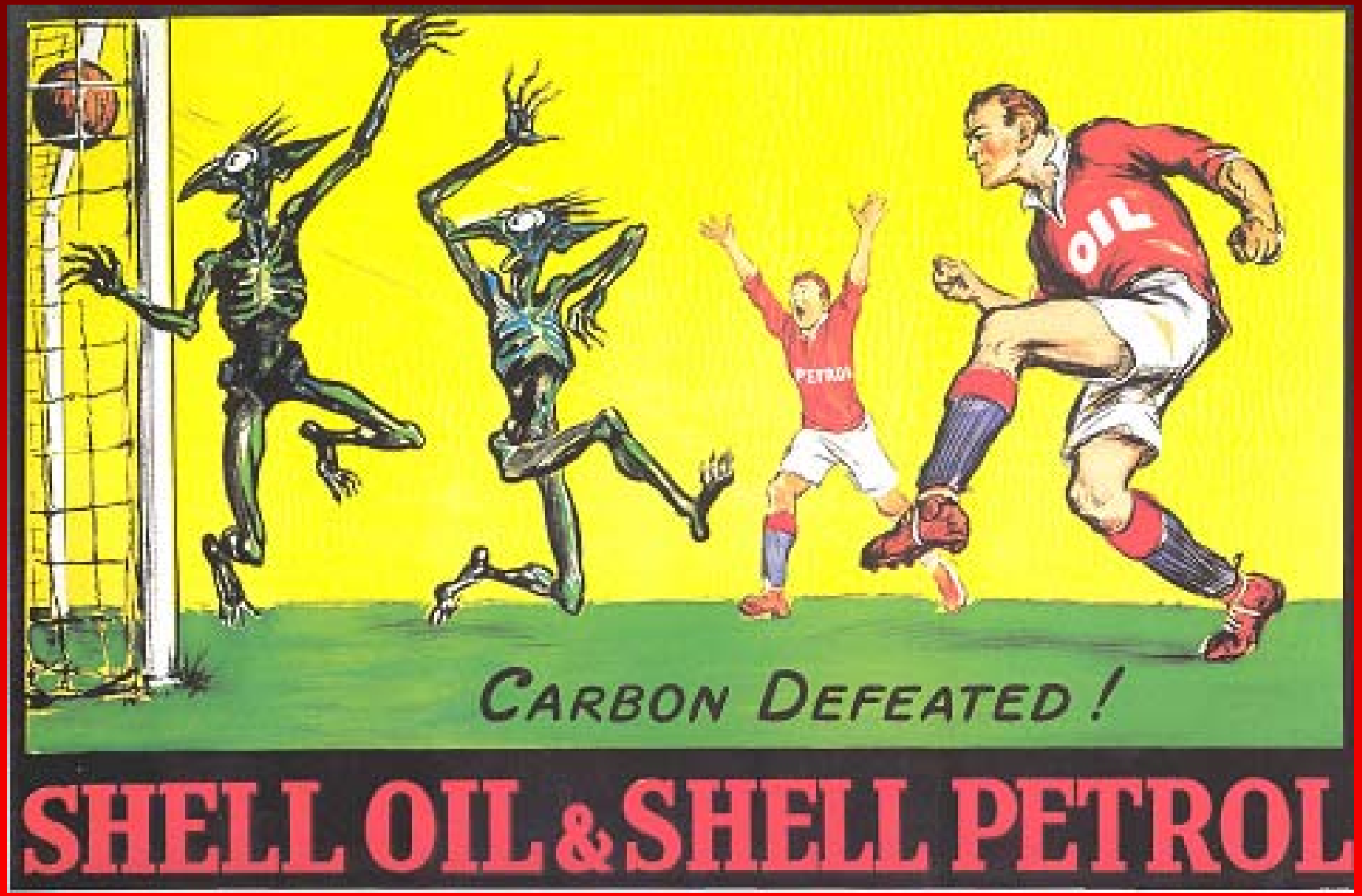


5 x 10^9 T x $50 ≈ Future trillion $ business

Data IPCC 4th Assessment, Ch. 4

Conclusions

- **World committed to fossil fuels for a number of decades**
- **CO_2 in power generation cannot be managed without CCS**
- **Present technology**
  - **Large foot print; hard to retrofit**
  - **‘expensive’**
- **Urgent need for new technology**
  - **more compact & cost-effective**
  - **Retro-fittable on existing plants**
- **Main CCS application power generation in China, India and US but would also have industrial application elsewhere**
- **CCS will become a major business (for IOCs?) over next 30 years**



Artist unknown,1929

The Future for Markets

- **Carbon market insufficient to support CCS anywhere**
  - **Too volatile**
  - **For the time being too low**
- **Could be supported by C market with a floor guarantee**
- **To become an internationally traded commodity**
  - **Requires international standards for certification/verification of storage**