Can Coal be Clean?
Efforts to Reduce Coal's Environmental Footprint

An Anglo American – Anglo Coal Perspective

Alaska Business Roundtable on Climate Change
14 February 2008

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Head of Strategy – Anglo Coal

Structure of the Presentation

- Energy and climate change – conflicting imperatives
- Climate change scenarios
- Coal fired route to near zero emissions
- Clean Coal Technologies (CCT) - coal upgrading, dealing with particulates, acid rain and other pollutants
- Global greenhouse gas emissions
- Coal fired plant efficiency and CO_2 emissions
- Carbon Capture and Storage (CCS) – its contribution, the technology, costs and recent developments
- Anglo Coal – approaches to and examples of process and product stewardship

Energy and Climate Change imperatives cannot be seen in isolation

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We live in a world where the contrast between energy abundance and energy poverty is stark

Earth at Night

NATIONAL GEOGRAPHIC

By 2030 - Global population approaching 8 billion; if nothing new is done, 1.4 bn without access to electricity and 2.6 billion still reliant on primitive/erratic sources

By 2030 the IEA forecasts Coal (44%) and Gas (23%) will account for two thirds of global power generation

We have to simultaneously address energy demand as a driver of development and climate change imperatives to reduce CO_2 and other GHG's

Source : Nat Geographic
WBCSD; WCI; Al Gore; WCI
IEA WEO 2006; Dong Energy

Immutable Force meets Global Imperative

Energy boom! ⟷ **Climate bust!**

Economic growth?

Energy provision and Energy security?

Environmental stewardship?

How will we respond?

World Energy Outlook 2007 – IEA Nov 2007

- World faces a fossil energy future to 2030
- Primary energy needs grow by 55% 2005 to 2030 (BAU)
- Developing countries contribute 74% of the increase in global primary energy use
- The resurgence of coal driven by power demand in China and India is a marked departure from past WEO's
- Rising demand poses a real and growing threat to energy security
- Unchecked fossil fuel use will hasten climate change
- Urgent action on CCS and related technologies by all

IPCC Fourth Assessment Report – Nov 2007

- Warming of the climate system is unequivocal
- CO_2 is most important anthropogenic GHG
- Very likely increase in frequency of weather extremes
- Adaptation and mitigation options are available but the pace of adoption and scale of application needs to increase markedly
- Cooperative efforts, a price for carbon – market pull and a research driven technological push are imperative
- Macro-economic costs are considered tolerable if we act early

Climate Change Policy Scenarios – where are we now?

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- Superficial co-ordination
- Some countries work actively to undermine international policy framework

Co-ordination

- US leadership
- China and India join a Kyoto 2
- Global carbon market
- Widespread technology transfer

"DANCES WITH WOLVES"

"STRICTLY BALLROOM"

Weak Political Will

Strong Political Will

?

Stern + IPCC 2007 + G8+5 + Bali COP MOP 3

"DIRTY DANCING"

"DIFFERENT DANCES"

Most likely in short/medium term with prospects over time for linkage between schemes

- No agreement on climate change
- International tensions
- Energy security overrides climate change concerns
- Resource nationalism & protectionism
- Immediate concerns dominate
- Confusion in the science community
- Initial warming impacts seen as positive

Fragmentation

- Varying efforts to reduce emissions
- Unconnected carbon markets
- Higher cost mitigation
- Unsustainable in longer term

Coal Fired Route to Near Zero Emissions

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Under the direct control of utilities; open to influence by producers and technology advance by equipment suppliers

Under the direct control of coal producers

The need for collaboration by coal producers, equipment suppliers and power utilities is paramount

CCT - Coal upgrading

- Washing raw coal in a processing plant
- Removes a portion of the non-combustible material
- Reduces the ash content – can be by up to 50%
- Reduces the sulphur dioxide (SO_2) subsequently emitted by the coal
- Improves thermal efficiency – so reducing CO_2 emissions

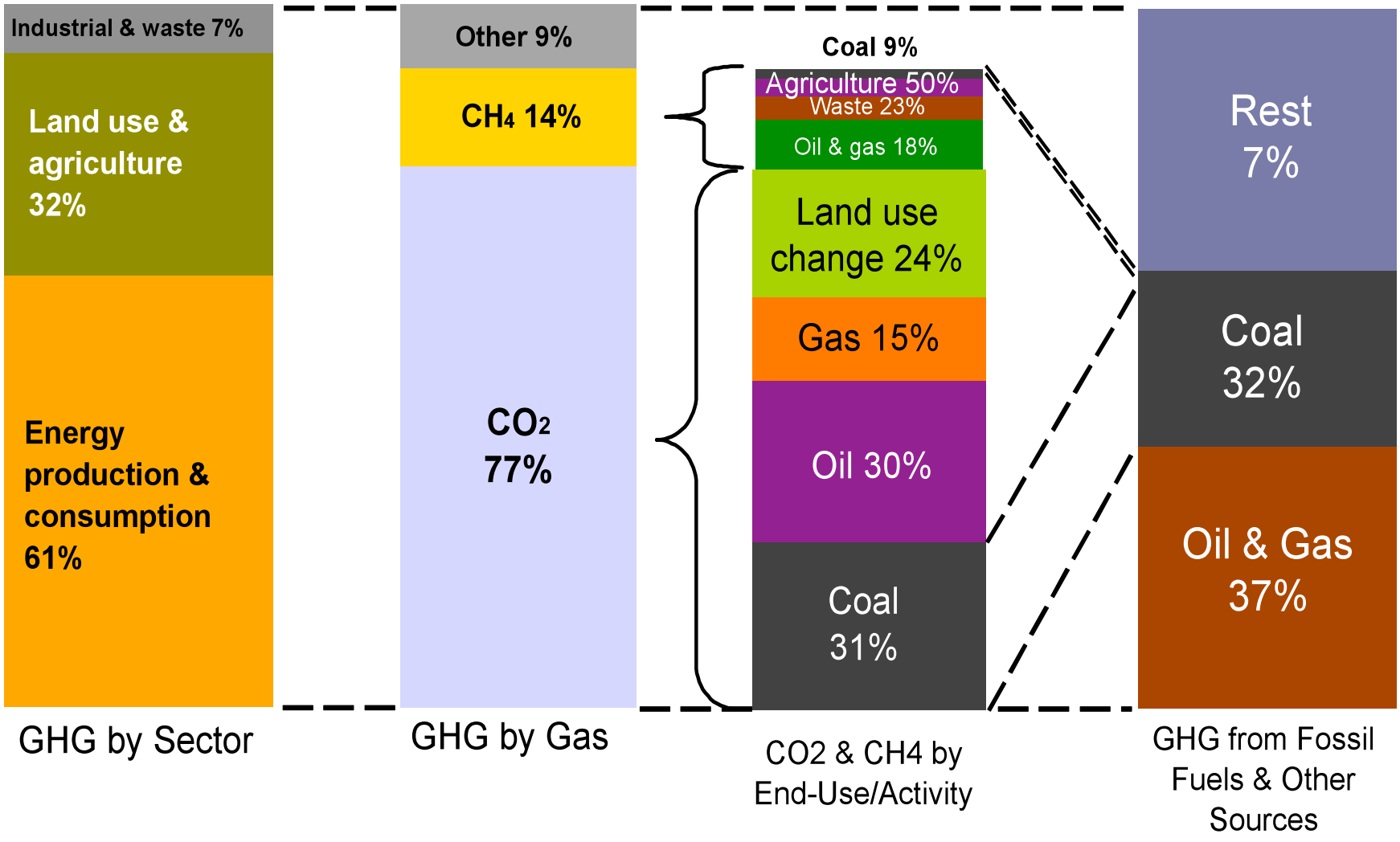
Source : WCI – Coal Meeting the Climate Challenge - 2007

CCT – Particulates, Acid Rain and Other

- **Particulates - finely divided solid and liquid (other than water) substances emitted from a power station**
  - Electrostatic precipitators
  - Fabric filters or bag houses
  - Wet particulate scrubbers
  - Hot gas filtration systems
- **SO_2 and NO_x emissions**
  - Flue gas desulpherisation
  - Low NO_x burners and burner optimisation
  - Selective catalytic and non-catalytic reduction
- **Other – Trace Elements, Mercury and Ash**

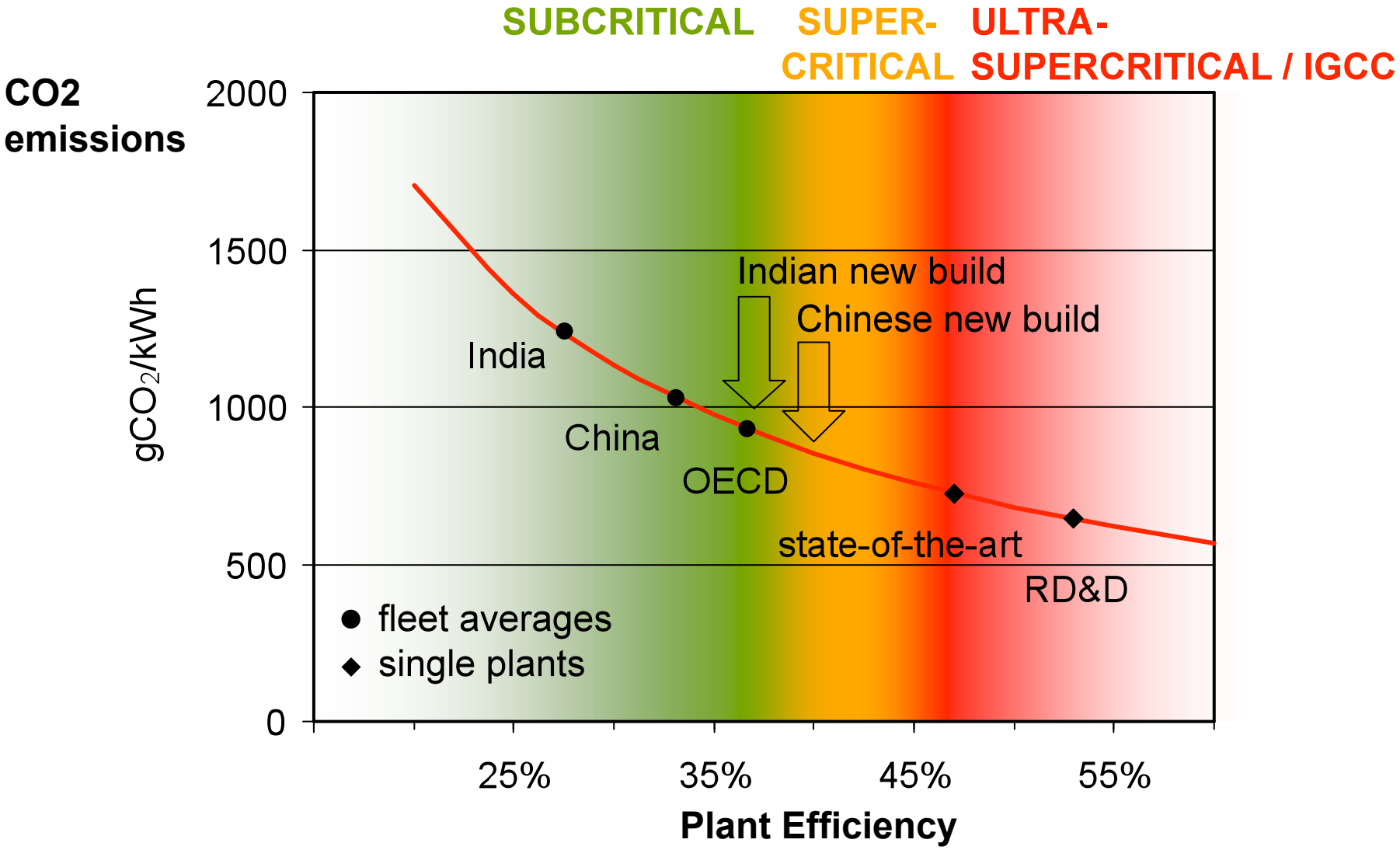
Source : WCI – Coal Meeting the Climate Challenge - 2007

Global Greenhouse Gas Emissions – Activity Sources and Fuels



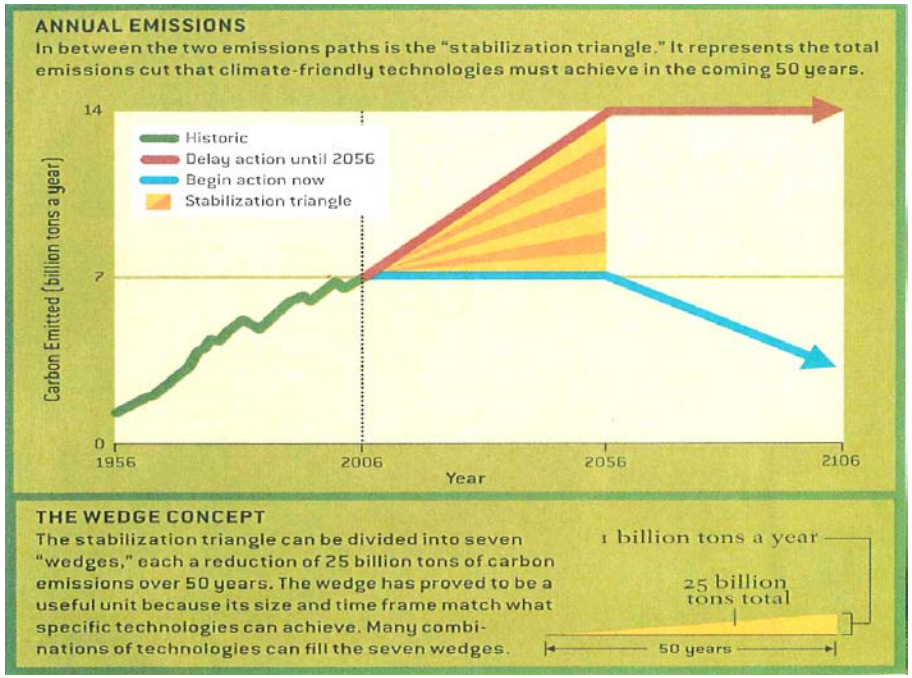
Source : UNFCC; WRI; WCI

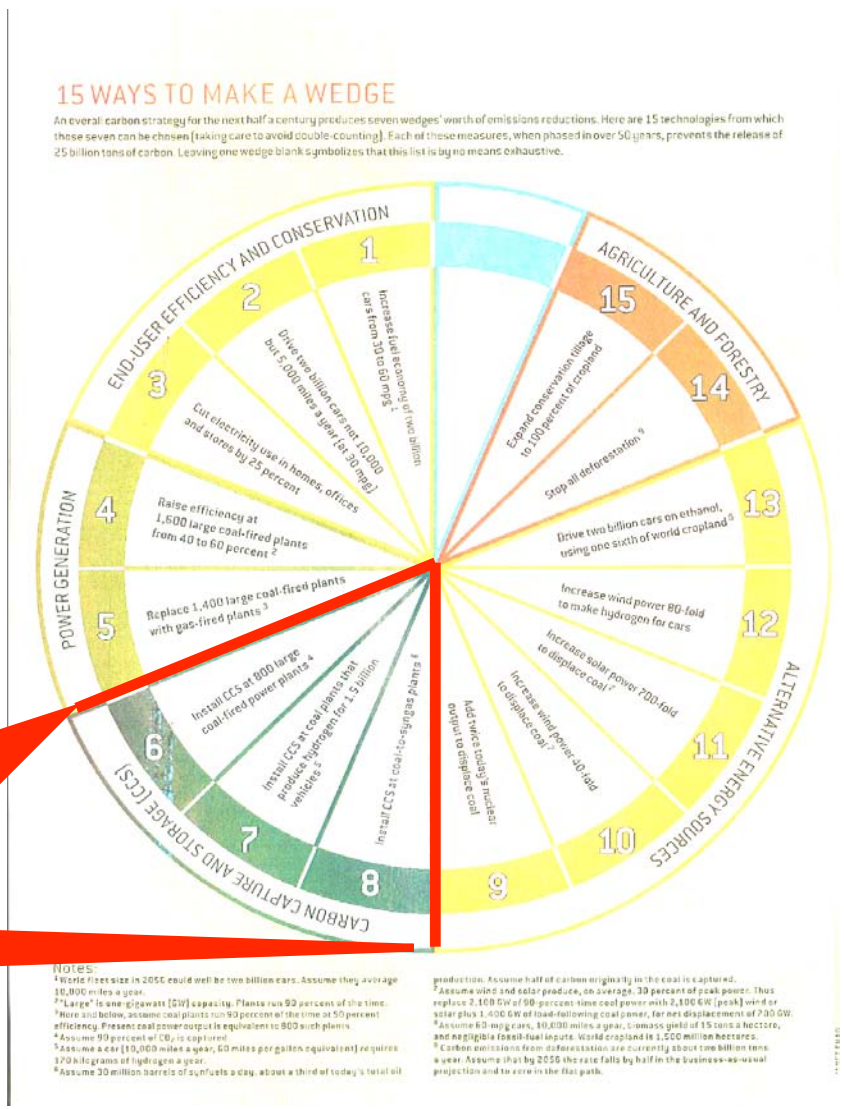
Coal Fired Plant Efficiency and CO_2 Emissions



Source : IEA/WCI and CURC/EEI/EPRI Forum 2007

Carbon Capture and Storage (CCS) - where does it fit and how does it contribute?



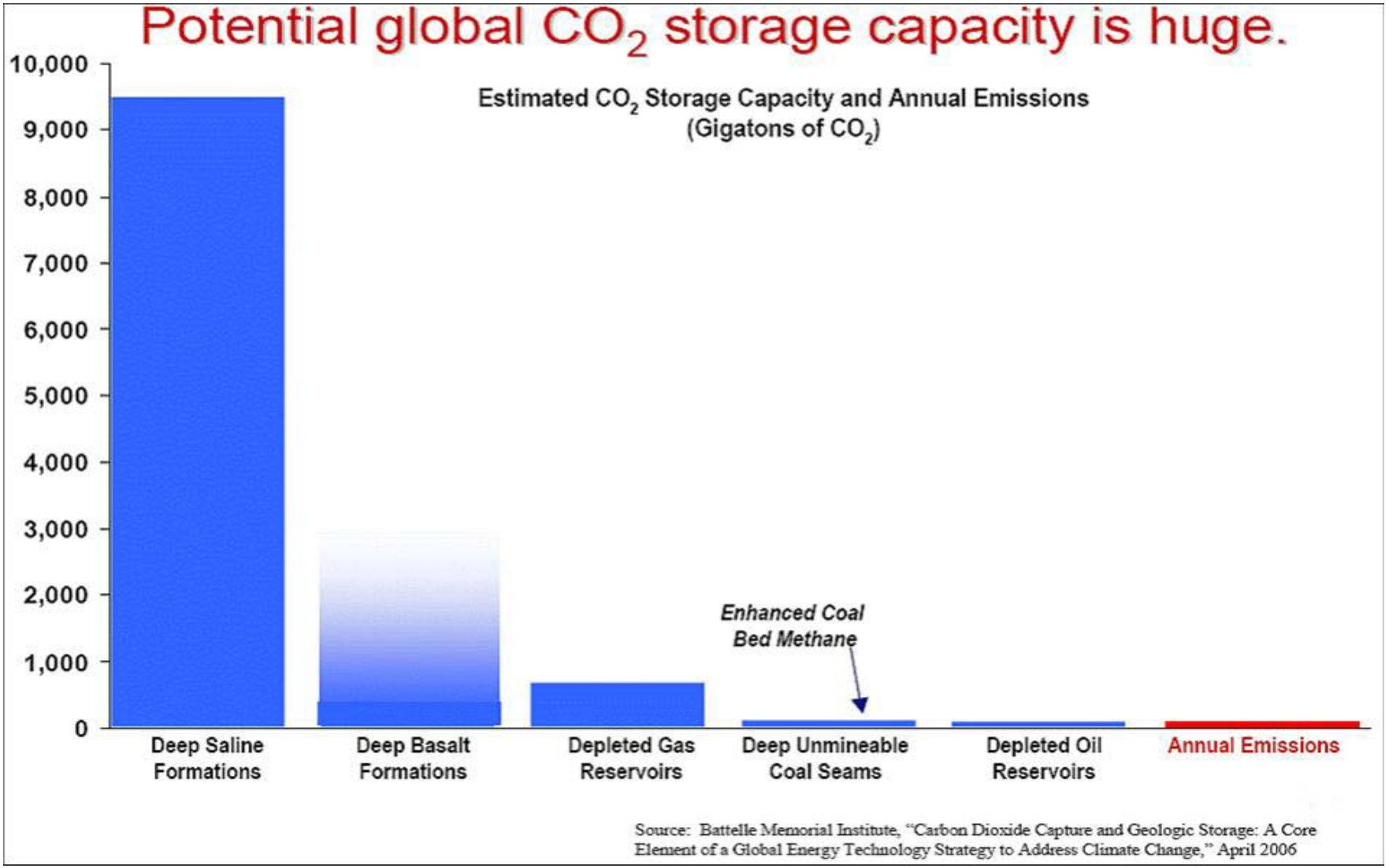


CCS is one of a number of key technologies to be developed and deployed at large scale

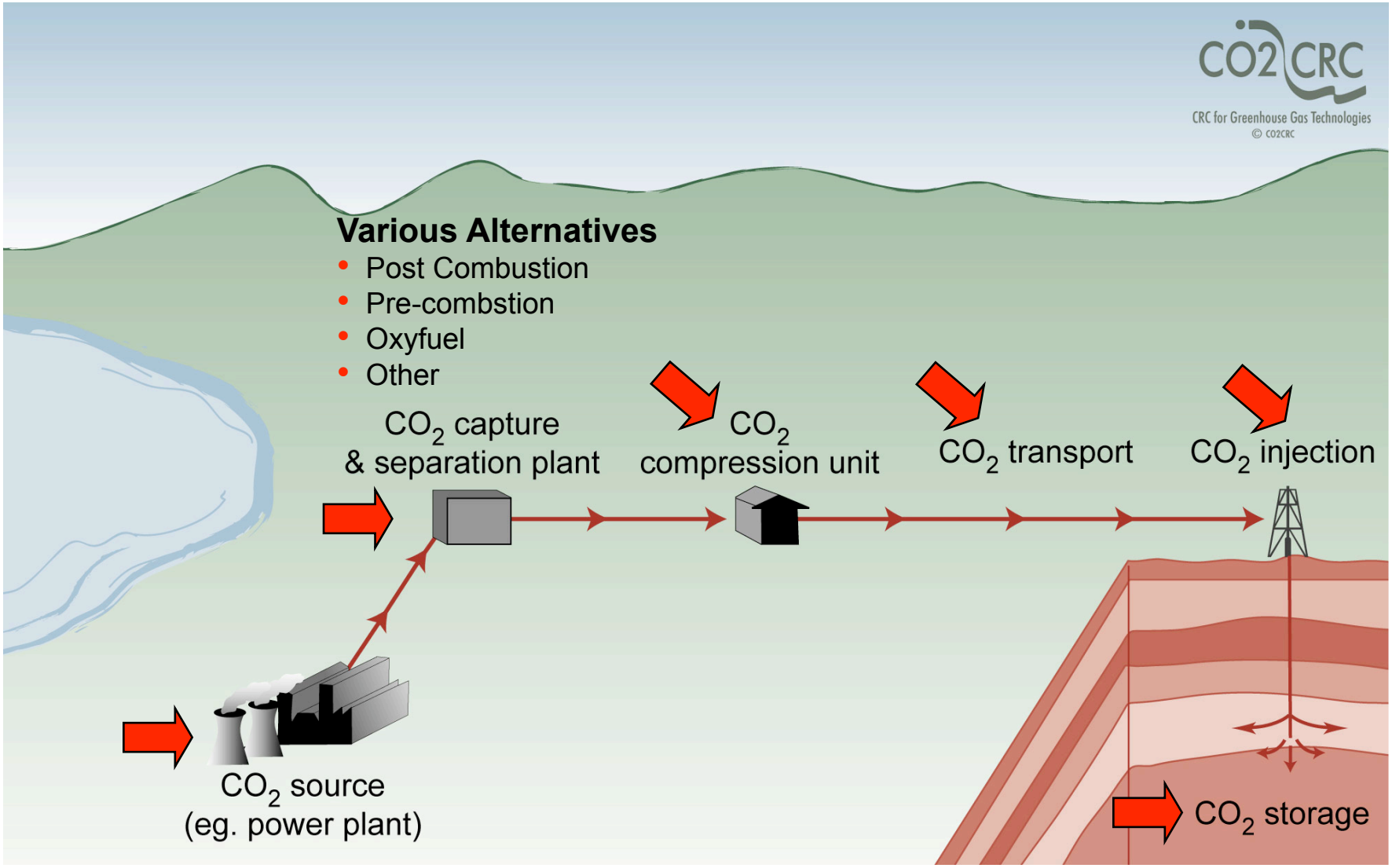
IPCC 2005 Study on CCS : "… could contribute 15 – 55% of the cumulative mitigation effort worldwide until 2100"

Source : R H Socolow & S W Pacala
Scientific American September 2006

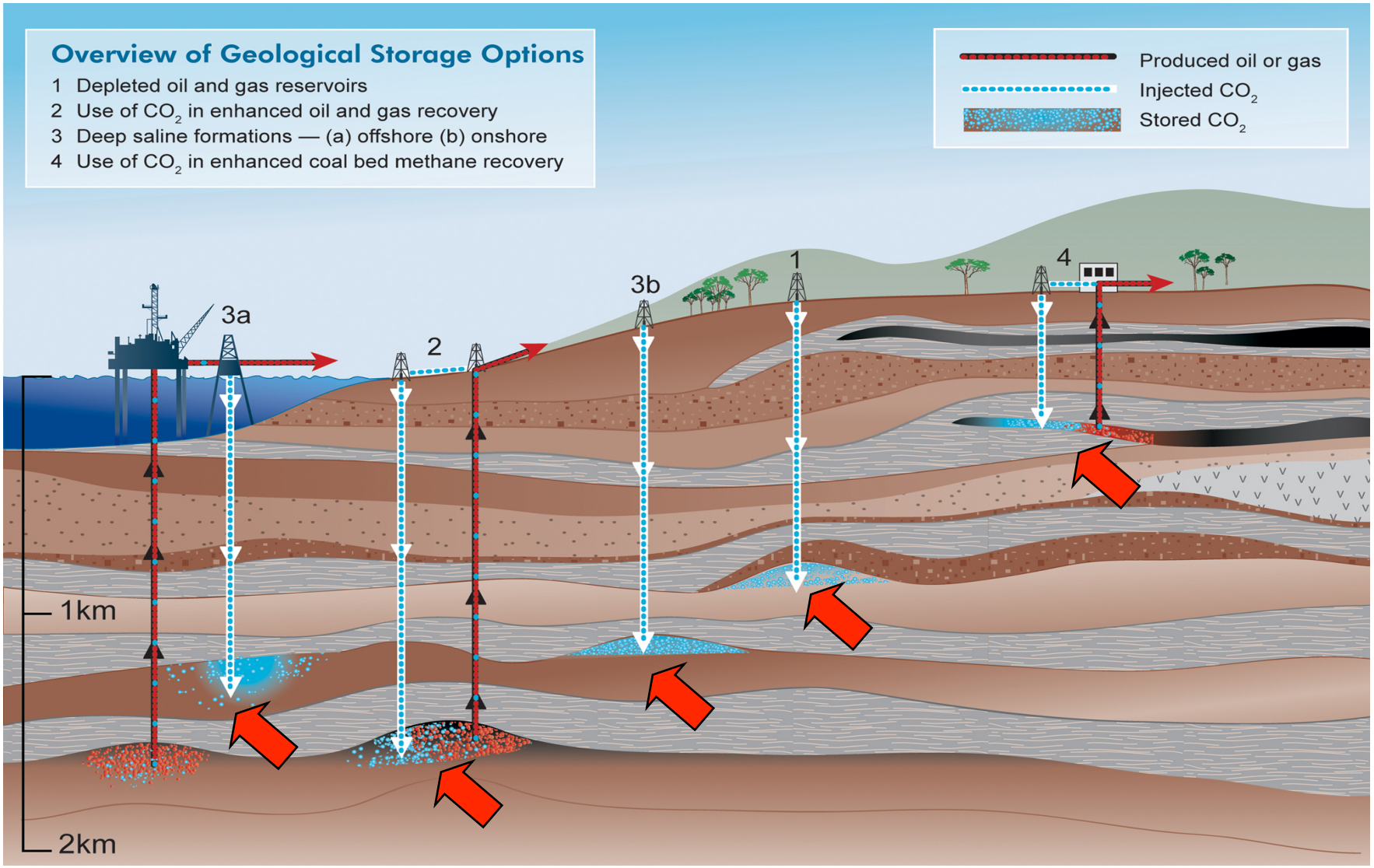
Global Storage Capacity



CCS – the basic concept – 1
Key components



CCS – the basic concept 2
Geological Storage Options



Source : CO2CRC - Australia

Why does CO_2 stay underground?

- When pumped underground it is compressed to a higher pressure and becomes a liquid
- The liquid is trapped between the spaces (pores) between the grains of rock by several means
  - **Structural storage**
    - Initially more buoyant than water, it rises up and is trapped by an impermeable layer or cap rock
  - **Residual storage**
    - Reservoir rocks act like a tight, rigid sponge trapping the CO_2 within the pore spaces
  - **Dissolution storage**
    - CO_2 dissolves in salty underground water and being heavier than the surrounding water sinks to the bottom of the reservoir
  - **Mineral storage**
    - CO_2 dissolved in salty underground water is weakly acidic and can react with minerals in the surrounding rocks to form new minerals and create coatings on existing rocks. Sometimes slow and sometime fast, this binds the CO_2 to the surrounding rocks

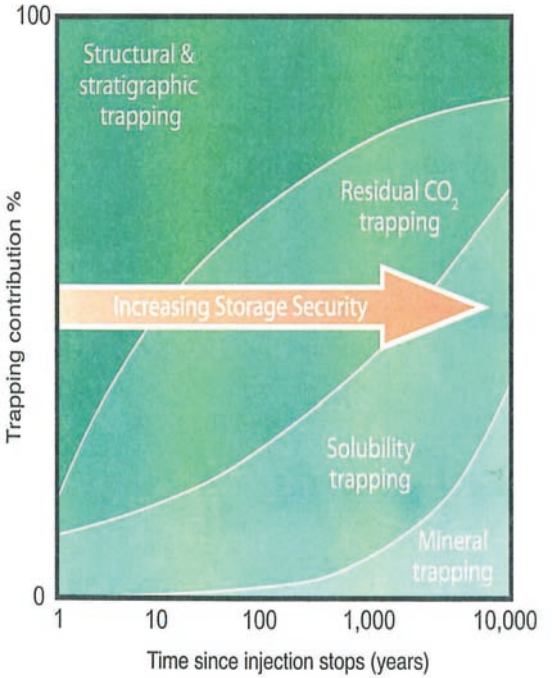


Figure 5.9 Storage security depends on a combination of physical and geochemical trapping. Over time, the physical process of residual CO_2 trapping and geochemical processes of solubility trapping and mineral trapping increase.

- Additional R&D on microalgae, ocean fertilisation and other methods

Source : WC/?IEA : Storing CO2 Underground 2007; IPCC

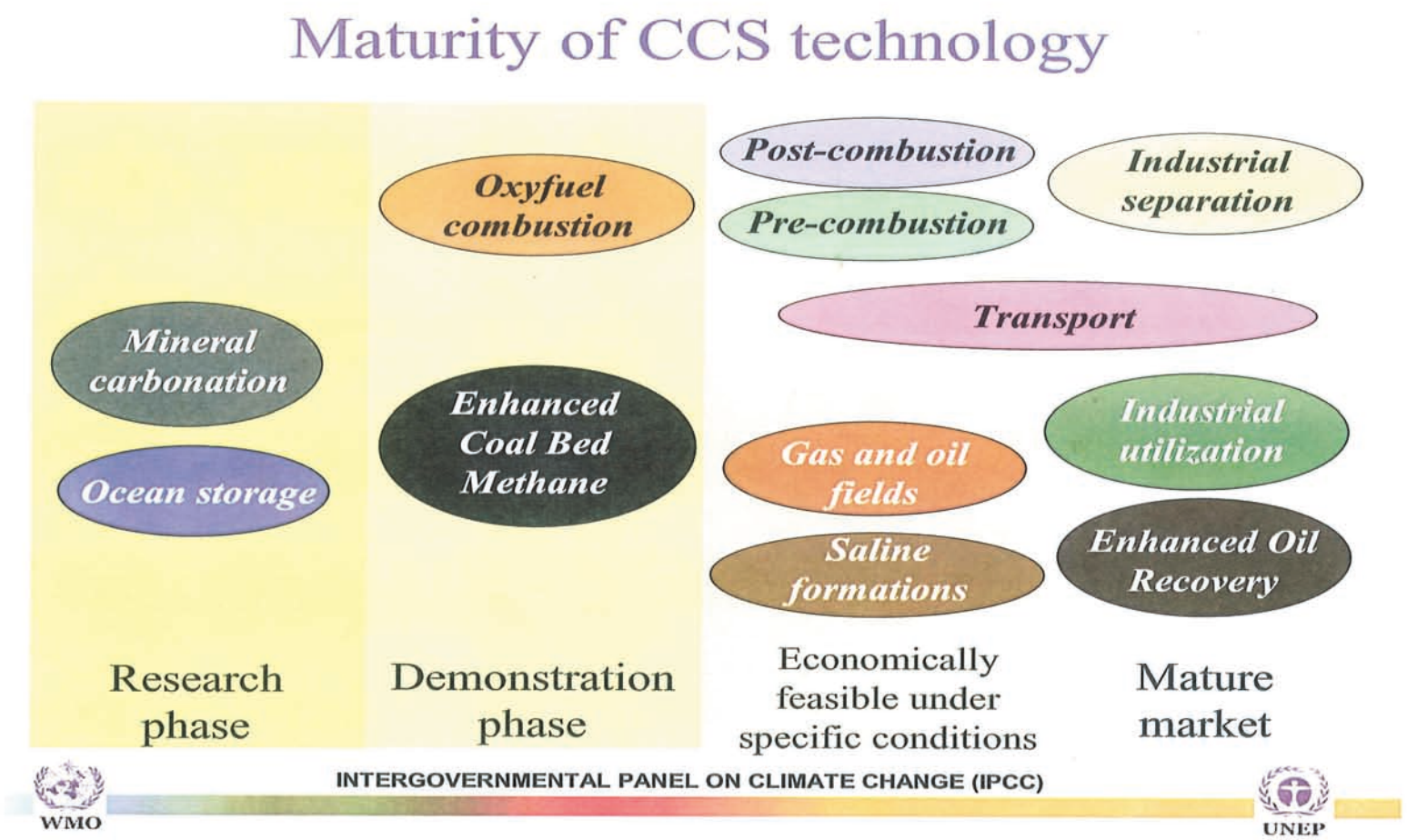
Geological storage of CO_2 – Project locations

CO_2 Storage Demonstration Projects

Source: IEA Greenhouse Gas R&D Programme

Source :IEA GHG Programme; WCI 2007

CCS technology is at varying states of maturity



Source: WMO;UNEP;IPCC

CCS Cost estimates vary

Tech Support, IPCC – IEA GHGP Financing Workshop July 2007

Power plant capture	US$/$tCO_2$ net captured 15 - 75
Capture (gas proc/amm prod)	US$/$tCO_2$ net captured 5 – 55
Capture ex other ind sources	US$/$tCO_2$ net captured 25 – 115
Transportation per 250 km	US$/$tCO_2$ net 1 -8
Geological storage	US$/$tCO_2$ injected 0.5 – 8
Ocean storage	US$/$tCO_2$ injected 5 – 30
Mineral carbonation	US$/$tCO_2$ net mineralized 40 - 100

RWE Scenario Analysis - IEA GHGP Financing Workshop July 2007

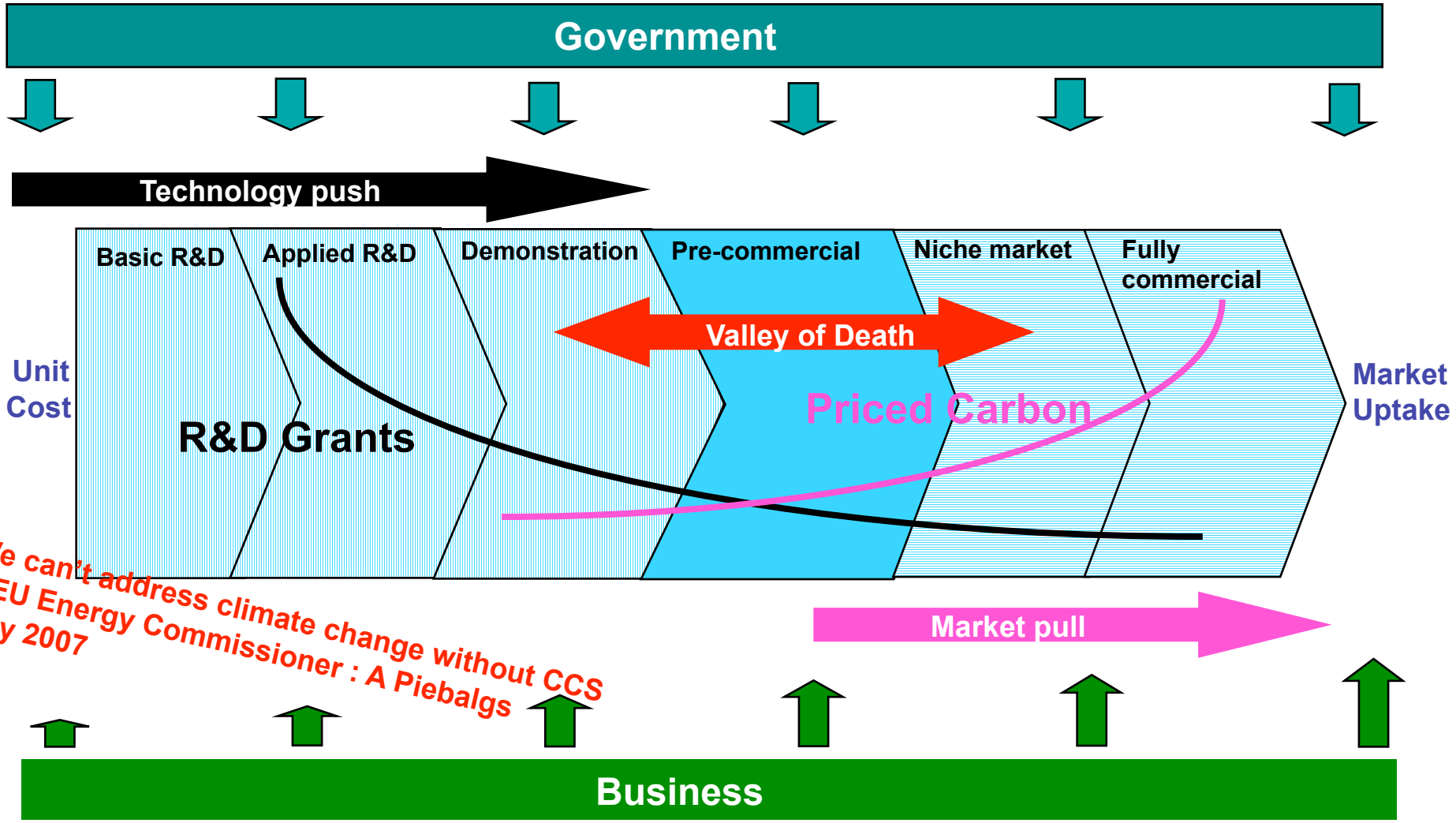
(Euro millions/MW)

Investment cost	Hard Coal	Lignite
Without CCS	1.2	1.35
With CCS	1.68	1.75

Efficiency after 2020 in %	Hard Coal	Lignite
Without CCS	52	51
With CCS	44	43

Source : IEA; Vattenfall GLOBE Feb 2007
IEA GHGP Expert Workshop on financing CCS – Jul 2007

The need for faster progress is clear, and there are pitfalls to be avoided …



Source: Grubb M (2002) Submission to UK Energy White Paper for The Carbon Trust

Important recent developments

- July 2007 - Ospar Commission (Protection of the Marine Environment for the North East Atlantic) decision to permit $C0_2$ storage under the seabed
- July 2007 - CDM Methodology panel : CCS for CDM projects – decision now late 2008
- EU decision to support CCS – EU Technology Platform on Zero Emission Power Plants (ETP ZEP) – going beyond Norway and the Netherlands
- Gleneagles Plan of Action – G8+5
  - GLOBE; IEA GHGP and CSLF working on accelerated development of policy to promote commercial deployment - G8 summit in Japan in 2008
- Bali Climate Conference

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Coal Stewardship in Anglo Coal

Product Stewardship

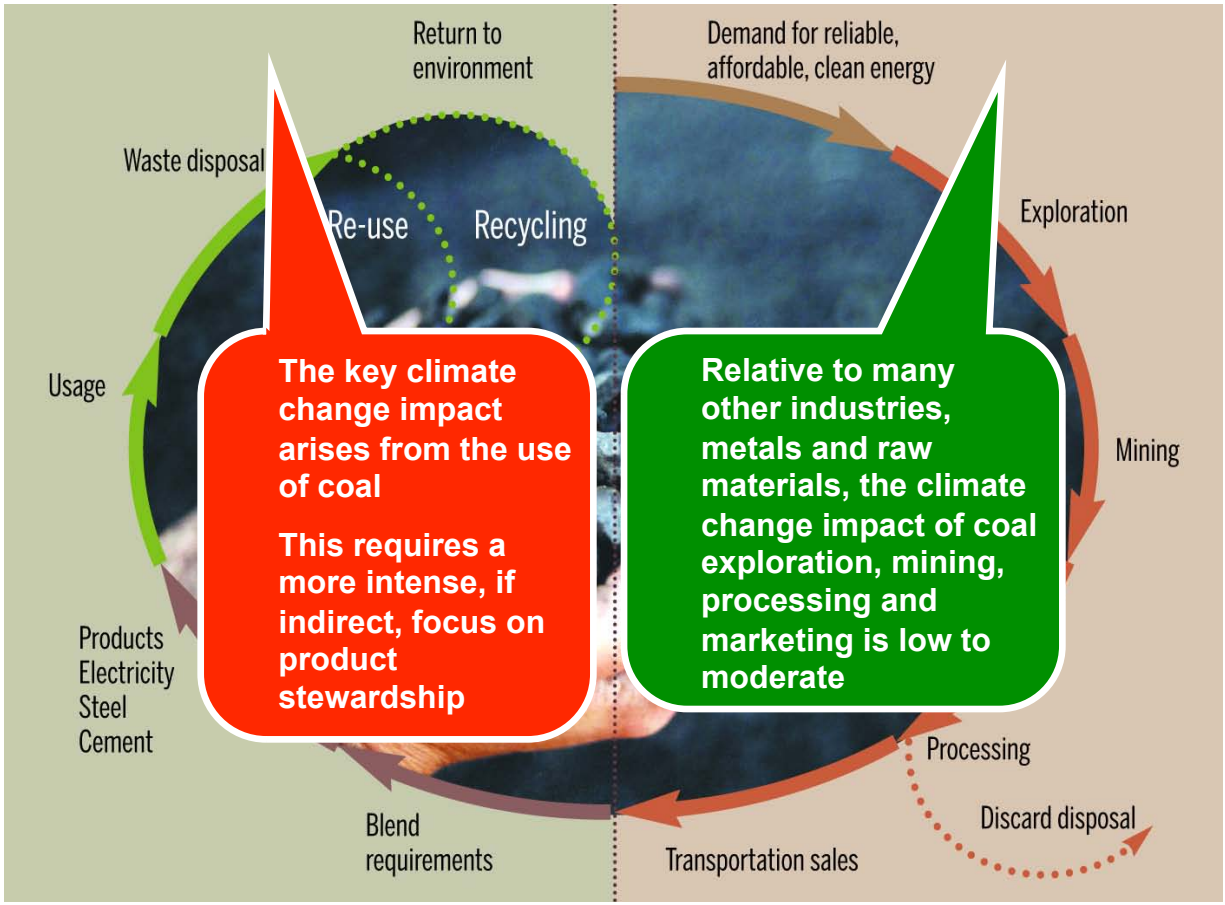
Process Stewardship

Key Elements

- Secure supply
- Quality
- Clean technology
- CO_2 Markets

Stakeholders

- Customers
- Regulators
- Industry



Key Elements

- Safety
- Health
- Environment
- Community

Stakeholders

- Employees
- Suppliers
- Community
- Regulators
- NGOs

* Adopted from the ICMM – Model of Material Stewardship

Responses to Climate Change imperatives

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Product Stewardship

Process Stewardship

Clean Coal Promotion and Technology Projects

Power generation and emission reduction from mine gas

Energy efficiency and carbon mitigation

Scare resource protection/ supplementation

HIV / AIDS Programs

Safety and Culture Programs

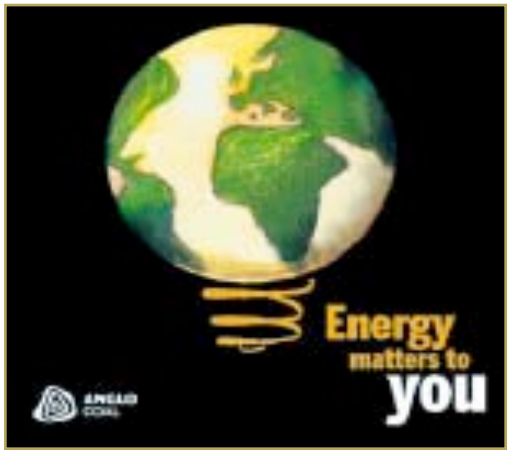
Working with indigenous communities

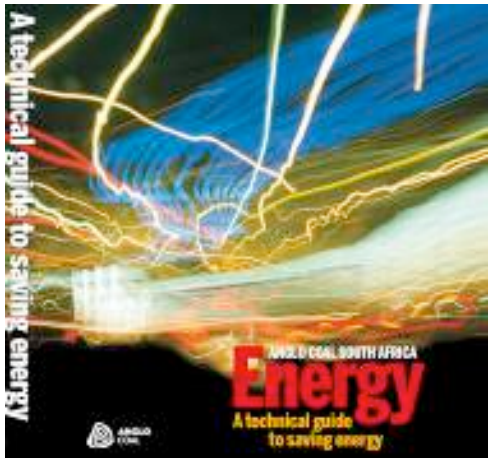
Understanding the impacts of climate change

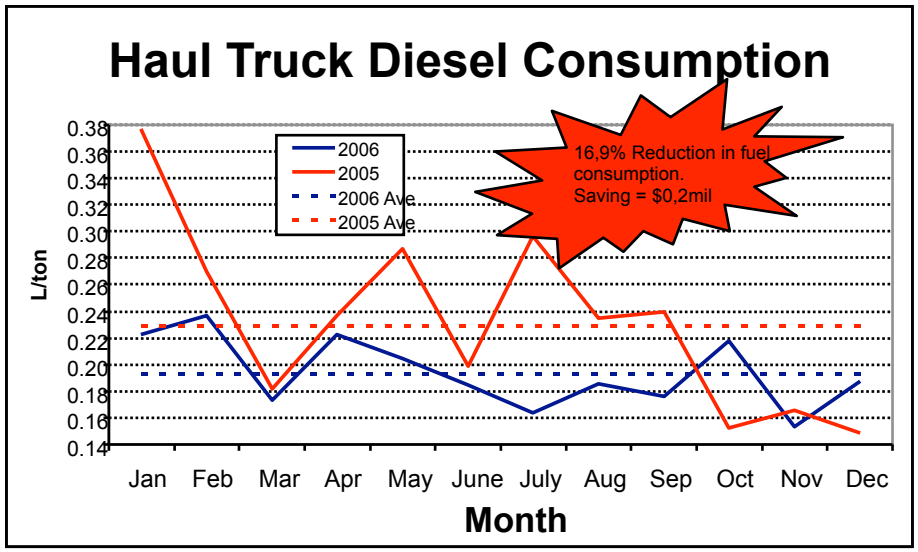
Energy Intensity and Carbon Emissions Intensity Reduction – RSA Example

Energy Management matrix on each operation:

- Energy Champion
- Baseline establishment and metering
- DSM Projects and DMP with Eskom
- Energy and CO_2 targeting
- Project portfolio







Landau Haul Road Project

- Diesel saving 17% (reduced rolling resistance and gradient)
- Improved safety (less dust and reduced wet weather impact – able to haul after 28mm rain)

Lighting

- 55 000 CFL Eco-lights at Operations
- 37 000 CFL Eco-lights at Mine Village Houses
- R 10 million investment

Policy Engagement and Technology Development

Global

- World Coal Institute
- IEA Coal Industry Advisory Board (+ regional inputs)
- IEA Clean Coal Centre and GHG Programme
- GLOBE G8+5 and GROCC
- Conferences

Regional

- Fossil Fuel Foundation (RSA)
- Chamber of Mines (RSA)
- Australian Coal Association – Clean Coal Initiative
- Australian Business and Climate Group
- Asia – Pacific Partnership (AP7) Working Groups

CO_2 Emission related initiatives

- International Emissions Trading Association (IETA)
- Carbon Sequestration Leadership Forum (CSLF) – global and regional
- CO2 Co-operative Research Centre (Australia)

CCS Legal, Regulatory and Technology Development

Aus/RSA/EU/USA

Coal Related Climate Change Projects

- Monash Energy/Otway Pilot Project
- Callide Oxyfuel firing and CCS pilot
- FutureGen – 275 MW Zero Emission plant
- Xiwan Coal project in China – possible CCS link
- Johnson Matthey - Anglo Coal Low Carbon Technologies Programme
- Methane conversion to Power at Australian mines –reduction of 1.2 Mt CO_2e pa
- Coal industry levy contribution to CCT and CCS projects in Australia
- Additional CCS demo project with involvement with customers being sought

Monash and Otway Pilot

FutureGen

Capcoal waste mine gas initiative

Award Winning Projects in RSA

Basa Magogo Njengo Project

- 10 000 low income households targeted for 2007
- Aims to reduce particulate emissions from domestic burning of coal
- Methodology developed by DME

Emalahleni Water Treatment Plant

- Winner of the prestigious Mail and Guardian' Greening the future award'
- The division's Emalahleni Water Reclamation Plant (EWRP) was recognised for its innovative approach to turning waste into water, and received top honours in two categories: Companies with Innovative Environmental Strategies that Improve Business Performance and Water Care

Isibonelo Wetlands Project

- Isibonelo colliery recently lived up to its name (which means 'an example to others') when the colliery's wetland rehabilitation project won the environmental category in the Nedbank Capital Green Mining Awards competition

Additional Initiatives

- Key Customer seminars on SD
- CCS Atlas in RSA
- Coal Industry Roadmap in RSA

To conclude – Can coal be clean ?

- The world needs coal as a secure, abundant and cheap energy source
- To meet the climate change challenge the environmental footprint of coal will have to be improved
- The costs of doing so will not be cheap
- Technological development is vital but without supporting policies and financial assistance for R&D, success will be elusive

"We at the IEA love coal. It's cheap and widely available, but we have to have carbon capture and sequestration."

(Claude Mandil, executive director of the IEA)