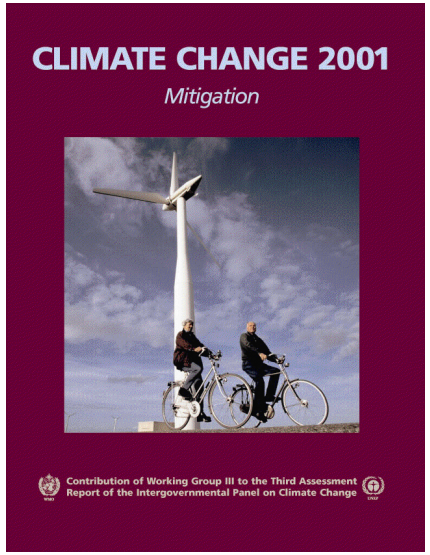
CCS in the IPCC Fourth Assessment

Expert meeting on Financing CCS projects
IEA GHG R&D Programme
London, 31 May 2007

Dr. Leo Meyer, IPCC Working Group III

About IPCC



- Founded 1988 by UNEP and WMO
- No research, no monitoring, no recommendations
- Preferably peer-reviewed literature
- Authors academic, industrial and NGO
- Reviews by Experts *and* Governments
- Policy relevant, but NOT policy prescriptive
- Summary for policymakers: government approval
- Fourth Assessment cycle 2003-2008

Key issues addressed in this presentation

The IPCC Special Report on CCS (2005)

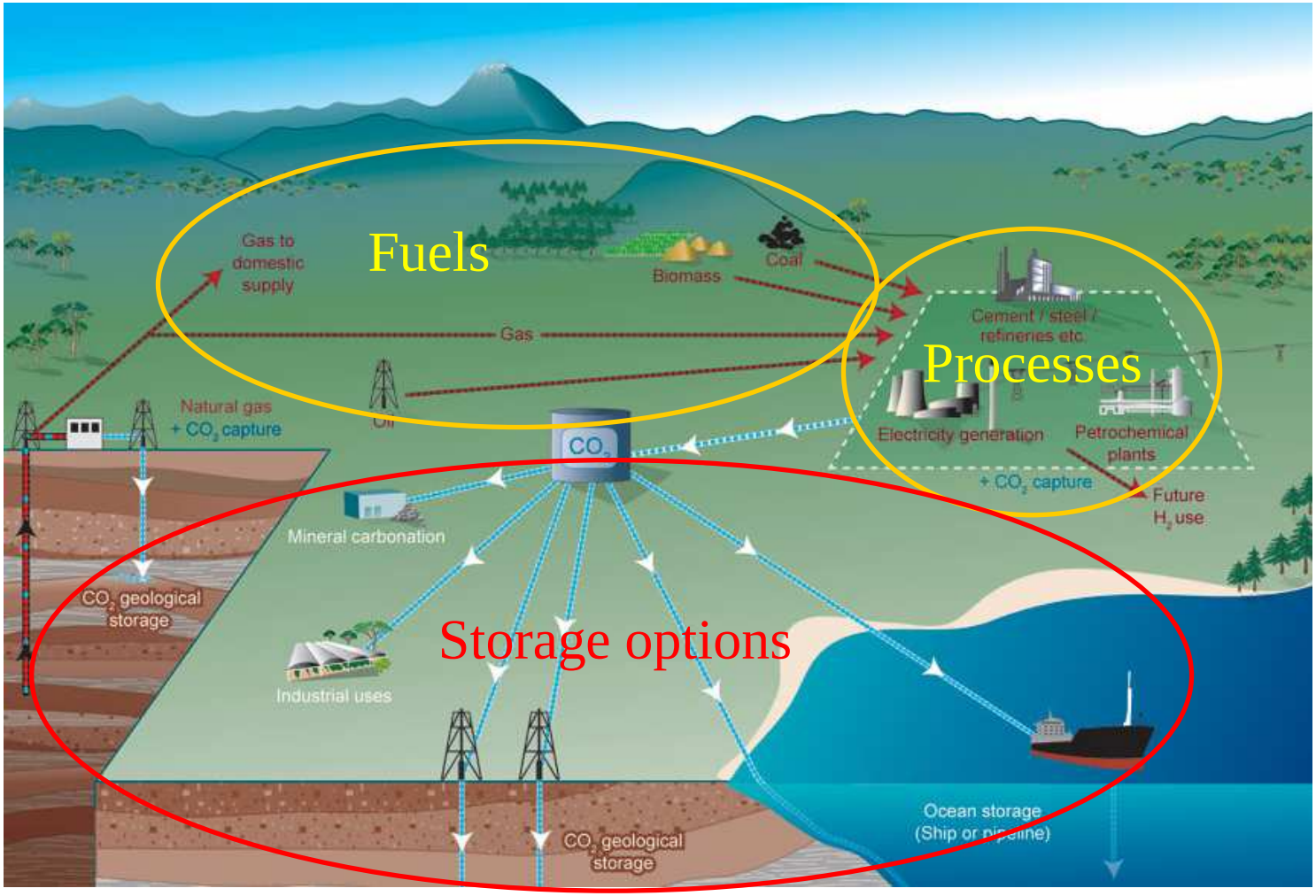
- What is CO_2 capture and storage?
- Sources, Capture, transport
- Geological storage, Ocean storage, mineral carbonation
- Maturity of the technologies
- Cost and potential
- Health, safety and environment risks

The IPCC WG III AR4: mitigation of Climate change (2007)

- CCS : transient or expansion;
- CCS readiness of power plants
- New cost and potential estimate in 2030 ; LT potential

'*take home' messages*

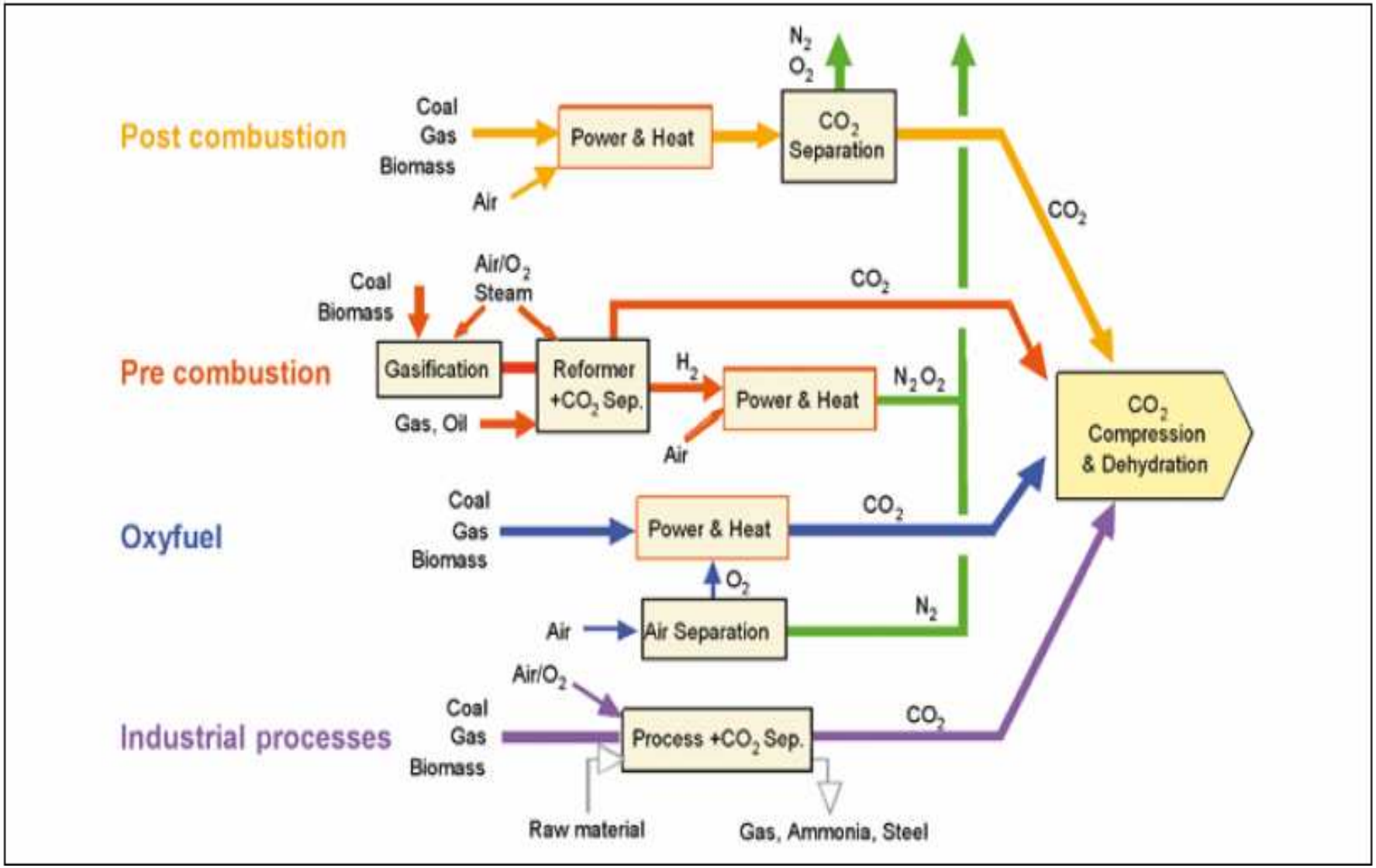
CO_2 capture and storage system



Global large stationary CO_2 sources with emissions of more than 0.1 $MtCO_2$/year

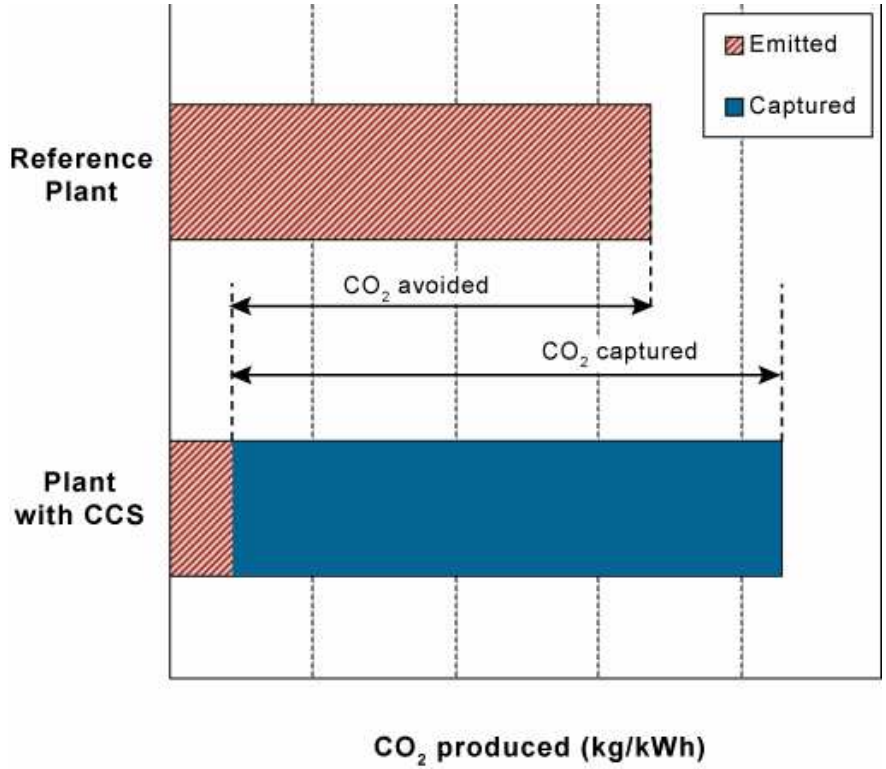
Process	No. of sources	Emissions ($MtCO_2$/yr)
Fossil Fuels		
Power (coal, gas, oil and others)	4,942	10,539
Cement production	1,175	932
Refineries	638	798
Iron and steel industry	269	646
Petrochemical industry	470	379
Oil and gas processing	N/A	50
Other sources	90	33
Biomass		
Bioethanol and bioenergy	303	91
Total	**7,887**	**13,466**

Overview of CO_2 capture systems



Capture and transport energy requirements

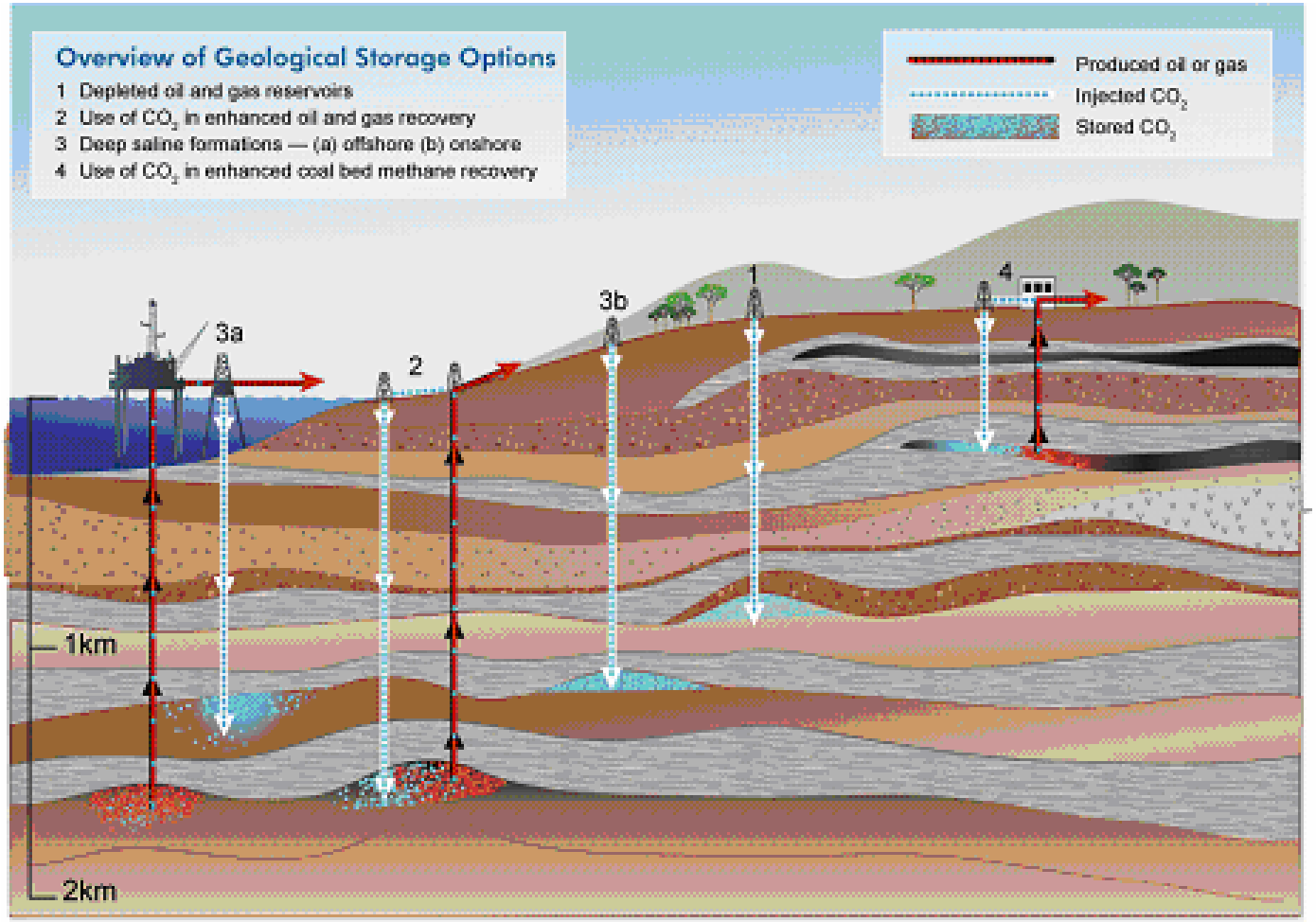
- Additional energy use of 10 - 40% (for same output)
- Capture efficiency: 85 - 95%
- Net CO_2 reduction: 80 - 90%
- Assuming safe storage



Capture energy requirements

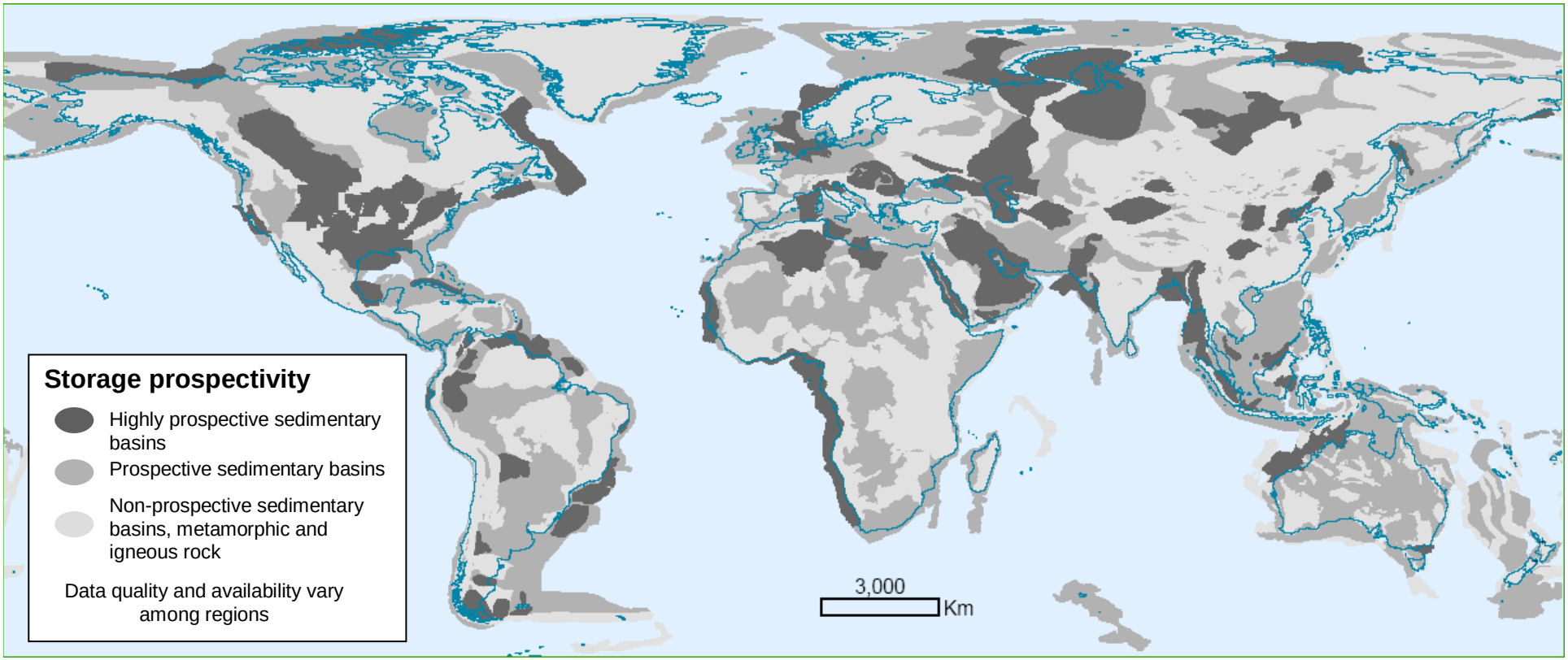
Power plant (new)	**Thermal eff. without capture (LHV), %**	**Thermal eff. with capture (LHV), %**	**Increased primary energy use / output electricity %**
Pulverized Coal	41- 45	30 - 35	24 - 40
NGCC	55 - 58	47 - 50	11 - 22
IGCC	38 - 47	31 - 40	14 - 25

Geological storage



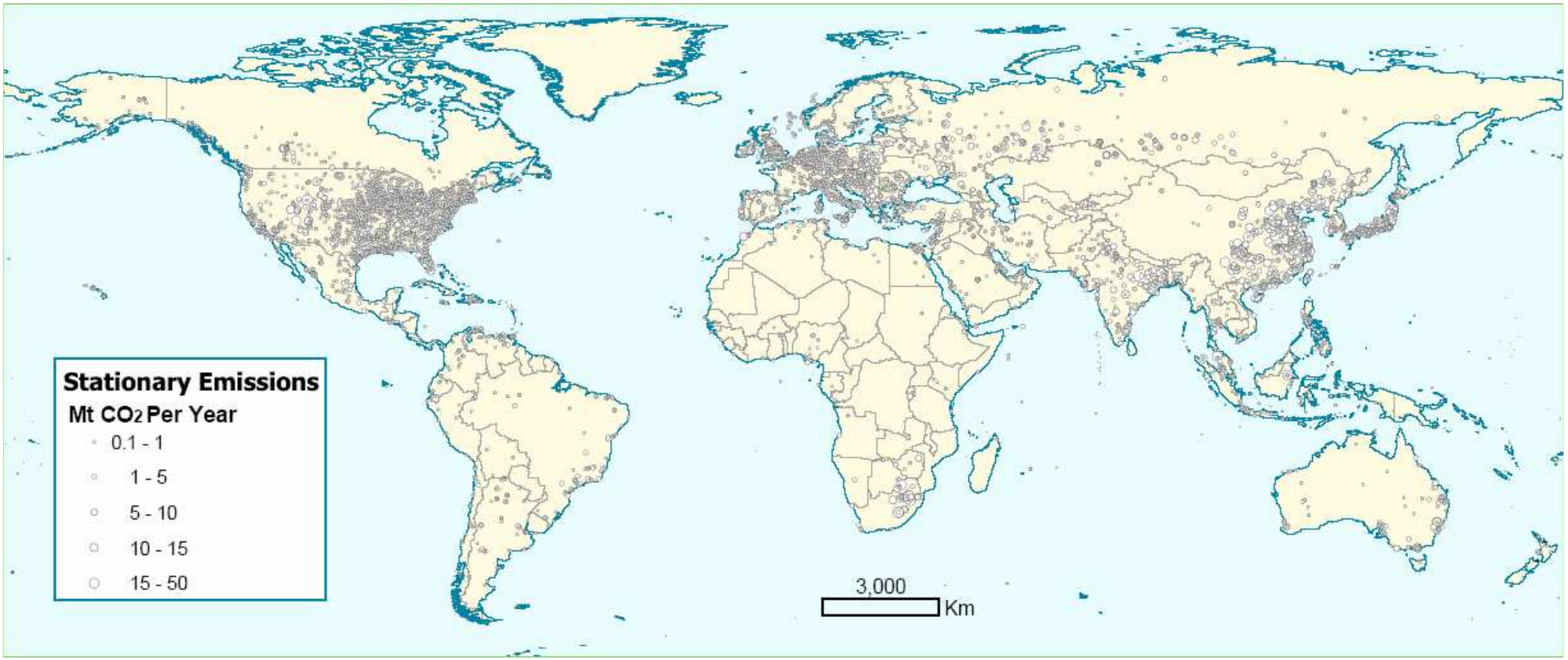
Planned and current locations of geological storage

Geographical relationship between sources and storage opportunities



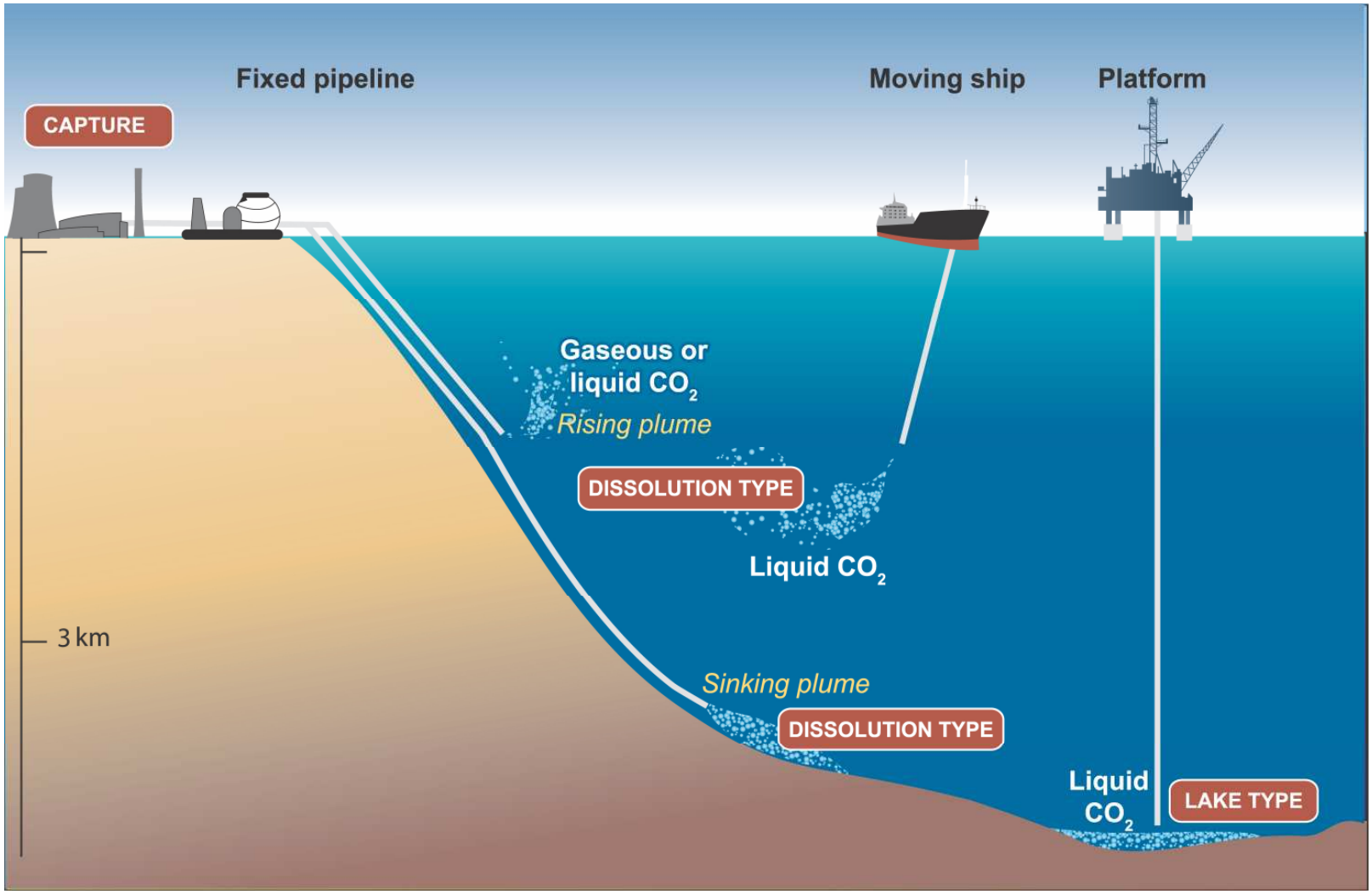
Prospective areas in sedimentary basins where suitable saline formations, oil or gas fields, or coal beds may be found. Locations for storage in coal beds are only partly included. Prospectivity is a qualitative assessment of the likelihood that a suitable storage location is present in a given area based on the available information. This figure should be taken as a guide only, because it is based on partial data, the quality of which may vary from region to region, and which may change over time and with new information (Courtesy of Geoscience Australia).

Geographical relationship between sources and storage opportunities

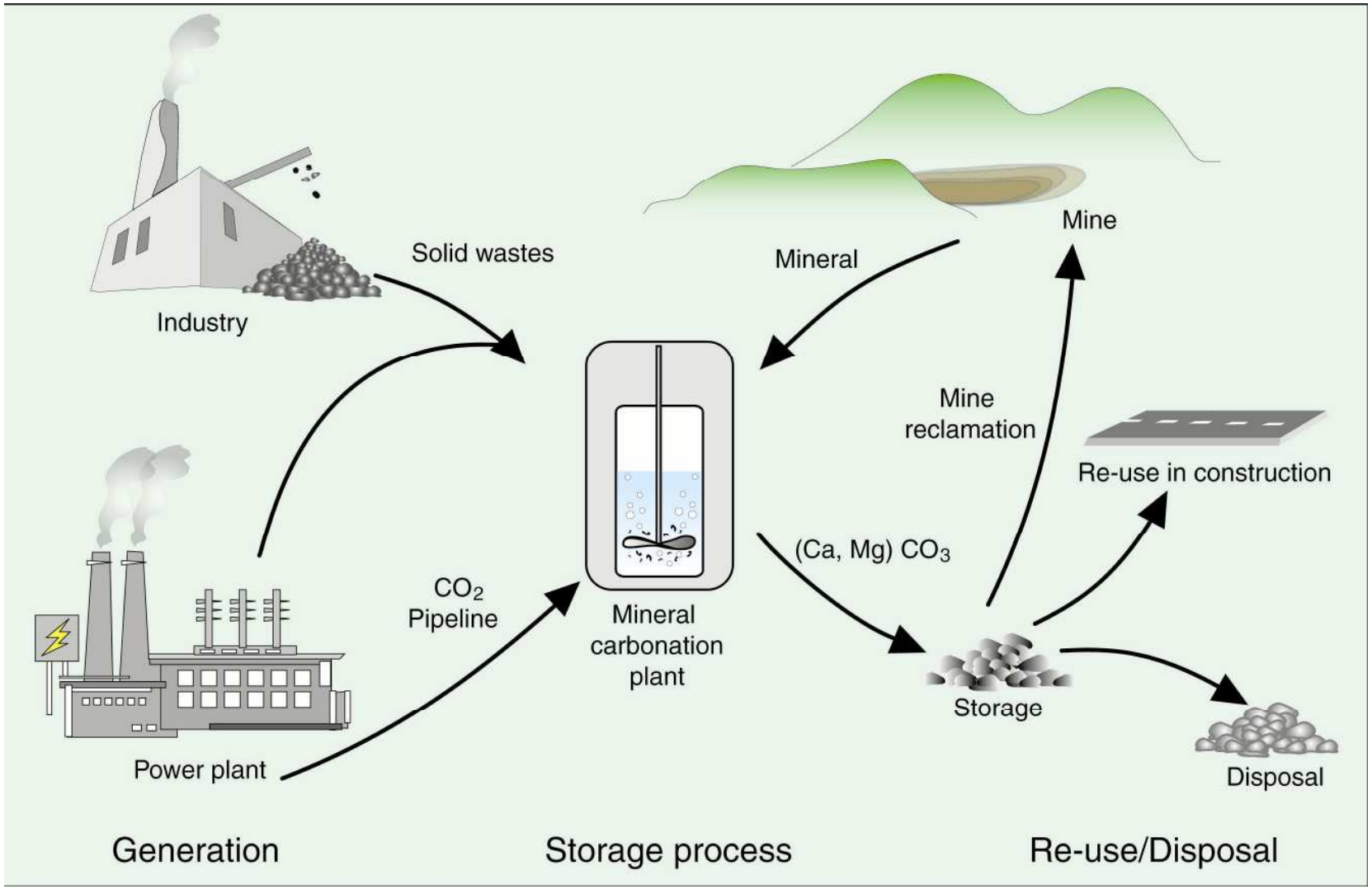


Global distribution of large stationary sources of CO_2 (Based on a compilation of publicly available information on global emission sources, IEA GHG 2002)

Ocean storage



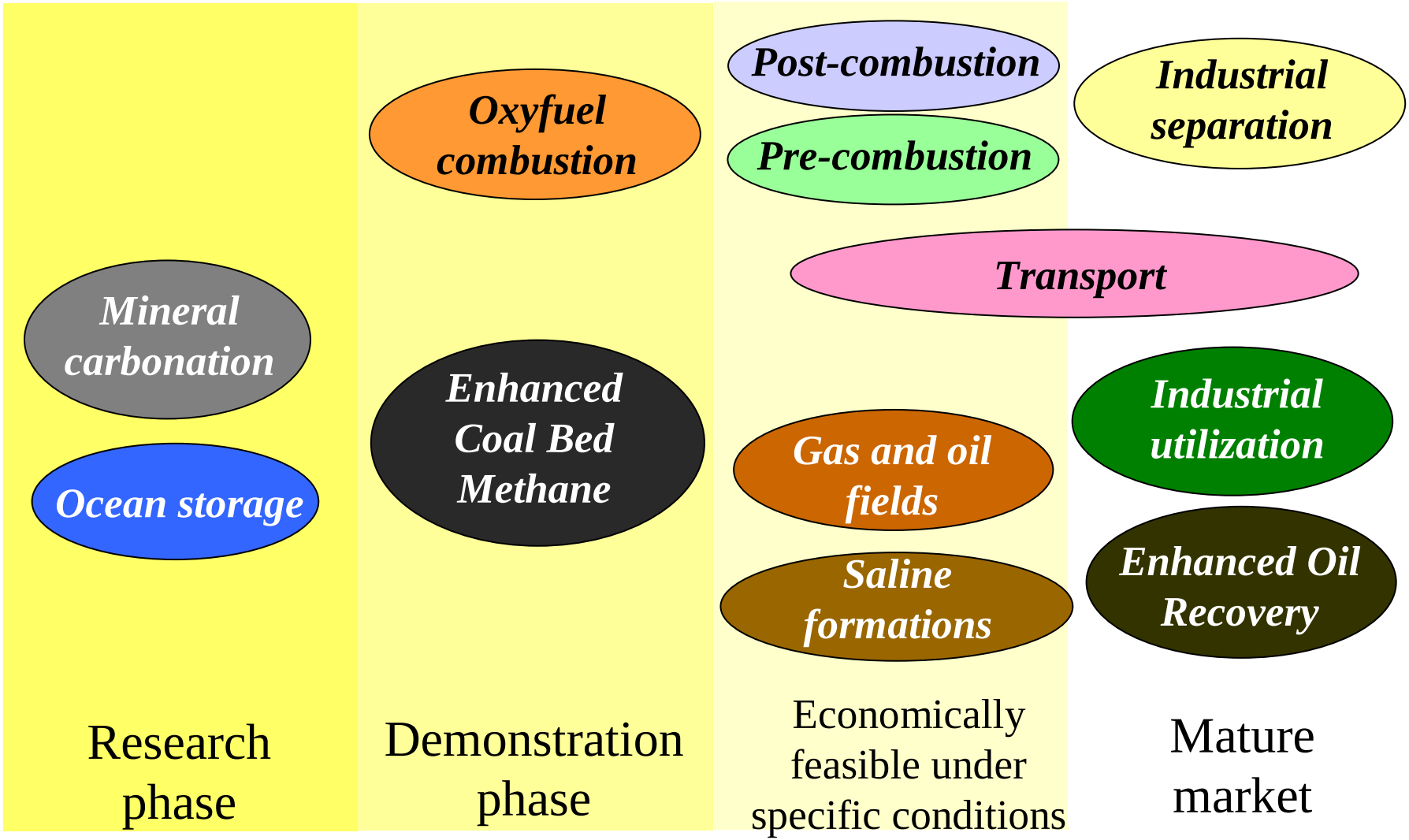
Mineral carbonation



Maturity of CCS technology

- Research phase means that the basic science is understood, but the technology is currently in the stage of conceptual design or testing at the laboratory or bench scale, and has not been demonstrated in a pilot plant.
- Demonstration phase means that the technology has been built and operated at the scale of a pilot plant, but further development is required before the technology is ready for the design and construction of a full-scale system.
- Economically feasible under specific conditions means that the technology is well understood and used in selected commercial applications, such as in case of a favourable tax regime or a niche market, processing at least 0.1 $MtCO_2$/yr , with few (less than 5) replications of the technology.
- Mature market means that the technology is now in operation with multiple replications of the commercial-scale technology worldwide.

Maturity of CCS technology



Costs

Two ways of expressing costs:

- Additional electricity costs
  - Energy policymaking community
- CO_2 avoidance costs
  - Climate policymaking community

Different outcomes:

0.01 - 0.05 US$/kWh

20* - 270 US$/t$CO_2$ avoided

(with EOR: 0*– 240 US$/t$CO_2$ avoided)

* low-end: capture-ready, low transport cost, revenues from storage: 360 MtCO_2/yr

CCS component costs

CCS component	Cost range
Capture from a power plant	15 - 75 US$/t$CO_2$ net captured
Capture from gas processing or ammonia production	5 - 55 US$/t$CO_2$ net captured
Capture from other industrial sources	25 - 115 US$/t$CO_2$ net captured
Transportation	1 - 8 US$/t$CO_2$ transported per 250km
Geological storage	0.5 - 8 US$/t$CO_2$ injected
Ocean storage	5 - 30 US$/t$CO_2$ injected
Mineral carbonation	50 - 100 US$/t$CO_2$ net mineralized

Economic potential

- Cost reduction of climate change stabilisation: 30% or more
- Most scenario studies: role of CCS increases over the course of the century
- Substantial application above CO_2 price of 25-30 US$/t$CO_2$
- 15 to 55% of the cumulative mitigation effort worldwide until 2100
- 220 - 2,200 GtCO_2 cumulatively up to 2100, depending on the baseline scenario, stabilisation level (450 - 750 ppmv), cost assumptions

Storage potential

- Geological storage: likely at least about 2,000 $GtCO_2$ in geological formations

  "Likely" is a probability between 66 and 90%.

- Ocean storage: on the order of thousands of $GtCO_2$, depending on environmental constraints
- Mineral carbonation: can currently not be determined
- Industrial uses: Not much net reduction of CO_2 emissions

Health, safety, environment risks

- **In general**: lack of real data, so comparison with current operations
- **CO_2 pipelines**: similar to or lower than those posed by hydrocarbon pipelines
- **Geological storage**:
  - appropriate site selection, a monitoring program to detect problems, a regulatory system, remediation methods to stop or control CO_2 releases if they arise:
  - comparable to risks of current activities (natural gas storage, EOR, disposal of acid gas)

Health, safety, environment risks

- **Ocean storage**:
  - pH change
  - Mortality of ocean organisms
  - Ecosystem consequences
  - Chronic effects unknown
- **Mineral carbonation**:
  - Mining and disposal of resulting products
  - Some of it may be re-used

CCS in the Fourth Assessment Report of IPCC WG 3 2007 (1)

- IPCC 2005: expansion towards 2100
- IEA 2006: CCS is ‘transitional’, peaking at 2050 and declining thereafter
- CCS and biomass could return CO2 conc below 450 ppm

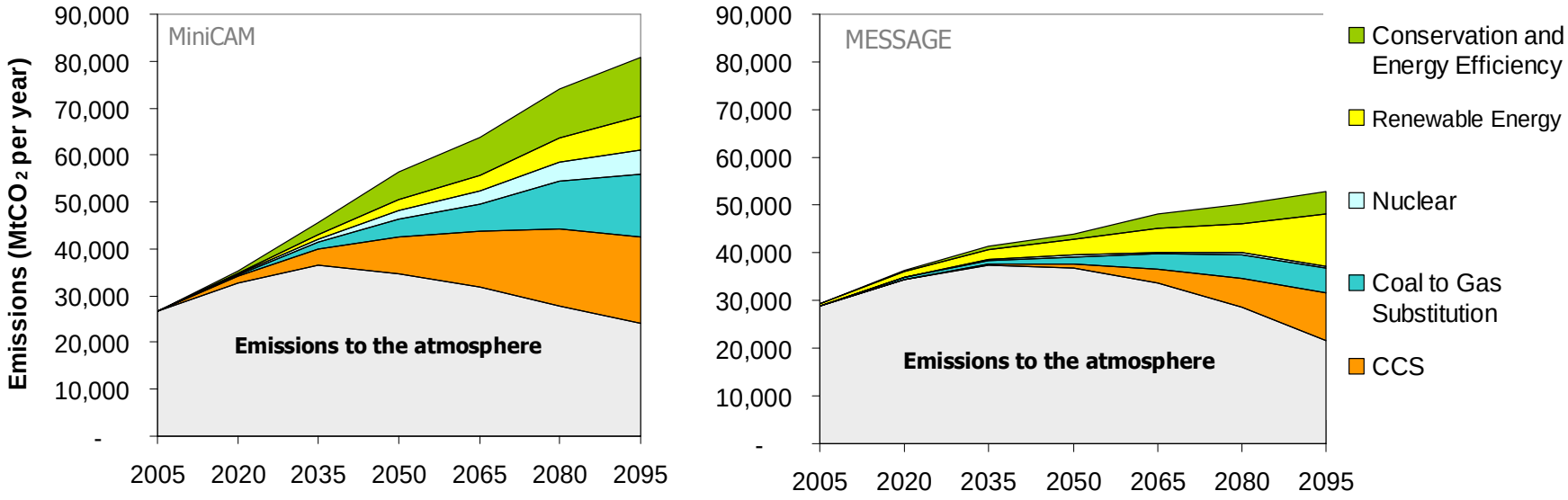
CCS in the Fourth Assessment Report of IPCC WG 3 2007 (2)

- ‘Make power plants CCS-ready if rapid deployment desired‘
- Significant pre-capital investments not justified
- Detailed reports not yet published

CCS in the Fourth Assessment Report of IPCC WG 3 2007 (3)

Global potential reduction and costs for CCS in 2030				
Power plants with CCS	Share %	Avoided emissions (GtCO2/y)	Costs US$/ tCO2	Costs (US ct/kWh)
Coal	6	0.49 (3%)	22-42	2-4
Gas	6	0.22 (1%)	43-79	1.3-2.4

Long term economic potential



‘Take home messages’

1. Potential 15 -55 % of mitigation effort to 2100 , but no silver bullet - portfolio needed to address climate change
2. Reduce overall mitigation costs (30%) by increasing flexibility in achieving greenhouse gas emission reductions
3. Energy requirements still considerable (10-40 %)
4. No substantive deployment unless CO_2 market price over 25-30 USD/tonne CO_2 to offset costs
5. Risks comparable to current industrial activities, but more experience needed

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