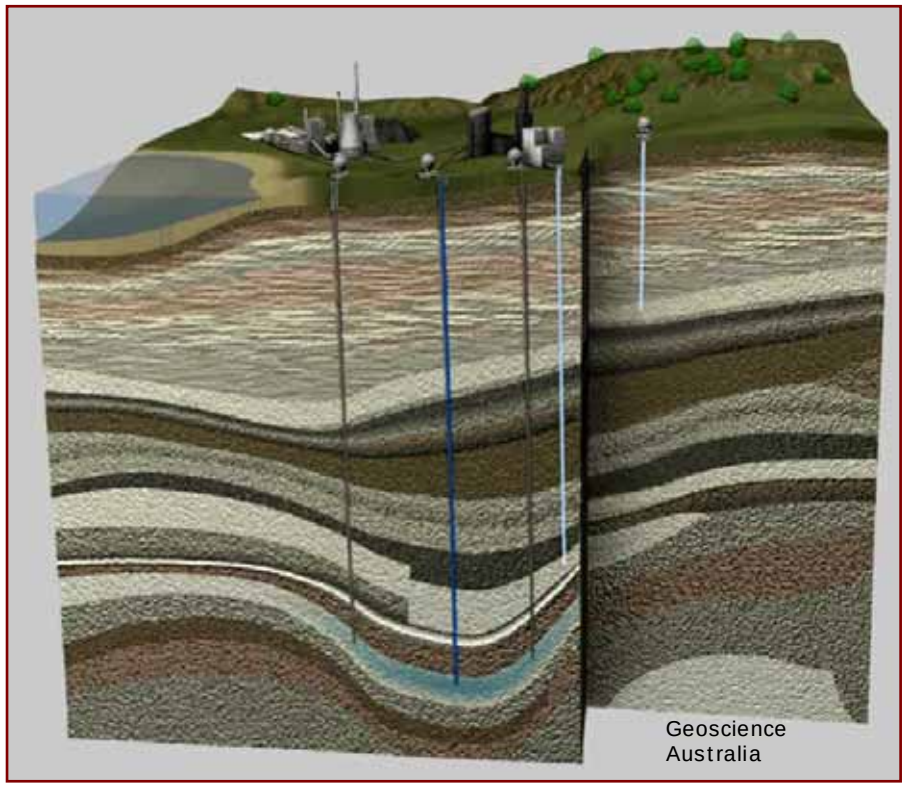
The context for Carbon Capture and Storage



Aleks Kalinowski
Geoscience Australia

Australian Government
Geoscience Australia

cags
China Australia Geological Storage of CO_2
中澳二氧化碳地质封存

Why are we here?

Why are we here?

- Climate scientists tell us that anthropogenic emissions of greenhouse gases (including CO_2) are contributing to global climate change.

Why are we here?

- Climate scientists tell us that anthropogenic emissions of greenhouse gases (including CO_2) are contributing to global climate change.
- Australia and China, along with much of the world, use fossil fuels (coal, gas, oil) for a significant proportion of their energy and electricity and will continue to do so for the foreseeable future.

Why are we here?

- Climate scientists tell us that anthropogenic emissions of greenhouse gases (including CO_2) are contributing to global climate change.
- Australia and China, along with much of the world, use fossil fuels (coal, gas, oil) for a significant proportion of their energy and electricity and will continue to do so for the foreseeable future.
- Carbon Capture and Storage is one technology that can help reduce our CO_2 emissions to the atmosphere, particularly from use of fossil fuels.

Why are we here?

- Climate scientists tell us that anthropogenic emissions of greenhouse gases (including CO_2) are contributing to global climate change.
- Australia and China, along with much of the world, use fossil fuels (coal, gas, oil) for a significant proportion of their energy and electricity and will continue to do so for the foreseeable future.
- Carbon Capture and Storage is one technology that can help reduce our CO_2 emissions to the atmosphere, particularly from use of fossil fuels.
- Geological storage is technically viable in many places. Petroleum studies show that oil, gas and CO_2 have been and can be stored in the deep subsurface for geological time.

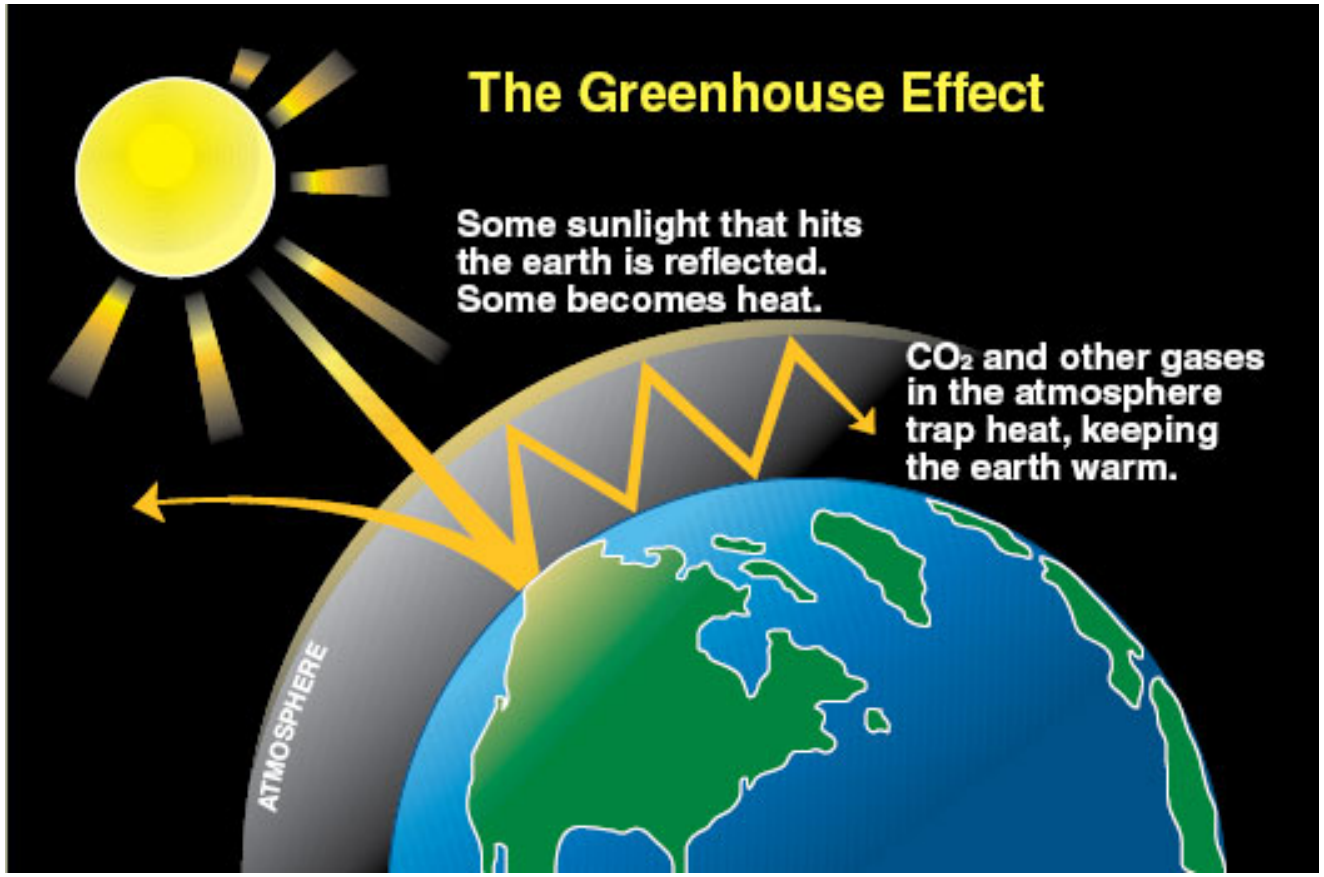
Why are we here?

- Climate scientists tell us that anthropogenic emissions of greenhouse gases (including CO_2) are contributing to global climate change.
- Australia and China, along with much of the world, use fossil fuels (coal, gas, oil) for a significant proportion of their energy and electricity and will continue to do so for the foreseeable future.
- Carbon Capture and Storage is one technology that can help reduce our CO_2 emissions to the atmosphere, particularly from use of fossil fuels.
- Geological storage is technically viable in many places. Petroleum studies show that oil, gas and CO_2 have been and can be stored in the deep subsurface for geological time.
- Geological storage of CO_2 is already happening in parts of the world.

Why are we here?

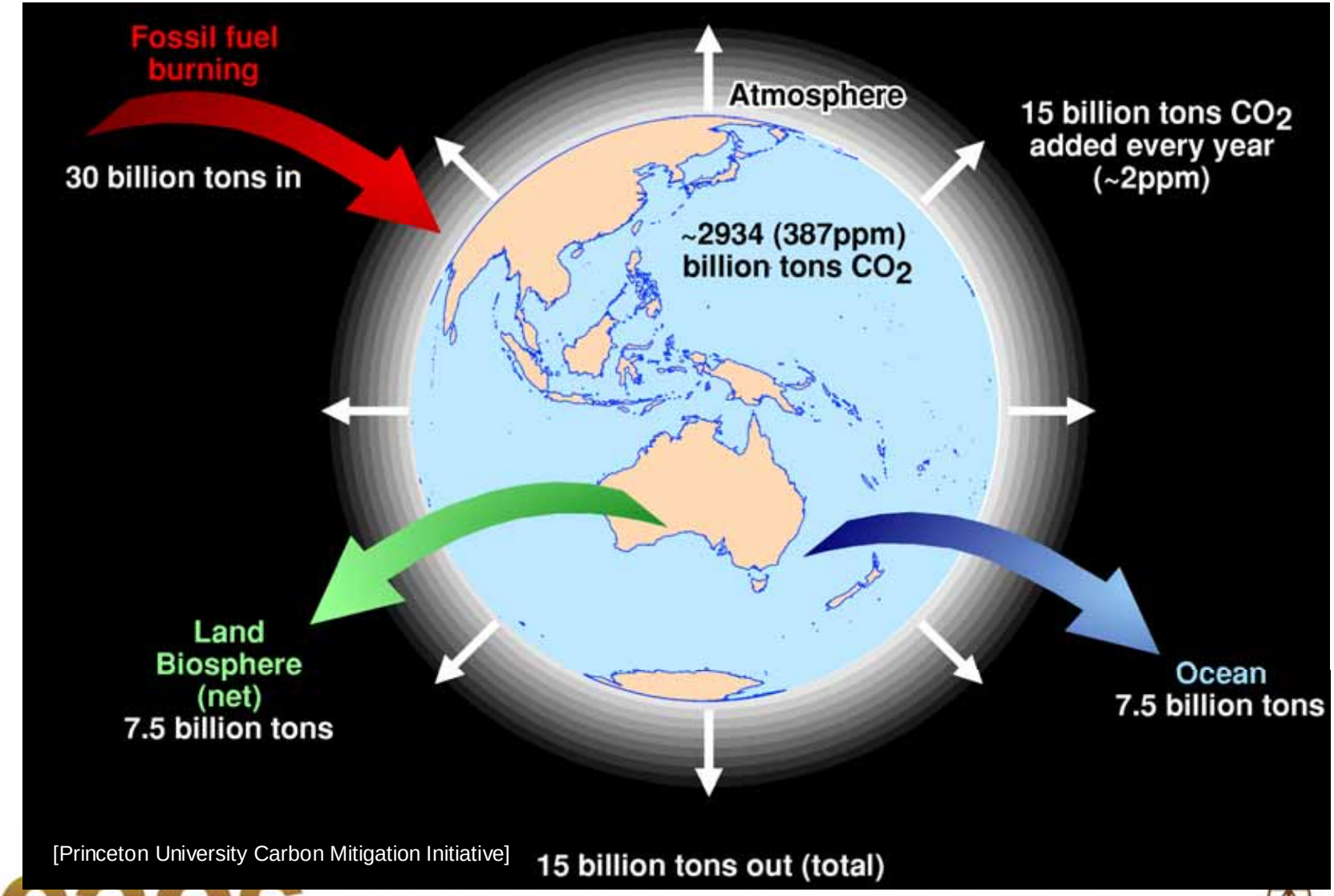
- Climate scientists tell us that anthropogenic emissions of greenhouse gases (including CO_2) are contributing to global climate change.
- Australia and China, along with much of the world, use fossil fuels (coal, gas, oil) for a significant proportion of their energy and electricity and will continue to do so for the foreseeable future.
- Carbon Capture and Storage is one technology that can help reduce our CO_2 emissions to the atmosphere, particularly from use of fossil fuels.
- Geological storage is technically viable in many places. Petroleum studies show that oil, gas and CO_2 have been and can be stored in the deep subsurface for geological time.
- Geological storage of CO_2 is already happening in parts of the world.
- Many of the remaining challenges for CCS are non-technical – financial, political, social…

What's the problem?



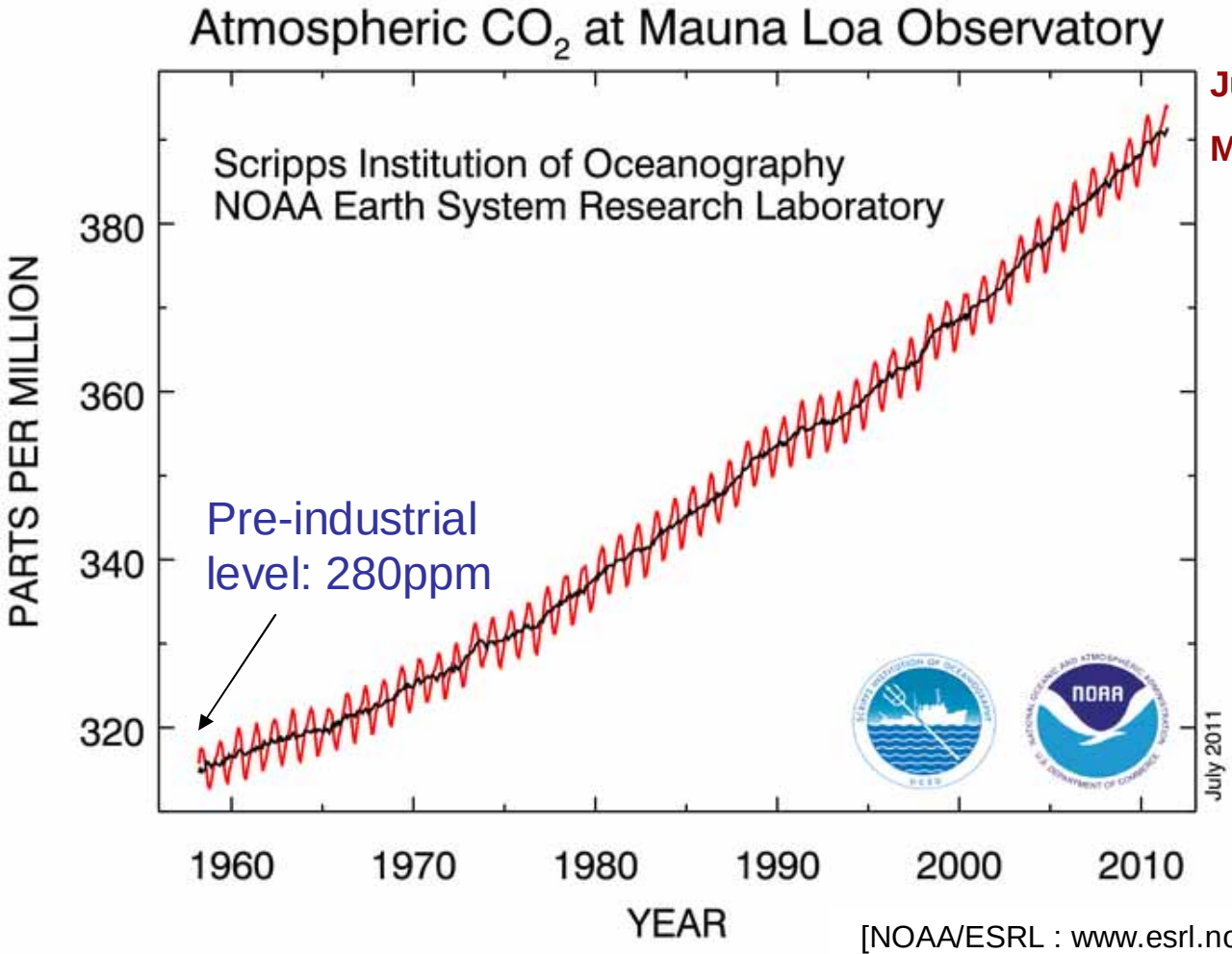
[State of Washington Department of Ecology www.ecy.wa.gov]

What's the problem?



[Princeton University Carbon Mitigation Initiative]

Recent Atmospheric CO_2 Levels



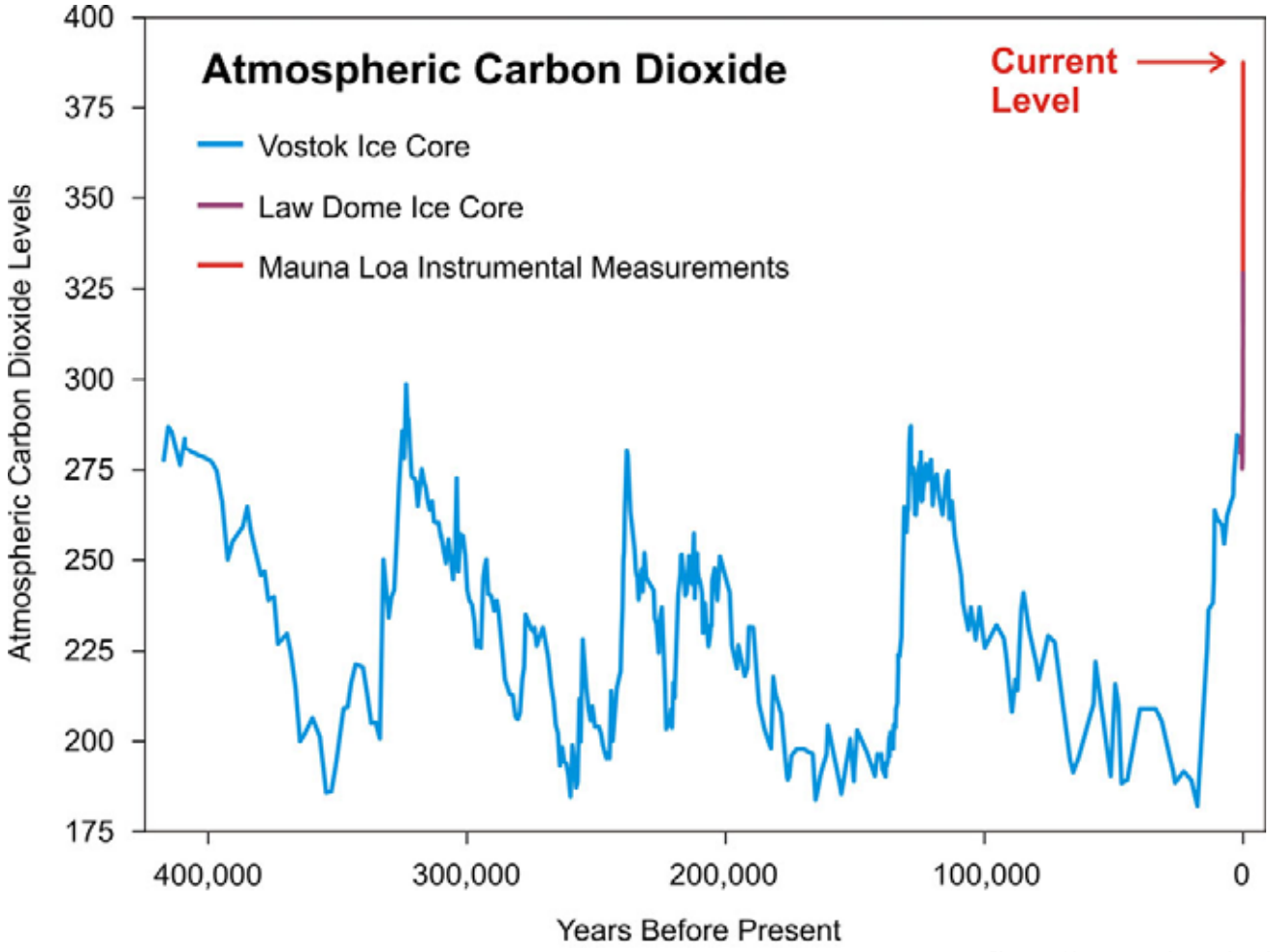
June 2011: 393.69 ppm

May 2010: 389.60ppm

- ~75ppm increase in atmospheric CO_2 concentration over the last 50 years, from <320 to >390.
- 110ppm or 40% increase from pre-industrial level.
- Currently increasing at >2ppm/year – and this rate is increasing

[NOAA/ESRL : www.esrl.noaa.gov/gmd/ccgg/trends]

Historical Atmospheric CO_2 Levels



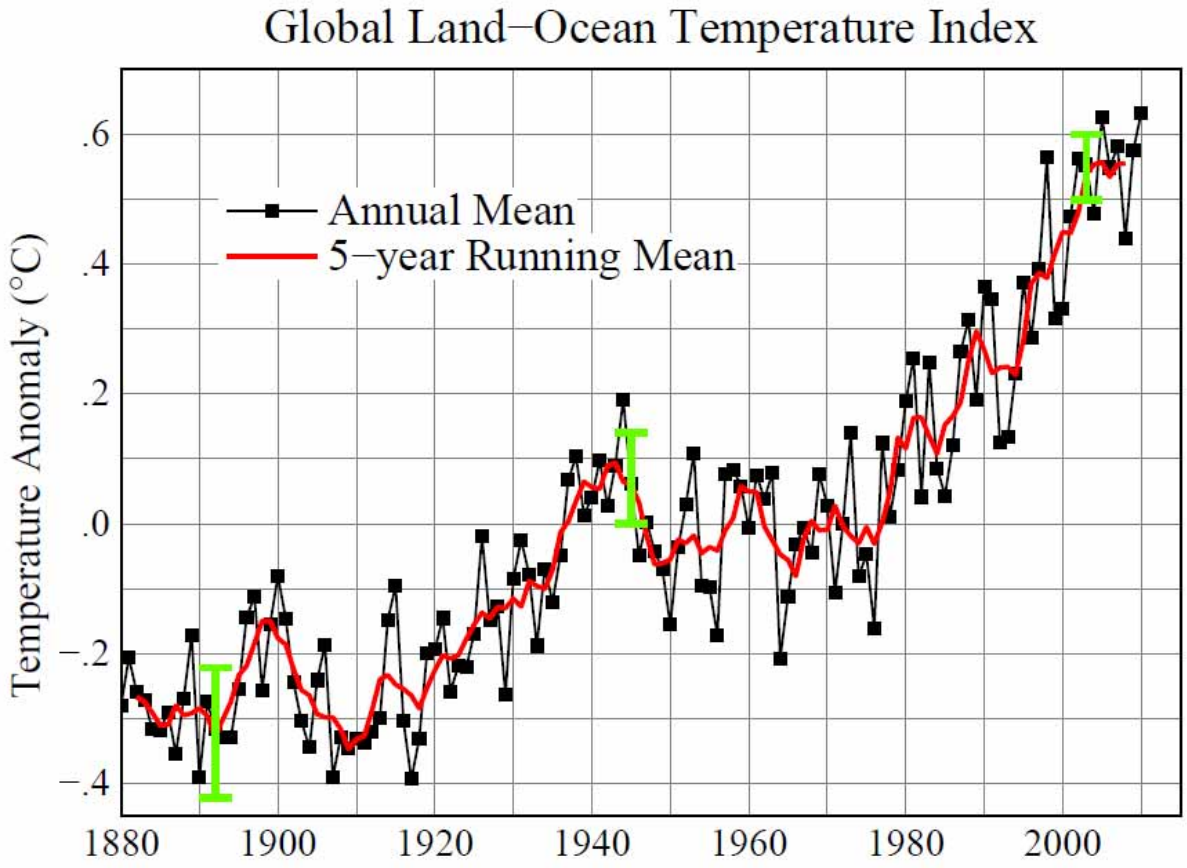
Historical data from ice cores (Vostok, Law Dome); Modern data from Mauna Loa.

Response to ice ages.

CO_2 levels in the atmosphere are now heading to levels not seen since the Cretaceous (>65My ago).

[http://www.skepticalscience.com/graphics/CO2_history_1024.jpg]

What does this mean?



Line plot of global mean land-ocean temperature index, 1880 to present, with the base period 1951-1980. The green bars show uncertainty estimates. [This is an update of Fig. 1A in Hansen et al. (2006).]

[http://data.giss.nasa.gov/gistemp/graphs/]

Essentially:

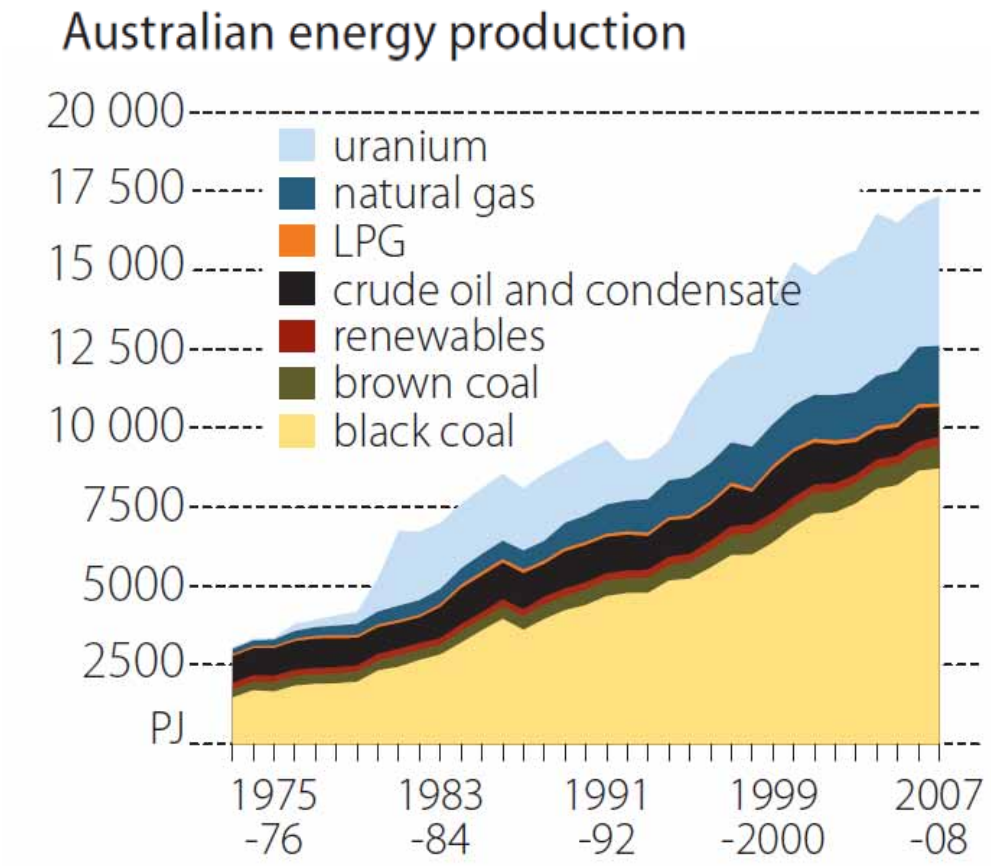
⬆ CO_2 = ⬆ mean temp

& climate change

So - we need to find ways to reduce CO_2 emissions to the atmosphere

Can’t we just stop using fossil fuels?

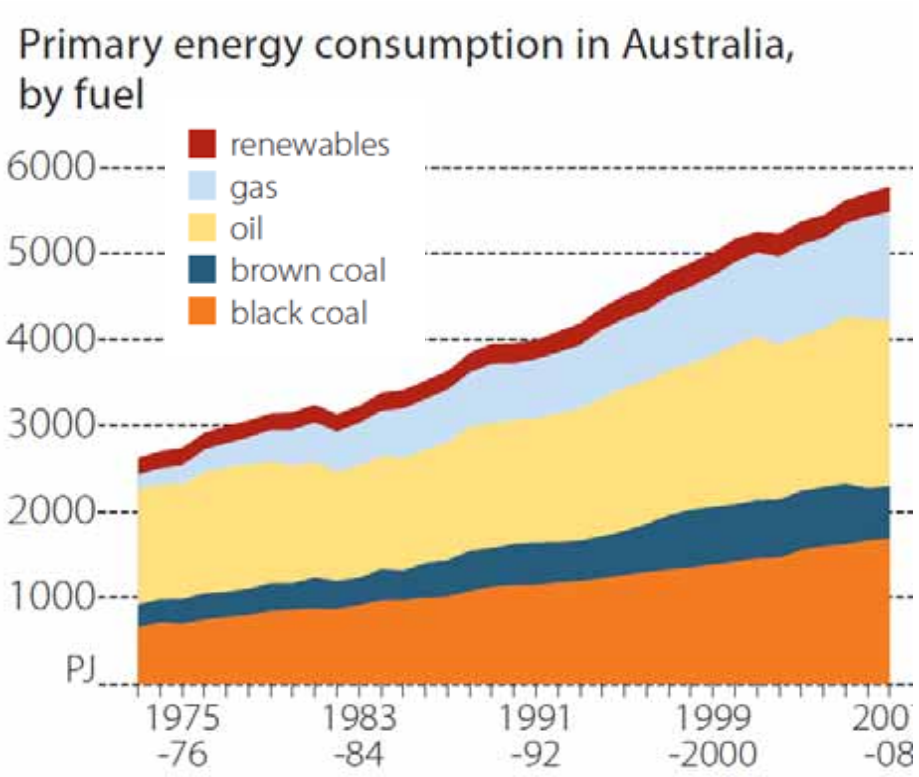
Example from Australia…

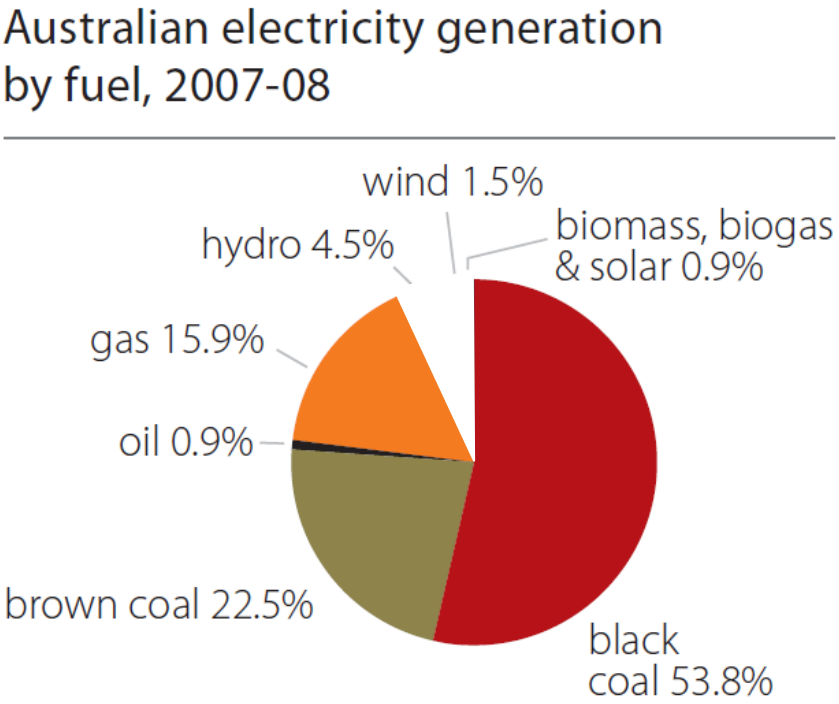


[ABARE, Australian energy statistics. In: RET / ABARE Energy in Australia 2010]

Can’t we just stop using fossil fuels?

Example from Australia…

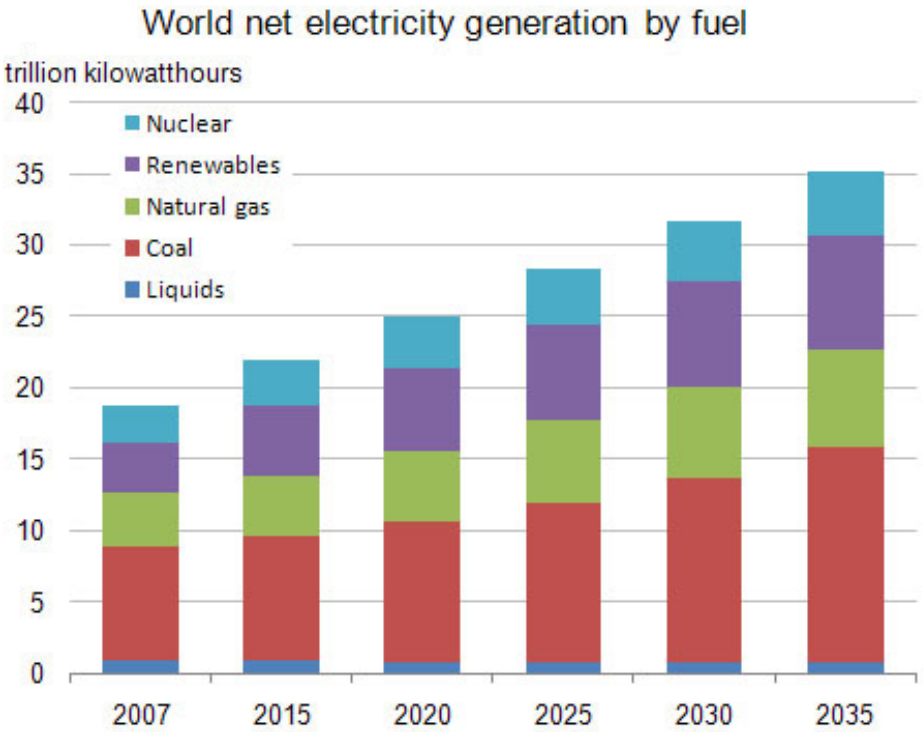


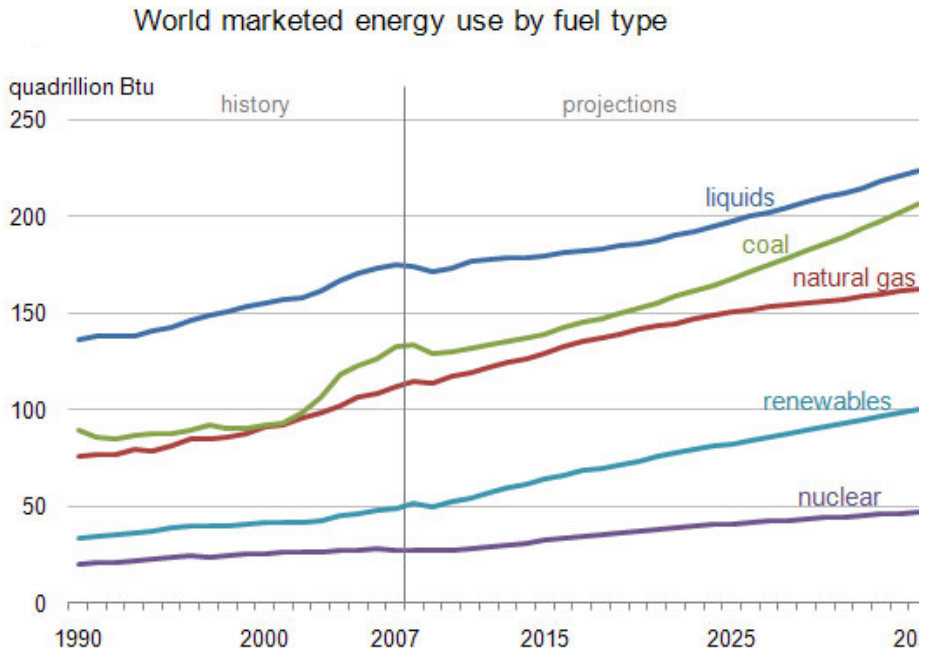


Source: IEA, *World Energy Balances 2009*; ABARE.

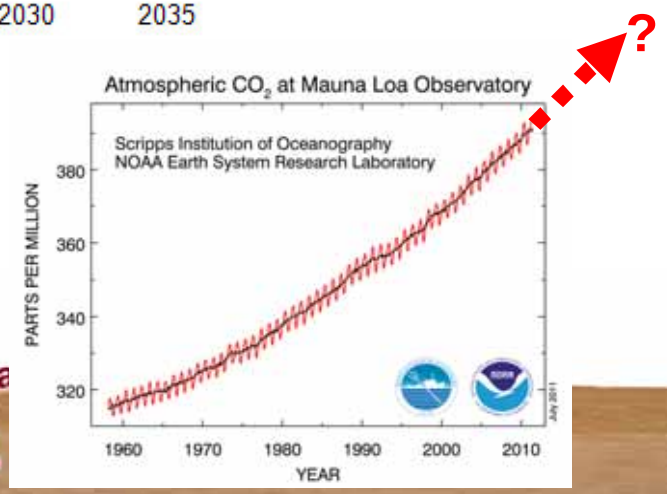
[ABARE, Australian energy statistics. In: RET / ABARE Energy in Australia 2010]

Can’t we just stop using fossil fuels?



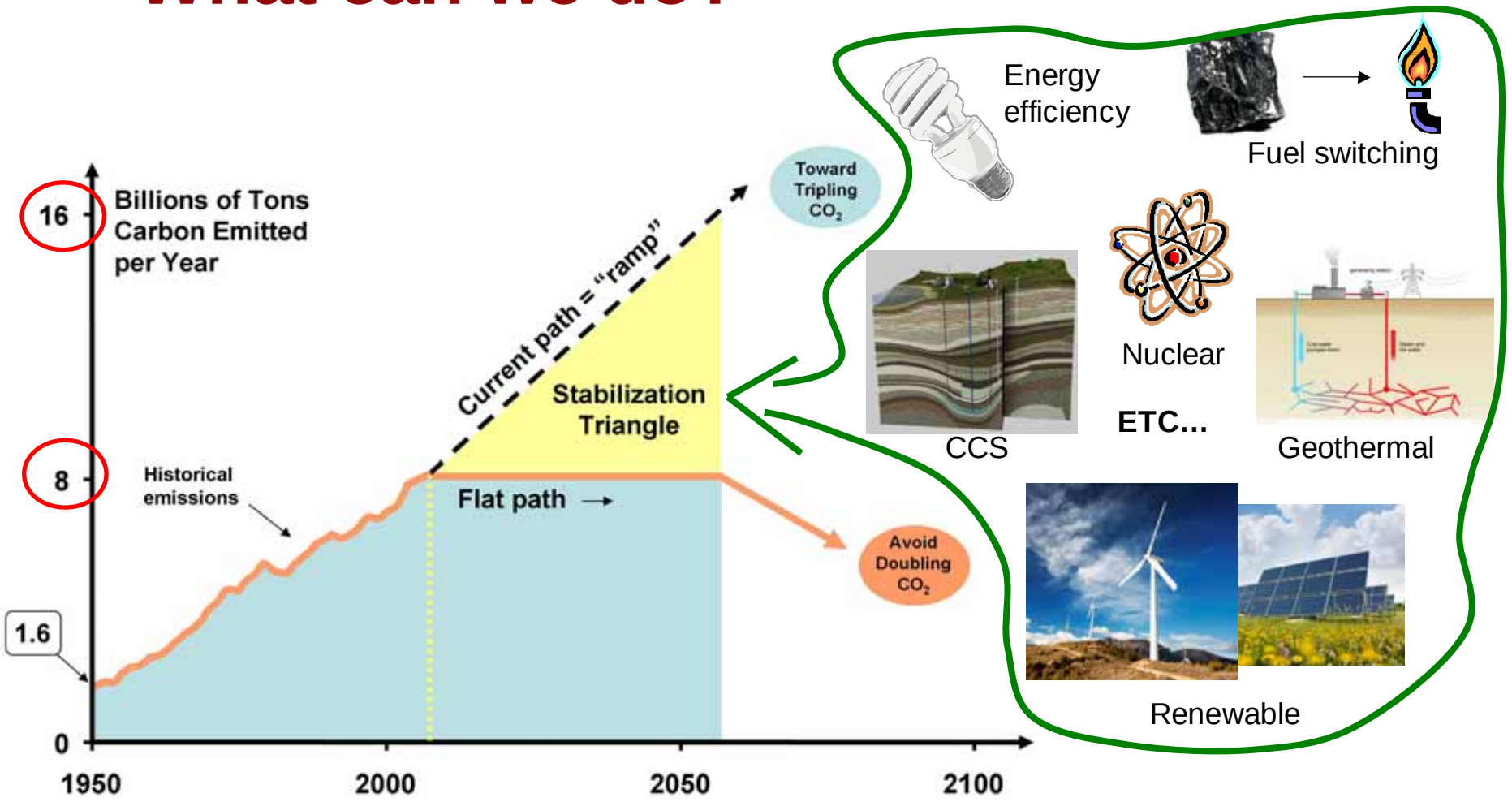


[EIA, International Energy Outlook 2010 Highlights]



What can we do?

Need a suite of technologies!

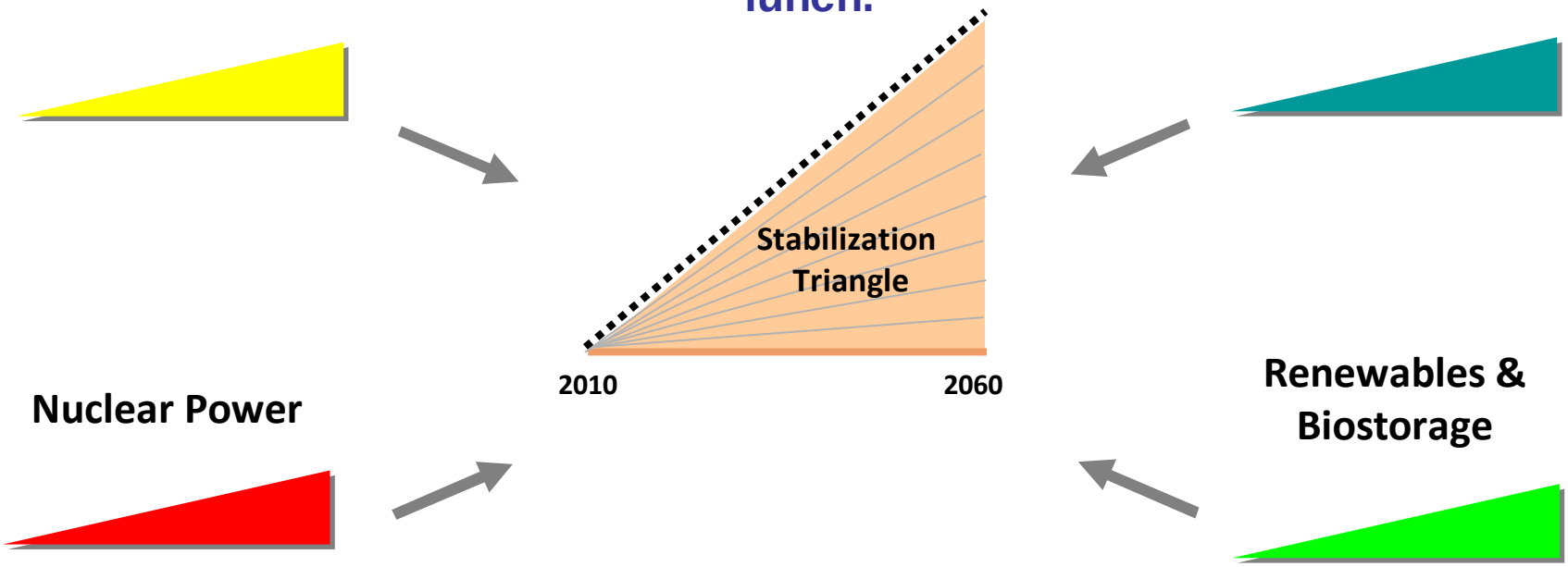


["Stabilization Wedges: Solving the Climate Problem for the next 50 Years with Current Technologies," S. Pacala and R. Socolow, Science, August 13, 2004.]

Stabilisation Wedges Game

Carbon Mitigation Initiatitive, Princeton University

Please review your handout in preparation for this game – we will be doing this exercise after lunch.



["Stabilization Wedges: Solving the Climate Problem for the next 50 Years with Current Technologies," S. Pacala and R. Socolow, Science, August 13, 2004.]

Carbon Capture and Geological Storage

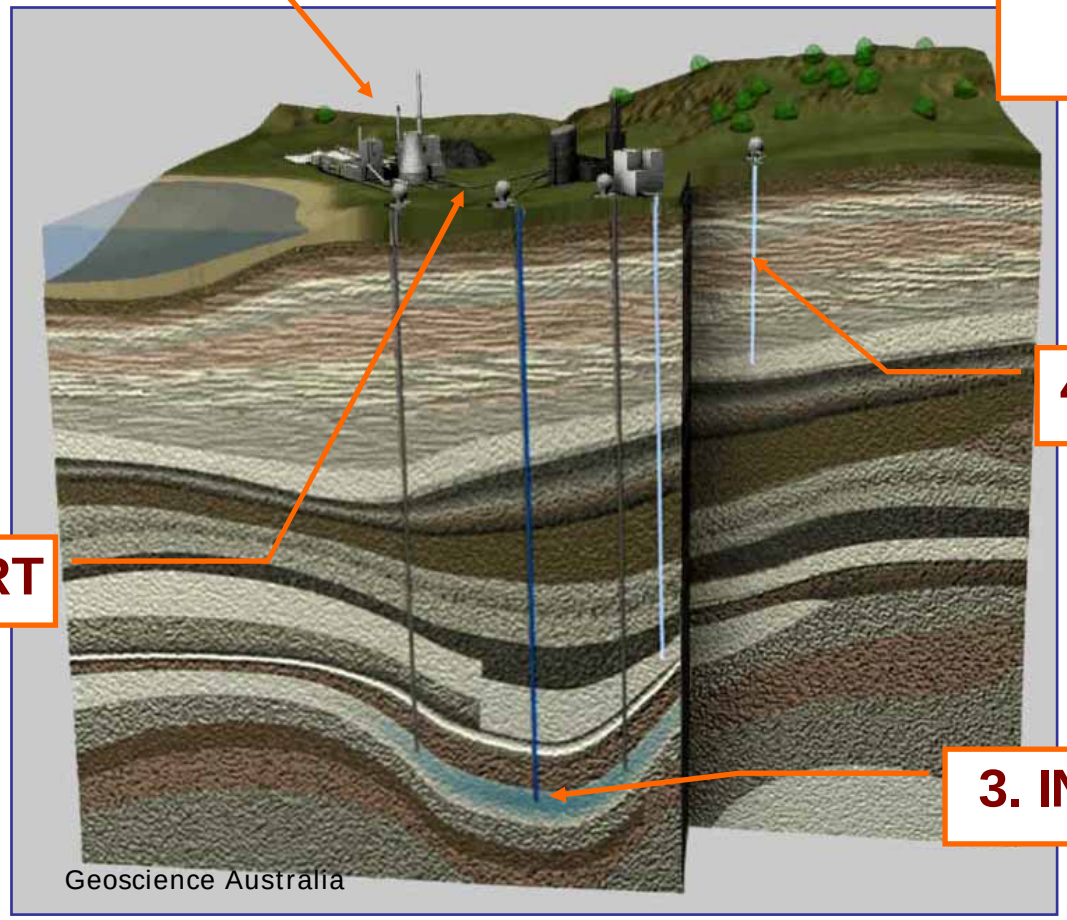
1. CAPTURE

2. TRANSPORT

3. INJECTION

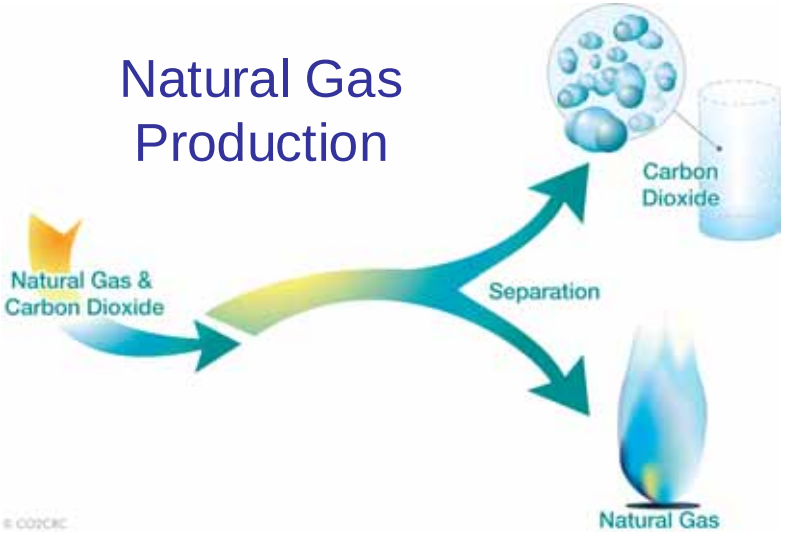
4. MONITORING

5. PERMANENT TRAPPING of CO_2

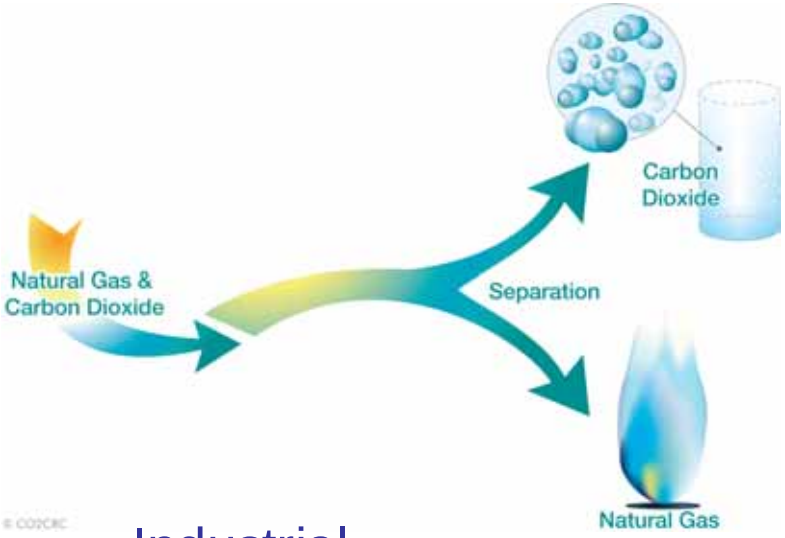


Geoscience Australia

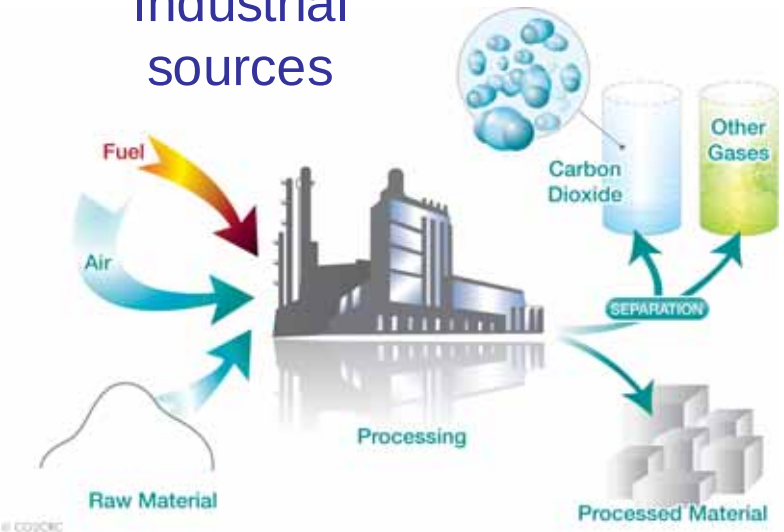
Capture


Natural Gas
Production
Carbon
Dioxide
Natural Gas &
Carbon Dioxide
Separation
Natural Gas

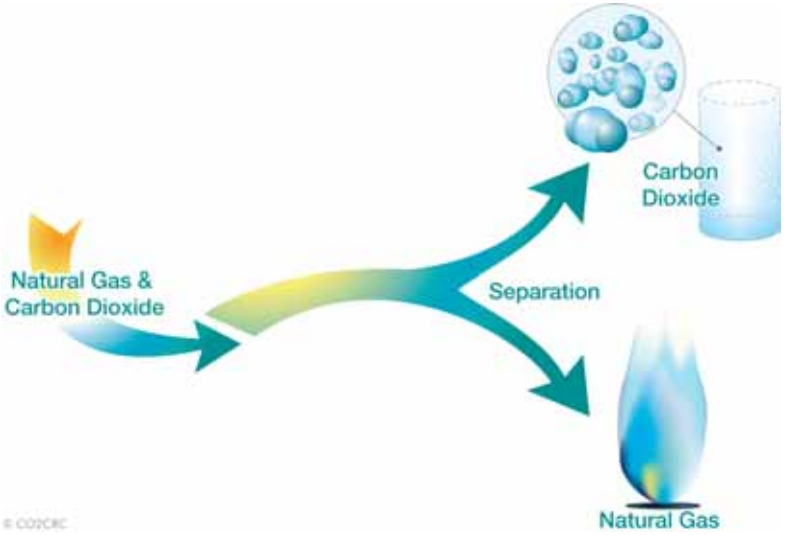
Capture



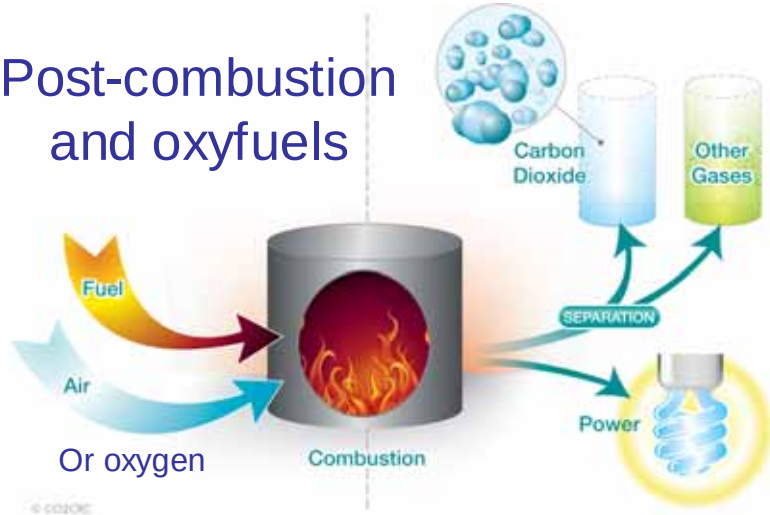
Industrial sources

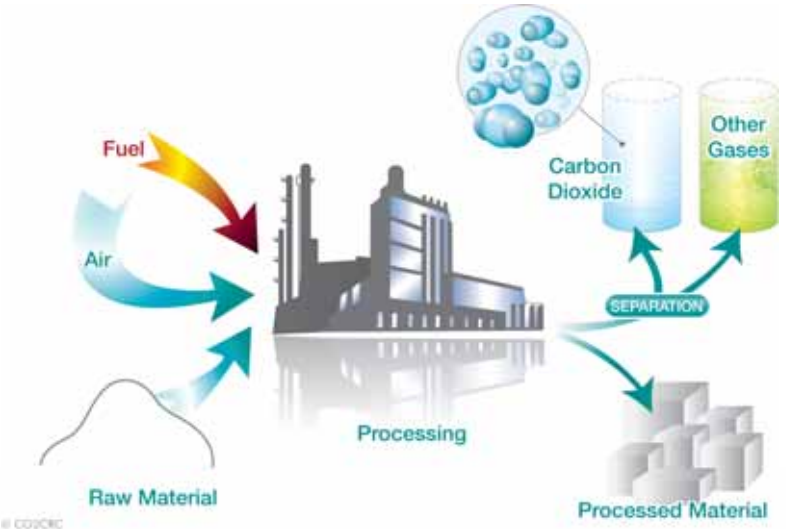


Capture

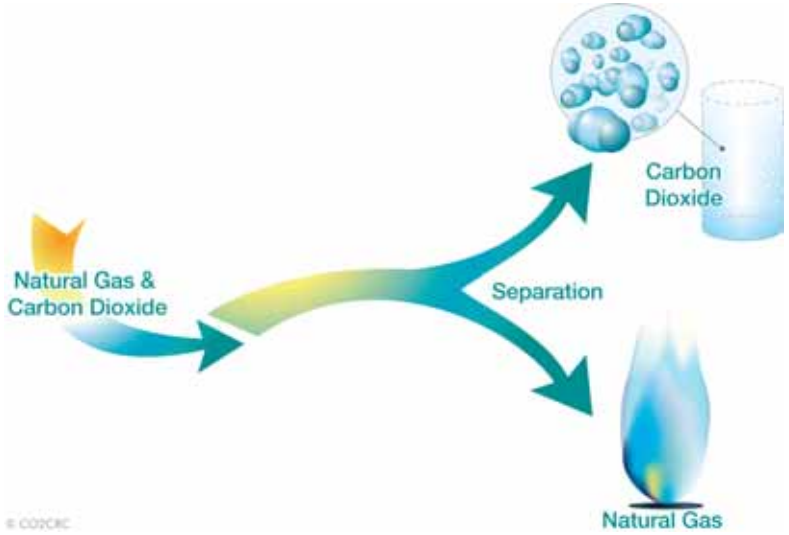


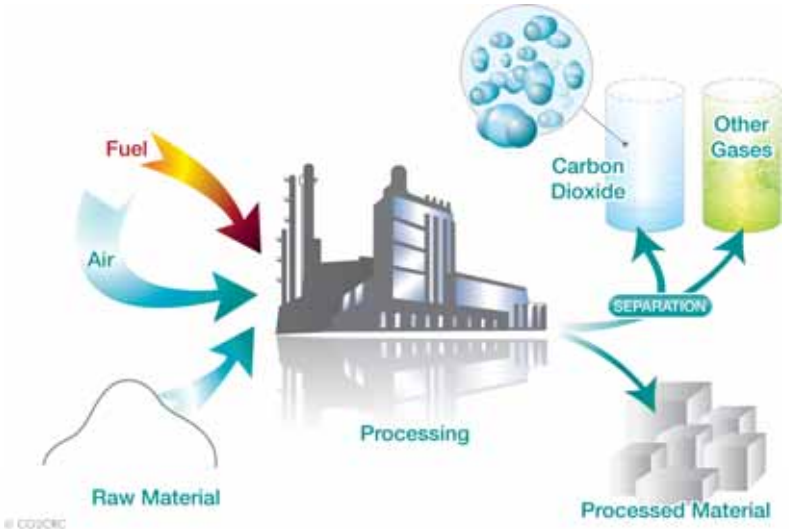
Post-combustion and oxyfuels





Capture





Pre-combustion

Transport

Pipeline

- >5,800km of CO_2 pipelines in N. America for EOR and industrial uses
- USA - KM Cortez pipeline: up to 20Mt/y CO_2 over 808km
- First offshore CO_2 pipeline for Snohvit CCS project, Barents Sea; 160km, 0.7Mt/y

[http://www.kema.com]

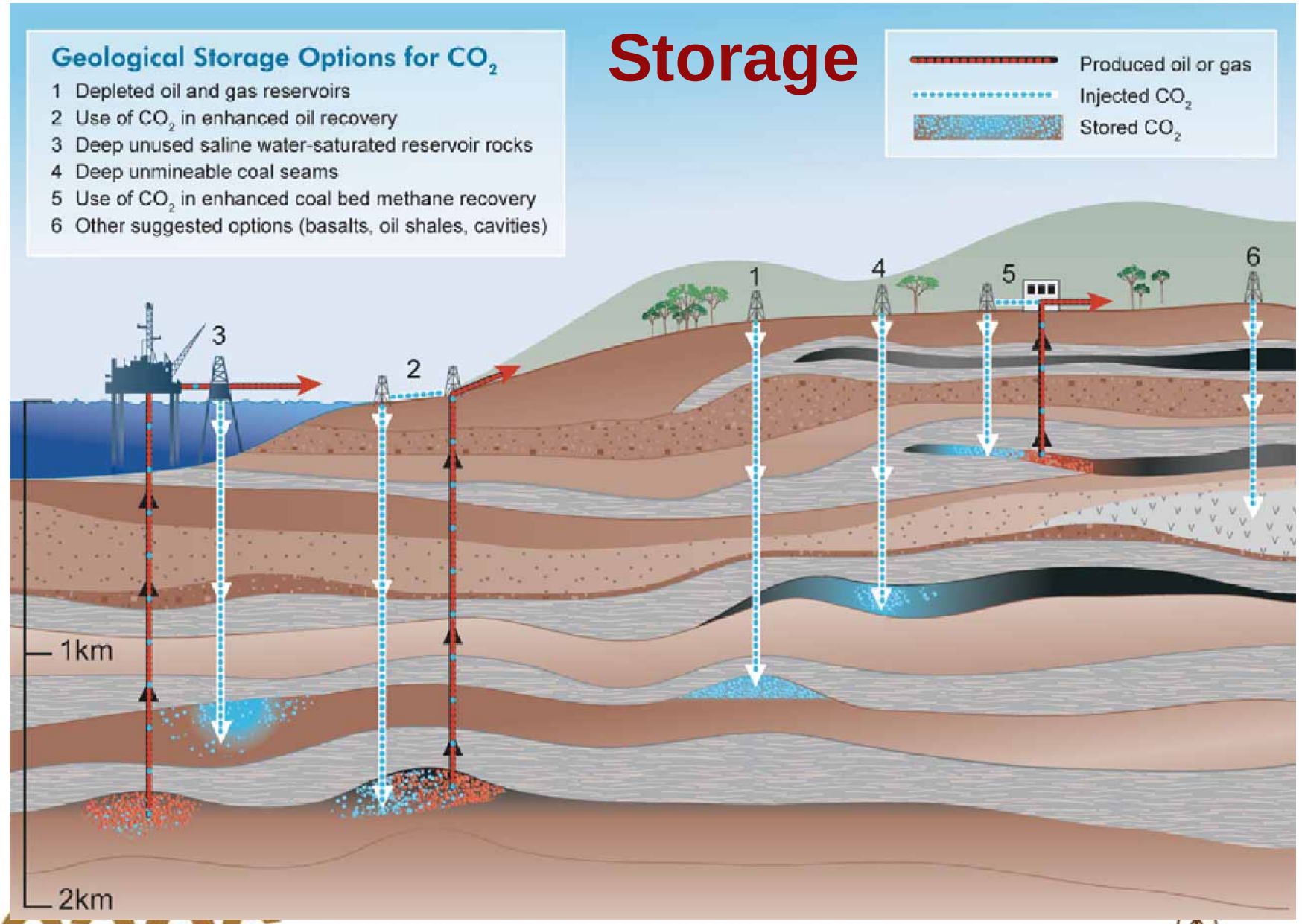
[http://www.nicholas.duke.edu/thegreengrok/graphics/CO2piplines-us]

Road (truck, rail)

- Suitable for small scale / pilot projects

[http://productimage.tradeindia.com/0030832 3/b/0/CO2-Transport-Tank.jpg]

Storage

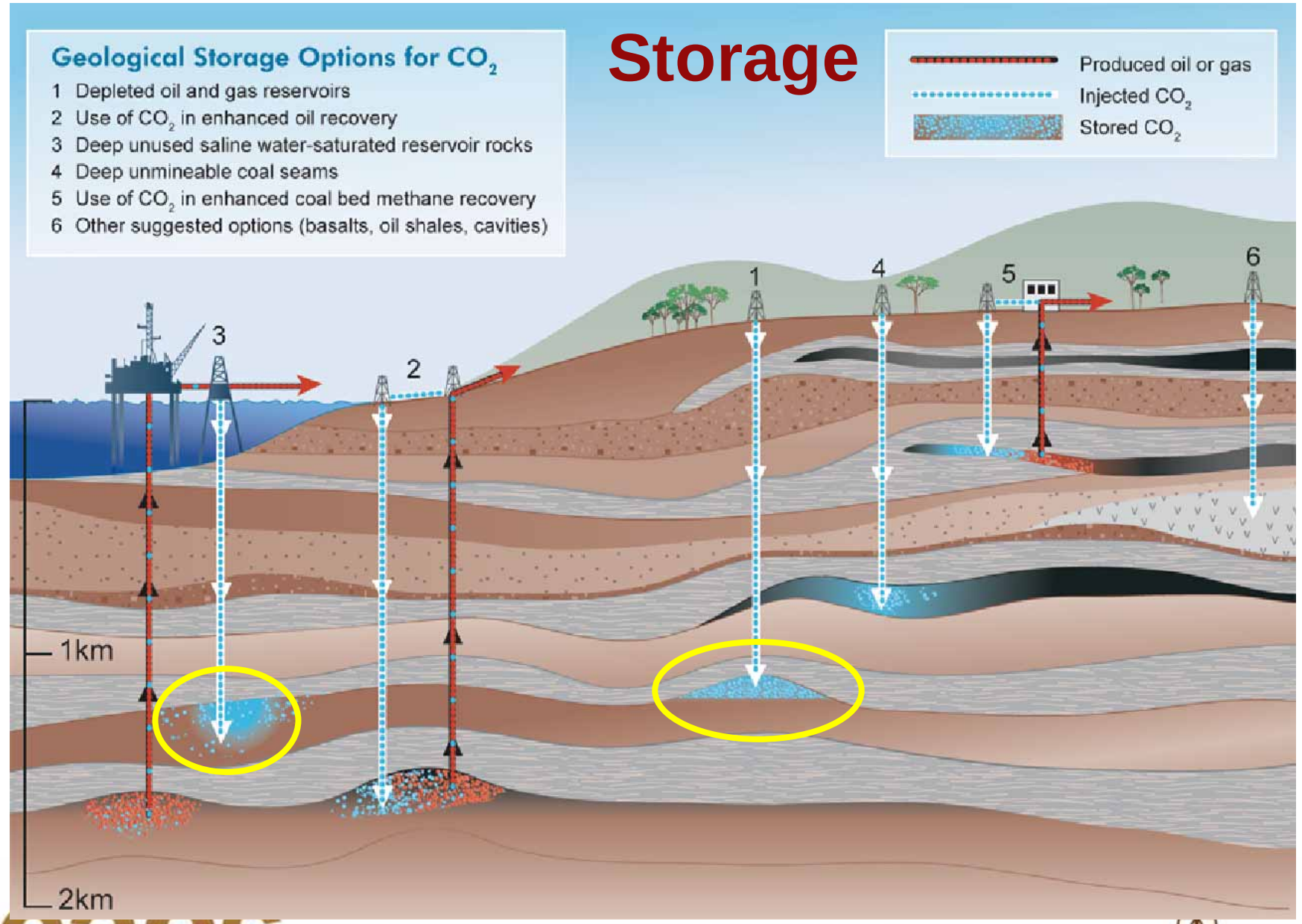


China Australia Geological Storage of CO_2

中 澳 二 氧 化 碳 地 质 封 存

[CO2CRC]

Storage



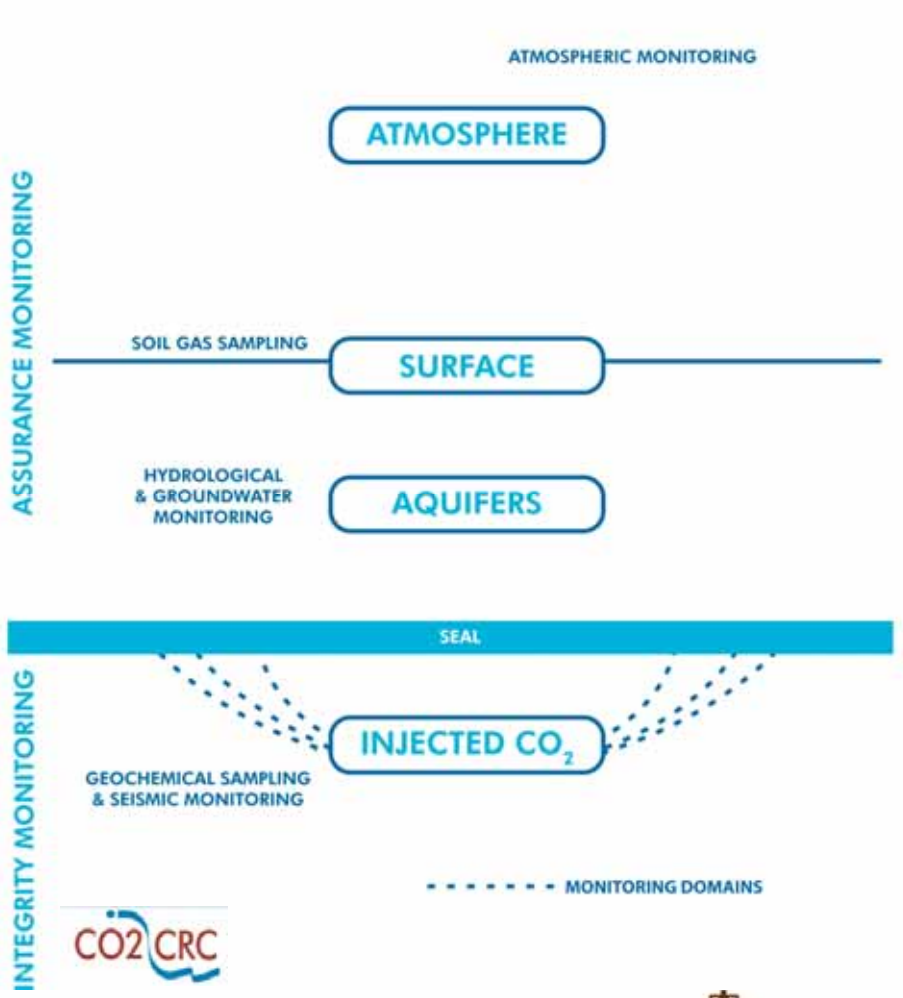
China Australia Geological Storage of CO_2

中 澳 二 氧 化 碳 地 质 封 存

[CO2CRC]

Risk assessment & Monitoring

- What are the risks?
  - Technical (leakage)
  - Non-technical (social acceptance, financial, etc.)
- Can they be mitigated?
- How can we tell if the site is working or leaking?



Is CCS happening anywhere?

Is CCS happening anywhere? Yes!

First commercial scale storage projects

- Statoil's **Snohvit** Project, Barents Sea (offshore) – 700kt/y, started 2008
- Statoil's **Sleipner** Project North Sea (offshore) – 1Mt/y, started 1996
- BP's **In Salah** Project, Algeria (onshore) – 1Mt/y, started 2004
- All associated with natural gas production

[Global CCS Institute]

Geography of Sleipner

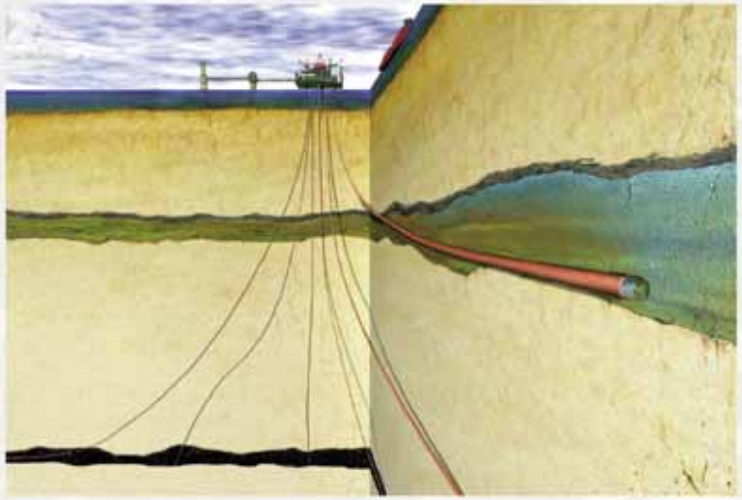
STATOIL

3

The Sleipner CO2-injection into the Utsira Formation at 1000 Meters Below Sea Bottom

- About 1 million tons/yr - **Since 1996**

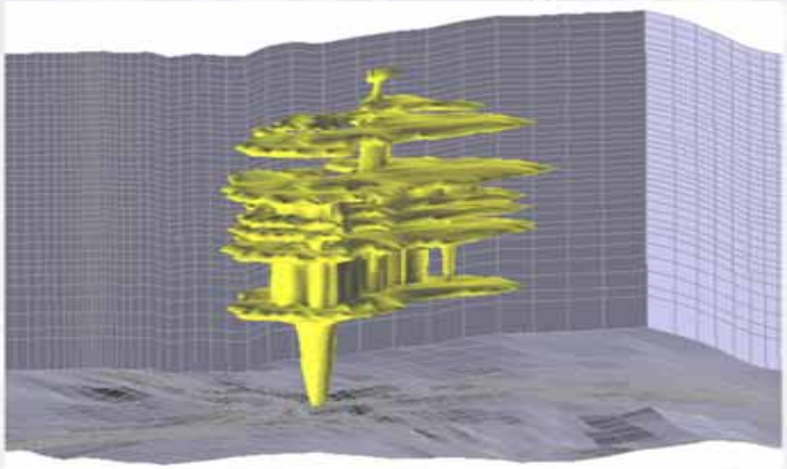
STATOIL



4

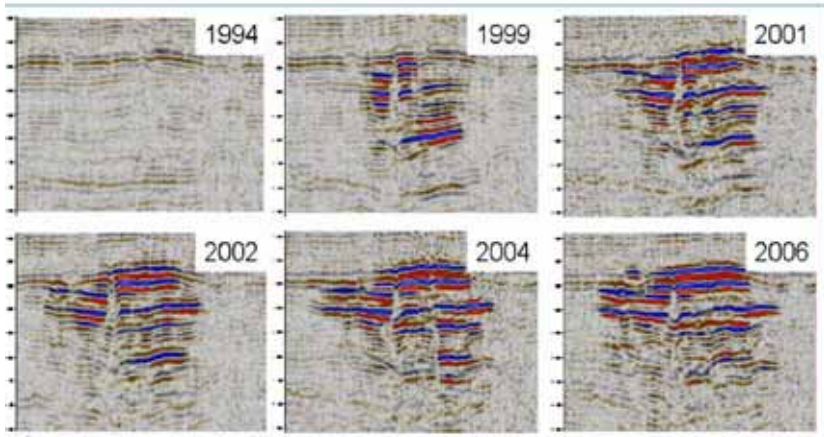
Reservoir model of CO_2 after 3 years

STATOIL



Source: SACS, Best Practise manual 2003

5



age of CO_2

中澳二氧化碳地质封存

Is CCS happening anywhere? Yes!

- Around 34 large scale integrated CCS projects are at various stages of development.

- There are also many more smaller demonstration and pilot scale projects at various stages of development around the world.

Purple: operating, blue: multiple, yellow: planned

[Global CCS Institute]

Green: active, yellow: planned, red: completed or cancelled

[Scottish Centre for Carbon Storage, Uni of Edinburgh www.geos.ed.ac.uk/ccsmap]

cags

China Australia Geological Storage of CO_2

中澳二氧化碳地质封存

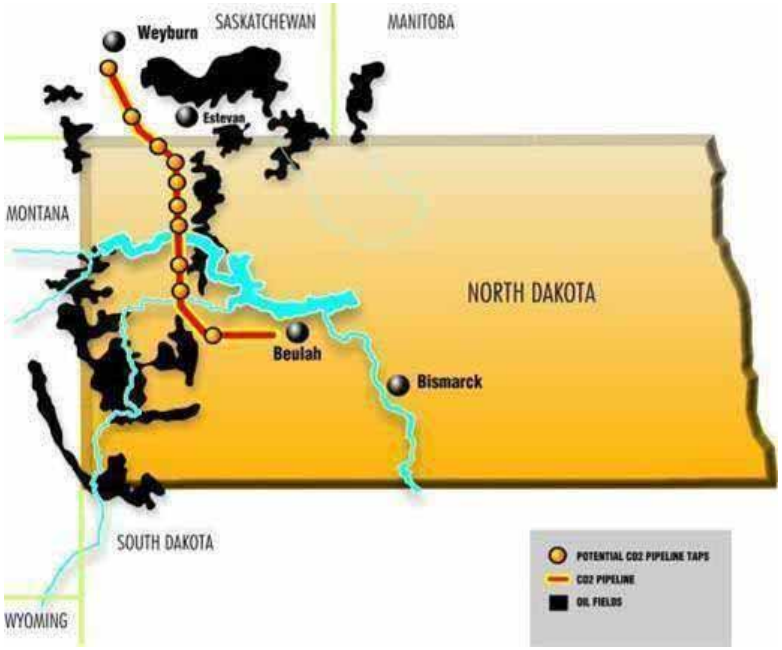
Is CCS happening anywhere? Yes!

EOR & CO_2-EOR

- >70 EOR projects in Canada and USA, >50 years experience
- Weyburn (Canada, onshore) 2.8Mt/y anthropogenic CO_2

Analogues

- Underground natural gas storage ~100 years, 470+ facilities in North America
- Acid gas injection / waste disposal
- Natural analogues



Challenges facing large scale deployment of CCS

These include:

- Technical – although many are based on petroleum industry processes and technologies
- Data for site characterisation
- Financial – total extra cost, efficiency penalty
- Policy & political will
- Legal, regulatory - liability, regulations
- Skills! People!
- Social acceptance – some projects (e.g. Barendrecht, Netherlands) stopped through public opposition

Public acceptance of CCS

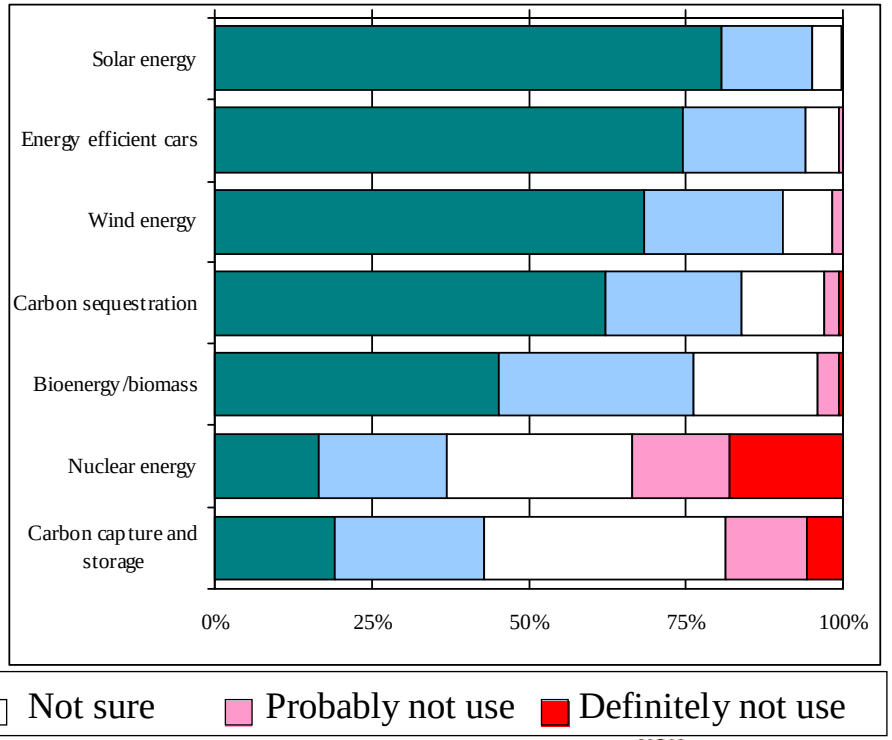
Nick Otter, CEO GCCSI, April, 2009

Resolution of safety issues related to leakage, seismicity and containment are essential to successful deployment of CCS.

[Source: Peta Ashworth, CLET, CSIRO]

Preferred energy technology to address global warming

[Source: D. Reiner et al., (2007) An international comparison of public attitudes towards carbon capture and storage technologies. GHGT-8]



cags

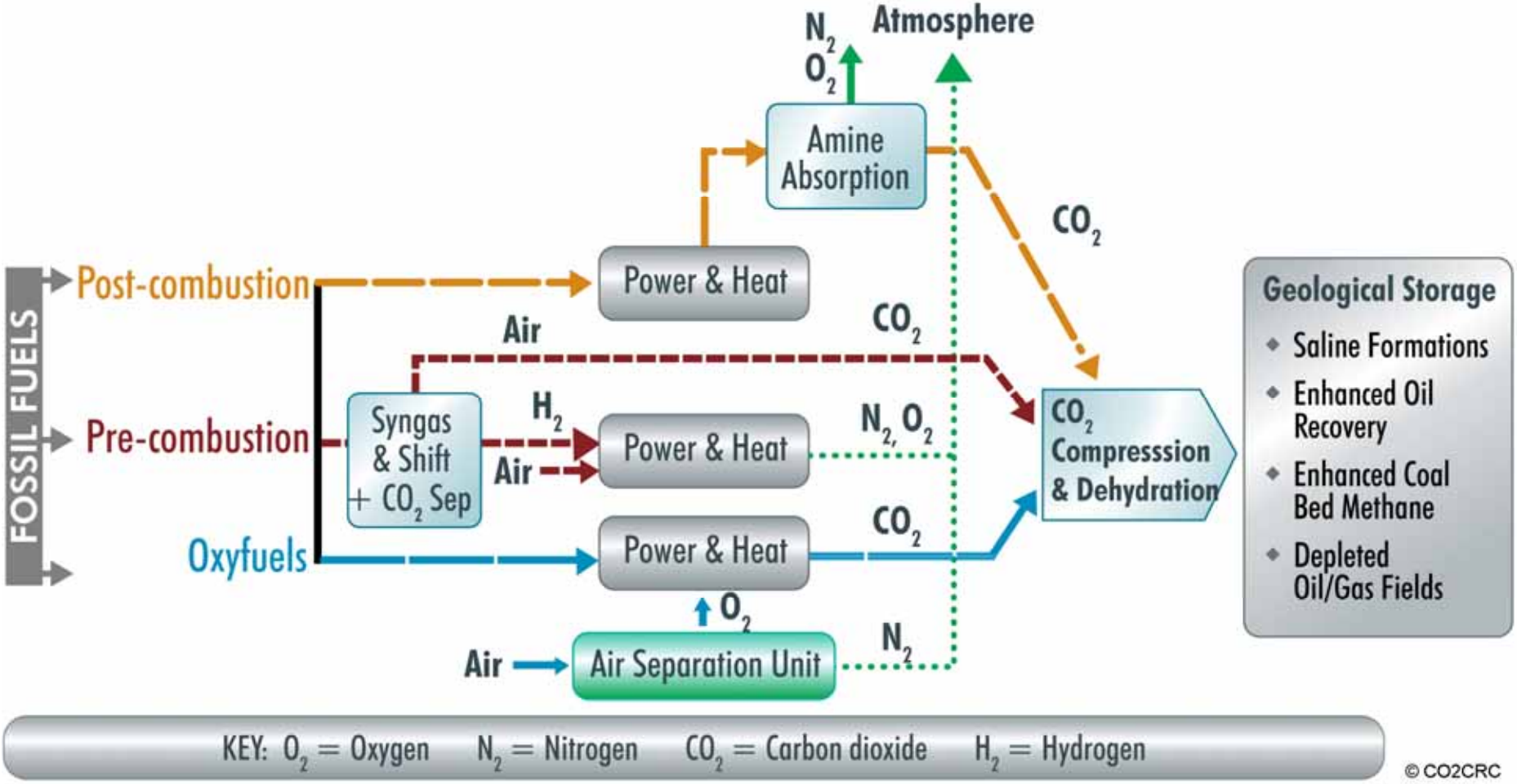
China Australia Geological Storage of CO_2

中澳二氧化碳地质封存

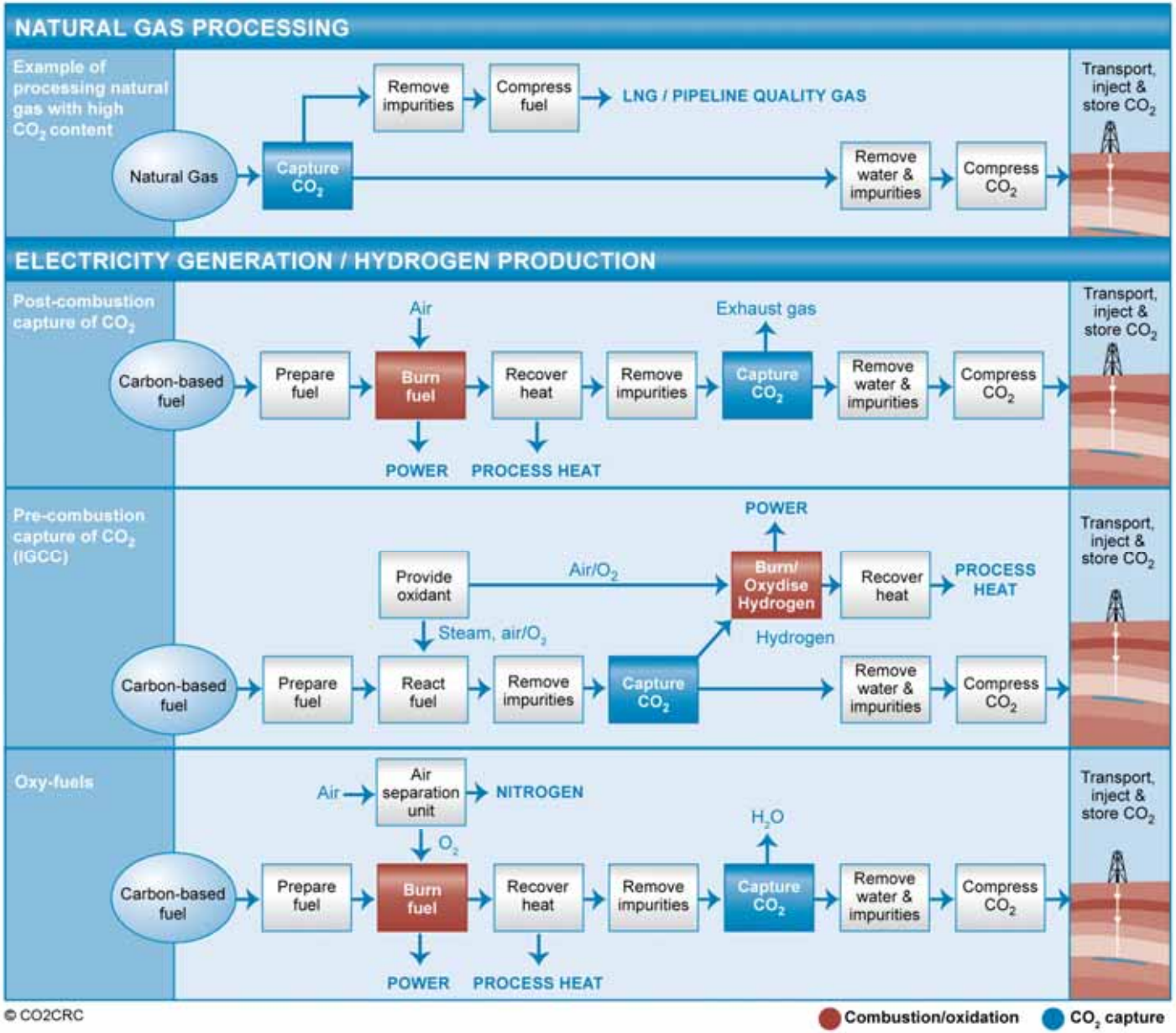
THE END!

For more information,
Contact: ghg@ga.gov.au

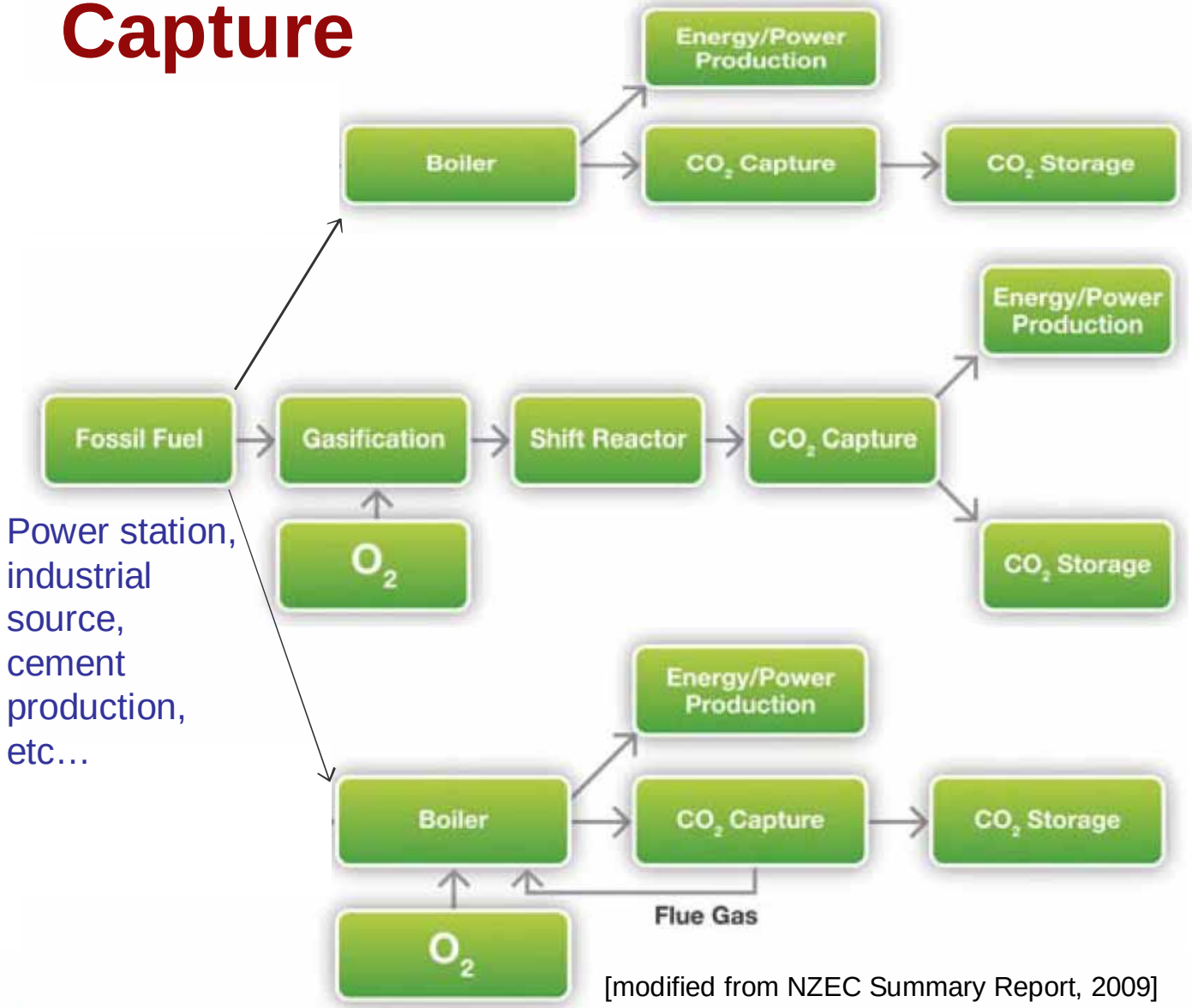
CO_2 Capture



Courtesy CO2CRC


NATURAL GAS PROCESSING
Example of processing natural gas with high CO_2 content
Natural Gas
Capture CO_2
Remove impurities
Compress fuel
LNG / PIPELINE QUALITY GAS
Remove water & impurities
Compress CO_2
Transport, inject & store CO_2
ELECTRICITY GENERATION / HYDROGEN PRODUCTION
Post-combustion capture of CO_2
Carbon-based fuel
Prepare fuel
Air
Burn fuel
Recover heat
Remove impurities
Exhaust gas
Capture CO_2
Remove water & impurities
Compress CO_2
POWER
PROCESS HEAT
Pre-combustion capture of CO_2 (IGCC)
Provide oxidant
Air/O_2
Steam, air/O_2
Burn/ Oxydise Hydrogen
POWER
Recover heat
PROCESS HEAT
Hydrogen
Carbon-based fuel
Prepare fuel
React fuel
Remove impurities
Capture CO_2
Remove water & impurities
Compress CO_2
Oxy-fuels
Air
Air separation unit
NITROGEN
O_2
H_2O
Carbon-based fuel
Prepare fuel
Burn fuel
Recover heat
Remove impurities
Capture CO_2
Remove water & impurities
Compress CO_2
POWER
PROCESS HEAT
Transport, inject & store CO_2
© CO2CRC
Combustion/oxidation
CO_2 capture

Capture



Post-combustion capture

Pre-combustion capture

Oxyfuel with capture

Power station, industrial source, cement production, etc…

[modified from NZEC Summary Report, 2009]