



Carbon Dioxide Capture and Storage and the International Climate Negotiations

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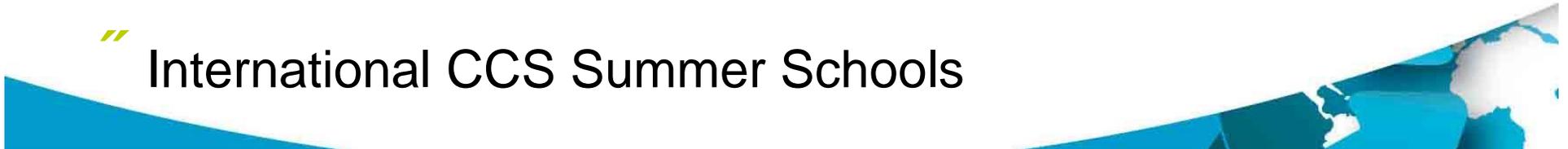
IEA Greenhouse Gas R&D Programme (IEAGHG)

- '' A collaborative international research programme founded in 1991
- '' Aim: To provide information on the role that technology can play in reducing greenhouse gas emissions from use of fossil fuels.
- '' Focus is on carbon dioxide capture and storage

IEAGHG Flagship Activities

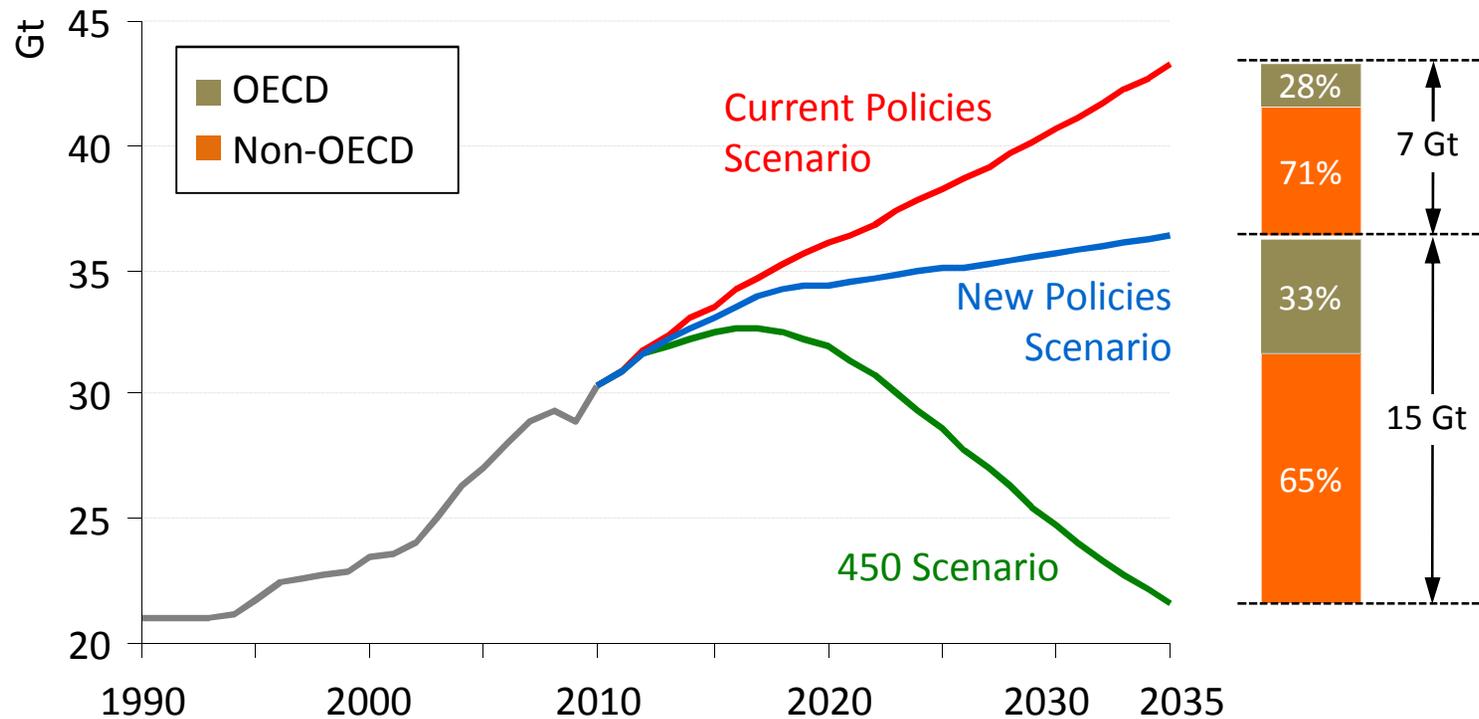


- “ Technical Studies >250 reports published on all aspects of CCS
- “ International Research Networks
 - “ Risk Assessment
 - “ Wellbore Integrity
 - “ Monitoring
 - “ Modelling
 - “ Environmental Impacts
 - “ Oxy-combustion - conf
 - “ Post-combustion Capture - conf
 - “ Solid Looping
 - “ Social Research
- “ GHGT conferences
 - “ International CCS Summer Schools



The 450 Scenario illustrates what the 2°C goal will require

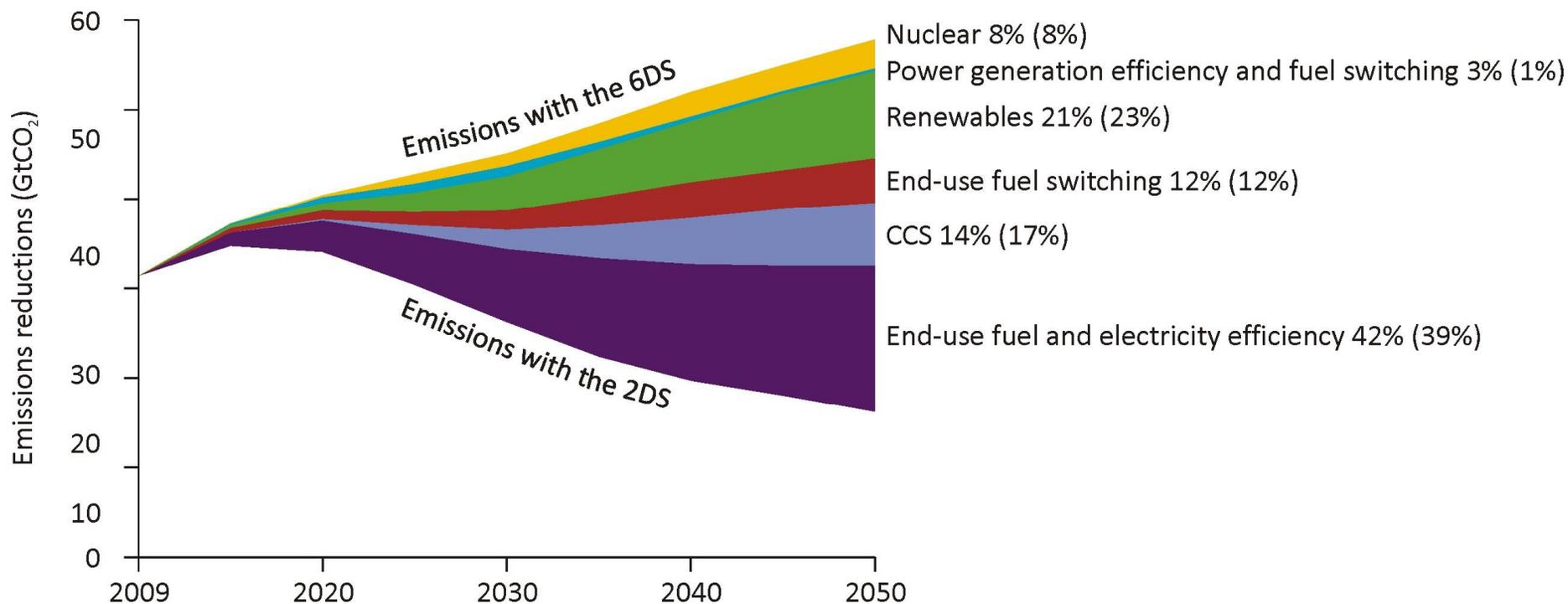
World energy-related CO₂ emissions by scenario



Restricting the greenhouse-gas concentration to 450 ppm would limit temperature increase to 2°C, compared with 3.5°C in the New Policies Scenario & 6°C in the Current Policies Scenario

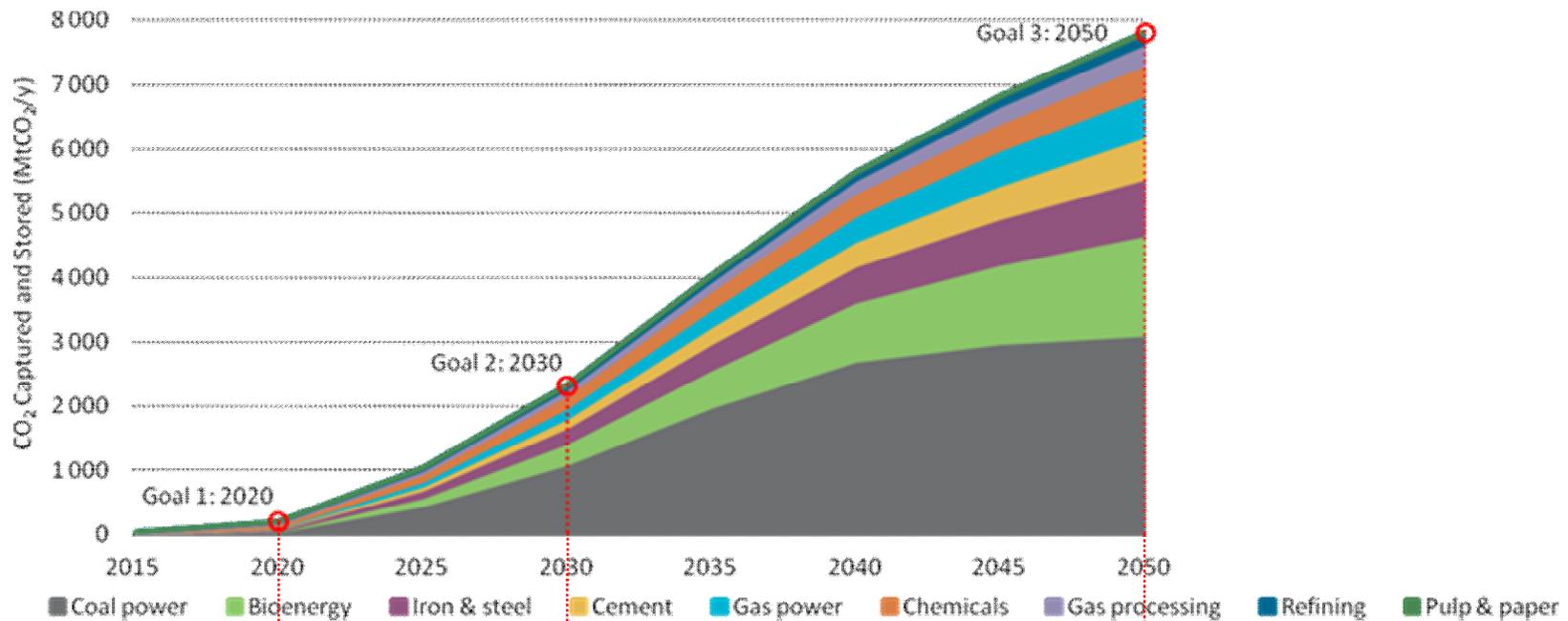


CCS is one part of a cost-effective emissions reduction portfolio





IEA vision: 120 Gt of CO₂ stored by 2050



Goal 1: 2020

Over 30 large projects in operation in power and across a range of industrial processes, storing 50 MtCO₂ per year.

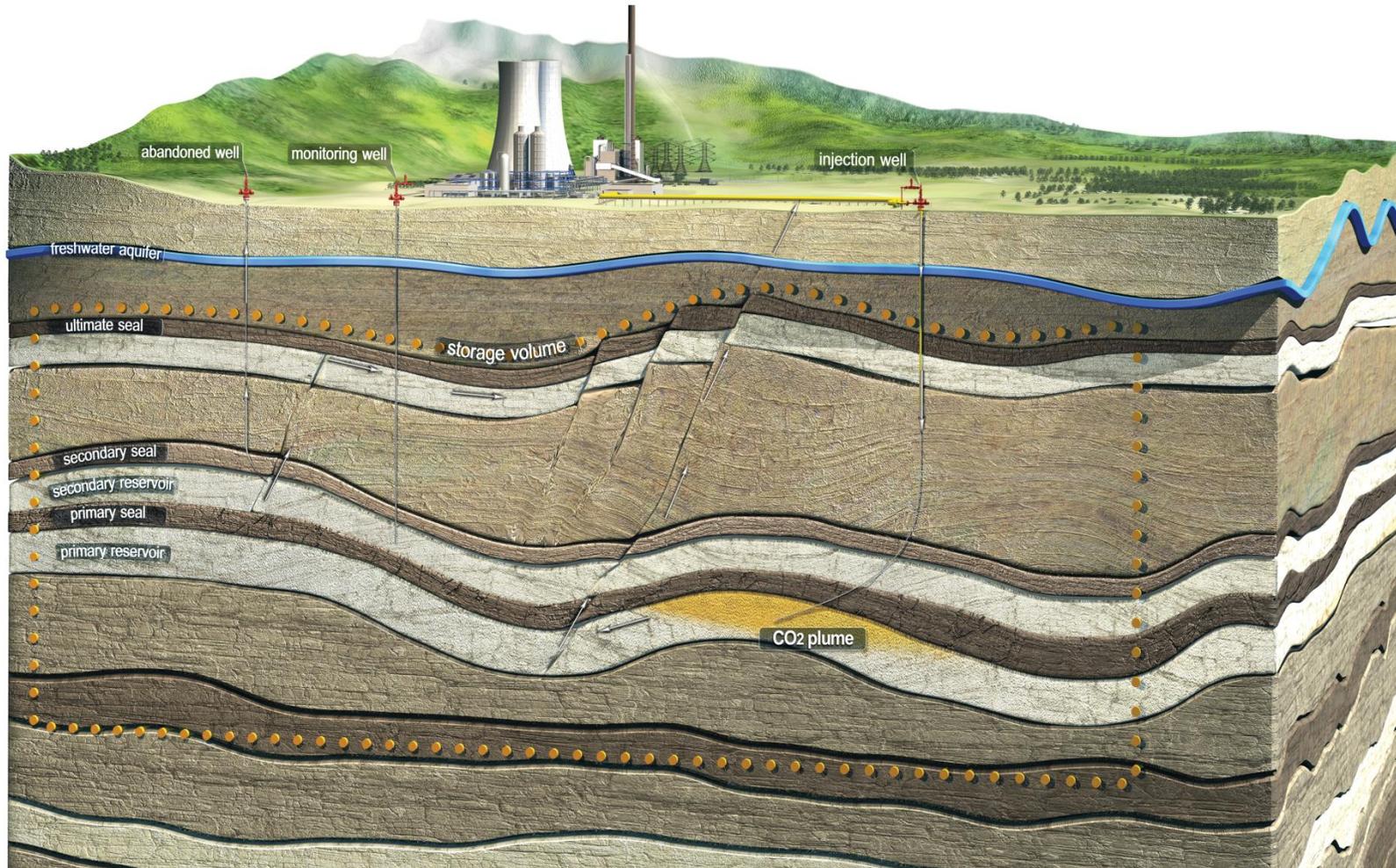
Goal 2: 2030

Over 2 GtCO₂ is stored per year. CCS routinely used in power and certain industrial applications.

Goal 3: 2050

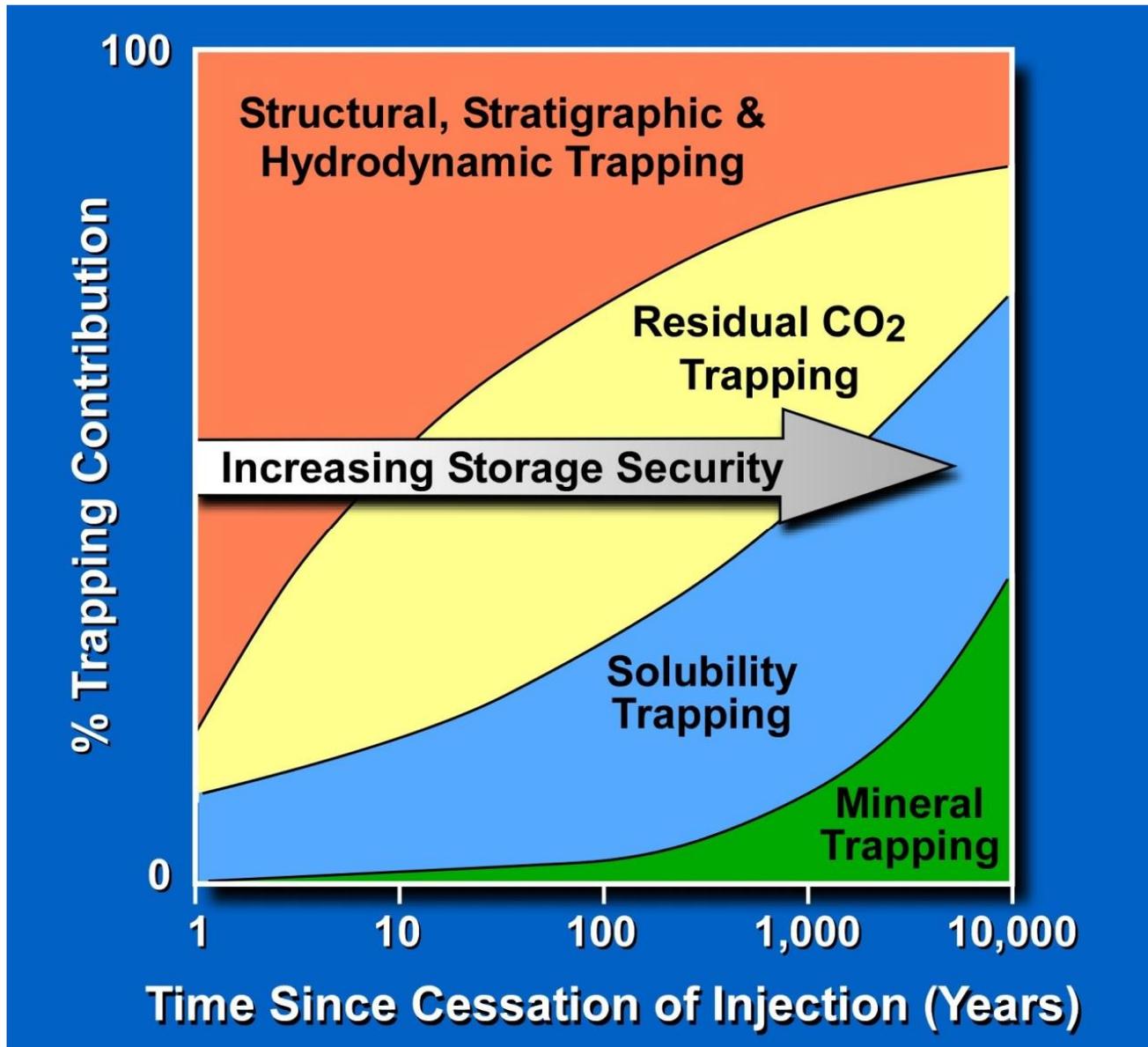
Over 7 GtCO₂ stored per year. CCS routinely used in all applicable power and industrial applications.

What is CCS?



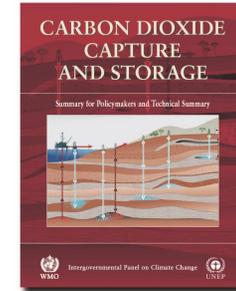
Source: DNV

CO₂ Storage Trapping Mechanisms



From IPCC SRCCS, 2005

IPCC Special Report on CCS (2005)



- “ Observations from engineered and natural analogues as well as models suggest that the fraction retained in appropriately selected and managed geological reservoirs is very likely to exceed 99% over 100 years and is likely to exceed 99% over 1,000 years. ”
- “ For well-selected, designed and managed sites, the vast majority of the CO₂ will gradually be immobilized by various trapping mechanisms and, in that case, could be retained for up to millions of years. Storage could become more secure over longer timescales. +



IPCC Guidelines for GHG Inventories



- “ Apr 2006
- “ Vol 2 Energy, Chp 5 - CO2 Transport, Injection and Geological Storage
- “ Each site will have different characteristics
- “ Methodology

Site characterisation . inc leakage pathways



Assessment of risk of leakage . simulation / modelling



Monitoring . monitoring plan



Reporting . inc CO2 inj and emissions from storage site

- “ For appropriately selected and managed sites, supports zero leakage assumption unless monitoring indicates otherwise

UNFCCC and CCS



Negotiating bodies relevant to CCS:

UNFCCC:

- COP . Conference of the Parties to the UNFCCC (194 Parties)
- AWG-LCA . Ad Hoc Working Group on Long-term Cooperative Action
- ADP . Ad Hoc Working Group Durban Platform for Enhanced Action
- SBSTA . Subsidiary Body for Scientific and Technological Advice
- SBI . Subsidiary Body for Implementation

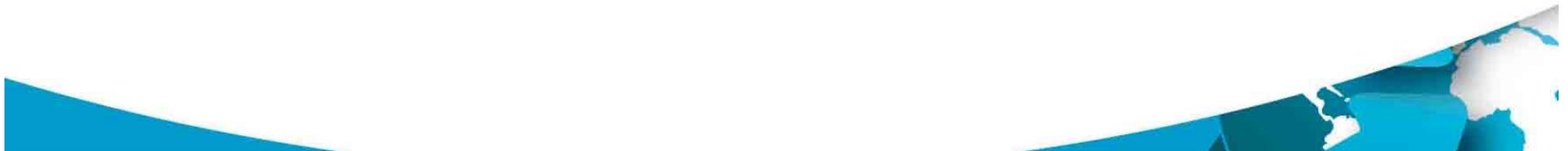
Kyoto Protocol:

- CMP . Conference of the Parties serving as a Meeting of the Parties to the Kyoto Protocol (188 Parties, 33 developed countries)
- AWG-KP . Ad Hoc Working group on Further Commitments for Annex I Parties under the Kyoto Protocol (Post 2012)

Kyoto Protocol and CCS



- “ 2008 - 2012 (Kyoto 1st Period)
- “ Developed country emission commitments
 - CCS included in KP Art 2.1
 - IPCC GHG Guidelines 2006 allows CCS to be reported
- “ CDM . Policy mechanism for rewarding CO₂ reduction in developing countries. Project-based carbon credits.
- “ > 7,400 projects, 1,400 Mt CO₂e



Information into UNFCCC



- “ Delegations inform themselves beforehand . challenge for some countries
- “ SBSTA work (including occasional workshops)
- “ Side events (official, unofficial) . relies on self-selecting audience, negotiators have limited time
- “ Booths - relies on self-selecting audience



Courtesy
H.Olson UT



Kyoto Protocol and CCS



Considering CCS in CDM since CMP1 Montreal 2005

- 2005 - 2 projects applied to CDM
- CDM Executive Board to consider new methodologies
- Under SBSTA:-
 - Technical workshops (2006)
 - Consideration of technical and policy Issues
 - Submissions from Parties and NGOs . two synthesis reports (2007 and 2008)
 - On agenda of every SBSTA meeting
 - Decision due at CMP4 Poznan (Dec 08) . **failed**
 - CMP request EB to look at implications
 - EB commission ~~an~~ Experts Reportq
 - Decision due at CMP5 Copenhagen (Dec 09) . **failed**
 - CMP6/COP16 Cancun

“ All CCS CDM reports and background <http://cdm.unfccc.int/about/ccs/index.html>

Key issues of concern



Included

- “ Timescales of benefits vs liability
- “ Impact on CDM market
- “ Scale and impacts of leakage
- “ Furthering use of fossil fuels . sustainable development
- “ Role of CCS in climate change mitigation

Since CMP 5

- “ Non-permanence
- “ MRV
- “ Environmental impacts . %massive catastrophic release+
- “ Project boundaries
- “ Liability
- “ Perverse outcomes
- “ Safety
- “ Insurance and compensation for leakage

Negotiations characterised by a few countries having strong views against CCS – but UNFCCC seeks consensus to progress

CMP7/COP16, 2010, Cancun



Decision CMP.16

- “ **CCS is eligible provided that certain issues are addressed**
- “ Issues include site selection, modelling, monitoring, risk assessment, liabilities (short and long-term)
- “ SBSTA to develop new Modalities and Procedures which address the issues

Work programme for 2011:

- “ Submissions and Synthesis report
- “ Technical workshop (technical and legal expertise)
- “ UNFCCC to draft Modalities and Procedures for SBSTA 35 (Durban Dec 2011)
- “ IEAGHG: Research Networks addressed Cancun issues

IEAGHG Research Networks



- “ **Risk Assessment**
- “ **Monitoring**
- “ **Modelling**
- “ **Wellbore Integrity**
- “ **Environmental Impacts Research**
- “ **Also: Oxy-firing; Post Combustion Capture; Solid Looping, Social Research**

- “ Bring together international key groups of experts to share knowledge and experience on regular basis
- “ Identify and address knowledge gaps
- “ Publish report of meetings - discussions, conclusions and recommendations (ppts on web site)
- “ Benefit experts and wider stakeholders

More info at www.ieaghg.org

IEAGHG Research Networks



Cancun Decision issues:

- “ In the area of the **Monitoring Network** (Potsdam, June 2011):
 - “*Stringent monitoring plans shall be in place and be applied during and beyond the crediting period in order to reduce the risk to the environmental integrity of carbon dioxide capture and storage in geological formations;*”
- “ In the area of the **Modelling Network** (Perth, April 2011):
 - “*Further consideration is required as regards the suitability of the use of modelling, taking into account the scientific uncertainties surrounding existing models, in meeting the stringency requirements of such monitoring plans;*”

(UNFCCC 7/CMP.6 2010)

IEAGHG Research Networks



Cancun Decision issues:

- “ In the area of the **Risk Assessment Network** (Pau, June 2011):
- “*A thorough risk and safety assessment using a methodology specified in the modalities and procedures, as well as a comprehensive socio-environmental impacts assessment, shall be undertaken;*
- “ *The risk and safety assessment shall include, inter alia, the assessment of risk and proposal of mitigation actions related to emissions from injection points, emissions from above-ground and underground installations and reservoirs, seepage, lateral flows, migrating plumes, including carbon dioxide dissolved in aqueous medium migrating outside the project boundary, massive and catastrophic release of stored carbon dioxide, and impacts on human health and ecosystems, as well as an assessment of the consequences of such a release for the climate”*

(UNFCCC 7/CMP.6 2010)

Technical Workshop 2011



Abu Dhabi 7-8 Sep 2011

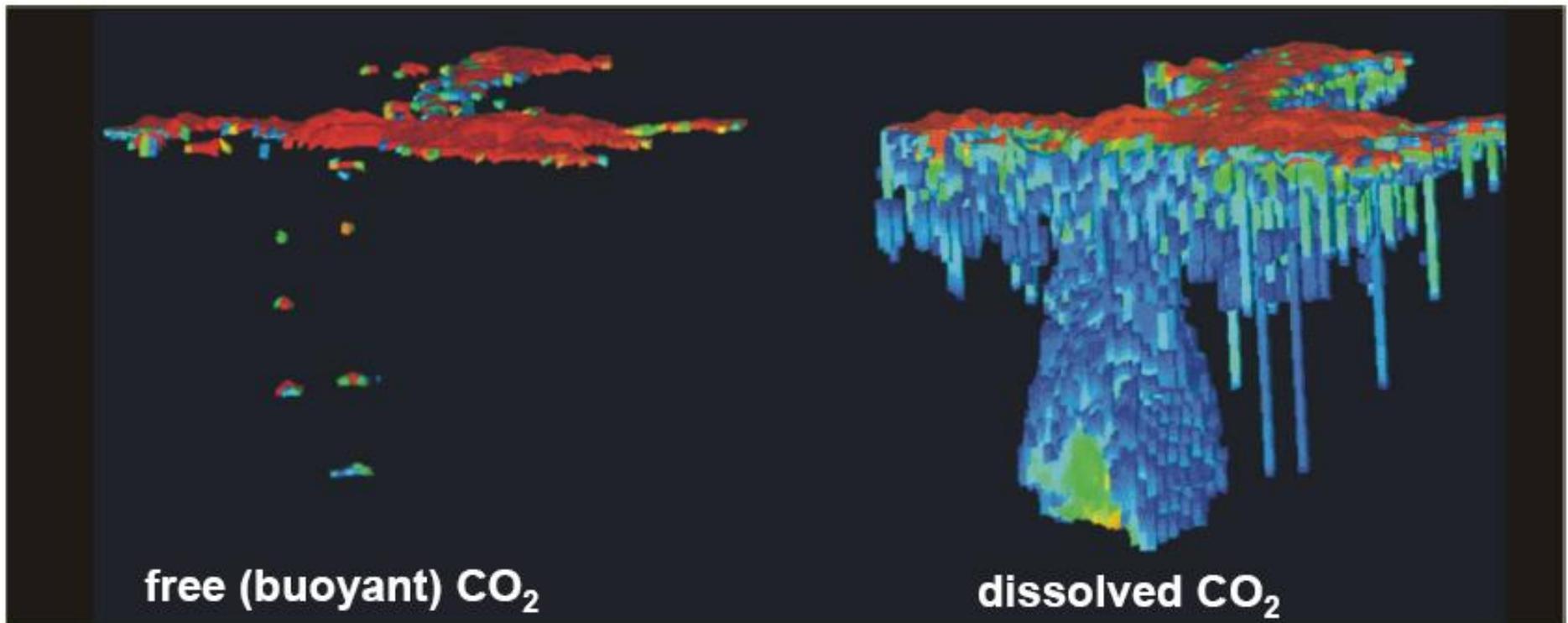
- “ Brought technical expertise to negotiators
- “ Technical experts on site selection; modelling; accounting; project boundaries; transboundary; risk assessment; environmental impacts; monitoring; liability (28 talks, several members of IEAGHG Networks).
- “ Results and experiences from real projects and natural systems, to support modelling and risk assessments
- “ Good Q&As from CCS negotiators and others



Courtesy H.Olson, BEG, UT

Sleipner predicted stabilization

(250 years after injection)

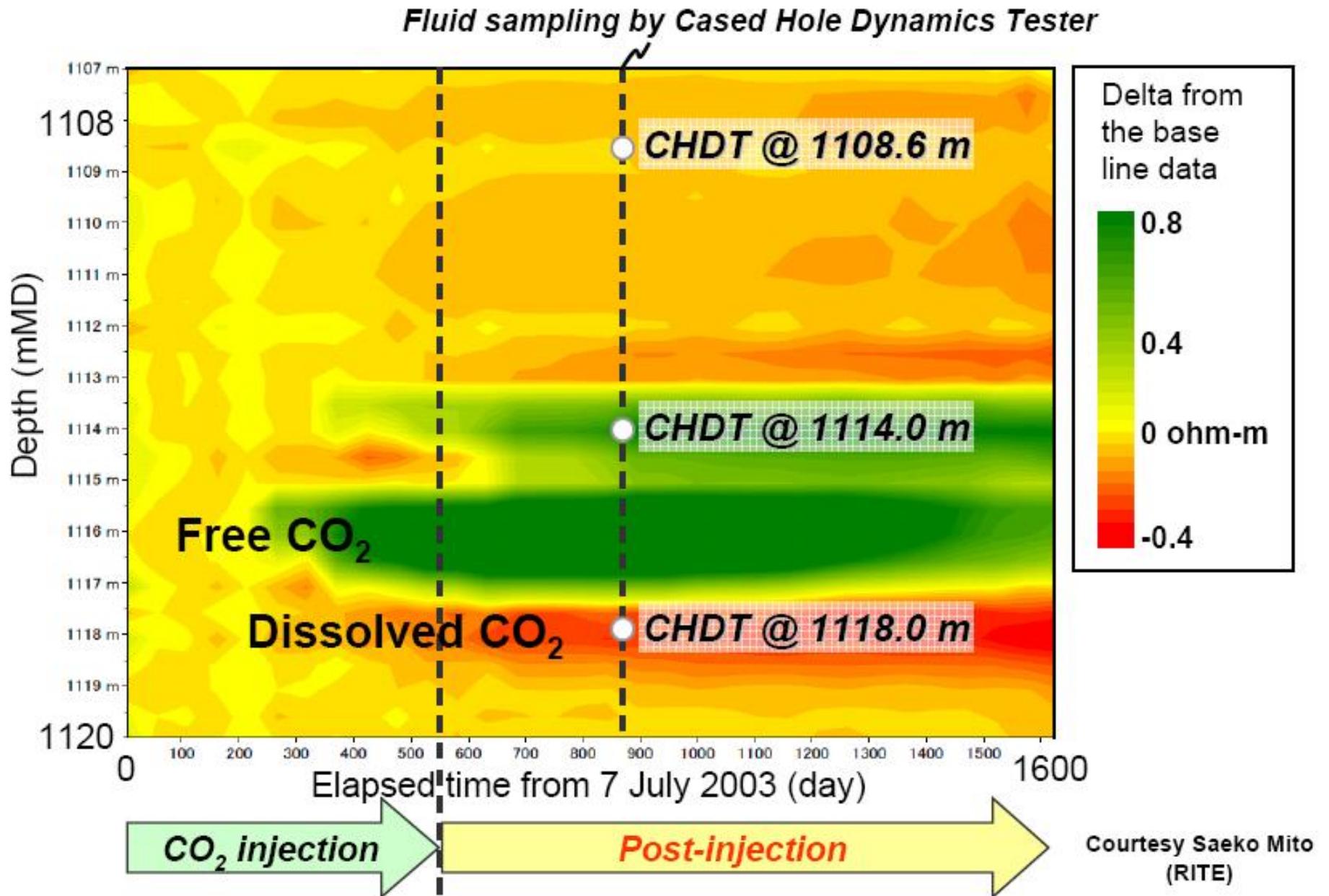


[Courtesy Erik Lindeberg]

Onset of dissolution: gravitational stabilization

Post-injection monitoring at Nagaoka (Japan)

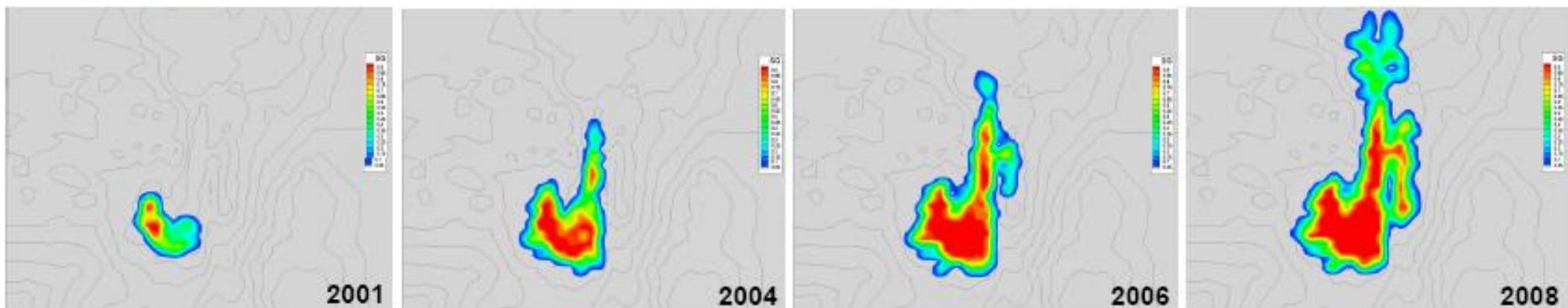
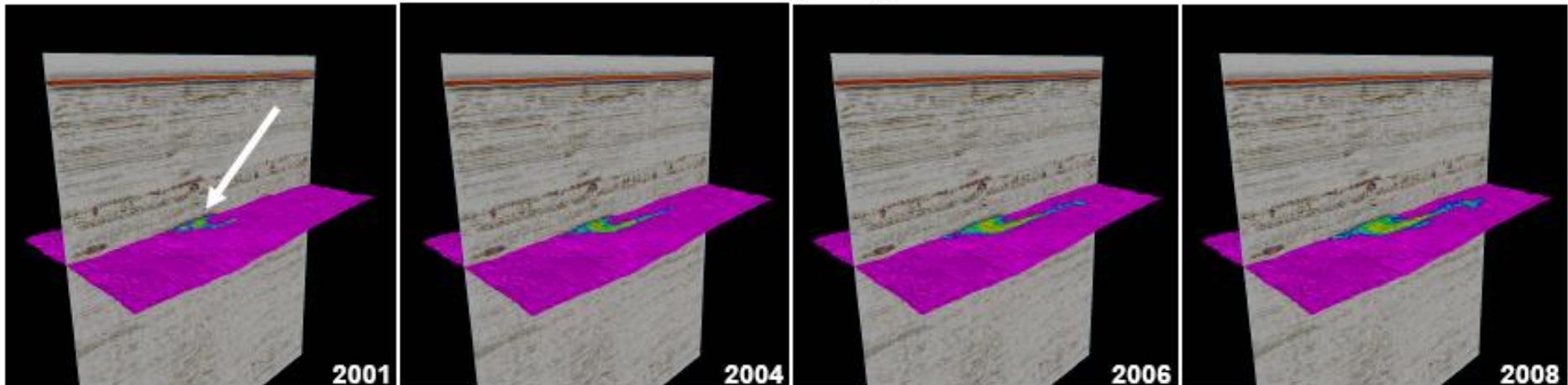
Courtesy A.Chadwick 2011



History-matching plume migration at Sleipner (3)

Courtesy A.Chadwick 2011

observed layer growth



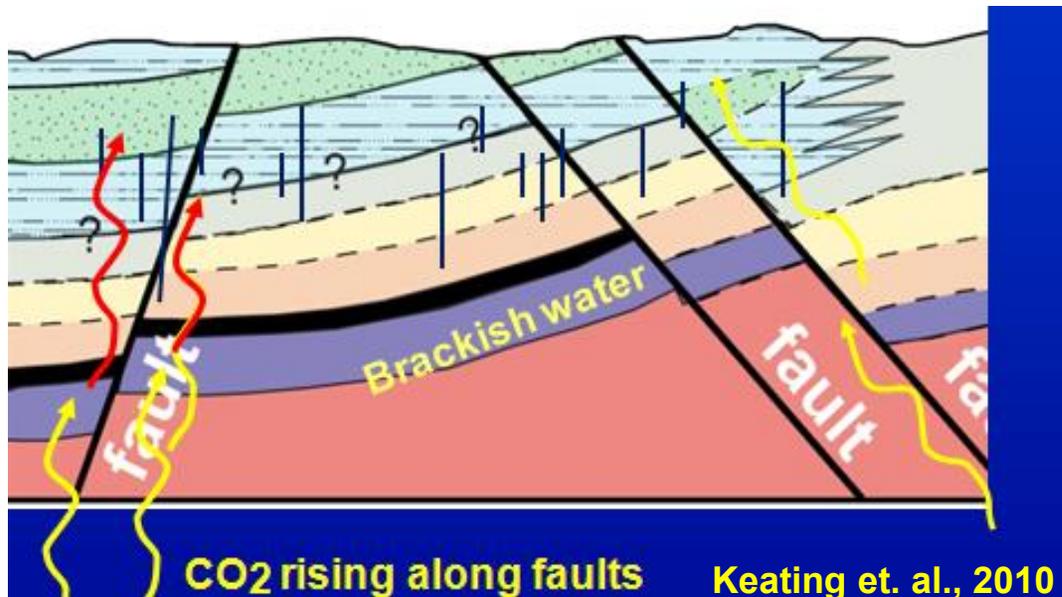
numerical flow simulation of layer growth

Match imperfect but sufficient to prove understanding of process

Scope for divergence in long-term predictions is limited



CO₂ at the surface. Natural Analog Chimayo, New Mexico, USA



“Integrated field, lab and modeling.

“Trace elements are strongly associated with brackish water; in-situ mobilization is negligible

“Mineral precipitation decreases metal concentrations



Technical Workshop 2011



Abu Dhabi 7-8 Sep 2011

Outcomes:

- “ Number of issues of concern shrunk considerably
- “ Liability remained as genuine concern . part technical, part policy issue
- “ UNFCCC produced draft Modalities and Procedures (M&Ps) drawing upon workshop and synthesis report, 20 pages of detail, the basis for negotiations in Durban



CMP7/COP17 Durban, Negotiations on CCS CDM



“ Over 32 hours of formal negotiations



CCS in COP-17, Durban



Decision CMP#.7 (final draft was FCCC/KP/CMP/2011/L.4)

“ **Agreed and adopted CCS Modalities and Procedures**

“ Review within 5 years

“ Transboundary left to resolve

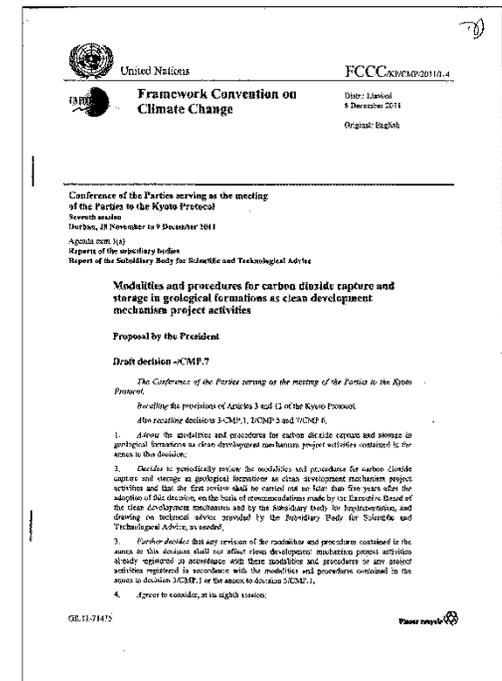
Two unresolved issues:

“ Transboundary CCS

“ Global reserve of CERs

➤ Consideration by SBSTA, draft decision to CMP-8

➤ **CMP-8 Doha - both ‘parked’ until SBSTA 45 (2016)**



M&Ps - Liability



- “ **Treatment of local liability** - *health, safety, environmental impacts*
 - “ Participation requirement; host party establish national laws and regulations that address local liability
- “ Liable entity identified for each phase of project lifecycle
 - “ Project participants liable from operation phase until transfer of liability
 - “ Transfer of liability to host party after monitoring period ends (20 yrs after crediting period)
- “ **Treatment of climate liability** - *obligations to surrender allowances for “net reversal of storage”*
 - “ Any CO₂ seepage results in retirement of credits equivalent to seepage emissions
 - “ Host party has 2 options;
 - ▶ Ultimate responsibility resides with the host party
 - ▶ Ultimate responsibility resides with developed country using the credits, i.e. a buyer liability.

M&Ps – Project Closure



- “ CDM project closure when monitoring stops
- “ Monitoring stops when:
 - “ Not less than 20 years after last CDM crediting period
 - “ No seepage observed in previous 10 years
 - “ All available evidence from observations and modelling indicates CO₂ will be completely isolated from the atmosphere in the long-term
 - History matching of modelling and monitoring
 - Modelling confirms no future seepage expected
- “ Enables transfer of liability to host party
- “ Enables final certification report, which triggers release of CERs from Reserve Account to project participants



Significance of CCS M&Ps from Durban



- “ **Allows CCS to be CDM project activity and earn CERs**
- “ Create incentives / signal for CCS in developing countries
 - ▶ CDM key international mechanism supporting low-C technology in developing countries
- “ Legitimises CCS as valid technology for developing countries
- “ Establishes precedence-setting regulatory framework for CCS funded under international mechanisms



Durban Platform for Enhanced Action



- “ **New negotiating process established (AWG on the Durban Platform for Enhanced Action);**
- “ Recognises that current emission pledges inadequate <math><2^{\circ}\text{C}</math>
- “ Process to develop ~~the~~ protocol, another legal instrument or outcome with legal force for all Parties
- “ Timeline;
 - ▶ Process to completed no later than 2015
 - ▶ Implemented by 2020



courtesy of IISD/Earth
Negotiations Bulletin

Durban COP17/CMP7 and Doha COP18/CMP8 Outcomes



- “ **AWG KP: Parties agreed to have Kyoto Protocol 2nd Commitment period**
 - “ 2nd Commitment period commences 1st January 2013 and ends 31 December 2020
 - “ Continued project-based mechanisms (CDM)
- “ **AWG LCA:**
- “ New Market Mechanism to be developed
- “ Technology Mechanism
- “ Green Climate Fund



courtesy of
IISD/Earth
Negotiations Bulletin



London Convention and Protocol



- “ Marine Treaty - Global agreement regulating disposal of wastes and other matter at sea
- “ Convention 1972 (87 countries)
- “ Protocol 1996 . ratified March 2006 (44 countries as of Jan 2014)
- “ Annual Meeting of the Contracted Parties.
- “ Annual meeting of Scientific Group.
- “ Changes need consensus or 2/3 majority vote (and ratification in some cases)
- “ How it works:
- “ Prohibition on dumping of all wastes, except for those listed in Annex 1, which need to be permitted under conditions in Annex 2.
- “ Annex 1: dredged material; sewage sludge; fish waste; vessels and platforms; inert, inorganic geological material; organic material of natural origin; bulky items primarily comprising unarmful materials, from small islands with no access to waste disposal options

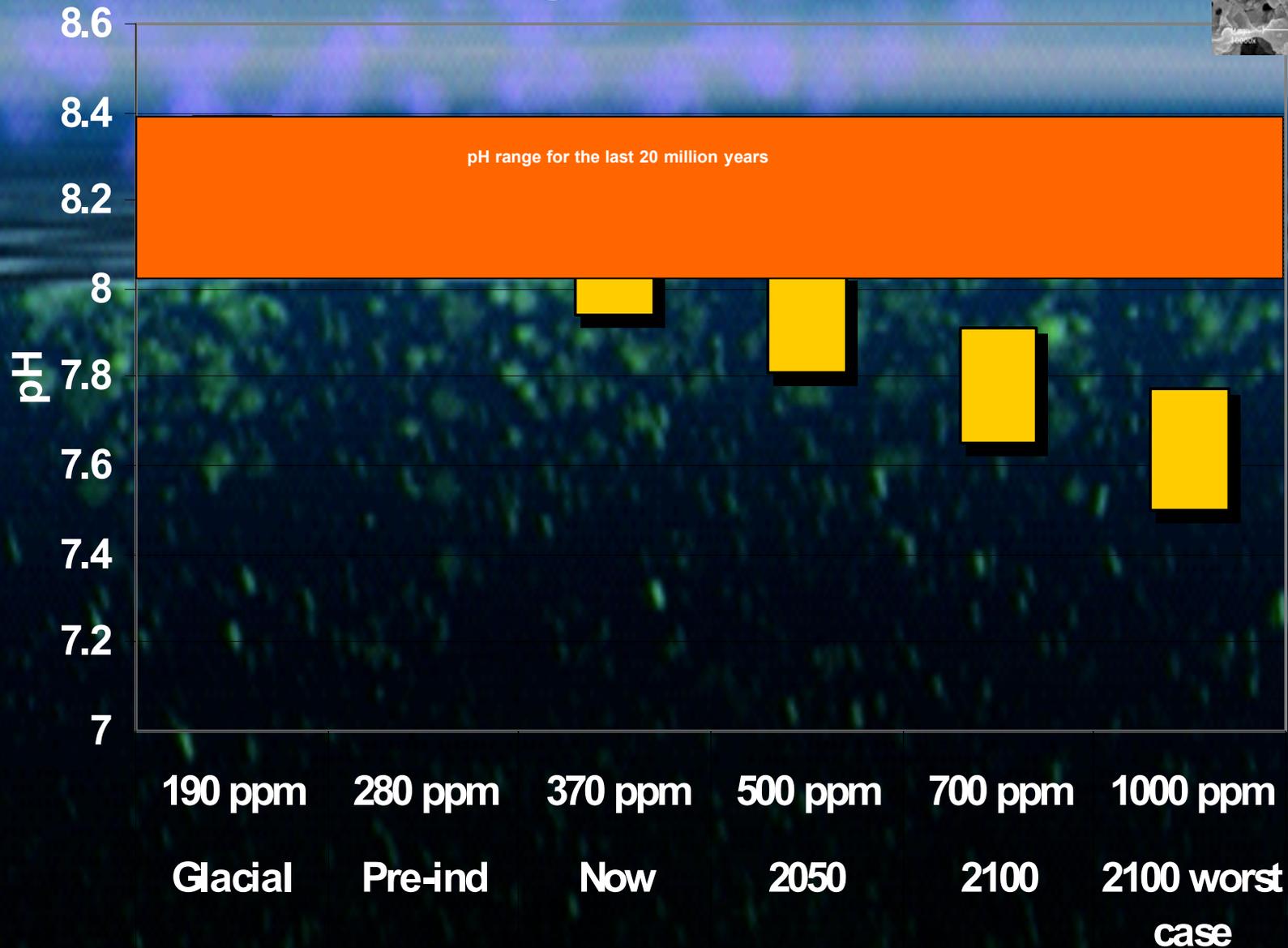
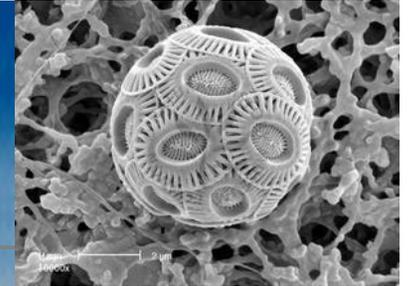
London Convention and Protocol and CCS



- “ Prohibited some CCS project configurations
- “ CO2 Geological Storage Assessed by LC Scientific Group 2005/6
- “ 2006 . developed a Risk Assessment Framework for CO2
- “ Protocol amendment adopted by vote at 28th Consultative Meeting (LP1), 2 Nov 2006 to allow CO2 disposal in geological formations - came into force 10 Feb 2007
- “ CO2 Specific Guidelines (2007)



Simulated and observed marine pH ranges till 2100



PML
2005



London Protocol Amendment



Allowed to dispose of %CO₂ streams from CO₂ capture processes for sequestration+

%Carbon dioxide streams may only be considered for dumping, if:

- 1 disposal is into a sub-seabed geological formation; and*
- 2 they consist overwhelmingly of carbon dioxide. They may contain incidental associated substances derived from the source material and the capture and sequestration processes used; and*
- 3 no wastes or other matter are added for the purpose of disposing of those wastes or other matter.”*

LC 28/15 (6 Dec 2006) Annex6

LP Transboundary



London Protocol Article 6

EXPORT OF WASTES OR OTHER MATTER

Contracting Parties shall not allow the export of wastes or other matter to other countries for dumping or incineration at sea.”

- “ Prohibits transboundary transport of CO₂ for geological storage
- “ 2009 LP4 (30 Oct) - Amendment to allow CO₂ for storage was adopted by vote.
- “ Article 6 , new para 2 : ~~Export~~ of CO₂ for disposal in accordance with Annex 1 may occur, provided an agreement or arrangement has been entered into by countries concerned
- “ Agreement shall include : permitting responsibilities; for export to non-LP Parties provisions equivalent to LP’s for issuing permits.
- “ To come into force needs ratification by two thirds all Parties
- “ Transboundary movement of CO₂ streams after injection is not export in the sense of article 6, of the London Protocol.

LP Transboundary



2013 Update

- “ 2012 - Revised CO₂ Specific Guidelines approved and adopted at LC-34, Oct29, London. Covering subsurface transboundary migration.
Transboundary storage offshore now possible
- “ 2013 - New Guidance on Export of CO₂ Streams for Disposal approved to cover responsibilities for arrangements or agreements for export
- “ **All safeguards are now in place for transboundary CCS activity in the marine environment, including export.**
- “ **But – 2009 Transboundary amendment for CO₂ export needs 29 countries to ratify in order to come into force. Only 2 so far (Norway, UK), 4 more on way**
- “ **So export of CO₂ still not permitted for offshore storage – unless for utilisation eg EOR.**



- “ Mr. Koji Sekimizu, the IMO Secretary-General in his opening speech to the 2013 LP meeting.
- “*The London Protocol currently is also the only global framework to regulate carbon capture and sequestration in sub-seabed geological formations.....*
- “*However, it remains a **serious concern** that, to date, only two of the 43 London Protocol Parties have accepted the 2009 amendment, which is a long way from satisfying the entry-into-force requirements. The importance of securing its entry into force cannot be over-emphasized, if the threat of acidification of the oceans from climate change is to be minimized.”*

Other new technologies...?



Ocean Fertilisation and other Geo-engineering in the London Convention and Protocol



- “ Ocean fertilization: any activity with the intention of stimulating primary productivity. Does not include conventional aquaculture.
- “ Eg the intentional introduction of nutrients such as iron to the ocean to stimulate phytoplankton. Iron is often the limiting nutrient for their growth. Phytoplankton growth results in increased CO₂ removal from the atmosphere for their photosynthesis.
- “ Geo-engineering: Marine geo-engineering means a deliberate intervention in the marine environment with the purpose of manipulating natural processes, including to counteract anthropogenic climate change and/or its impacts, and that has the potential for widespread, long-lasting or severe effects.



Ocean Fertilisation and other Geo-engineering in the London Convention and Protocol



- “ 2013. Proposal adopted to add Article 6bis to prohibit marine geoengineering unless listed in Annex 4 and permitted using generic Assessment Framework (to prevent pollution or reduce to a minimum).
- “ Annex 4 lists one activity . Ocean Fertilization
- “ Only for research purposes.
- “ Requires permit which uses Ocean Fertilization Assessment Framework
- “ Allows for the addition of other marine geoengineering activities in the future. Which will need specific assessment frameworks.
- “ Provides for a global, transparent and effective regulatory and control mechanism for marine geoengineering activities which have potential to cause harm to the marine environment.



Useful information sources and references



- “ UNFCCC documents on CCS at <http://cdm.unfccc.int/about/ccs/index.html> and from Durban <http://unfccc.int/2860.php>
- IEA Regulatory Network <http://www.iea.org/ccs/legal/index.asp>
(CCS Legal Review, Webinars, Model Regulatory Framework)
- “ UCL Carbon Capture Legal Programme <http://www.ucl.ac.uk/cclp/> and <http://www.globalccsinstitute.com/networks/cclp>

- “ Dixon, T, et al. *International Marine Regulation of CO2 Geological Storage*. Elsevier Energy Procedia 1 (2009) 4503-4510
- “ Dixon, T. et al. *Trials and Tribulations of Getting CCS in an ETS*. Elsevier Energy Procedia 1 (2009) 4443-4450
- “ Dixon, T. et al. *Getting Science and Technology into International Climate Policy: CCS in the UNFCCC*. Elsevier Energy Procedia 37 (2013) 7590-7595

- “ Technical information on CCS :
- “ www.ieaghg.org , <http://www.ukccsrc.ac.uk/>





Oral Sessions

Time	Topic	Speaker
10:00-11:00	Session 1	Speaker A
11:00-12:00	Session 2	Speaker B
13:00-14:00	Session 3	Speaker C
14:00-15:00	Session 4	Speaker D
15:00-16:00	Session 5	Speaker E
16:00-17:00	Session 6	Speaker F
17:00-18:00	Session 7	Speaker G
18:00-19:00	Session 8	Speaker H
19:00-20:00	Session 9	Speaker I
20:00-21:00	Session 10	Speaker J

Poster Sessions

Poster Session A: Tuesday, 27th November, 13:00-17:00
Poster Session B: Wednesday, 28th November, 13:00-17:00

Prof. Yoichi Kaya
University of Tsukuba



www.GHGT.info

5–9 October 2014
AUSTIN, TX – USA

AUSTIN TX

"Call for papers	27 th September 2013
"Deadline for abstracts	10 th January 2014
"Registration opens	7 th March 2014
"Authors notified	2 nd May 2014
"Early bird closes	13 th June 2014



Thank You

Any questions?

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