



Carbon Capture and Storage: Developments, Potential and Challenges in the Global Context

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Storage Technologies*

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IEA Greenhouse Gas R&D Programme



A collaborative research programme founded in 1991; under the terms of an Implementing Agreement from the International Energy Agency (IEA).

Aim: Provide members with definitive information on the role that technology can play in reducing greenhouse gas emissions.

Producing information that is:

- Objective, trustworthy, independent
- Policy relevant but NOT policy prescriptive
- Reviewed by external Expert Reviewers
- Subject to review of policy implications by Members

IEAGHG Participants contribute to a common fund to finance the activities like technical studies, conferences, networks, summer school etc.

IEAGHG Activities



Technical studies

- The core of our work
- More than 250 studies have been published
- Reports are freely available to our member countries

Assist international collaboration and information dissemination

- Organise GHGT conference series and other (OCC3 & PCCC2)
- Networks of researchers on aspects of CCS
- Workshops on CCS (High Temperature Looping, CO₂ Storage)
- International CCS summer schools

Support implementation

- Provide information to policy makers & regulators
- Collaborate with relevant organisations



ALSTOM



EnBW



VATTENFALL



ExxonMobil



Schlumberger



ieaghg

EPRI



Partner Organisations:



Effect of CO₂ on Environment

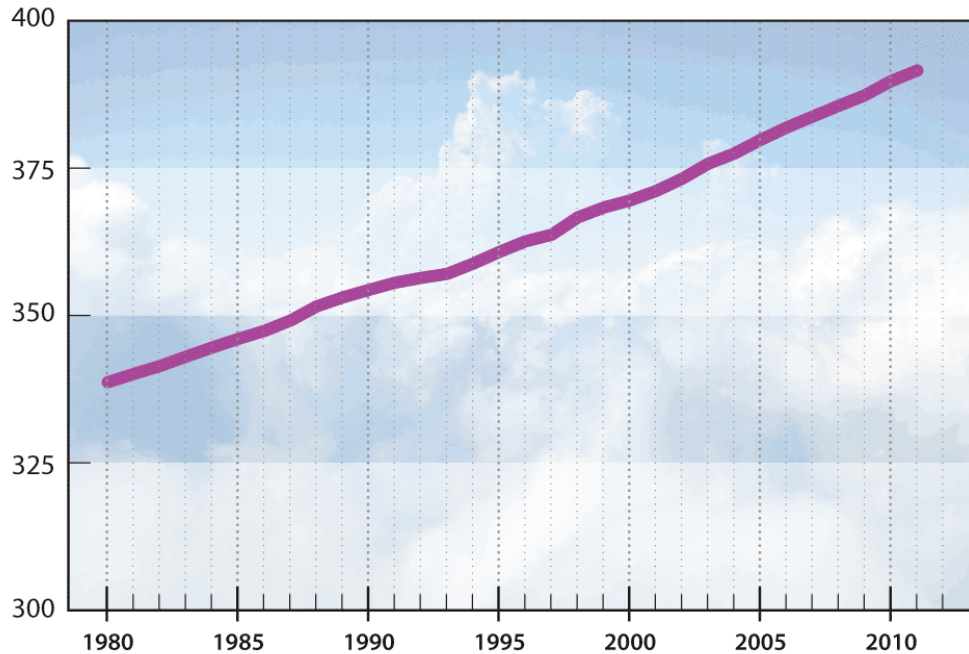


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Atmospheric CO₂

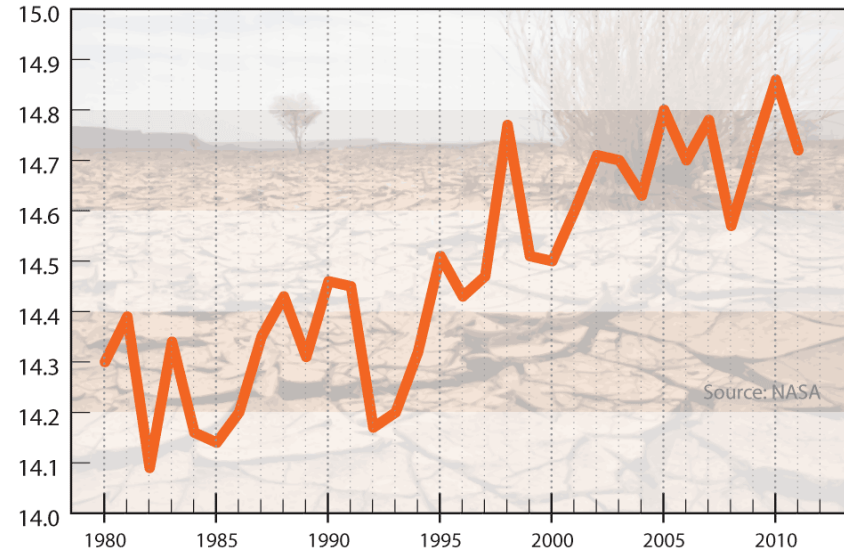
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Parts per million



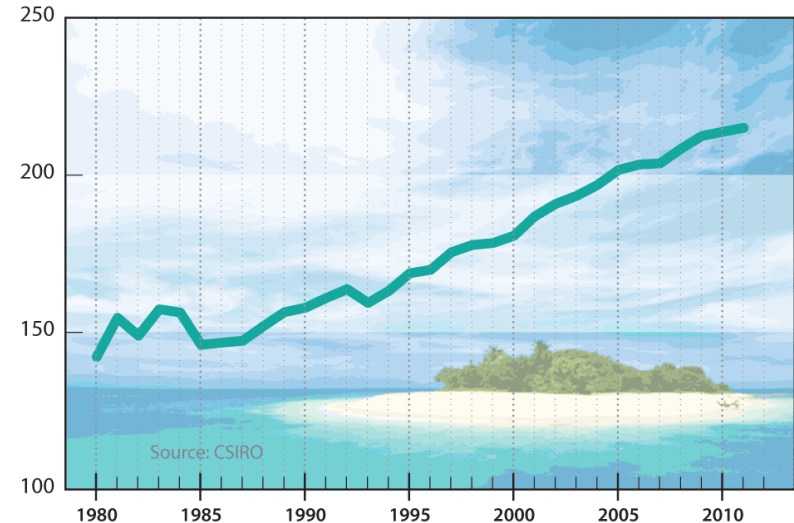
Global average land surface temperature

Degrees C



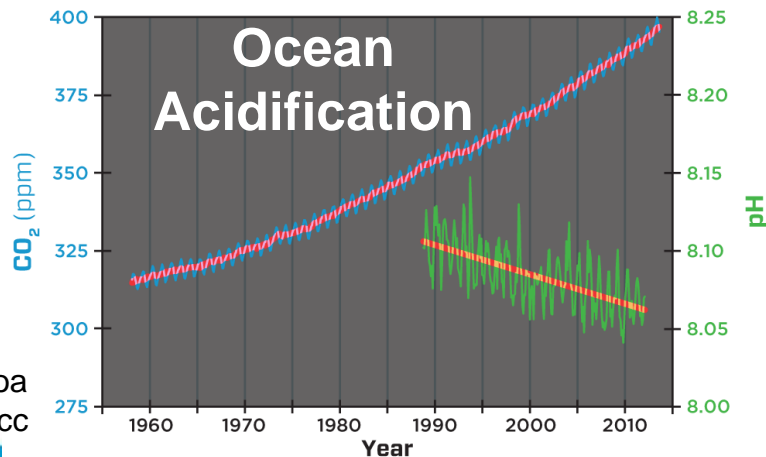
Global sea level

Millimeters



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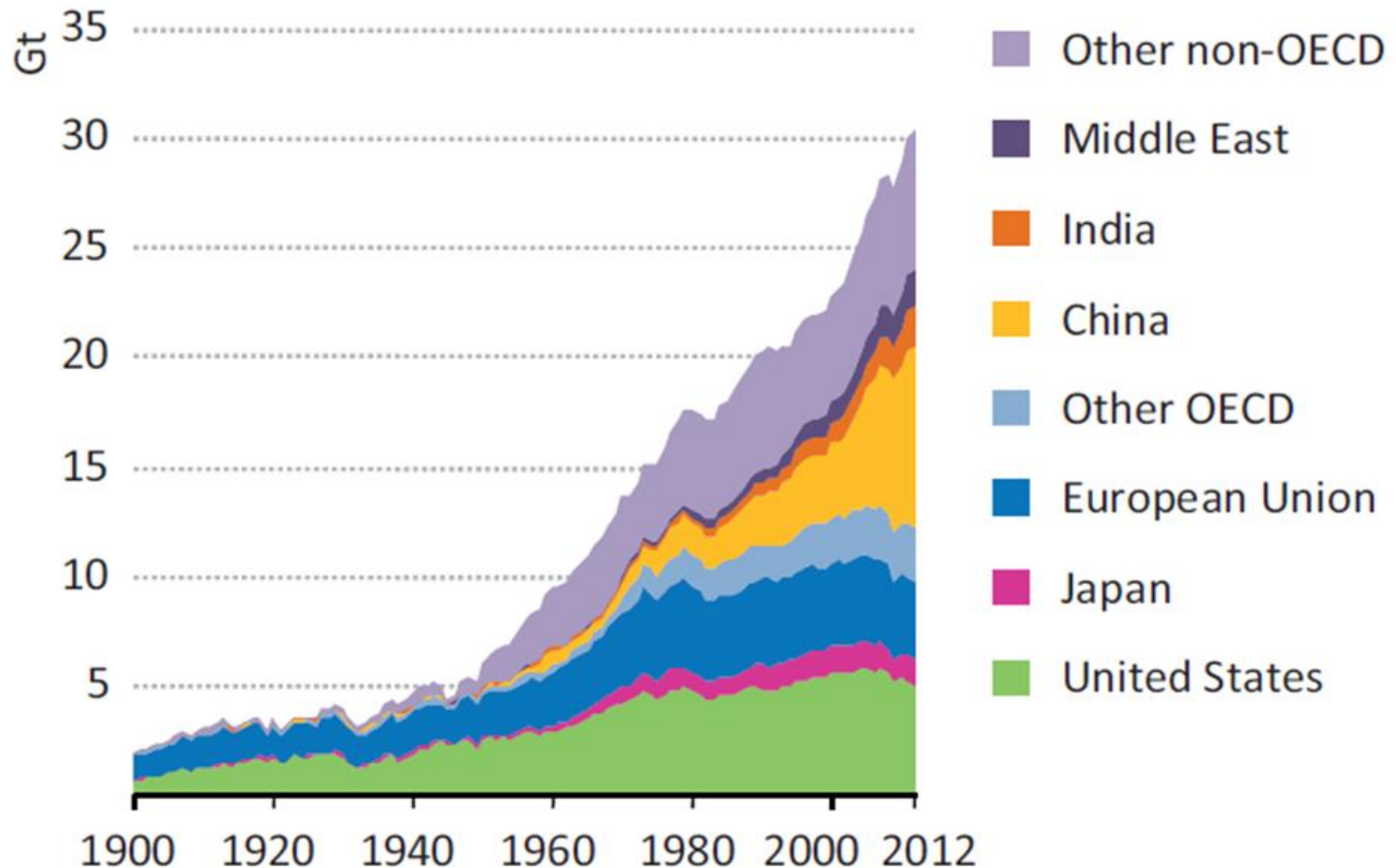
Ocean Acidification



Increase in CO₂ Emission



Annual CO₂ emissions reached record high **31,6 Gt** in 2012

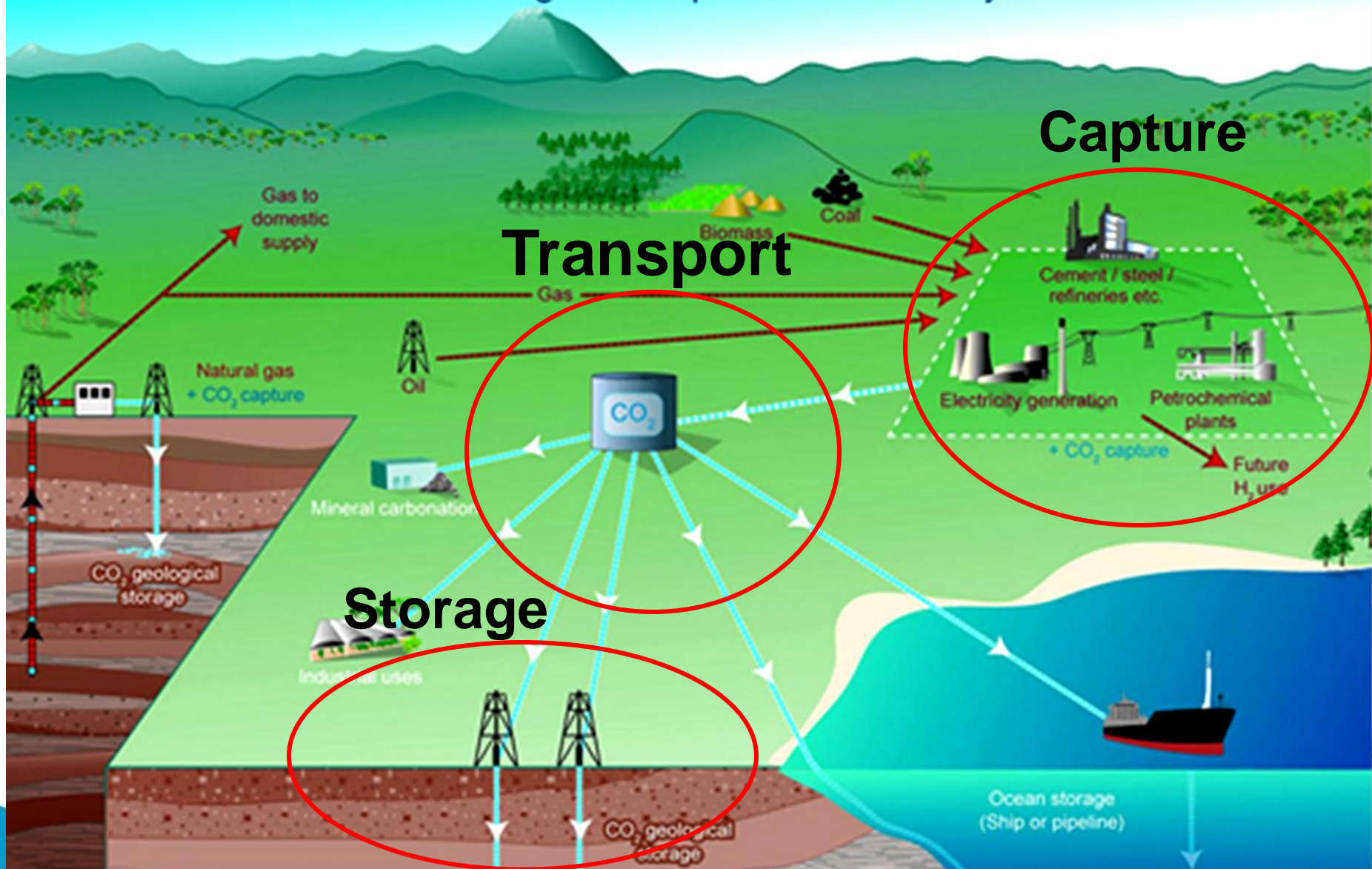


Sources: IEA databases and analysis; Boden *et al.*, (2013).

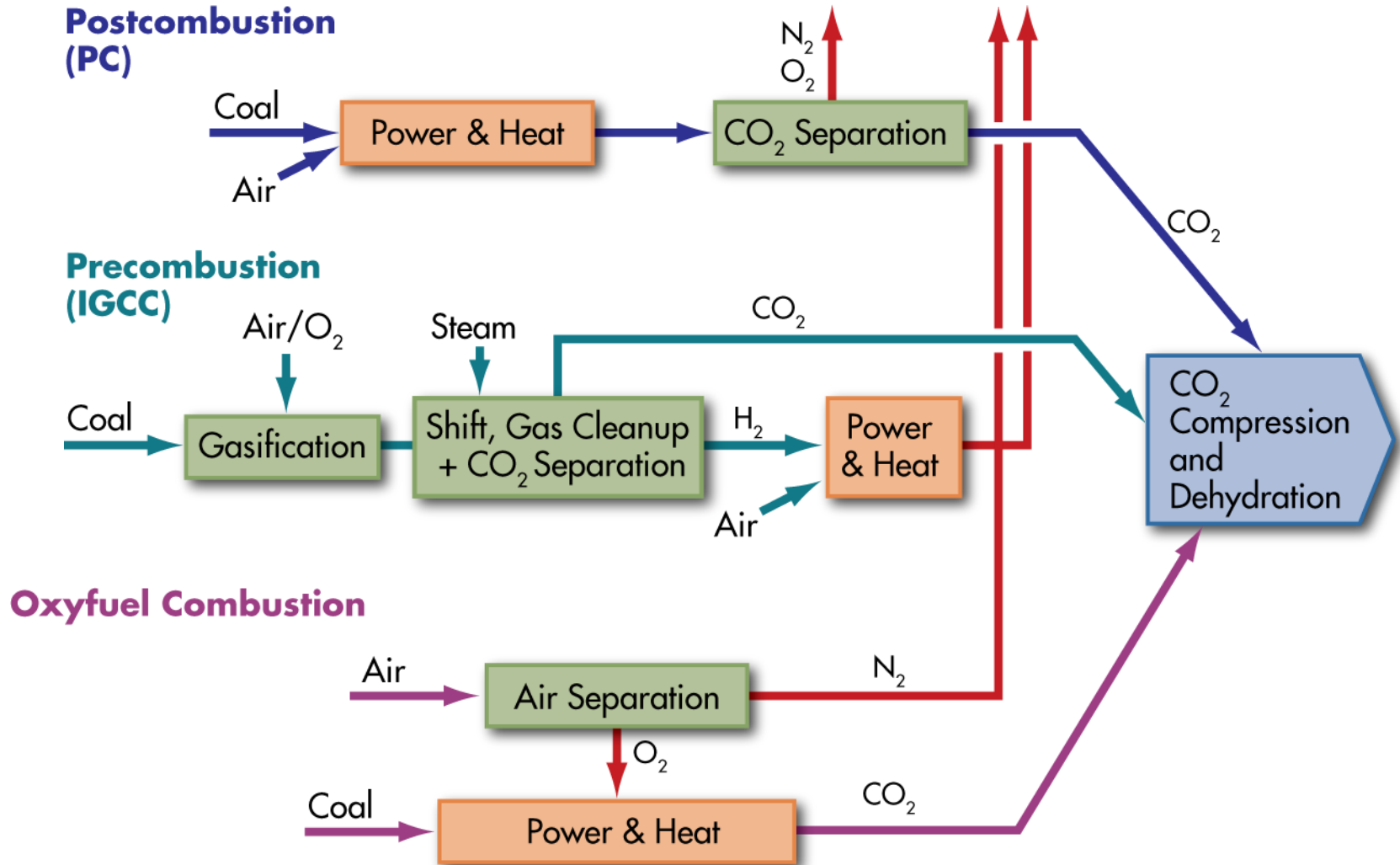


Carbon Capture & Storage (CCS)

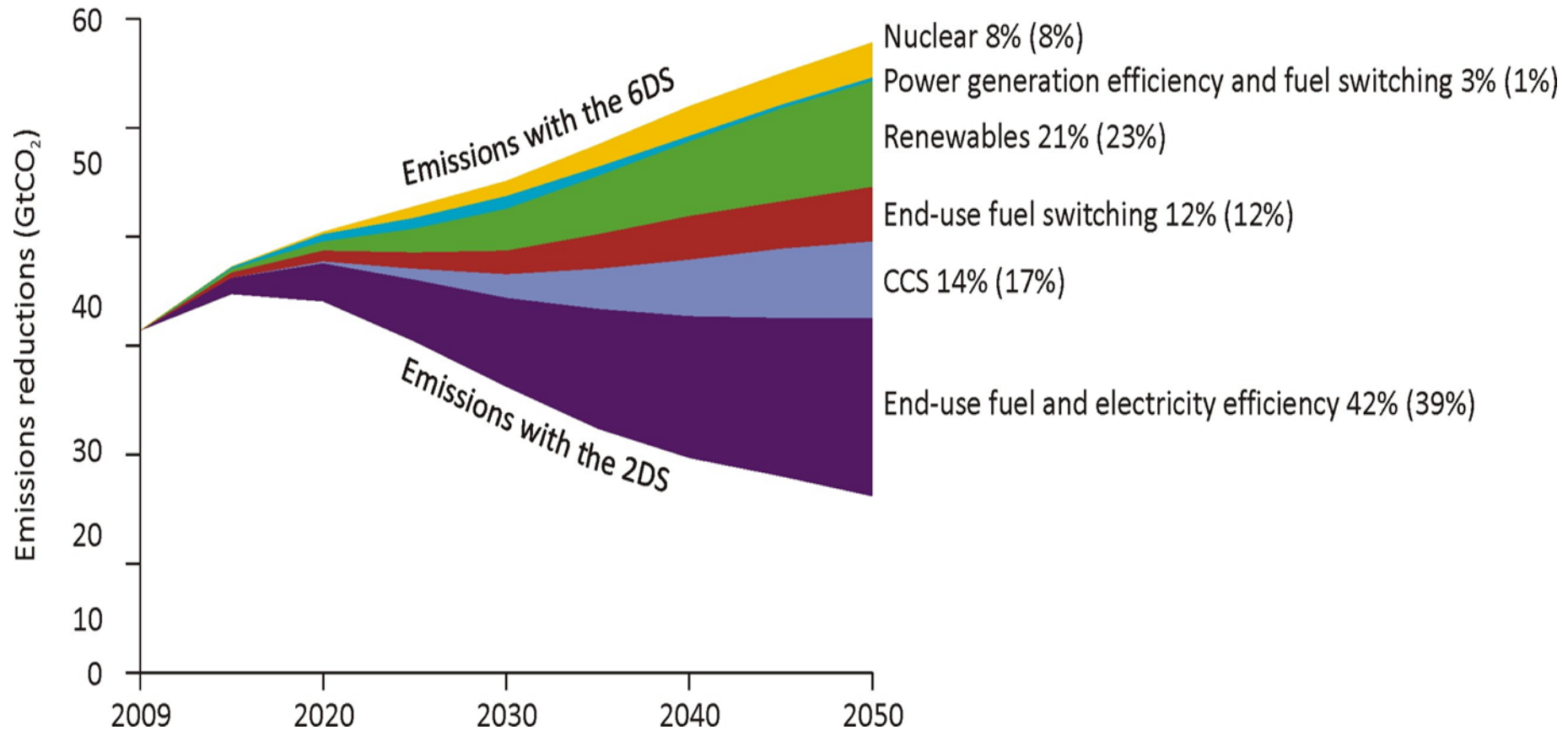
Schematic diagram of possible CCS systems



CO₂ Capture Technology Options



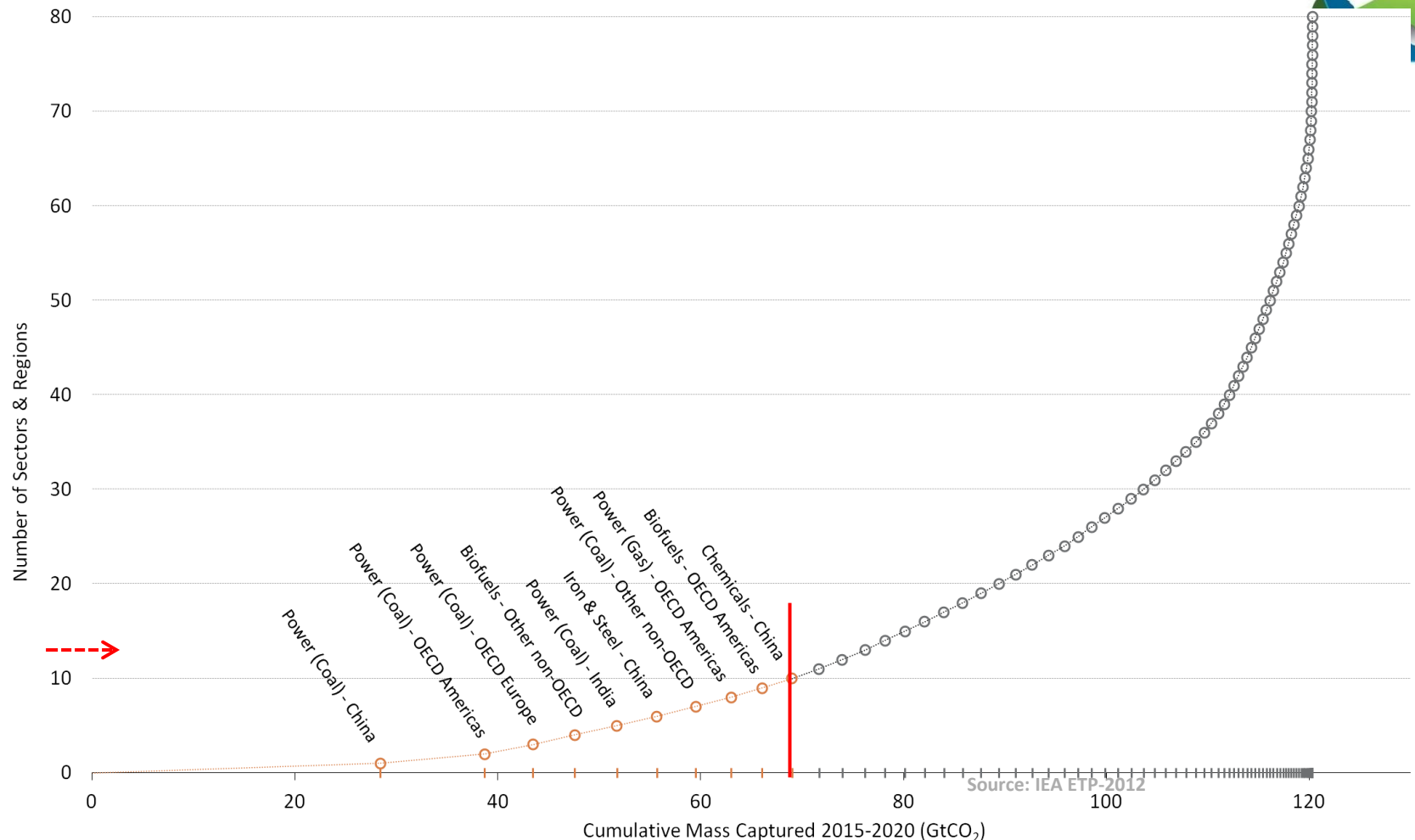
Why do we need CCS?



Source: IEA 2013 Technology Roadmap for Carbon Capture and Storage



Top-10 region-sectors: ½ of total CCS



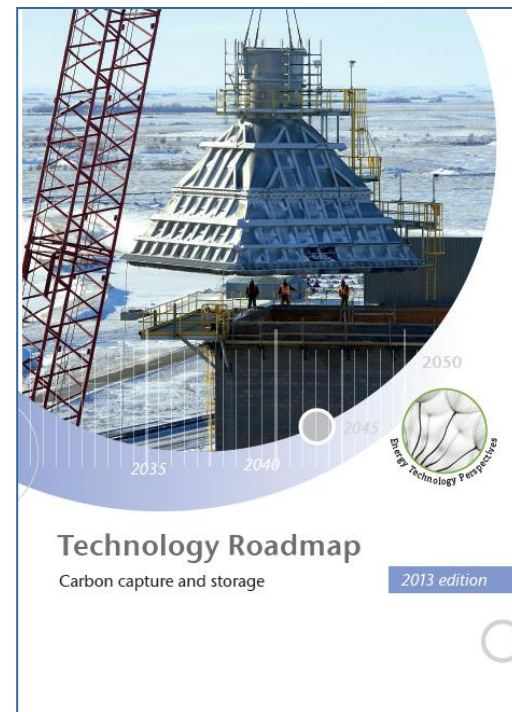
- Potential of CCS is concentrated in a limited number of sectors
- Top-10 sector-region combinations could capture and store 70Gt by 2050
- **Top-3: coal-power in China, North-America and Europe: >40Gt**

Source: IEA CCS Technology Roadmap 2013



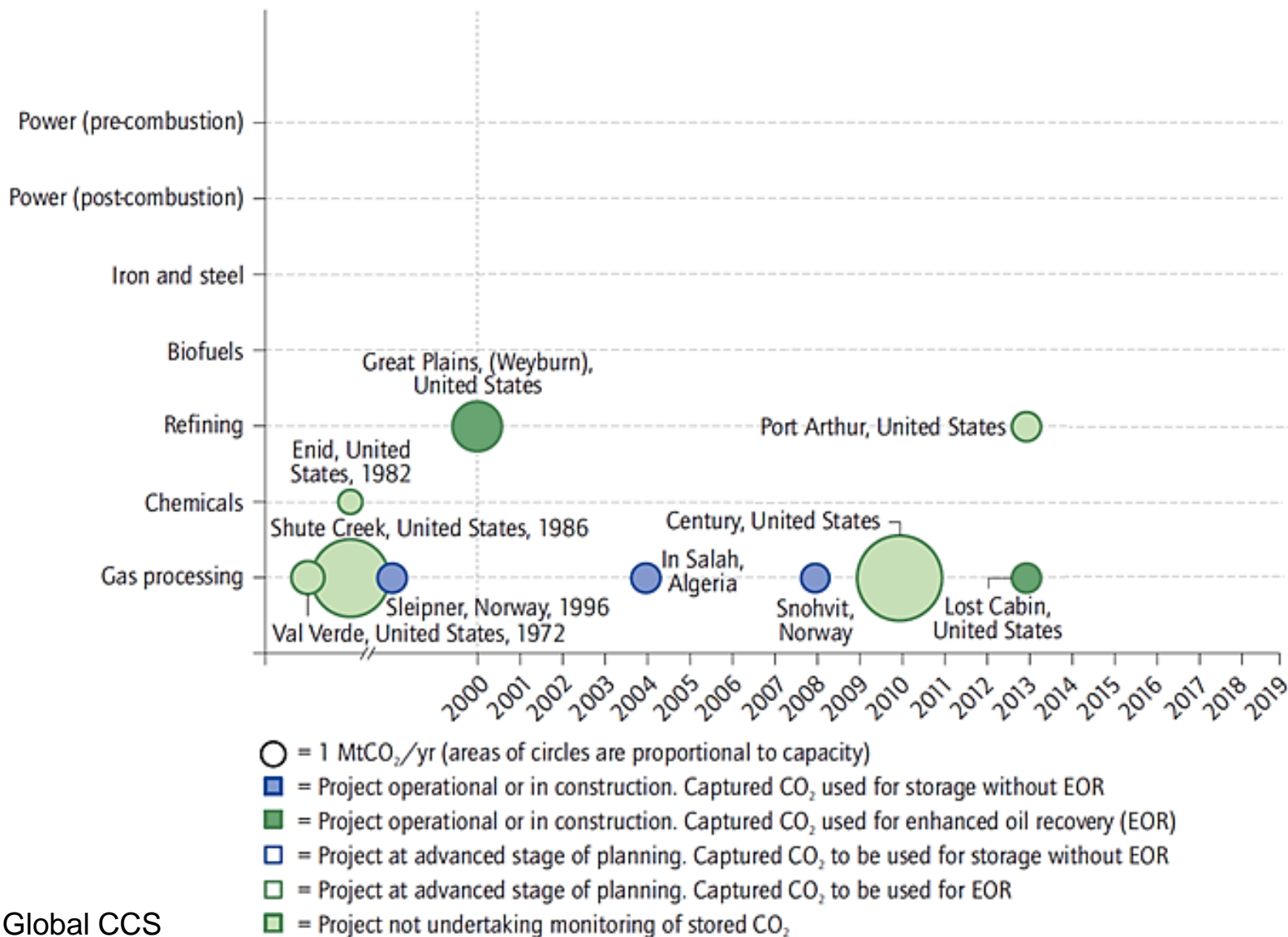
2013 CCS Roadmap: Key findings

- CCS is a **critical component** in a portfolio of low-carbon energy technologies, contributing 14% of the cumulative emissions reductions between 2015 and 2050 compared with business as usual.
- The individual component technologies are generally well understood. **The largest challenge is the integration** of component technologies into large-scale demonstration projects.
- Incentive frameworks are urgently needed to deliver upwards of **30 operating CCS projects by 2020**.
- CCS is not only about electricity generation: 45% of captured CO₂ comes from **industrial applications** between 2015 and 2050.
- The largest deployment of CCS will need to occur in **non-OECD countries, 70% by 2050**. China alone accounts for 1/3 of the global total of captured CO₂ between 2015 and 2050.
- The urgency of CCS deployment is only increasing. **This decade is critical** in developing favourable conditions for long-term CCS deployment.





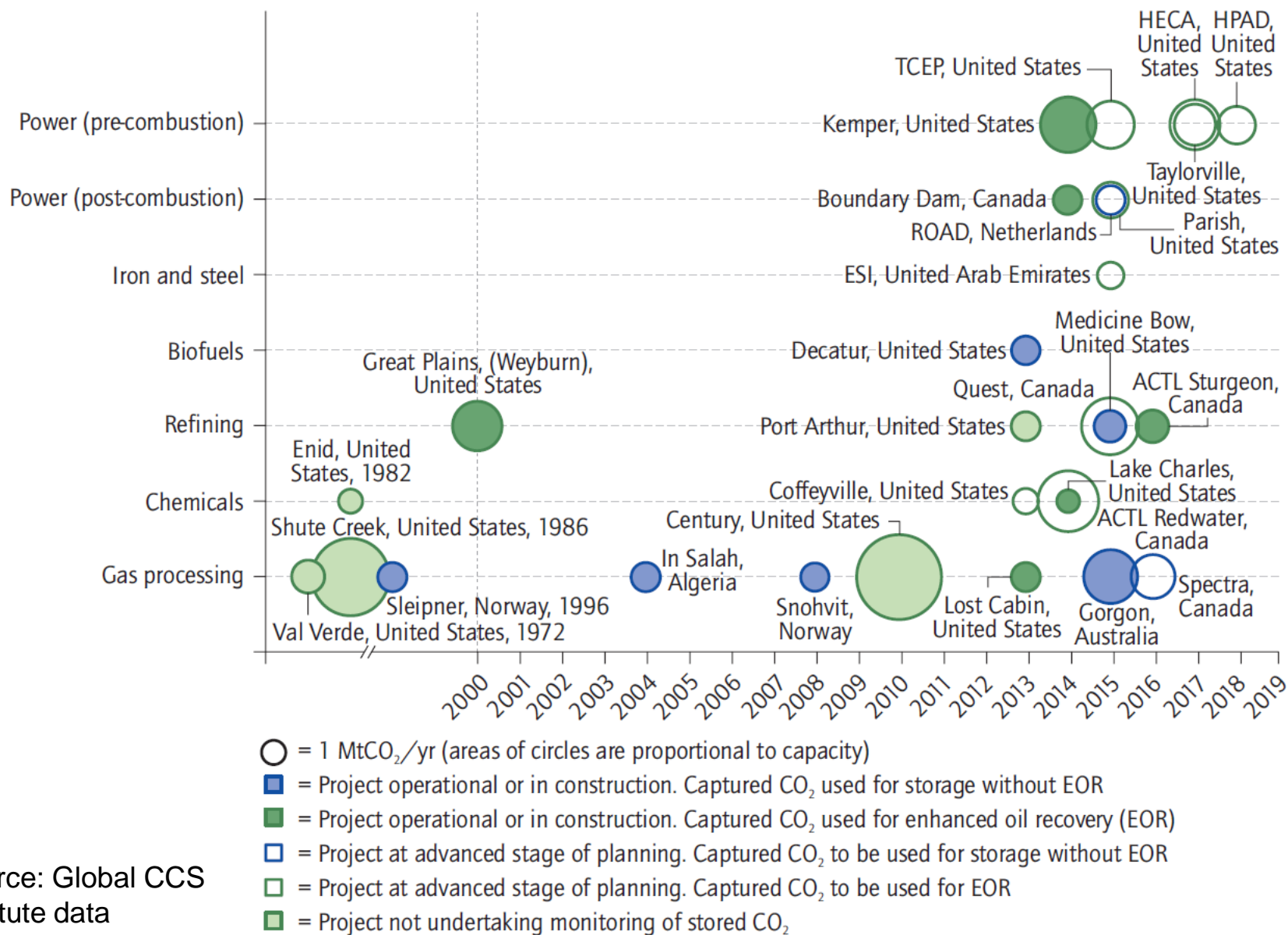
Progress with integrated projects



Source: Global CCS
Institute data



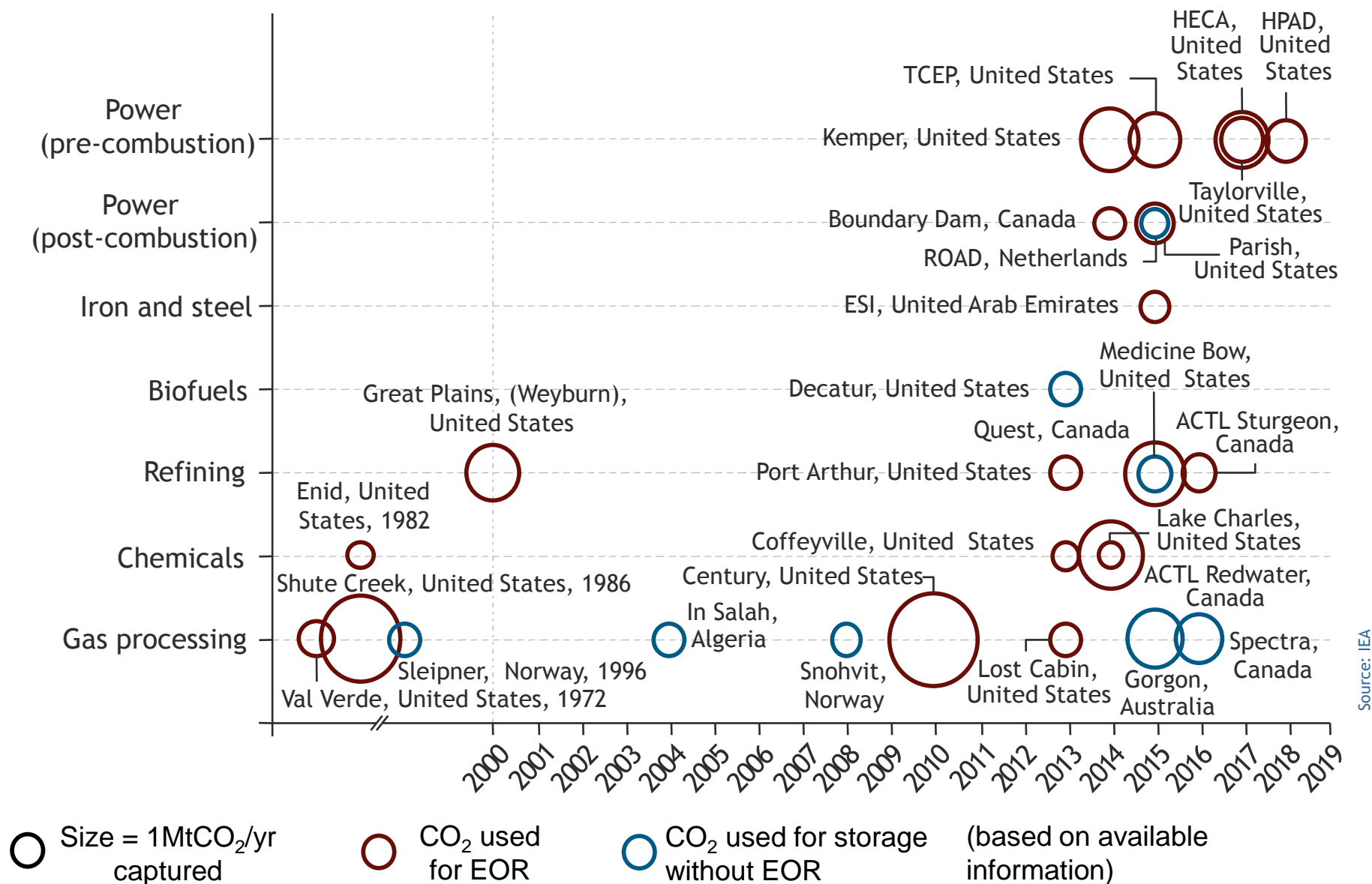
Progress with integrated projects



Source: Global CCS Institute data



Progress with large-scale capture projects



Different Approaches by Region



Europe

- ❑ Portfolio of 12 demonstration projects (2007)
- ❑ 2009 CCS Directive launched
- ❑ Financial incentives provided
 - ETS (2005) /NER300 (2010)
- ❑ Demonstration funding set aside in EEPR (2009)
 - One project still operating
- ❑ Second NER300 call (2013)
 - One UK CCS project submitted
- ❑ No EC funded demonstration projects yet
 - UK, Netherlands and Norway going it alone

USA

- ❑ FutureGen Announced 2003
- ❑ Regional Carbon Sequestration Programme started (2003 to date)
 - 3 phase Regional Carbon Sequestration Programme (2010)
 - 4 X1 million tonne injections underway by 2013
- ❑ Energy Recovery Act 2009
 - 3 Industry demos – 1 started
 - 4 Power Gen demos
- ❑ FutureGen II Funded (2009)
- ❑ USEPA CO2 injection rule announced 2010
 - No Class VI wells permitted yet



1 BSCSP Basalt	16 MGSC Sugar Creek EOR Phase II	31 SECARB - Stacked Storage Project Cranfield Phase II
2 Carbfix	17 MGSC Tanquary ECBM Phase II	32 SECARB - Mississippi Saline Reservoir Test Phase II
3 CarbonNet	18 Mountaineer	33 South West Hub (Collie South West Hub)
4 CIDA China	19 MRCSP Appalachian Basin (Burger) Phase II	34 Surat Basin CCS Project (Previously Wandoan)
5 CS Energy Callide Oxyfuel Project	20 MRCSP Cincinnati Arch (East Bend) Phase II	35 SWP San Juan Basin Phase II
6 CSEMP	21 MRCSP Michigan Basin Phase II	36 Teapot Dome, Wyoming
7 Fenn/Big Valley	22 Nagaoka Pilot CO2 Storage Project	37 Total Lacq
8 Frio, Texas	23 Otway I (Stage I)	38 West Pearl Queen
9 JCOP Yubari/Ishikari ECBM Project	24 Otway II Project (Stage 2A,B)	39 WESTCARB Arizona Pilot (Cholla)
10 K12B	25 PCOR Lignite	40 WESTCARB Northern California CO ₂ Reduction Project
11 Ketzin	26 PCOR Williston Basin -Phase II (NE McGregor Field)	41 WESTCARB Rosetta-Calpine test 1
12 Marshall County	27 PennWest Energy EOR Project	42 WESTCARB Rosetta-Calpine test 2
13 Masdar/ADCO Pilot project	28 Recopol	43 Western Kentucky
14 MGSC Ioudon Field EOR Phase II	29 SECARB - Black Warrior Basin Coal Seam Project	44 Zeronen Project
15 MGSC Mumford Hills EOR Phase II	30 SECARB - Central Appalachian Coal Seam Project	

The Role of CCS Pilots



CO₂ injection pilots are currently the key to global implementation of CCS

- Building a science/knowledge base
 - Journals/Conference proceedings; The American Association of Petroleum Geologists, European Geosciences Union etc.
- Key to developing public confidence
 - On site exhibitions/public interaction & social science research
- Contributing to demonstration implementation
 - K12-B allowed the Storage permit for ROAD (The Netherlands) to be gained from European Commission
- Develop expertise for future larger scale implementation
 - Skilled engineers, contractors, equipment suppliers

Changes in Focus



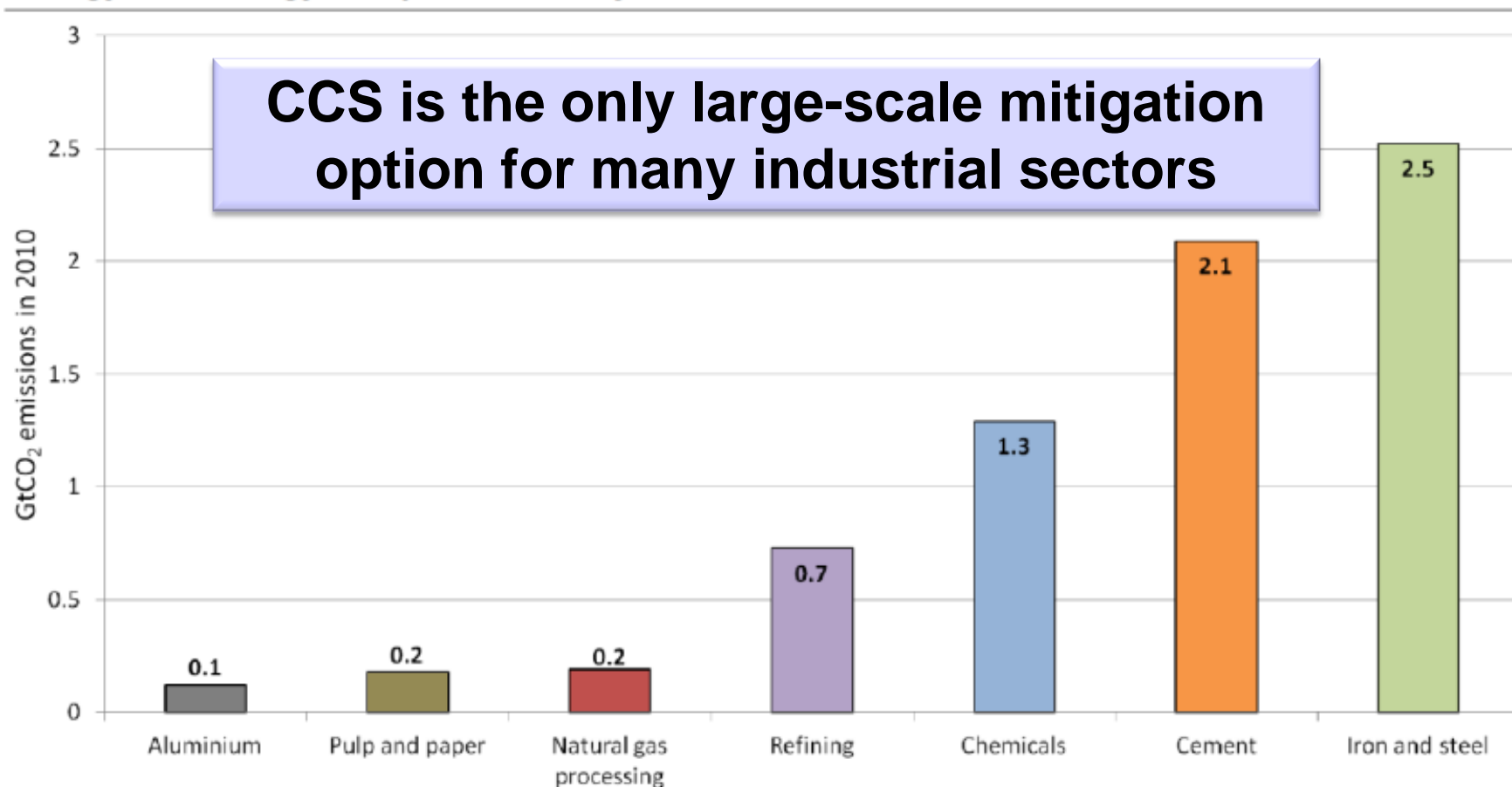
- CCS started off in gas supply industry
- Increasing interest in CCS on gas fired in Europe
 - USA – Environment Protection Agency (EPA) regulations likely to mean only coal fired power plant will be fitted with CCS
- Norway formerly had most advanced plans for gas fired CCS
 - Mongstad full scale plant –deferred until 2020
- UK now stepping up its activity
 - Energy Technologies Institute (ETI) call for 5MW pilot plant
 - Peterhead Gas fired CCS power plant selected in 2nd UK CCS competition



Rationale for CCS:

Only large-scale option for many industries

Figure 1. Global emissions from the seven most CO₂-intense industrial sectors in the IEA
Energy Technology Perspectives analysis



Some Examples of CCS Research in Steel Industry



ULCOS (EU) Project - Europe

- Developing oxy blast furnace with top gas recycle and capture

Japan - COURSE 50 Project

- Demonstrate post combustion capture from blast furnace
– 30tpd pilot scale

Korea

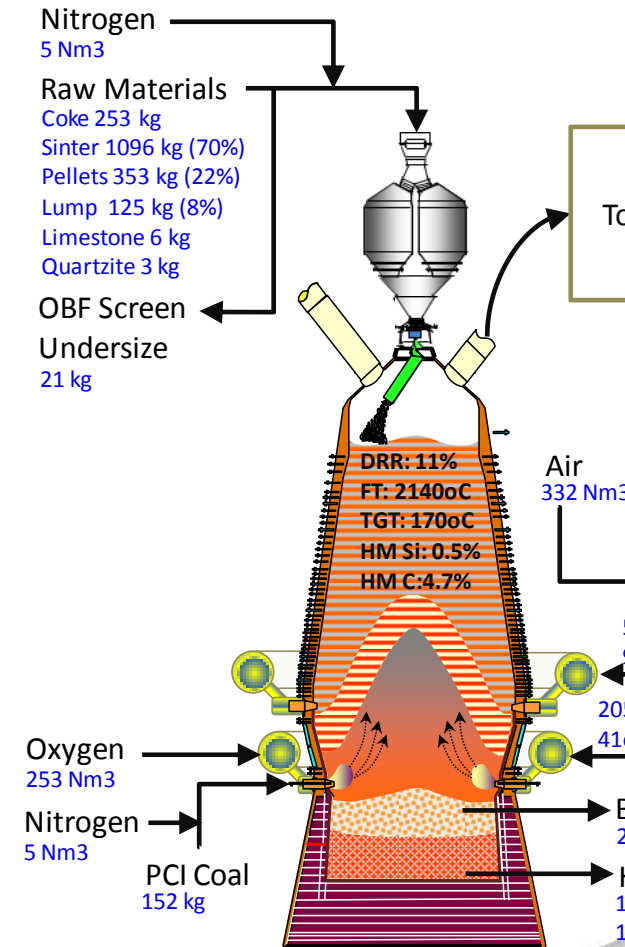
- Demonstrate ammonia scrubbing of blast furnace gas,
First stage pilot testing

Developments in Industry CCS



Iron and Steel sector

- IEAGHG with SWEREA MEFOS/Swedish Energy Agency first independent assessment of CCS integration in a reference steel plant
- Breakthrough technology was ULCOS (EU) oxy blast furnace
- Technical feasible to introduce CCS into steel plant, but challenging from an integration perspective
- Non-technical issues of concern are global competitiveness of the industry



CCS Research in Cement Industry



European Cement Research Association (ECRA)

- Phased development project for pilot scale demonstration of oxy fuel firing of cement kiln in late 2013.

NORCHEM/CLIMIT (Norway) & ECRA

- Pilot scale project for post combustion capture on cement kiln in 2013/14

ITRI – Taiwan

- 10 MW Calcium Looping pilot plant constructed in 2013



Where is CCS today?

- Taking a breather until first integrated demonstration plants come on line
 - Boundary Dam retrofit early 2014
- Once the demonstrations prove the technology in the power sector we can take the next step (5 to 10yrs)
- Industry development taking place in the same time frame, ready for demonstration in 5 to 10yrs from now
- We are probably moving slower than the climate would like
- But not that slowly in terms of technology development
 - First coke blast furnace operated in 1709
 - First hot blast furnace was developed in 1829

“It does not matter how slowly you go as long as you do not stop” Confucius

What can we expect and what do we need?



Increased CCS pilot activity globally

Demonstration activities in industrial sector building

- Notably in China

Need a lot more activity on basin scale evaluation of CO₂ storage capacity

- This area of research is proceeding too slowly



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October 5 – 9 2014
AUSTIN, TX – USA

- Call for papers
- Deadline for abstracts
- Registration opens
- Authors notified
- Early bird closes

27th September 2013
10th January 2014
7th March 2014
2nd May 2014
13th June 2014

AUSTIN TX



Thank you

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