



IEA Greenhouse Gas R&D Programme

Update Report from IEAGHG

**Tim Dixon
IEAGHG**

***CSLF Technical Group, London
28 June 2016***

Greenhouse Gas R&D TCP



Part of the IEA ETN since 1991



32 Members from 15 countries plus OPEC, EU and CIAB

What We Are:



Members set strategic direction and technical programme



Independent Technical Organisation

- We don't define policy
- We are not advocates

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 (CCS)
- Producing information that is:
 - ✓ Objective, trustworthy, independent
 - ✓ Policy relevant but NOT policy prescriptive
 - ✓ Reviewed by external Expert Reviewers

IEAGHG



- **Flagship activities:**
- **Technical Studies** >300 reports published on all aspects of CCS
- **International Research Networks**
 - Risk Assessment/Management
 - Monitoring
 - Modelling
 - Environmental Research
 - Social Research
 - Oxy-combustion
 - Post-combustion Capture
 - Solid Looping
- **GHGT conferences**

IEAGHG



- Other activities include:
- International CCS Summer Schools - 2015 - Perth, Australia, 6-11 Dec 2015; 2016 - Regina, Canada
- Peer reviews, eg US DOE, US EPA; CO2CRC
- Active in international regulatory developments – UNFCCC, London Convention, ISO TC265
- Collaborations with IEA, CSLF, CCSA, EU ZEP, UT and others



ieaghg





Update on CSLF and IEAGHG Collaboration

Arrangement between CSLF Technical Group and IEAGHG

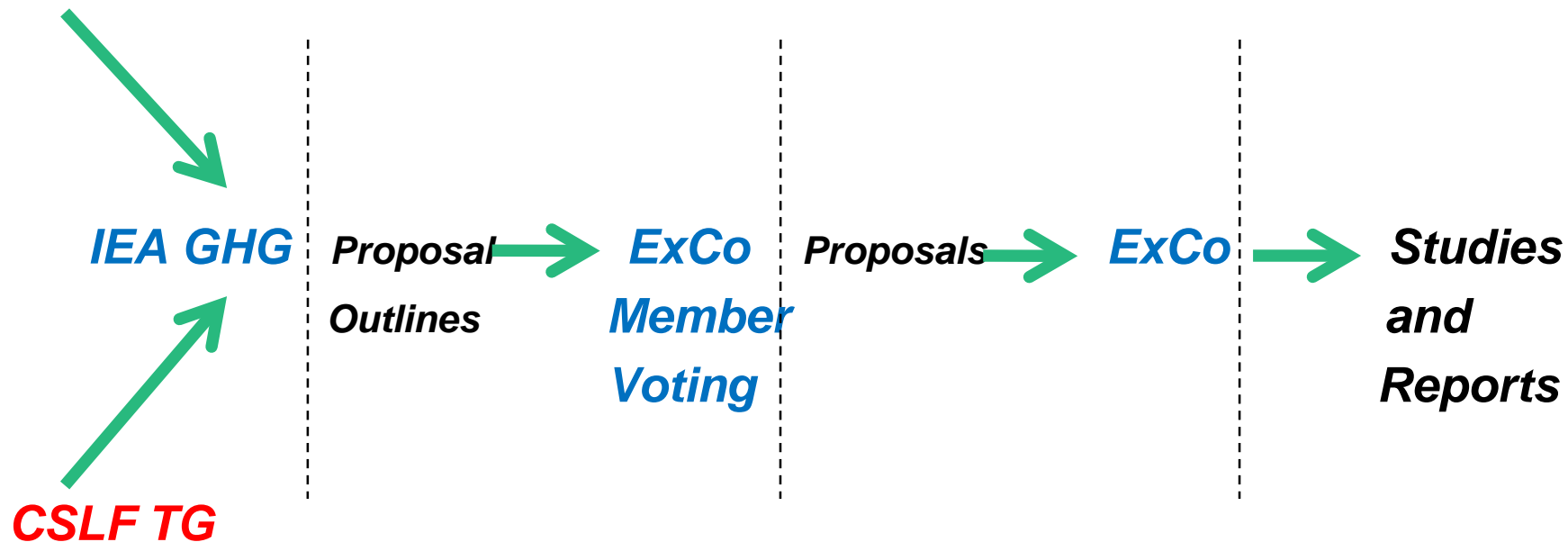


- ***How CSLF TG/PIRT and IEAGHG will interact for mutual benefit through increased co-operation***
 - Mutual representation of each at CSLF TG and IEAGHG ExCo (no voting)
 - Liaison with PIRT co-chairs to discuss potential activities or projects – two way process
 - Activities would require approval by ExCo or TG
 - Due reference to org providing the resource
- ***Agreed by IEAGHG ExCo Oct 2007 and CSLF Technical Group Jan 2008***



IEA GHG – Study generation

IEAGHG ExCo members





CSLF-proposed studies

- ‘Development of Storage Coefficients for CO₂ Storage in Deep Saline Formations’. IEAGHG Report 2009/13. Presentation at CSLF TG Mar 2010
- ‘Geological Storage of CO₂ in Basalts’, IEAGHG Report 2011/TR2. Presentation at CSLF TG Sep 2011
- Potential Implications of Gas Production from Shales and Coal for CO₂ Geological Storage. ARI. Report published 2013. IEAGHG Report 2013/10. Presentation at CSLF TG Nov 2013
- ‘LCA of CCUS – Benchmarking’. Proposed to 46th ExCo. To be developed as round-table/workshop: 11-12 Nov 2015 London. CSLF on Steering Committee. **Report issued as “Workshop on LCA in CCUS”, IEAGHG 2016/03, March 2016**
- Additional new study ideas invited from CSLF TG/PIRT
- **Outline required by 8 July 2016**

Reports published



	Contractor	Report number	Publication date
U.S. DOE Carbon Storage Program: 2015 Project Peer Review Summary Report	IEAGHG	2015-TR2	October 2015
Monitoring Network Meeting	N/A - Meeting	2015-07	January 2016
Social Research Network 2015	N/A - Meeting	2016-02	January 2016
LCA in CCUS	N/A - Meeting	2016-03	March 2016
Operational Flexibility of CO ₂ Transport and Storage	EERC	2016-04	March 2016
Impact of CO ₂ Impurity on CO ₂ Compression, Liquefaction and Transportation'	Newcastle and Edinburgh Universities	2016-01	April 2016
Comparison of Accounting Protocols for CCS	Carbon Counts (UK)	2016-TR3	May 2016
Review of ROAD Permit under London Protocol	TNO (NL)	2016-TR4	June 2016

Reports in progress to be published



Title	Contractor	Publication date
CO ₂ -EOR Emissions Accounting	Carbon Counts (UK)	June 2016
Hydrogen Production with CO ₂ Capture – Techno—economic assessment	AMEC/Foster Wheeler (Italy)	July 2016
CCS and Unburnable Carbon	SGI/Imperial (UK)	May 2016
Cost Components for Storage of CO ₂ in Association with Enhanced Oil Recovery	TNO (NL)	June 2016
CO ₂ Capture in Natural Gas Production by Adsorption	SINTEF (Norway)	July 2016
Fault Permeability	GNS (New Zealand)	June 2016
Evaluation of Various Process Control Strategies for Normal and Flexible Operation of PCC	Imperial College (UK)	July 2016

Studies underway



Title	Contractor	Draft Report date
Value of Flexibility in CCS Power Plants	Imperial College (UK)	February 2016
Criteria for Depleted Oil and Gas Fields to be Considered for CO ₂ Storage	BGS and BEG	March 2016
Understanding the Cost of Retrofitting CO ₂ Capture in Oil Refineries	Consortium led by SINTEF, cofounded by CLIMIT (Norway)	2017
Techno-economic evaluation of CO ₂ capture for Pulp and Paper	VTT and AF Engineering (Finland)	May 2016
Regional Variation of Capture Costs	AMEC	August 2016
Leakage into the Overburden	BGS (UK)	September 2016
CO ₂ Storage Efficiency – Stage 2	EERC (USA)	September 2016

Studies awaiting start



Title	Expected start	Proposal number
Techno-Economic Evaluation of CO ₂ Capture in LNG Process	Specification was shared with members Q1 2016. Estimate Q2 2016.	46-03
Further Assessment of Emerging CO ₂ Capture Technologies and their Potential to Reduce Costs	Screening phase first. Estimate Q4 2016	48-03
Understanding the Cost of Reducing Water Usage in Coal and Gas Fired Power Plants with CCS	Phased, after data from Regional Variation in Capture Costs. Estimate Q1 2017	48-12
Commercial and Economic Arrangements for Deployment of Industry CCS Clusters	Q2 2016	48-05
Refineries and Electricity Production	Q3 2016	48-04
Opportunities for CO ₂ recycle and use	Q2 2016	48-11
Application of Capture Ready in Practice	Q4 2016	49-01

Research Networks



2015

- **LCA workshop.** 12-13 November 2015

2016

- **Workshop on Offshore CCS.** BEG at University of Texas, Austin, with SANEDI, and CSLF support, 19-21 April 2016
- **Monitoring Network and Modelling Network** combined meeting. BGS, Edinburgh, UK, 5-9 July

GHGT-13



- Lausanne, Switzerland, 14-18 Nov 2016
- Deadline for abstracts 10th February 2016
 - **1035 abstracts, 39 countries**
- Draft technical programme 1st June 2016
 - **338 Oral presentations, over 600 Poster presentations**
- Registration opened 6th April 2016
- Early bird registration closes 13th July 2016

www.ghgt.info



ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Swiss Federal Office of Energy SFOE



International Energy Agency



Regular briefing on CCS status
ROAD permit assessment



Input to WFFF



Technical reports to CSLF
Technical Group
5 IEAGHG presentations to June 2016 meeting



ISO Technical Committee on CCS, TC-265
4 draft standards, 2 technical reports – IEAGHG input



United Nations Framework Convention on Climate Change

Side Events on CCS Projects at COP20 and COP21
Planning for COP-22

UNFCCC



United Nations
Framework Convention on
Climate Change



UNFCCC: United Nations Framework Convention on Climate Change (1992)

- COP – Conference of the Parties to the UNFCCC (195 Parties)
- ADP – Ad Hoc Working Group Durban Platform for Enhanced Action
- **APA - Ad Hoc Working Group on the Paris Agreement**
- SBSTA – Subsidiary Body for Scientific and Technological Advice
- SBI – Subsidiary Body for Implementation

Kyoto Protocol (1997: 1st period 2008-2012; 2nd period 2013-2020)

- CMP – Conference of the Parties serving as a Meeting of the Parties to the Kyoto Protocol (KP1 - 188 Parties, 33 ‘developed’ countries)

Paris Agreement (from 2020)

- **CMA - Conference of the Parties serving as the meeting of the Parties to the Agreement (195 Parties?)**

Kyoto Protocol



- 2008 - 2012 (KP 1st Period)
- 2013 - 2020 (KP 2nd Period)
- Developed country emission commitments
 - CCS included in KP Art 2.1
 - IPCC GHG Guidelines 2006 allows CCS to be reported
- Clean Development Mechanism (CDM) – Policy mechanism for rewarding CO₂ reduction in developing countries. Project-based carbon credits.
- > 7,500 projects, 1,500 CERs (Mt CO₂e)

- **COP-15 (2009) Copenhagen**

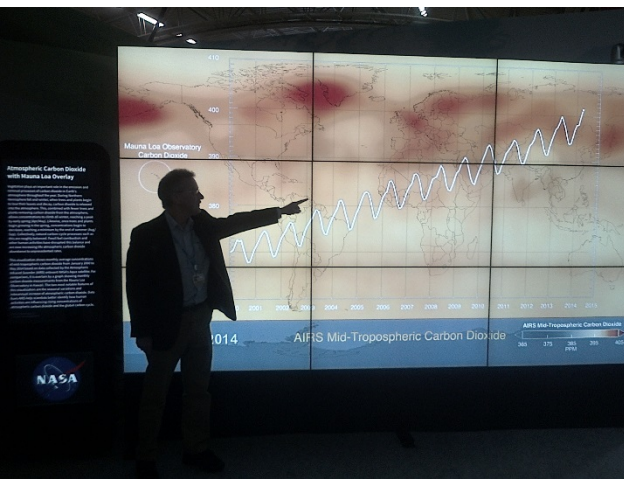
- Mandated to reach a new post-2020 agreement
- Only “takes note” of ‘Copenhagen Accord’ - 2C target, based on pledge and review
- Considered a failure

- **COP-17 (2011) Durban**

- ADP (Durban Platform for Enhanced Action)
- Recognised that current emission pledges inadequate <math><2^{\circ}\text{C}</math>
- Process to develop “protocol, another legal instrument or outcome...with legal force” for all Parties. To be agreed by 2015, to be implemented by 2020
- ADP worked hard, meeting multiple times each year.....



COP-21 Paris (2015)



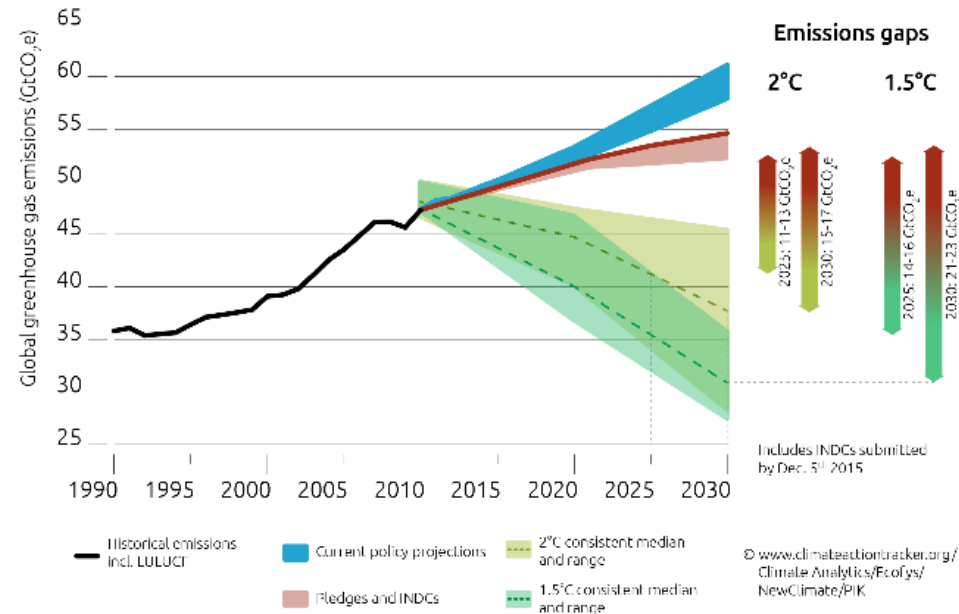
Intended Nationally Determined Contributions (INDCs)



- 187 INDCs submitted
- 94% global emissions
- New trajectory to ~ 2.7C
- ~ 3.6C from existing policies

CAT Emissions Gaps

7th December 2015



Climate Action Tracker

<http://climateactiontracker.org/global/173/CAT-Emissions-Gaps.html>

‘*Mission Innovation*’ launch



- 20 countries will seek to double governmental and/or state-directed clean energy R&D investment over five years
- “*Accelerating the Clean Energy Revolution*”
- Aims to reinvigorate and accelerate global clean energy innovation with the objective to make clean energy widely affordable (for climate challenge, affordable and reliable energy for everyone, and energy security)
- also *Breakthrough Energy Coalition* - 28 investors from 10 of these countries make a commitment to invest in early-stage technology development.

COP-21 – Paris Agreement



- **Article 2 – ‘Objectives’**
- Purpose of the agreement is limit warming to “well below” 2.0 C (by 2100) and pursue 1.5C
 - To be delivered by the pledges in Articles 3 and 4
- Increasing adaptation
- Ensuring finance
- Continues principle of “common but differentiated responsibilities and respective capabilities, in the light of different national circumstances”

COP-21 – Paris Agreement



- **Article 3 and Article 4 – ‘Mitigation’**
- via (Intended) Nationally Determined Contributions (NDCs)
 - Global peak of emissions asap, rapid reductions thereafter to achieve balance between emissions and sinks in second half of century
 - Developed countries to lead, Developing countries to enhance efforts over time. Reflecting common but differentiated responsibilities and respective capabilities, in the light of different national circumstances
 - NDCs to be updated every 5 years to represent a progression (from 2020) (current INDCs cover from 2020 to 2025 or 2030)

COP-21 – Paris Agreement



- **Article 6 – “Cooperative Approaches” mechanism** - for “internationally transferred mitigation outcomes” – a new CDM-type mechanism?
- **Article 7 – ‘Adaptation’**
- **Article 8 ‘Loss and Damage’** - Warsaw International Mechanism continues its work
- **Article 9 ‘Finance’** – Financial Mechanism continues. Administered by continuing Green Climate Fund (\$100bn by 2025) and GEF.

COP-21 – Paris Agreement



- **Article 10 – ‘Technology Development and Transfer’**
- technology framework to provide overarching guidance to the Technology Mechanism (ie CTCN) in promoting technology development and transfer
- “strengthen collaborative approaches to research and development”
- Technology neutral at the moment, depends on the technology framework which will be developed

COP-21 – Paris Agreement



- **Article 11 – ‘Capacity Building’**
- **Article 12 – ‘Education’**
- **Article 13 – ‘Transparency’**
- **Article 14 – ‘Stocktake’** - in 2023 [2018 also], then every 5 years

- Open for signing from 22 April 2016 to 21 April 2017
- Enters into force when 55 Parties ratify with 55% of emissions

Paris, France



Photo Courtesy of IISD/ENB



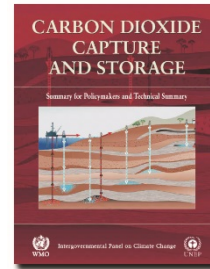
What does this mean for CCS?



CCS in UNFCCC



➤ **2005 - IPCC SR on CCS**



➤ 2005– 2011 CCS in CDM ?.....!

➤ 2011 – CCS CDM Abu Dhabi workshop



➤ **2011 - COP-17 CCS in CDM**



CCS became an accepted technology

➤ 2014 - ADP TEM on CCS – project focussed



➤ 2014 - COP-20 – CCS projects Side Event



➤ 2015 - COP-21 – CCS projects Side Event





IPCC Fifth Assessment Report Synthesis Report

2nd November 2014
Copenhagen

IPCC AR5 Synthesis Report

ipcc
INTERGOVERNMENTAL PANEL ON climate change



Mitigation Measures



More efficient use of energy



Greater use of low-carbon and no-carbon energy

- Many of these technologies exist today



Improved carbon sinks

- Reduced deforestation and improved forest management and planting of new forests
- Bio-energy with carbon capture and storage



Lifestyle and behavioural changes





AR5 WGIII SPM

IPCC AR5 – Role of different low-carbon energy technologies



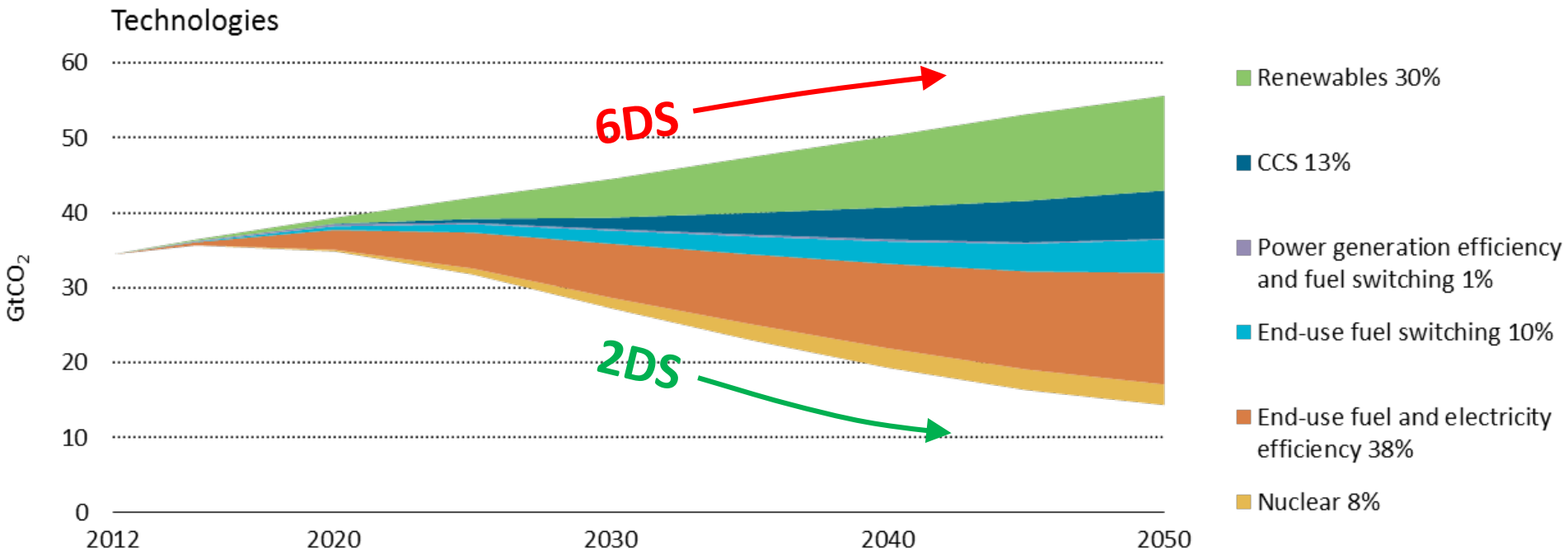
Mitigation cost increases in scenarios with limited availability of technologies ^d

[% increase in total discounted ^e mitigation costs (2015–2100) relative to default technology assumptions]

2100 concentrations (ppm CO ₂ -eq)	no CCS	nuclear phase out	limited solar/wind	limited bioenergy
450 (430 to 480)	138% (29 to 297%) 	7% (4 to 18%) 	6% (2 to 29%) 	64% (44 to 78%) 

A portfolio of technologies is required to get from here to there

ETP
2015



Percentages represent cumulative contributions to emissions reduction relative to 6DS



Climate Action Now

Summary
for Policymakers
2015



United Nations
Climate Change Secretariat

- **‘Climate Action Now’
UNFCCC - 18 Nov 2015**
- High level summary of policy actions with high mitigation potential at 2020
- Builds on Technical Expert Meetings (TEMs)
- Includes CCUS as one of the six priority areas
- Significance of Boundary Dam CCUS project
- Solutions through international cooperation – eg IEAGHG, CSLF, GCCSI



Intended Nationally Determined Contributions (INDCs)

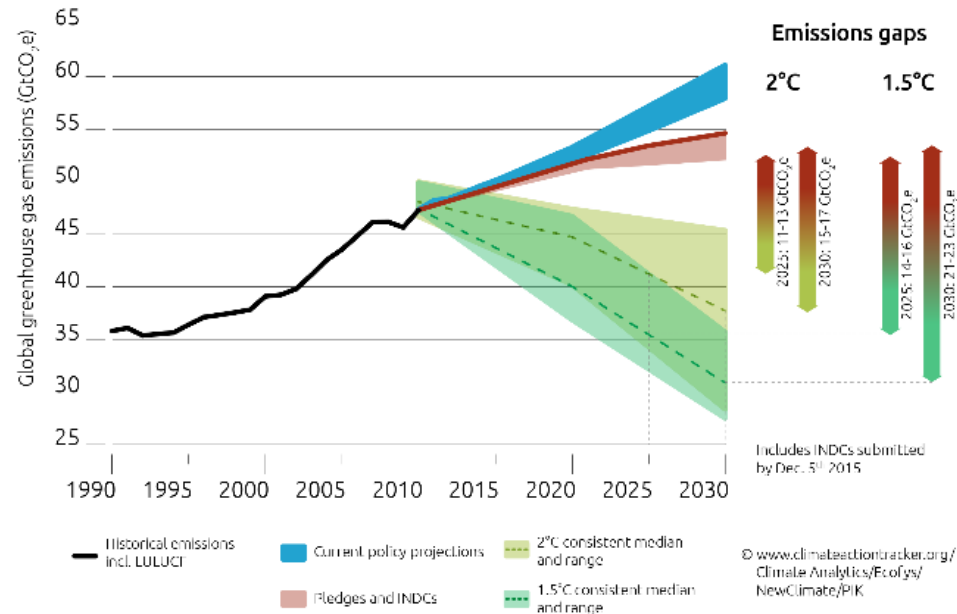
- 187 INDCs submitted
- 94% global emissions
- New trajectory to ~ 2.7C
- ~ 3.6C from existing policies

CCS in 10 INDCs

Bahrain	Malawi
Canada	Norway
China	Saudi Arabia
Egypt	South Africa
Iran	UAE
	(and EU and USA)

CAT Emissions Gaps

7th December 2015



Climate Action Tracker

<http://climateactiontracker.org/global/173/CAT-Emissions-Gaps.html>

© www.climateactiontracker.org/
Climate Analytics/ECofys/
NewClimate/PIK

COP-21 Paris Side-event



“Carbon Capture and Storage (CCS): Achievements and Opportunities for Developing Country Involvement”

In collaboration with UT/CCSA/CO2GeoNet



Tim Dixon *IEAGHG*;
The Honourable Brad Wall *Premier of Saskatchewan Canada*;
Mike Marsh *President Saskpower*
Katherine Romanak *University of Texas*;
Philip Ringrose *Statoil*;
Ton Wildenborg *CO₂GeoNet*;
Jukka Uosukainen *Director CTCN*



Photos courtesy of IISD/ENB and UKCCSRC



COP-21 Exhibit booths on CCS

- inside COP-21 with University of Texas, CO2GeoNet, CCSA
- also public area with University of Texas, CO2GeoNet, CCSA and GCCSI.



'Unburnable Carbon'

Fossil fuel reserves which cannot be used and their GHG emitted if the world is to adhere to a given atmospheric carbon budget



FINANCIAL TIMES

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Energy Finance Health Industries Luxury 360 Media Retail & Consumer Tech Telecom Transport By Region Tech

November 30 2014 8:10pm

Bank of England to examine financial risks linked to fossil fuels

Pilla Clark, Environment Correspondent



The Bank of England has revealed it is to examine formally for the first time the risks fossil fuel companies pose to financial stability.

In a shift from the bank's past statements, Mark Carney, its governor, has written to MPs informing them that his officials have discussed the idea that most of the world's proven coal, oil and gas reserves may be "unburnable" if global warming is to be kept within safe limits.



'Unburnable Carbon' and CCS



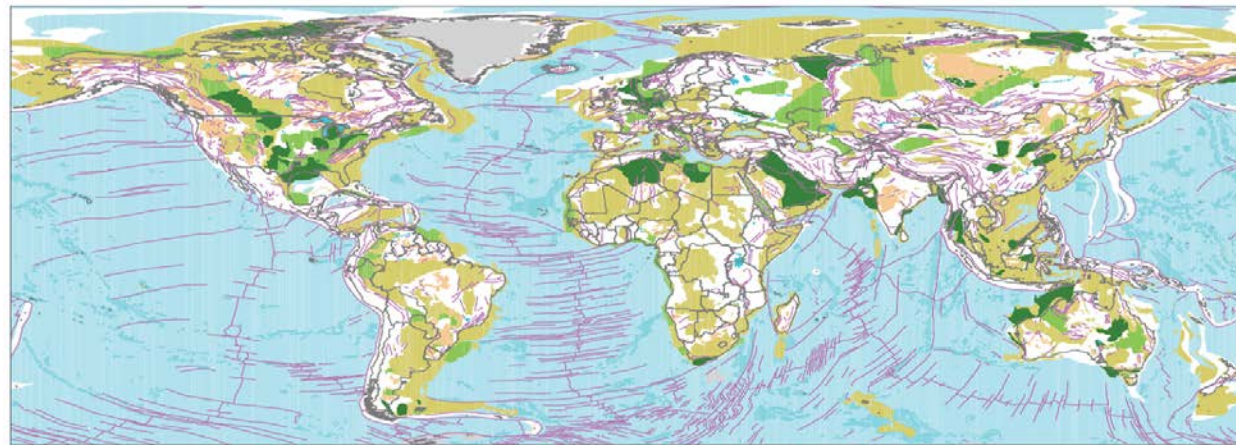
IEAGHG Study contractor: SGI at Imperial College UK

- Considered EMF27 Integrated Assessment Models (IAMs) used by IPCC and global CCS potential
- Cost assumptions do not limit CCS uptake in IAMs - hypothesis: residual emissions limit CCS uptake in IAMs
- The impact of CCS on unburnable carbon is significant, starting from 2030/2040 and becoming more apparent by 2100
- **CCS enables access to significant quantities of fossil fuels in a 2°C world**
- **Global CO₂ storage capacity (volumetric) is large and well above known fossil fuel reserves**
- - improve storage efficiencies - pressure and brine management

UNFCCC - What Next?



- A lot of work to develop the details to implement the Paris Agreement - especially the 'Technology Framework' and Article 6 mechanism - starting in SBSTA-44 and APA-1 (May 2016) and COP-22 Marrakech (7-18 Nov 2016)
- IPCC to examine 1.5C scenarios – Special report by 2018
- Further TEMs
- NDCs updated.....
.....with CCS ?



World geological storage suitability

- Highly suitable, sedimentary basin or continental margin
- Suitable, sedimentary basin or continental margin
- Possible, sedimentary basin or continental margin
- No data
- Unsuitable, deep water
- Unsuitable, igneous rock
- Unproven
- Main faults



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