Implementing the Paris Agreement Requires CCS: Examples of Large-scale Installations

Tim Dixon

IEAGHG

CCUS Locally and at EU Level

GIG, Katowice

10 December 2018

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 >320 reports published on all aspects of CCS
- International Research Networks
  - Risk Assessment/Management
  - Monitoring
  - Modelling
  - Environmental Research
  - High Temperature Solid Looping
  - Costs
- GHGT conferences –
- GHGT-14, Melbourne, Australia, 22-26 Oct 2018
- PCCC conferences

IEAGHG

Other activities include:

- International CCS Summer Schools: 560 alumni, 59 countries
- 2018 – 25-29 June, Trondheim, NCCS

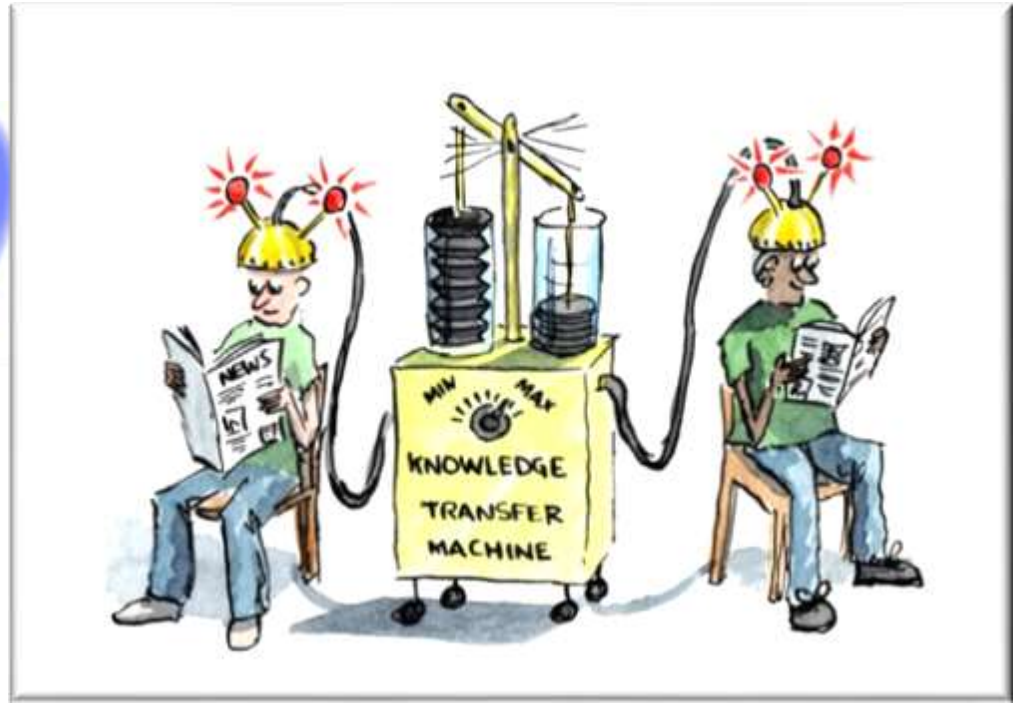
- Peer reviews, eg US DOE, US EPA; CO2CRC
- Active in international regulatory developments – UNFCCC, IPCC, London Convention, ISO TC265
- Collaborations with IEA, CSLF, CCSA, EU ZEP and many others

International Energy Agency

United Nations Framework Convention on Climate Change

UNFCCC Side Events at COP20, COP21, COP-22, COP-23**, COP-24**

Input to WPFF



IPCC Intergovernmental Panel on climate change

Expert Reviewers, Accredited Observer

carbon sequestration leadership forum

IEAGHG Technical reports to CSLF Technical Group

Zep Zero emissions platform

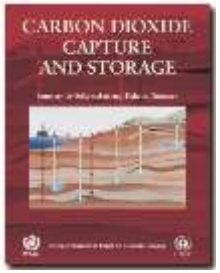
ISO

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

IMO

London Convention:
Regular updates on CCS:
ROAD permit assessment;
Offshore workshops

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**

- 2014 - ADP TEM on CCS – project focussed
- 2014 - COP-20 – CCS projects Side Event
- 2015 - COP-21 – CCS projects Side Event
- 2016 – COP-22 – CCS in Africa Side Event
- 2017 – COP-23 – CCS, Oceans and SIDS


SOUTHERN COMPANY
Chevron
TOTAL
J-POWER
CIAB
ExxonMobil
INSTITUTO DE INVESTIGACIONES ELECTRICAS
Evaluating technology options to mitigate greenhouse gas emissions
ieaghg
EPRI
JÜLICH
FORSCHUNGSZENTRUM
DOOSAN
Doosan Babcock
equinor
PETROBRAS
جامعة خليفة
Khalifa University
JGC
RWE
The energy to lead

Why CCS ?

IPCC Fifth Assessment Report
Synthesis Report

2nd November 2014
Copenhagen

ipcc
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

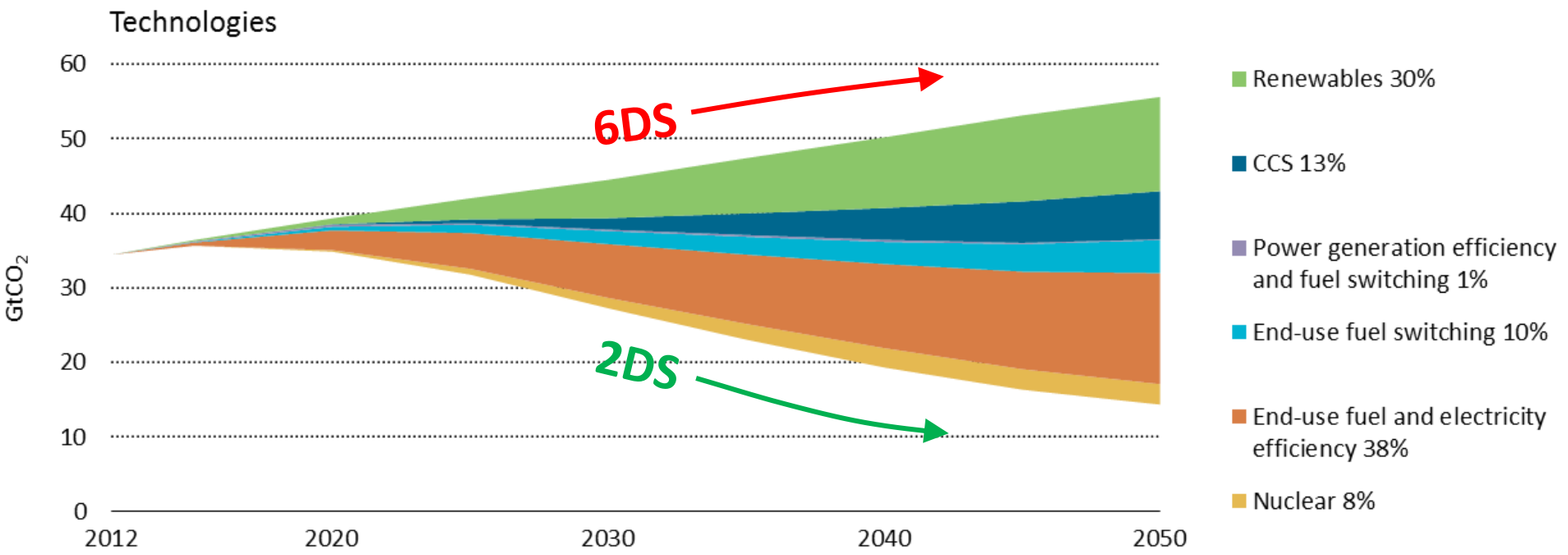
IPCC AR5 – Role of different low-carbon energy technologies

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%) 

IPCC AR5 SYR from Table 3.2 (2014)

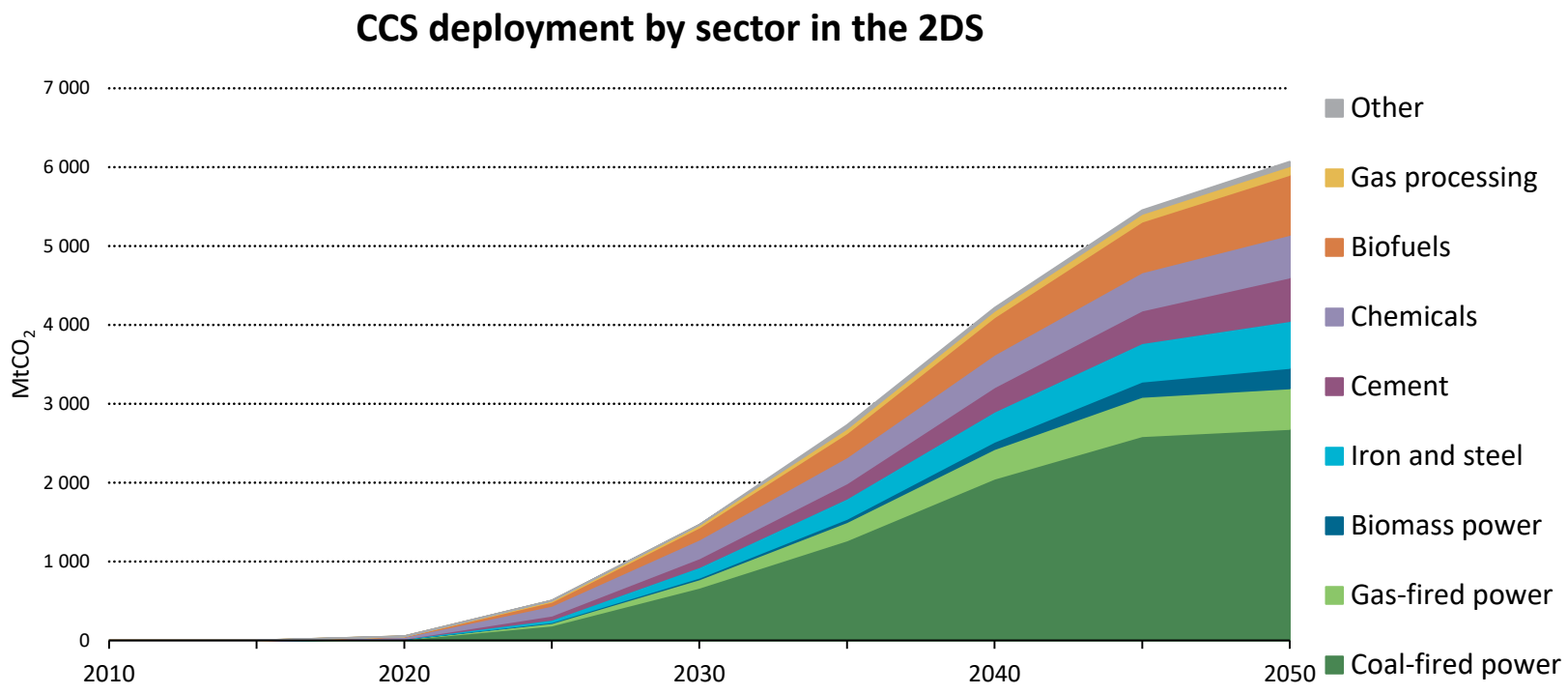
A portfolio of technologies is required to get from here to there

ETP 2015



Percentages represent cumulative contributions to emissions reduction relative to 6DS

IEA: 94Gt CO_2 captured and stored in 2DS



- From 50Mt in 2020 to 6Gt in 2050
- A total of 94Gt captured and stored through 2050
  - 52Gt → 56% power
  - 29Gt → 31% process industries
  - 13Gt → 14% gas processing and biofuel production

ETP 2017
The role of CCS in achieving global climate ambitions

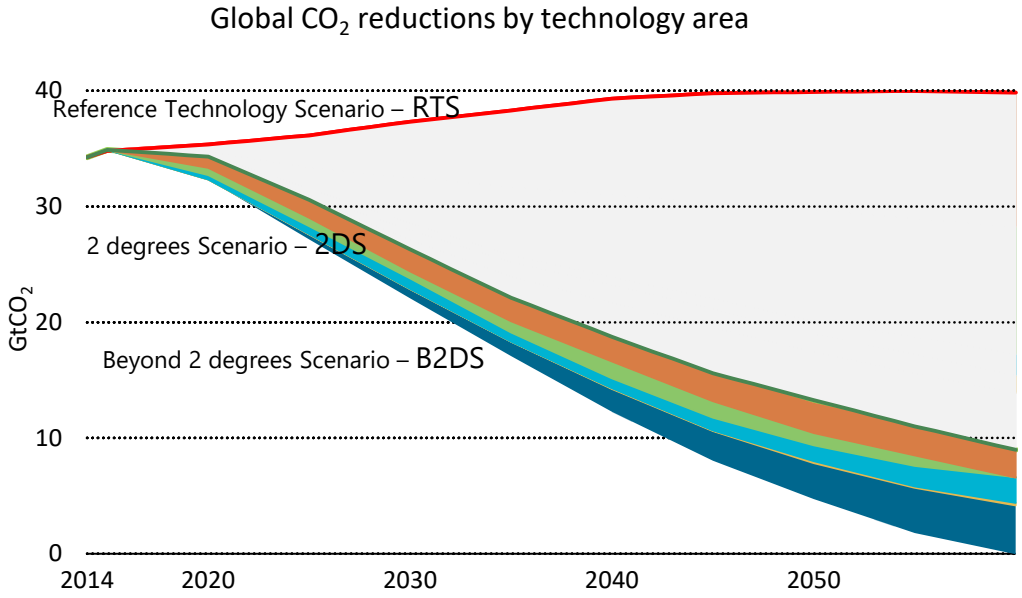
Samantha McCulloch

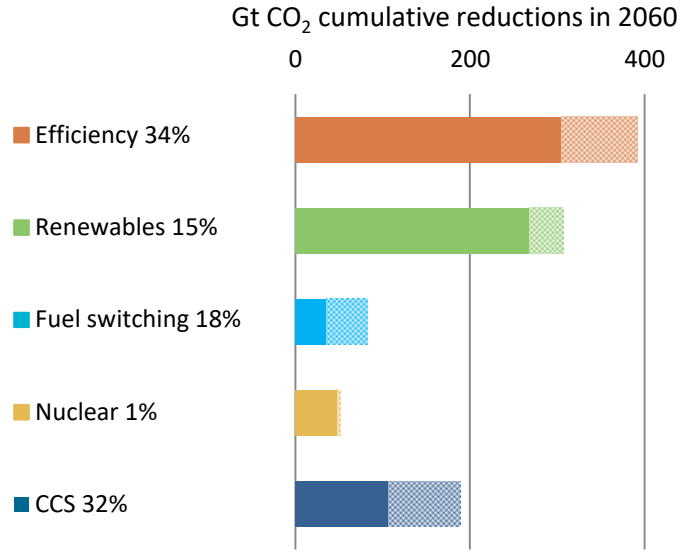
June 2017

IEA

CCS plays a leading role in the energy transformation

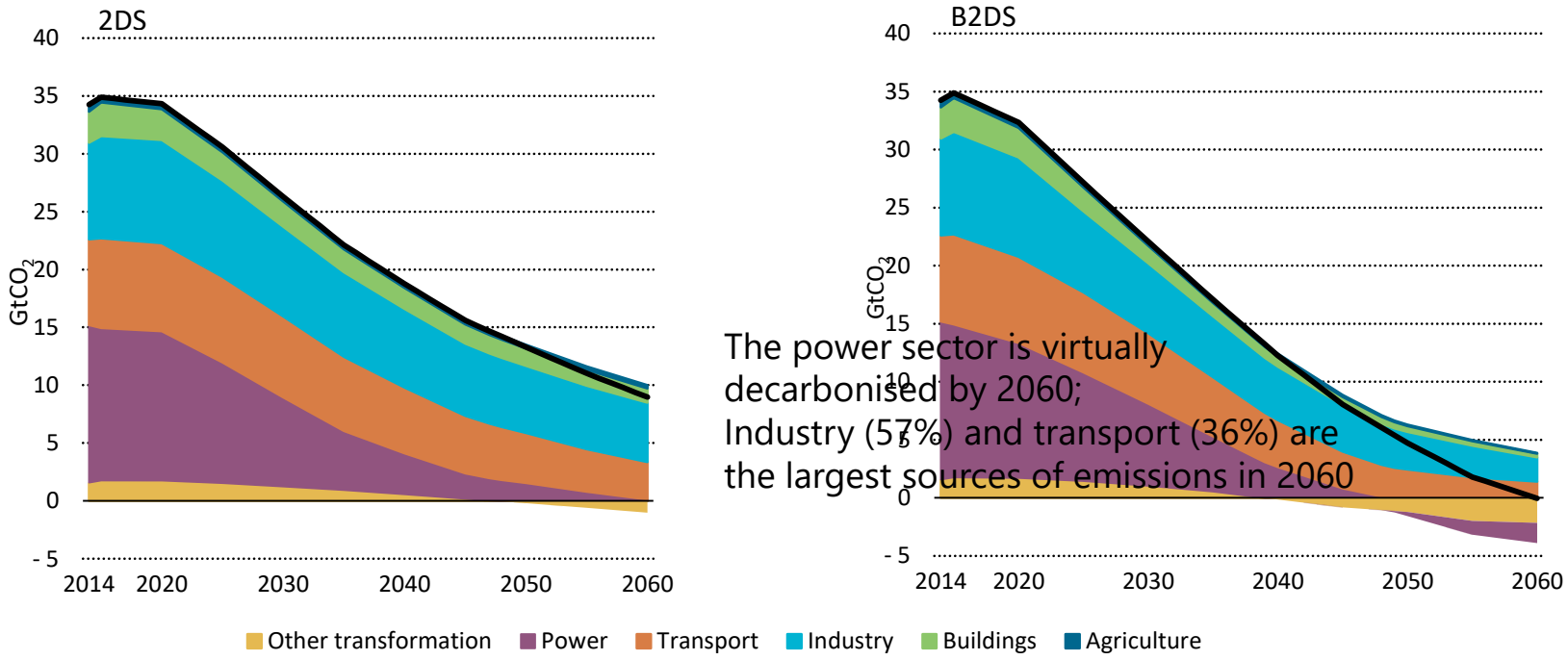
Technology area contribution to global cumulative CO_2 reductions





Pushing energy technology to achieve carbon neutrality by 2060 could meet the mid-point of the range of ambitions expressed in Paris

Remaining CO_2 emissions in the 2DS and B2DS



The power sector is virtually decarbonised by 2060;
Industry (57%) and transport (36%) are the largest sources of emissions in 2060

The remaining CO_2 emissions in industry and power must be targeted for the B2DS
Negative emissions are necessary to achieve net-zero emissions in 2060

Paris Agreement Update on CCS

Nationally Determined Contributions (NDCs)

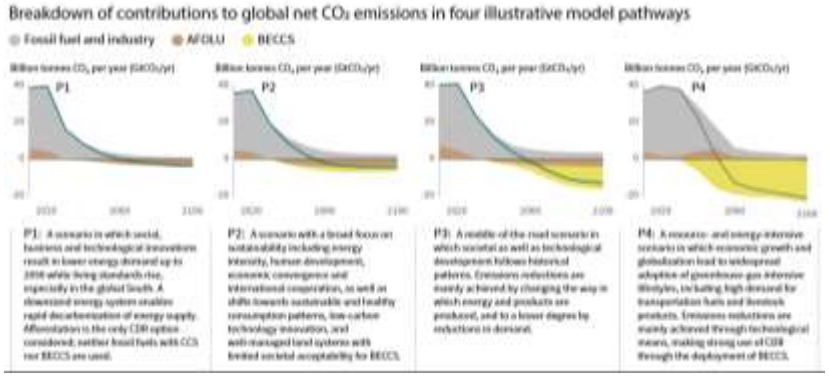
- 187 Nationally Determined Contributions submitted ahead of COP-21 - 10 included CCS as a mitigation activity, these countries covered a signification proportion of the world's emissions.
- Should be noted that these NDCs were short-term focussed in being 5 years duration and only to 2025 or 2030.

Low GHG emission development strategies

- Longer-term, the Paris Agreement invited Parties to communicate 'long term low GHG emission development strategies' to the mid-century.
- **Nine** countries have submitted these, and **eight o**f which contain CCS as a mitigation activity, particularly for industrial emissions (USA, Canada, Germany, Mexico, France, Czech Republic, UK, and Ukraine)(Sep2018).

IPCC 1.5 Special Report

- Impacts and pathways to achieving 1.5C by 2100, in context of increasing global response, sustainable development and poverty



- **"Removing BECCS and CCS from the portfolio of available options significantly raises mitigation costs."** (Chp 4.3)
- IEAGHG Note: IAMs typically assume Capture rate of 90% - this is a limiting factor for CCS deployment from IAMs later this century. Can be increased to 99% cost increase only ~ 5%

- https://www.ipcc.ch/report/sr15/

‘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

Bank of England to examine financial risks linked to fossil fuels

IEAGHG Report 2016-05. Contractor: SGI at Imperial College UK

- Global CO_2 storage capacity (volumetric) is large and well above known fossil fuel reserves
- CCS enables access to significantly higher quantities of fossil fuels in a 2°C world
- CCS unlocks ‘Unburnable Carbon’

Key CCS Facility Developments Globally

GLOBAL CCS INSTITUTE

2017

Commercial-scale Application of CCS (to 2010)

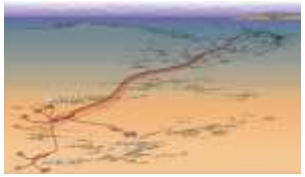
Sleipner
1Mt/y CO_2

IEAGHG Weyburn
2.5 Mt/y CO_2

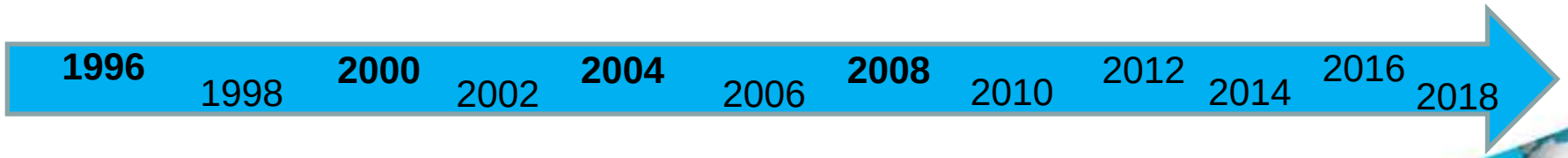
In-Salah
1.2 Mt/y CO_2

Snohvit
0.7Mt/y CO_2

350km overland pipeline

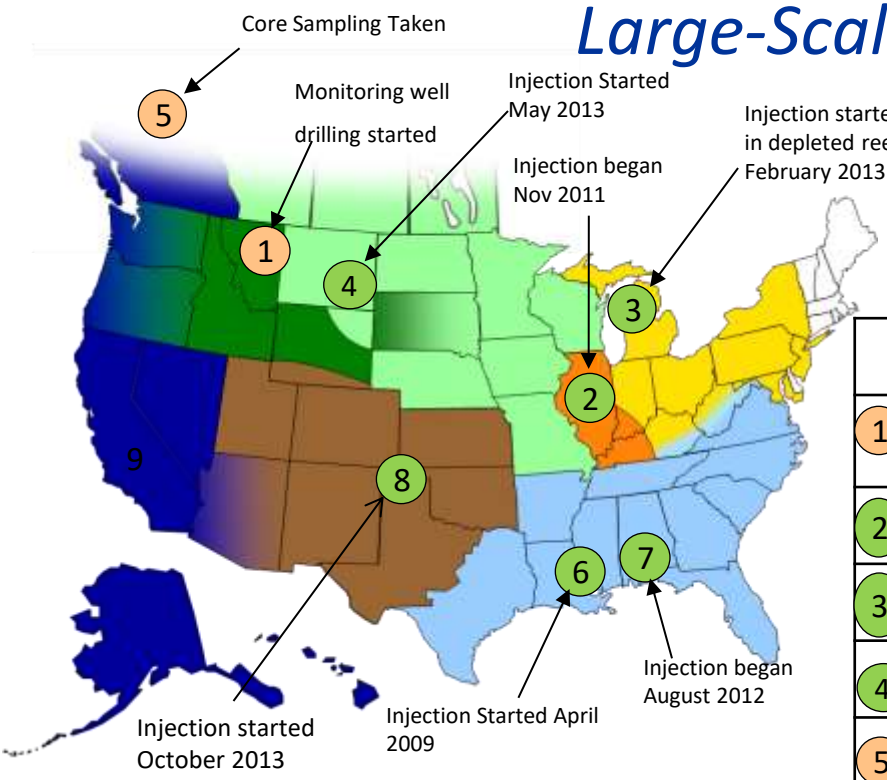


160km sub sea pipeline



RCSP Phase III: Development Phase

Large-Scale Geologic Tests



Note: Some locations presented on map may differ from final injection location

- ✓ *Large-volume tests*
- ✓ *Four Partnerships currently injecting CO_2*
- ✓ *Remaining injections scheduled 2013-2015*

	Partnership	Field Project – Geologic Formation	Metric Tons Injected to Date
1	Big Sky	Kevin Dome- Duperow Formation	0
2	MGSC	Illinois Basin Decatur- Mt. Simon Sandstone	> 850,000
3	MRCSP	Michigan Basin - Niagaran Reef	> 234,000
4	PCOR	Bell Creek - Muddy Sandstone	> 741,000
5		Fort Nelson - Sulfur Point Formation	0
6	SECARB	Early Test (Cranfield Field) - Tuscaloosa Formation	> 4,300,000
7		Anthropogenic Test (Citronelle Field) – Paluxy Formation	> 100,000
8	SWP	Farnsworth Unit - Morrow Formation	> 102,000
	WESTCARB	Regional Characterization	

Courtesy NETL 2014

2013 Port Arthur Project

- H2 Plant – SMR operated by Air Products
  - Consists of 2 Trains of SMR

- Retrofit capture VSA
- Operational 2013
- 1mt CO2 pa to EOR

2014 Worlds first integrated coal fired power plant with CCS

- **SaskPower's Boundary Dam Coal PS, Saskatchewan, Canada**
- 110MWe Retrofit
- Shell/Cansolv Post combustion capture technology.
- EOR, and storage at Aquistore
- Started operation October 2014
- 2016 - International CCS Knowledge Centre

Introduction: *The Shand CCS Feasibility Study* *(Corwyn Bruce GHGT-14)*

- The Shand CCS Feasibility Study was undertaken to evaluate the economics of a CCS retrofit and life extension on what was believed to be the most favorable host coal fired power plant in SaskPower's fleet.
- Collaboration between Mitsubishi Heavy Industries (MHI), Mitsubishi Hitachi Power Systems (MHPS), SaskPower and The International CCS Knowledge Centre (Knowledge Centre).

Figure 1. 3D model of the proposed Shand CCS facility

Table 1. Division of Labour by Scope of Work

MHI/MHPS Scope	Stantec/Knowledge Centre Scope
• SO_2 Capture System	• Steam Supply to Battery Limit
• CO_2 Capture System	• Feed-heating Modifications
• CO_2 Compressor	• Condensate Preheating
• Turbine Modifications	• Deaerator Replacement
	• Flue Gas Supply
	• Flue Gas Cooler
	• Hybrid Heat Rejection System
	• Waste Disposal

Conclusions: *The Shand CCS Feasibility Study*

- A second generation CCS facility on coal is in sight
- Capital costs have been reduced by 67%
- Calculated cost of capture would be $45US/tonne of CO2
- Novel optimizations and lessons learned have de-risked aspects of CCS
- Emissions are significantly lower than Canadian regulations
- Carbon Neutral Coal Power is Possible

2015

Quest, Shell, Canada

H_2 Refining

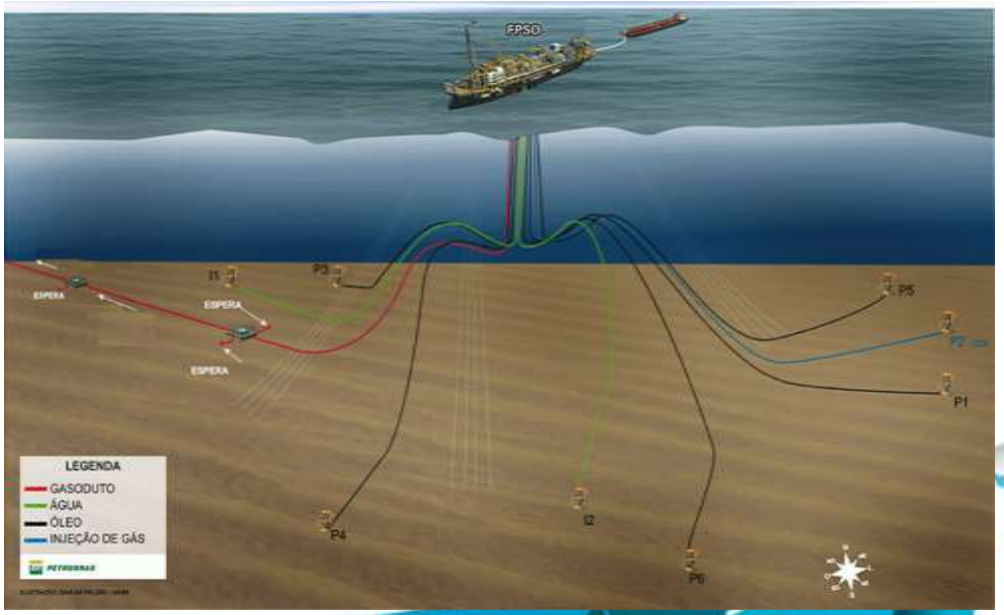
1Mt CO2 pa to DSF storage

Lula, Petrobras, Brazil

Offshore gas separation and CO2-EOR

FPSO

Deep: 2000m water depth, 3000m beneath seabed



2017

Petra Nova,
NRG Parish, USA

- Refit of existing coal fired unit
- Operational Jan 2017
- MHI amine based PCC technology
- 250 MW slip stream, 90% capture
- 1.6Mt pa CO_2 for EOR

ADM's Illinois
Industrial CCS Project

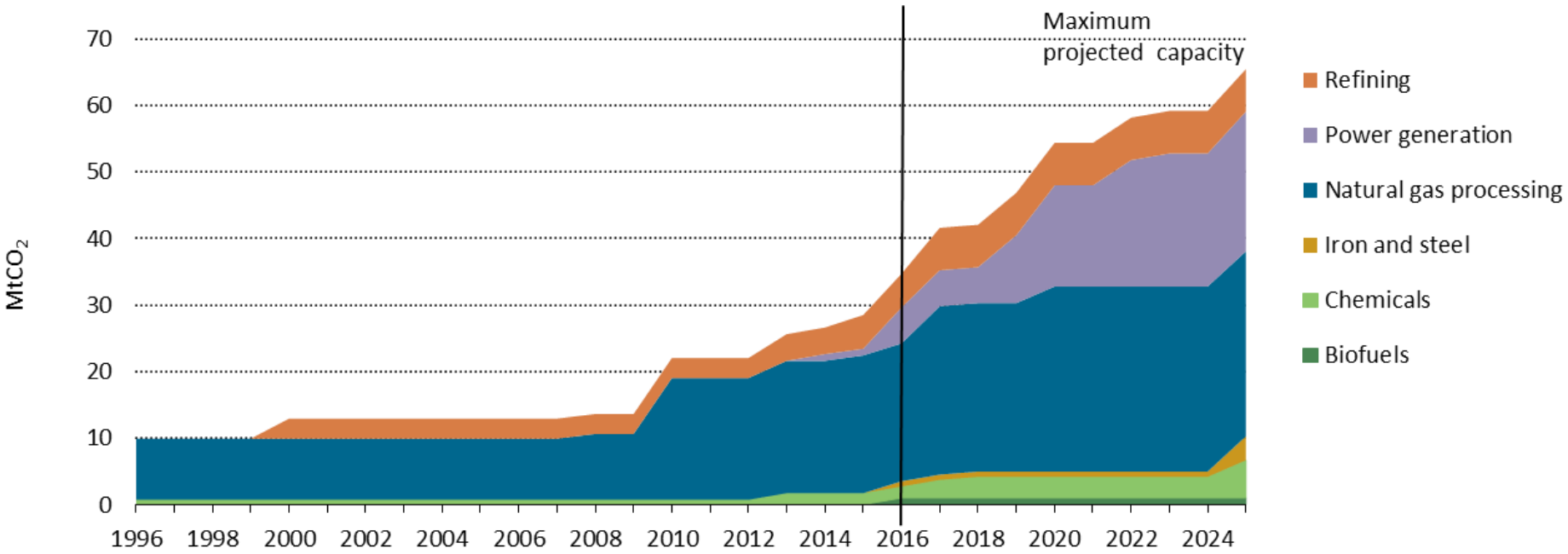
- 1Mt pa CO_2 to DSF
- Operational April 2017
- Bioethanol = BioCCS

Other Project Developments

- Norway
  - Assessing 2 industry CCS projects - WtE, Cement
    - Ship - hub - pipeline - Offshore Storage
- Gulf States
  - Uthmaniyah CO2-EOR Demonstration Project, Saudi Aramco
  - The Abu Dhabi CCS Project - the first iron and steel CCS project
- Japan – Tomakomai
- Australia – Gorgon LNG project

IEA: CCS is not “on track”

- CCS has moved forward – but is far from being consistent with a 2°C pathway
  - If all projects known today were to proceed, the maximum capture rate would be less than 70 $MtCO_2$



Capture potential of the project pipeline, by sector. Data source: GCCSI

IEA: Accelerating future progress

- Stable policies, including financial support, are urgently needed.
- CO_2 storage development critical
- New approaches and a re-focusing of efforts can also promote faster deployment:
  - Greater emphasis on CCS retrofitting
  - Cultivating early opportunities for BECCS
  - Developing markets for "clean products"
  - Moving from conventional enhanced oil recovery (EOR) practices to "EOR+" for verifiable CO_2 storage
  - Disaggregating the CCS value chain to enable new business models to emerge

"Deployment of CCS will not be optional in implementing the Paris Agreement"

Dr Fatih Birol, Executive Director, International Energy Agency 2016

Thank You

Any questions?

www.ieaghg.org