International Energy Agency

Role of CCS Globally: IEA 2013 CCS Roadmap

Beijing, 5 December 2013
Juho Lipponen, IEA

Carbon capture and storage

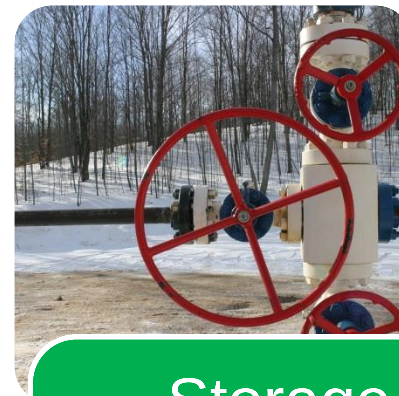
Carbon capture and storage defined

Capture

Separation of CO_2 produced during production of power or other products, followed by clean-up and compression of the CO_2

Transport

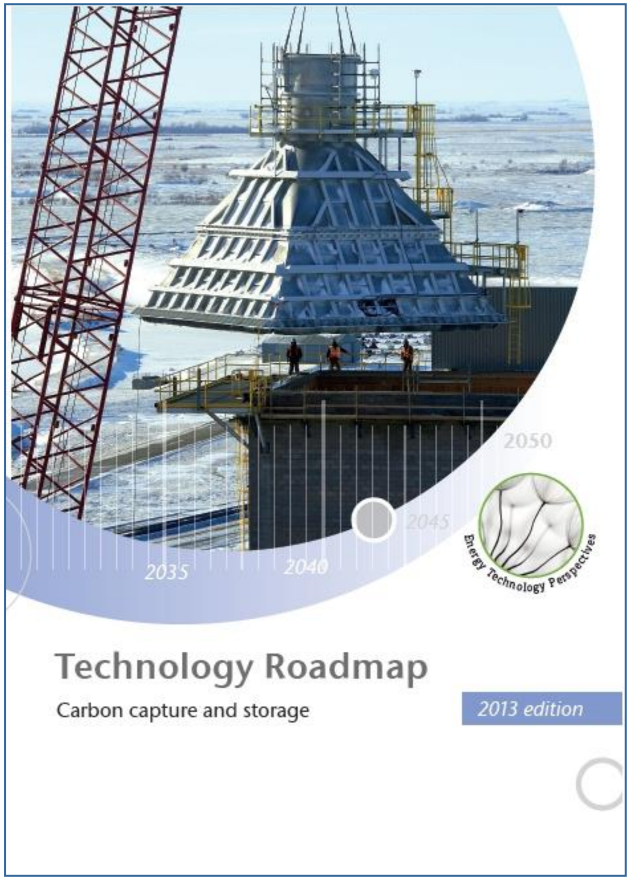
Movement of CO_2 by pipeline, truck, rail, ship, or barge to a storage facility



Storage

Injection of CO_2 into a suitable storage unit, selected to safely contain the injected CO_2 for long timescales

Source: From L-R, Vattenfall, http://startupblog.files.wordpress.com, US DOE/NETL

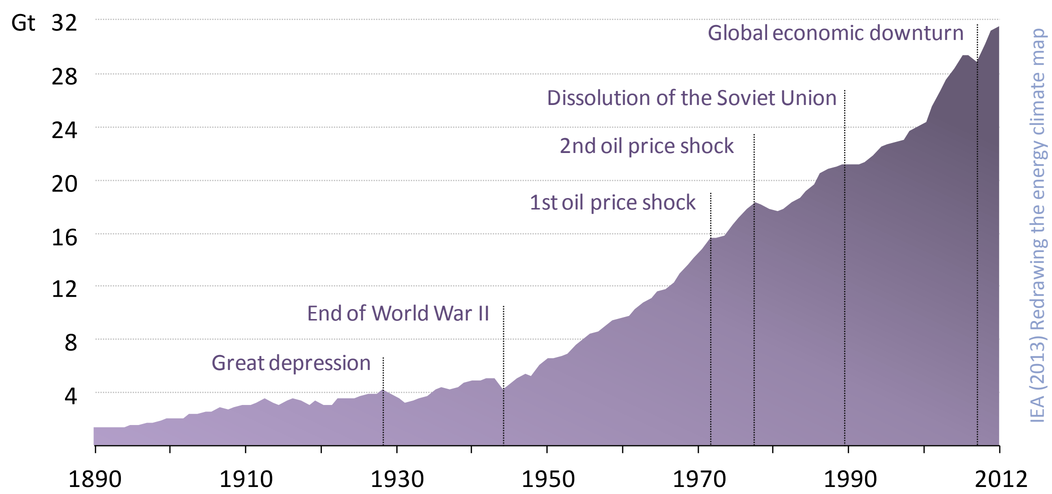


Outline

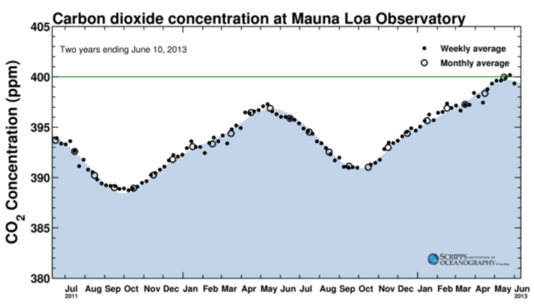
1. **CO_2 challenge and role of CCS**
2. Status of CCS today
3. Charting the way forward

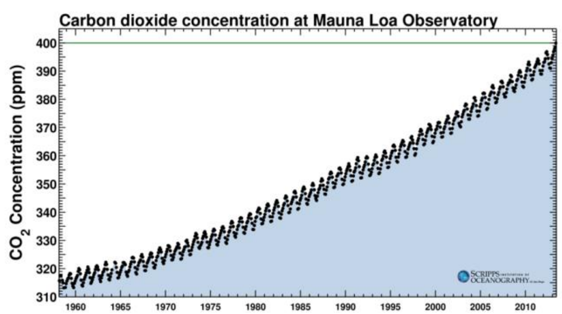
Record-high CO_2 emissions in 2012

Global energy-related CO_2 emissions



400ppm CO_2 concentration recorded in May 2013



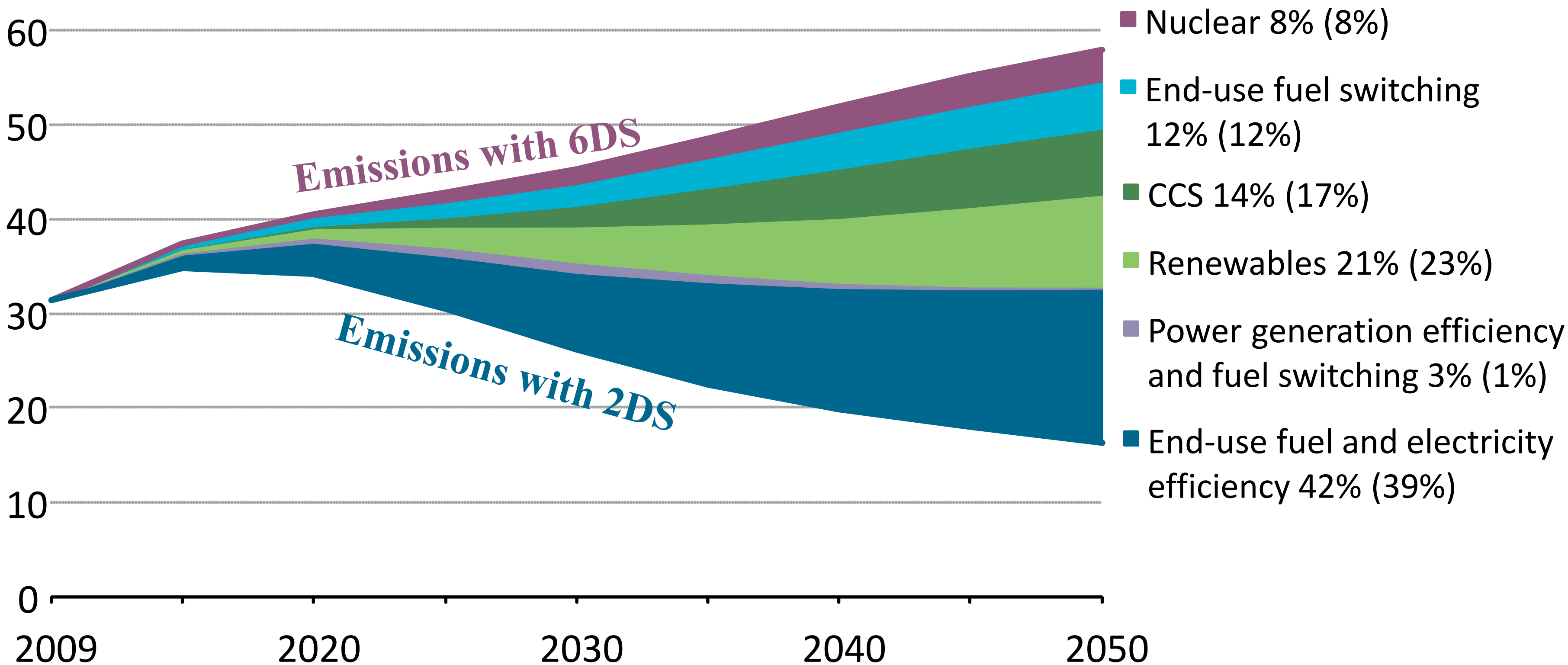


http://keelingcurve.ucsd.edu/

CO_2 emissions trends point to a long-term temperature increase of up to 5.3 °C

Portfolio of decarbonising measures

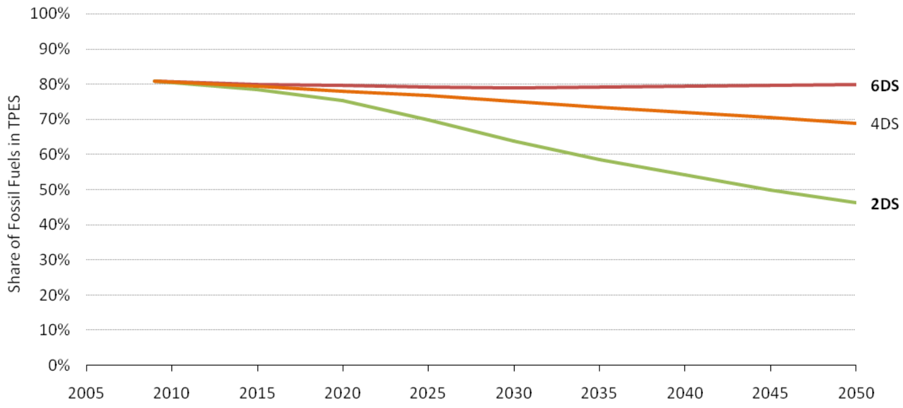
Emissions Reductions (Gt CO_2)



Near-term solutions important, but not enough!

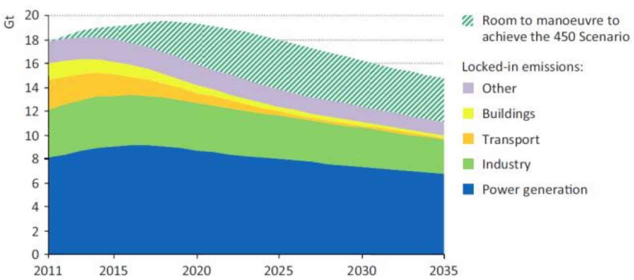
The case for CCS: fossil fuels

Trend in fuel mix 2010-2050: fossil fuels continue to dominate.



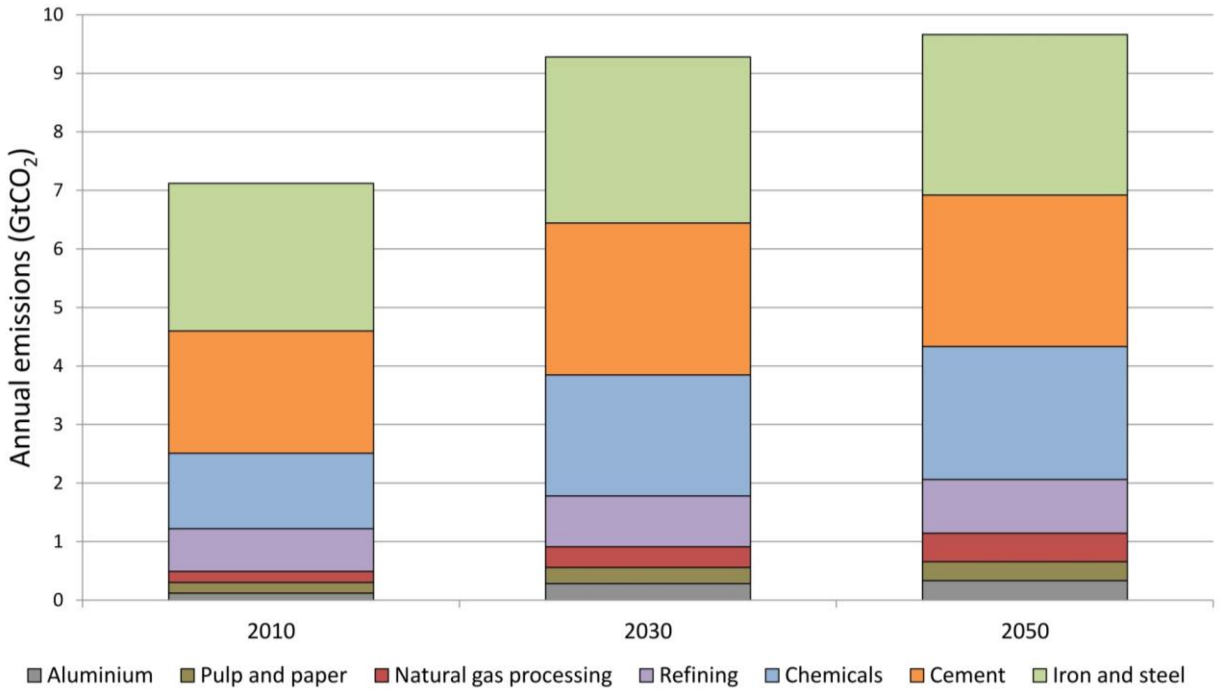
CCS can help to deal with emissions already “locked-in”.

Figure 8.14 ▷ Energy-related CO_2 emissions from locked-in infrastructure in 2011 and in the 450 Scenario in non-OECD countries



The case for CCS: process industries

Emissions from key industrial sectors expected to increase.

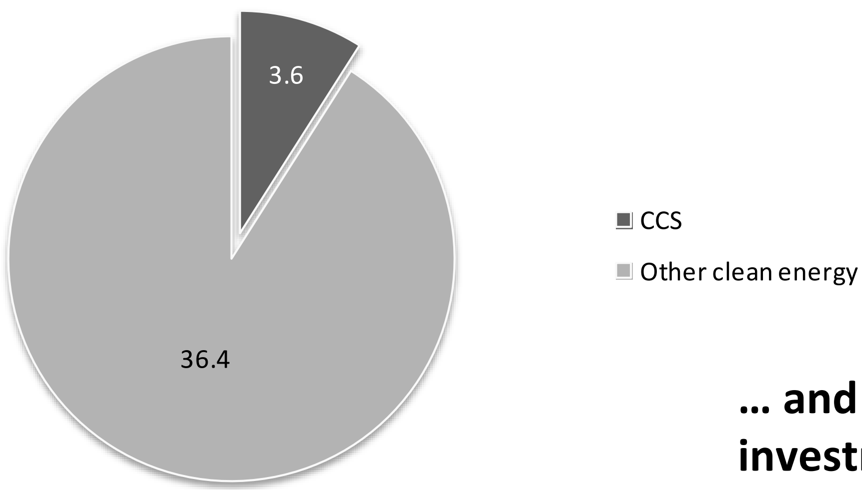


Source: IEA ETP 2012 4DS, incorporating recent policy pledges

CCS is the only large-scale mitigation option for many industrial sectors.

The case for CCS: economic advantage

Additional USD 36 trillion in investments through 2050 to reach 2DS scenario goals → CCS is 10% of this…

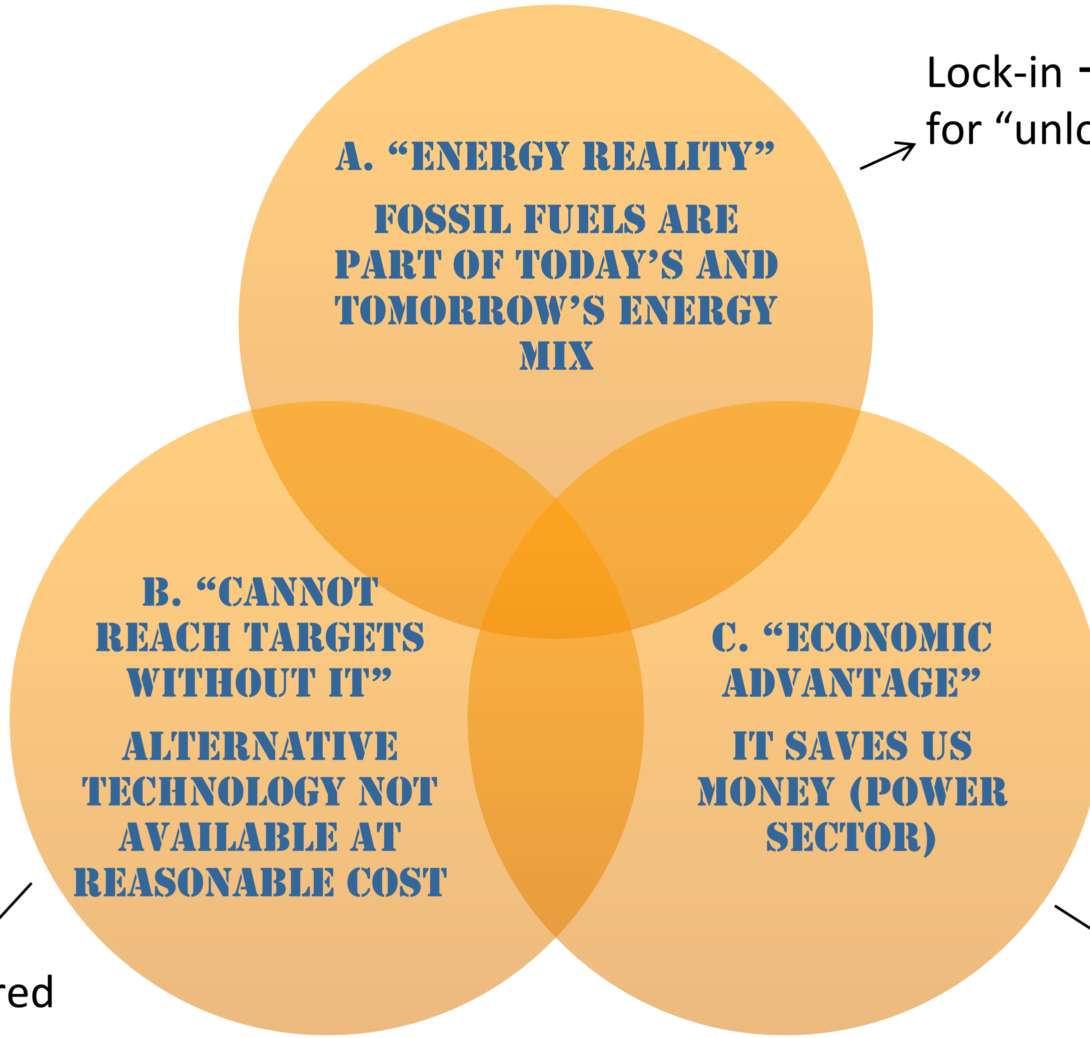


… and if CCS not available for power, investment required in the power sector will increase by

40%

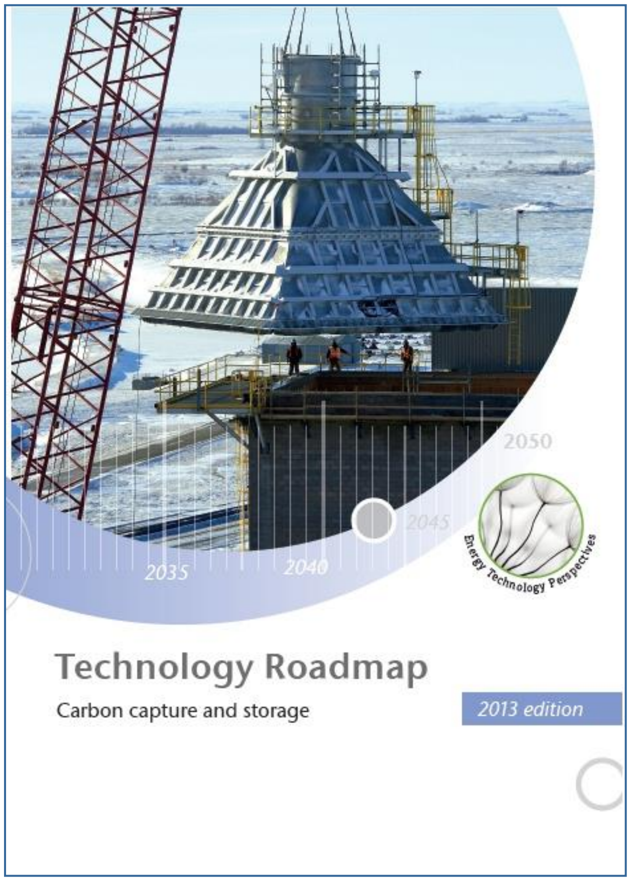
The case for CCS is clear!

Lock-in → CCS needed for "unlocking"



CCS required in industry

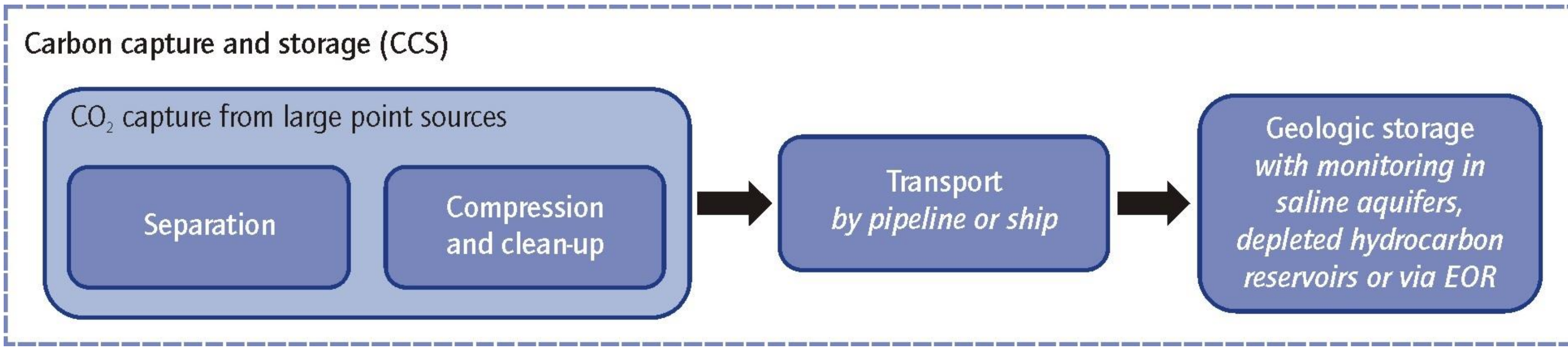
40% more investment in power if CCS not available



Outline

1. CO_2 challenge and role of CCS
2. **Status of CCS today**
3. Charting the way forward

CCS is ready for scale-up



- Post-process capture
- Syngas/hydrogen capture
- Oxy-fuel combustion
- Inherent separation

Capture technologies are well understood but expensive.

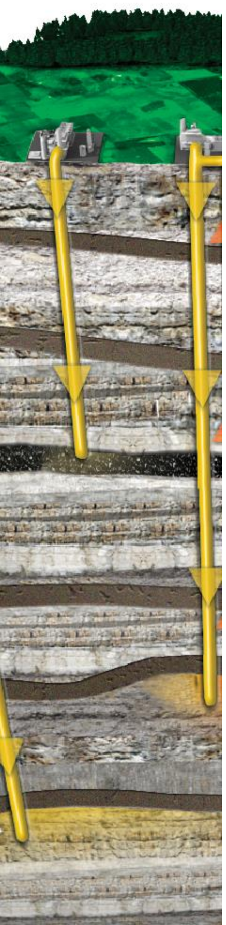
- 6000km existing pipelines
- Existing technical standards
- Transport by ship (albeit in small quantities)

Transport is the most technically mature step in CCS.

- Decades of research
- Natural CO_2 accumulations
- Pilot projects
- Existing large-scale projects

CO_2 storage has been demonstrated but further experience is needed at scale.

Capture technologies understood but expensive



		Syngas-hydrogen capture	Post-process capture	Oxy-fuel combustion	Inherent separation
First-phase industrial applications	Gas processing	-	-	-	Sweetening
	Iron and steel	direct reduced iron (DRI)*, smelting (*e.g.* Corex)		-	DRI*
	Refining	-	-	-	Coal-to-liquids; synthetic natural gas from coal
					Hydrogen production
	Chemicals	-	-	-	Ammonia/methanol
	Biofuels	-	-	-	Ethanol fermentation
Power generation	Gas	Gas reforming and combined cycle	Natural gas combined cycle	Oxy-fuel combustion	Chemical looping combustion
	Coal	Integrated gasification combined cycle (IGCC)	Pulverised coal-fired boiler	Oxy-fuel combustion	Chemical looping combustion
	Biomass	IGCC	Biomass-fired boiler	Oxy-fuel combustion	Chemical looping combustion
Second-phase industrial applications	Iron and steel	Hydrogen reduction	Blast furnace capture	Oxy-fuel blast furnace	-
	Refining	Hydrogen fuel steam generation	Process heater and combined heat and power (CHP) capture	Process heater and CHP oxy-fuel	-
	Chemicals	-	Process heater, CHP, steam cracker capture	Process heater and CHP oxy-fuel	-
	Biofuels	Biomass-to-liquids	-	-	Advanced biofuels
	Cement	-	Rotary kiln	Oxy-fuel kiln	Calcium looping
	Pulp and paper	Black liquor gasification	Process heater and CHP capture	Process heater and CHP oxy-fuel	-

Legend: technical maturity of operational CO_2 capture plants to date.

Commercial | Demonstration | Pilot | Lab or concept

Three CO_2 capture routes in power

Post-combustion CO_2 capture	• Fossil fuel or biomass is burnt normally and CO_2 is separated from the exhaust gas
Pre-combustion CO_2 capture	• Fossil fuel or biomass is converted to a mixture of hydrogen and CO_2, from which the CO_2 is separated and hydrogen used for fuel
Oxy-combustion CO_2 capture	• Oxygen is separated from air, and fossil fuels or biomass are then burnt in an atmosphere of oxygen producing only CO_2 and water

At the present time, none of the options is superior; each has particular characteristics making it suitable in different power generation applications

Selected CCS demonstration projects in process industries

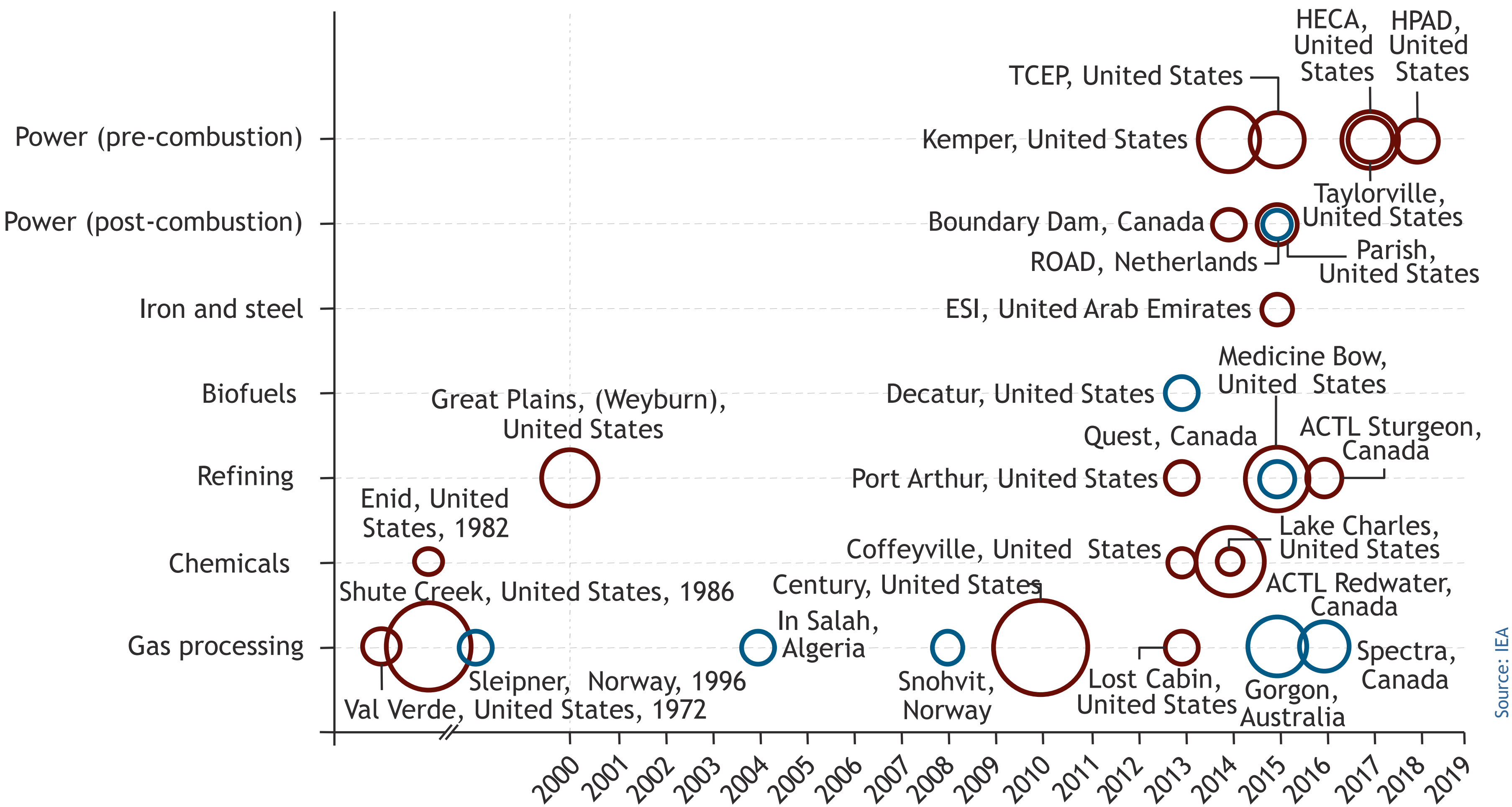
Name	Location	Sector (Process)	Size ($MtCO_2/y$)	Operation Date
Great Plains Synfuel	North Dakota, USA	Refining (SNG)	3	2000
ADM Decatur	Illinois, USA	Biofuels (Fermentation)	1	2013
Shell Quest	Alberta, Canada	Refining (H_2)	1	2015
NWR Sturgeon	Alberta, Canada	Refining (H_2)	1	2016
ESI-Masdar	Abu Dhabi, UAE	Iron & Steel (DRI)	<1	2015
Gorgon	Barrow Island, Australia	Gas Processing	3	2015


Great Plains Synfuels
(Source: Dakota Gasification)


Gorgon, Dec. 2012
(Source: Chevron)

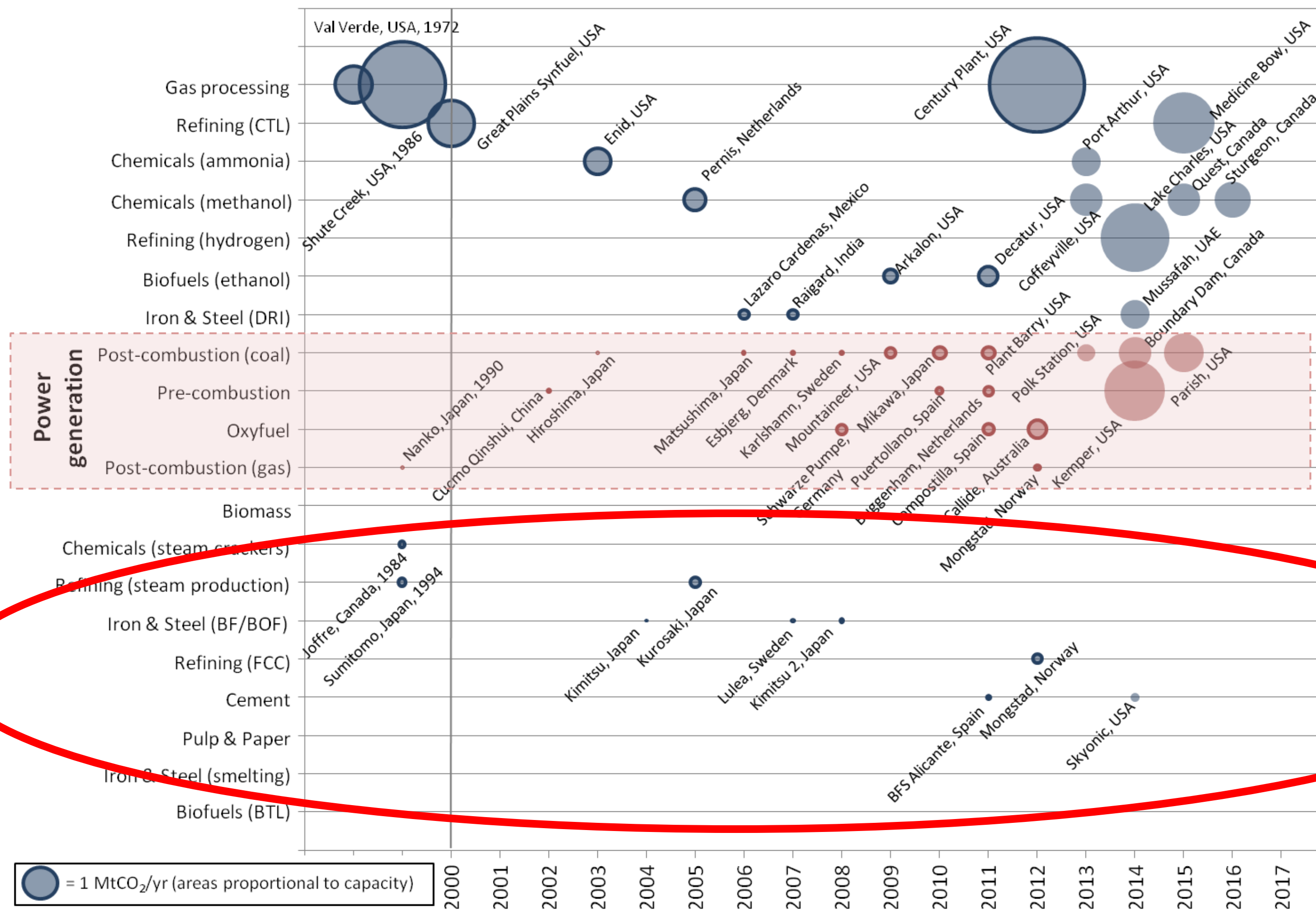

Scotford Upgrader
(Source: Shell)

Progress with large-scale capture projects



Size = 1MtCO_2/yr captured CO_2 used for EOR CO_2 used for storage without EOR   (based on available information)

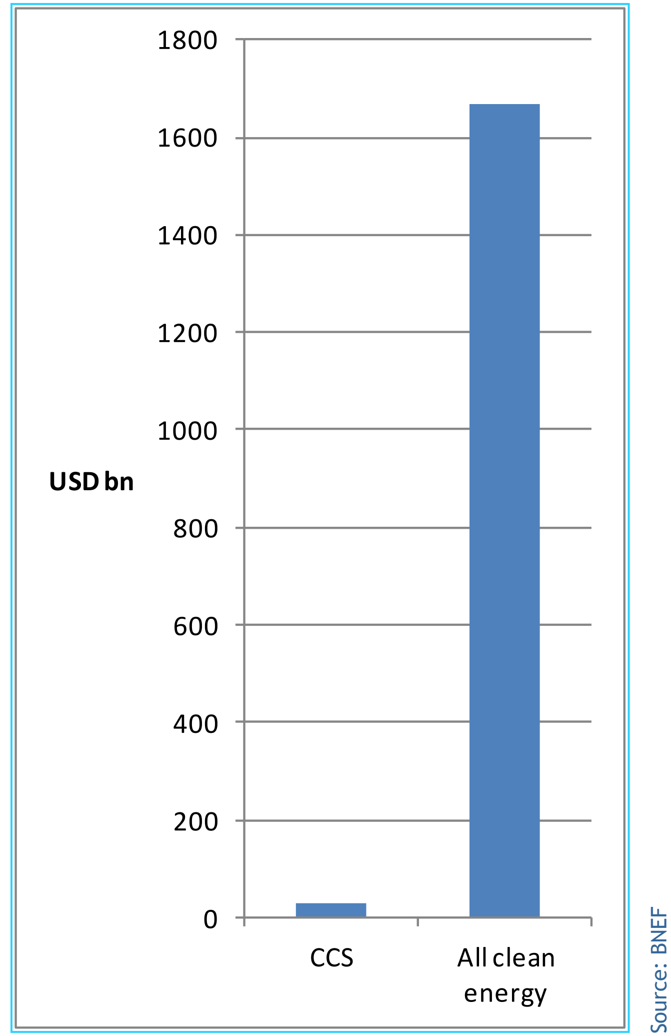
The need for project experience in industry-CCS



Source: Industry-CCS annex to TCEP report 2013

Low-carbon & CCS investment to date

- Investment in CCS 2004-2012: USD**20**bn
- Investment in all clean energy in 2004-2012: USD**1670**bn



International Energy Agency

Assembling the parts – still a challenge

Economics

- High cost of capture
- Limited business opportunity (EOR, small scale use)
- Unvalued benefit of CCS technology learning

Policy

- Uncertainty about long term climate mitigation goals
- Lack of political recognition of the role of CCS
- Low or inexistent carbon price
- Lack of or limited incentives for CCS

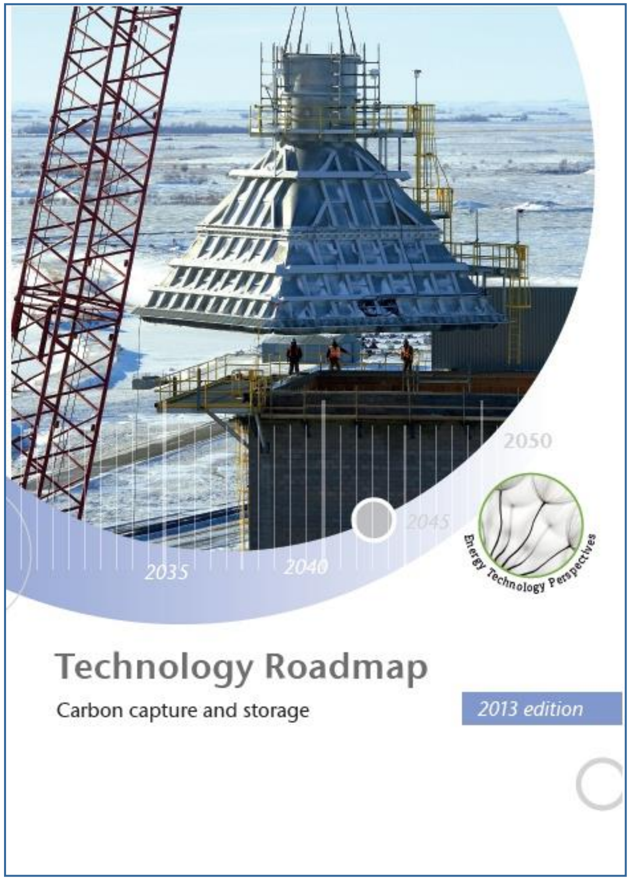
Technology

- No large-scale experience in power and many industrial applications
- Technical complexity of adding capture
- Risks related to storage
- Complex commercial arrangements

Stakeholder views

- Unfavorable views on CCS as perpetuating a fossil fuel world
- Concerns over risks of CO_2 escape
- Opposition to projects
- Lack of understanding

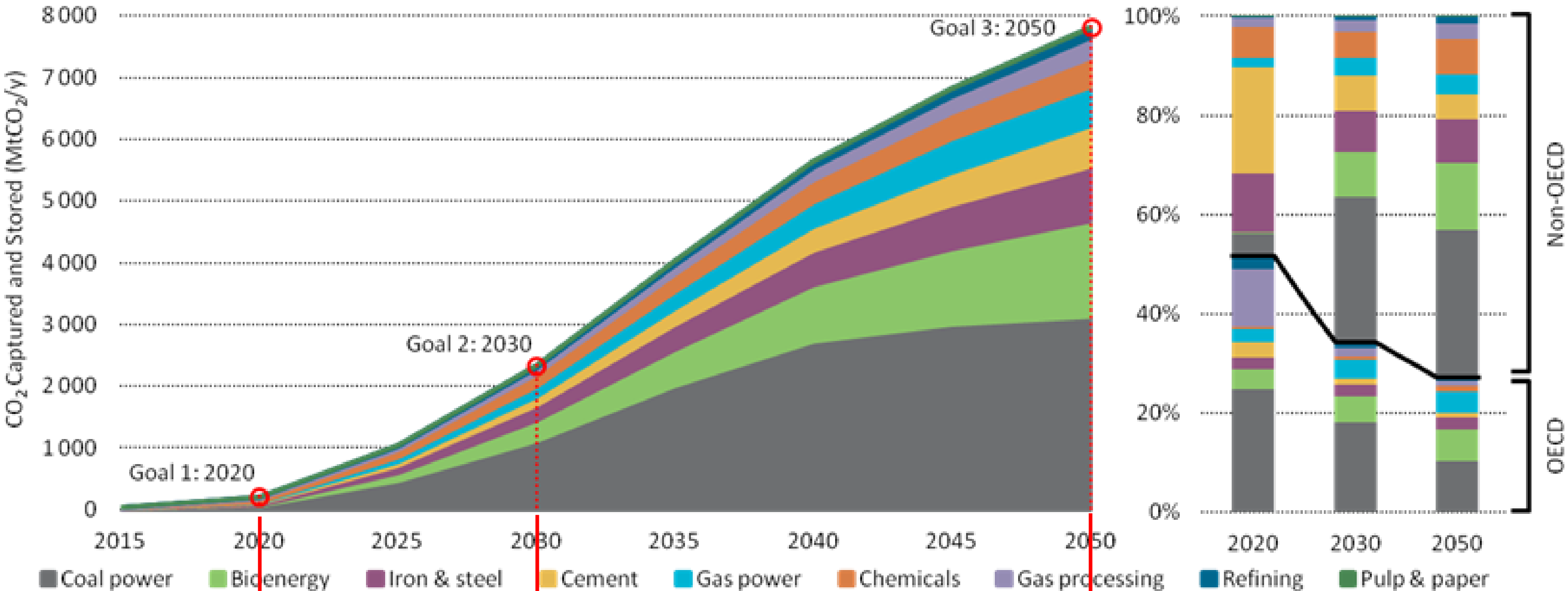
International Energy Agency



Outline

1. CO_2 challenge and role of CCS
2. Status of CCS today
3. **Charting the way forward**

IEA vision: 120 Gt of CO_2 stored by 2050

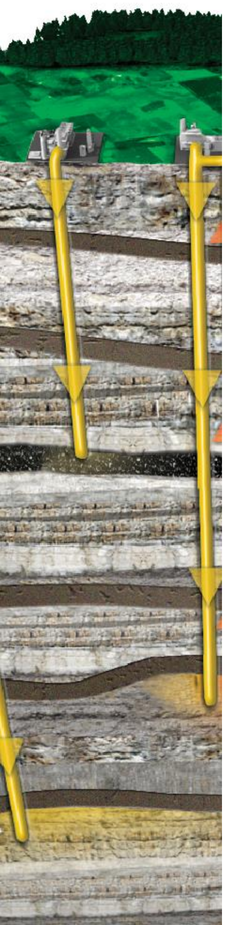


Goal 1: 2020:
Over 30 large projects are in operation in power and across a range of industrial processes, storing 50Mt CO_2 per year.

Goal 2: 2030:
Over 2Gt of CO_2 is stored per year. CCS is routinely used in power and certain industrial applications.

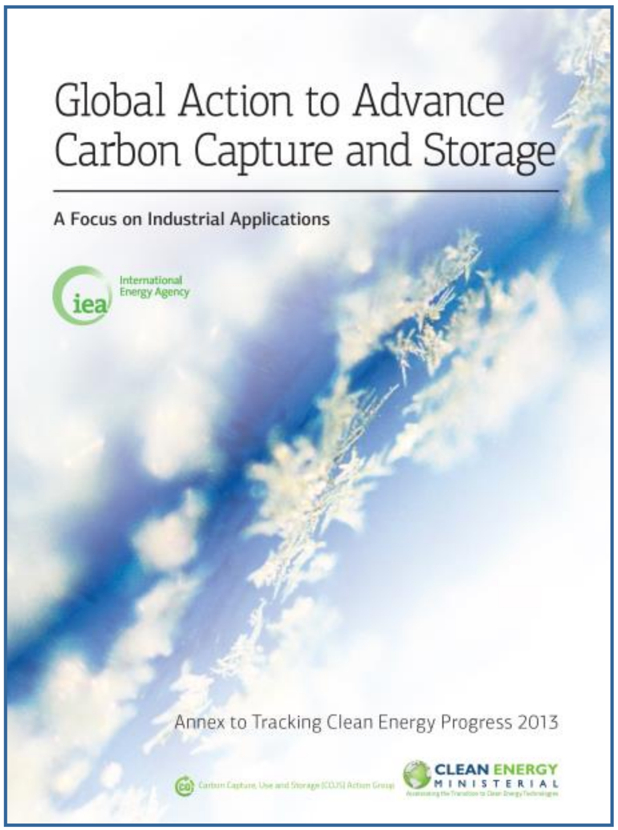
Goal 3: 2050:
Over 7Gt of CO_2 is stored per year. CCS is routinely used in all applicable power and industry.

Seven key actions for next seven years



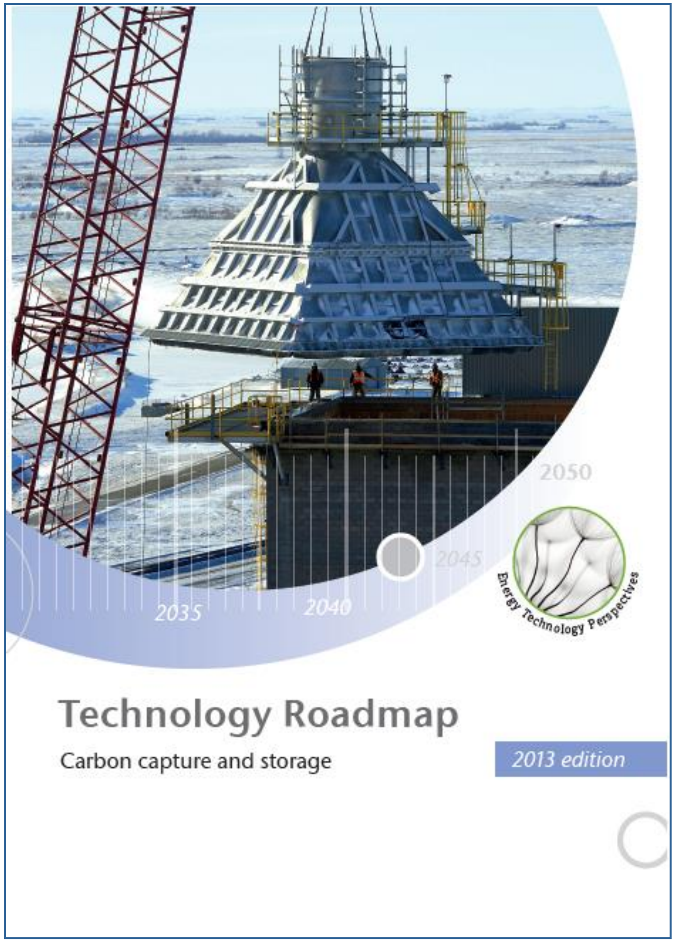
- Introduce **financial support mechanisms** for demonstration and early deployment.
- Develop laws and regulations that effectively require new-build power capacity to be **CCS-ready**.
- Significantly increase efforts to **improve understanding** among the public and stakeholders of CCS technology.
- Implement policies that **encourage storage** exploration, characterisation and development for CCS projects.
- Reduce the **cost of electricity** from power plants equipped with capture through continued technology development.
- Prove capture systems at pilot scale in **industrial applications**.
- Encourage efficient development of CO_2 **transport infrastructure**.

CCS in industrial applications needs a boost



SIX RECOMMENDATIONS:

1. Commit public funds to **10** pilot and demo scale projects
2. Support projects for contribution to **knowledge** (not short-term emission reductions)
3. Include CCS into industrial **strategies**
4. Start to address **competitiveness** concerns
5. Exploit **synergies** between sectors
6. Involve **all sectors** and stakeholders



THANK YOU!

juho.lipponen@iea.org

DOWNLOAD THE ROADMAP AT:

http://www.iea.org/topics/ccs/ccsroadmap2013