Centre for Climate Change Economics and Policy

Grantham Institute
Climate Change and the Environment
An institute of Imperial College London

Grantham Research Institute on Climate Change and the Environment

Bridging the gap:

improving the economic and policy framework for carbon capture and storage in the European Union

A policy brief by the Grantham Research Institute on Climate Change and the Environment (LSE) & the Grantham Institute (Imperial College)

Samuela Bassi, Rodney Boyd, Simon Buckle, Paul Fennell, Niall Mac Dowell, Zen Makuch and Iain Staffell

Brussels, 16 June 2015
London, 24 June 2015

E·S·R·C Economic & Social Research Council

Imperial College London

The Grantham Foundation for the Protection of the Environment

University of Leeds

LSE The London School of Economics and Political Science

This presentation

- Aim and focus
- CCS globally and in the EU
  - Scenarios
  - State of CCS
- Key challenges
  - Technology, infrastructure & storage
  - Costs
  - Finance
  - Regulation & policy
- Policy recommendations
- Conclusions

Aim and focus of the study

Aim of the study: Provide policy advice on how to make CCS more bankable in the EU

Focus on CCS - Why?

- Central in most energy scenarios & EU Energy Roadmap:
  - Essential in lowest cost technology portfolios
  - Can provide low-carbon electricity back up
  - Potential for negative emissions (BECCS)
  - Industrial applications

- Yet not progressing as fast as expected in the EU

CCS globally
and in the European Union

CCS in 2C scenarios (2050)

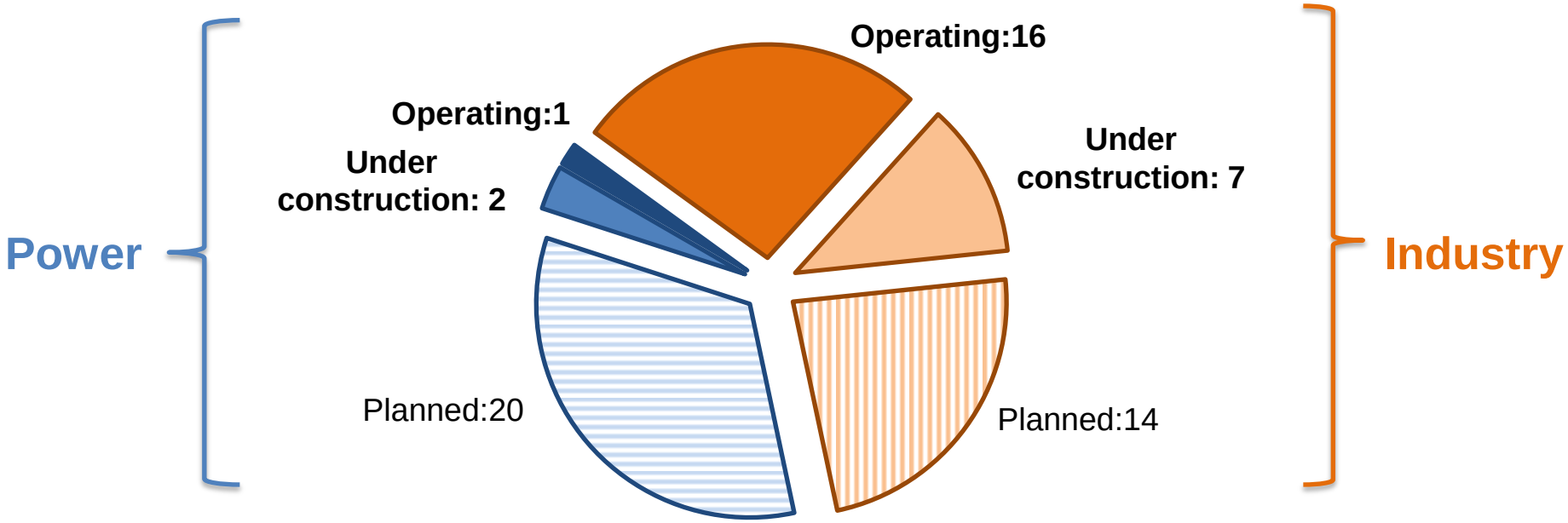
Source	Scenario	CCS generation	% total generation	CCS capacity
World		TWh	%	GW
IEA	2DS base	6,299	15%	960
	2DS hiRen	2,945	7%	460
	2DS hiNuc	3,055	7%	470
	2DS no CCS	0	0%	0
Global Energy Assessment	Mix	18,158	35%	n/a
	Efficiency	9,441	22%	n/a
	Supply	11,761	20%	n/a
European Union				
EU Commission	Low nuclear	1,548	**32%**	248
	Diversified	1,189	**24%**	193
	High energy efficiency	878	**21%**	149
	Delayed CCS	926	**19%**	148
	High RES	355	**7%**	53
Energy Modelling Forum (EMF28)	80% DEF	570	14%	n/a
	80%EFF	536	14%	0
	80% PESS	0	0%	0
	80% GREEN	0	0%	0
Global Energy Assessment	Mix	2,470	37%	n/a
	Supply	1,841	26%	n/a
	Efficiency	990	19%	n/a

- **CCS up to 50% of electricity by 2050**
- **Some scenarios not feasible without CCS**
- **If feasible, more expensive (IPCC: +140%)**

All scenarios in EU Energy Roadmap 2050 include CCS

Sources: IEA, 2012; EMF 28: Knopf et al., 2013; European Commission, 2011c; UKERC, 2013 ; CCC, 2010 ; HMG, 2011; Utrecht University, 2014; GEA, 2012

State of world CCS projects



EU: 12 power plants expected by 2015 , however to date

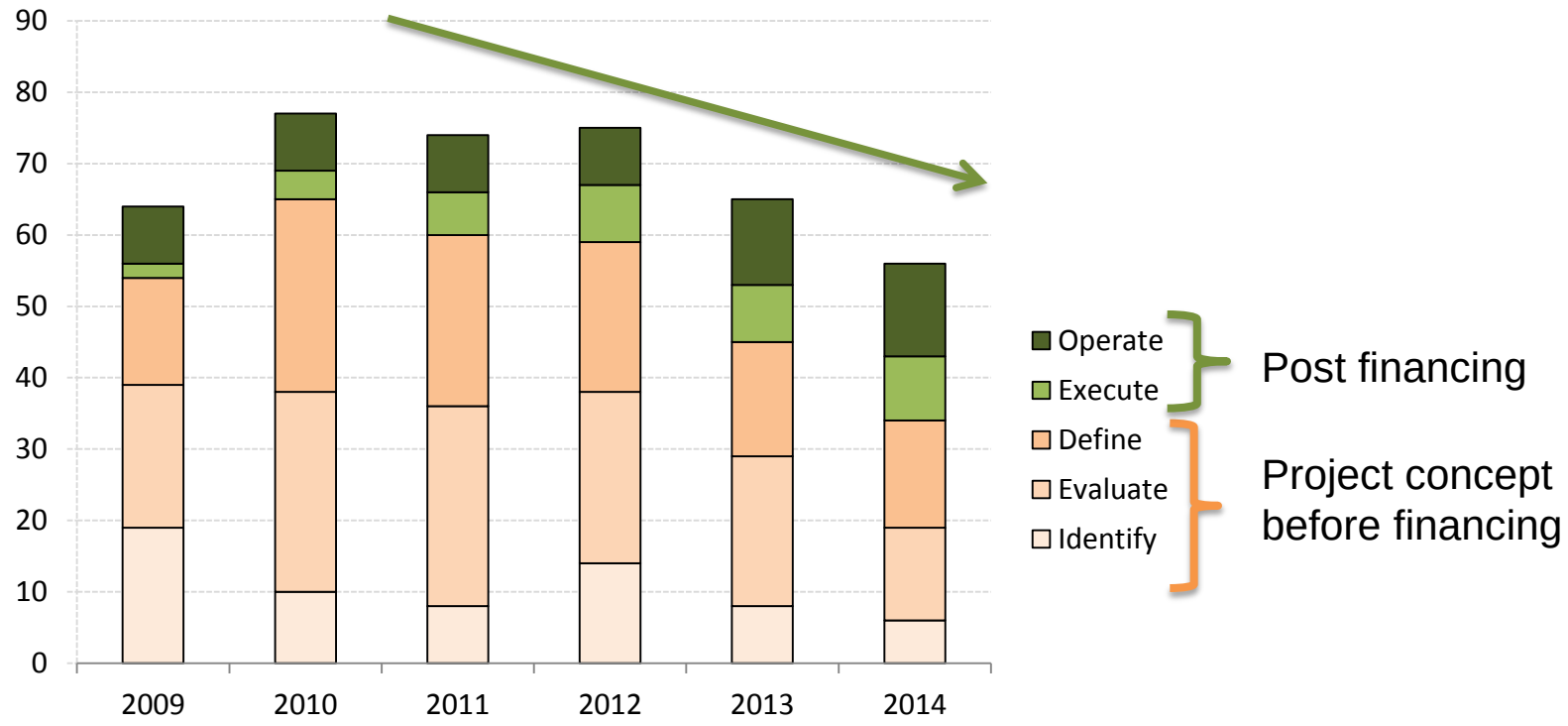
0 operating/under construction

6 planned (power)

- **5 UK** (Peterhead; White Rose; Don Valley; C.GEN; Captain Clean)
- **1 Netherlands** (ROAD)

…and the pipeline of projects is drying out

Global CCS large scale integrated projects by development phase, 2009-2014



Source: Based on GCCSI (2014a, 2014b)

Key challenges

Technology, infrastructure and storage

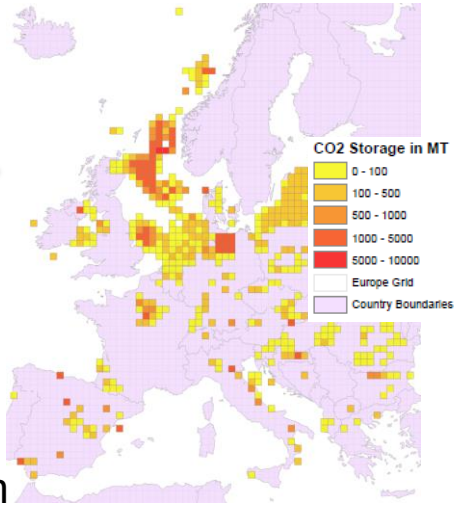
- **Capture & infrastructure:** technology is well known, low risk
  - → More understanding needed on: integration, cost reductions, industrial CCS, BECCS
  - → Pipelines require planning (especially for clustering) + regulation

- **Storage:** Potential bottleneck

  Storage shortage in some countries (e.g. central EU)

  → Further sites characterisation is crucial

EU potential CO_2 storage



- **EOR & utilisation (CCSU)** Can provide near term incentive

  Some potential for EOR in North Sea; CCSU still under investigation

  → More research needed, likely not game changer

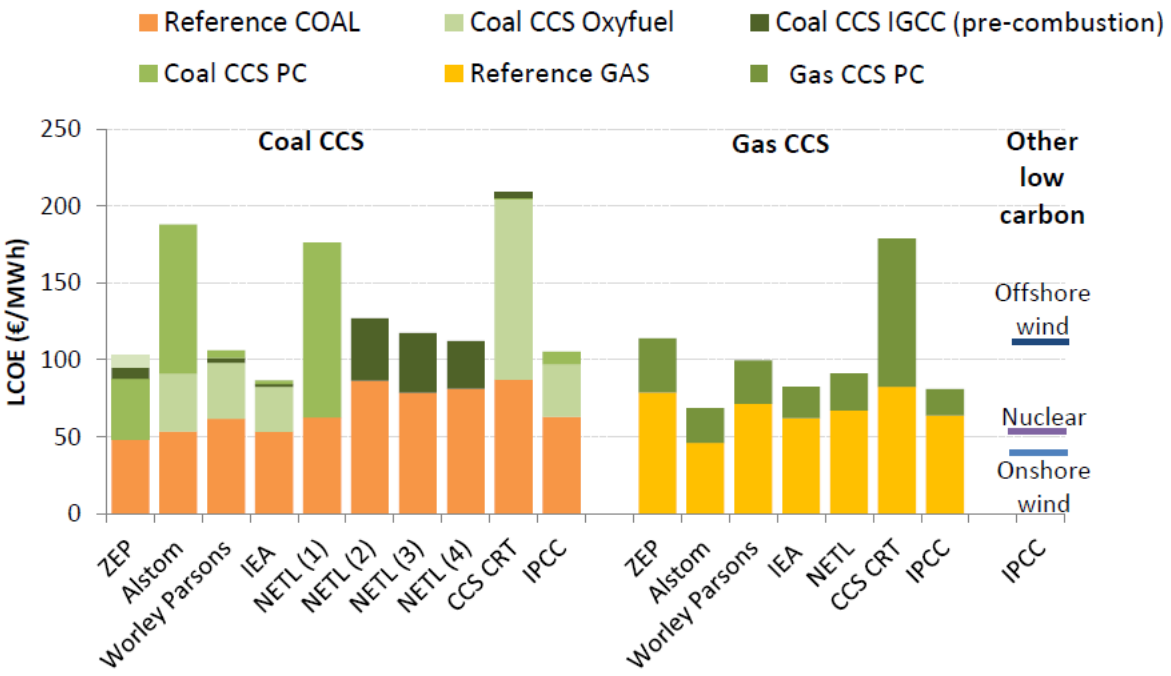
Source: Arup (2010)

Costs

ELECTRICITY

- **LCOE does not take into account back-up role of CCS**
- **Large variability of LCOE – depends on theoretical assumptions**
- **CCS is currently 30-120% more expensive than unabated plants**
- **Some estimates within range of offshore wind**

Levelised cost of electricity (LCOE), €2013 values



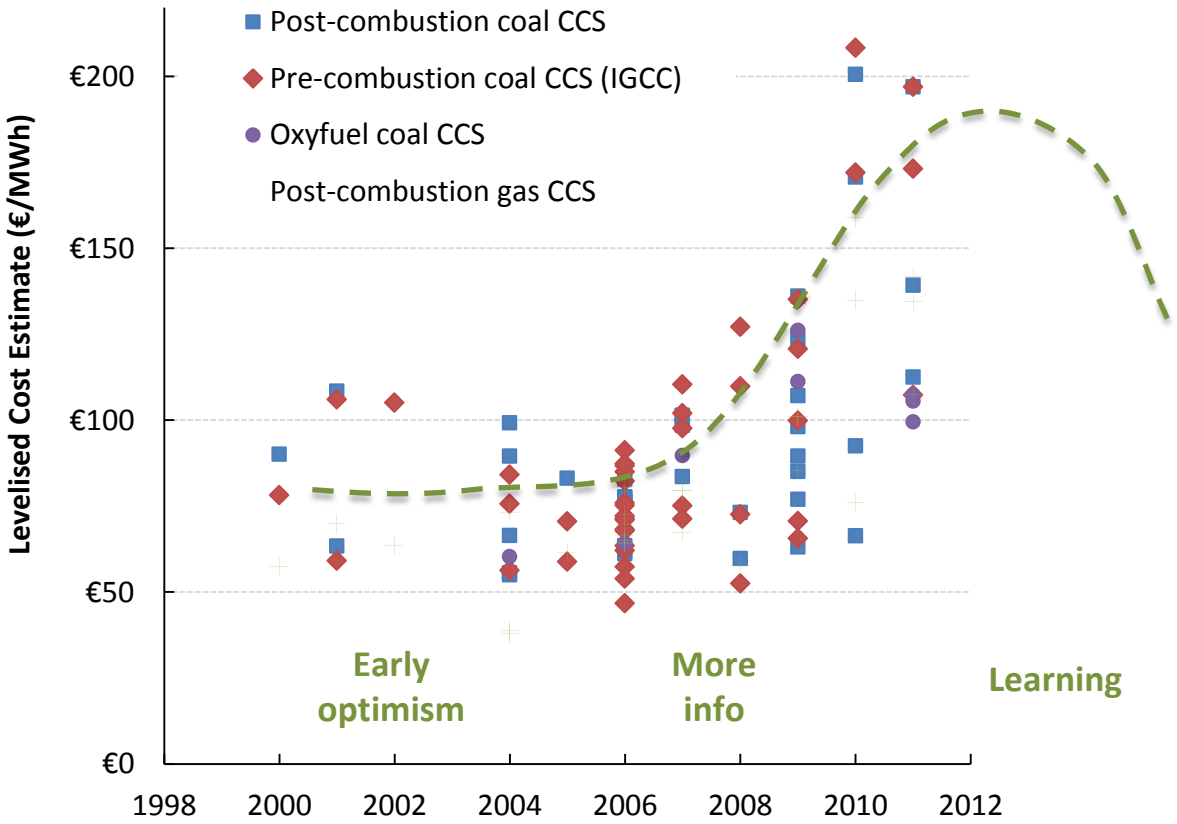
Sources: Based on CCS CRT, 2013; Léandri et al., 2011; NETL, 2013; WorleyParsons, 2011; IEA, 2011; IPCC, 2014a; GCCSI, 2011b; ZEP, 2011.

…Costs evolve across time

- Cost estimates have gone up: + 15-30% compared to 2010
- But expected cost reductions as technology evolves: **- 14-40% by 2030.**

Boundary Dam: -30% if built again

Estimates of CCS levelised cost of electricity since 2000 (€2013 values)

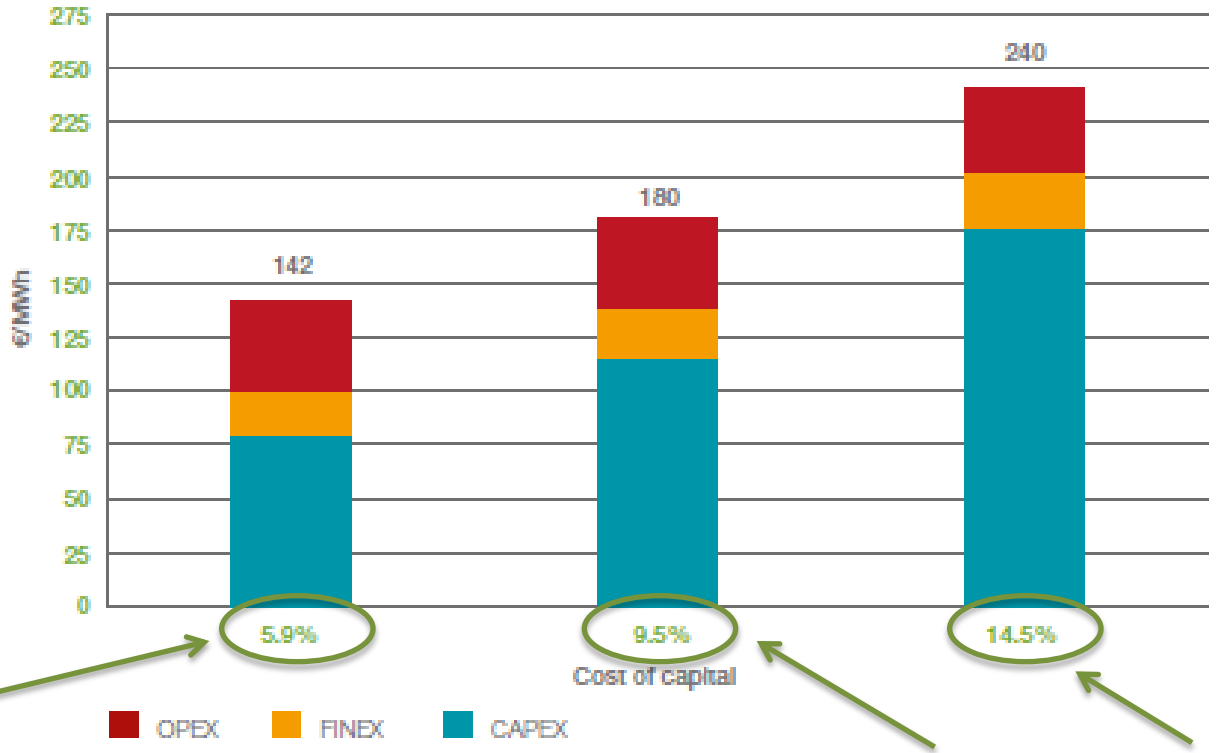


Source: Based on Gross et al. (2013) and Jones (2012)

Finance

- CCS perceived high risk → **high cost of capital**
- Significant impact on LCOE

Estimated LCOEs based on the Boundary Dam project and assumptions on cost of capital



Estimate for Boundary Dam (publicly funded)

Literature average

DECC

Source: Authors

Policy & regulation

- **Funding**
  - Limited EU funds (NER300, EEPR) – €1.3 bn
  - Almost no national funding programmes except UK - €1.2 bn
  - Uncertain size of future funds (e.g. NER400, cohesion funds), likely insufficient
  - Low investment in CCS R&D (in 2012: EU €125 m; UK: €32 m)

- **Policy uncertainty**
  - No coordination across MS policies.
  - Low commitment in EU 2030 framework & Energy Union

- **Regulatory issues** especially on **liability** in case of leakage:
  - Storage operators to cover leakage risk at (future) ETS prices: uncertain, potentially open-ended risk

Policy recommendations

- Policy incentives
- Coordination
- Regulation

Policies to incentivise CCS investment

Carbon pricing alone is not enough:

€40-60/t CO_2 for coal power plants; >€100/t CO_2 for gas → unfeasible in next decade

Up to 2020:

- EU/national **funds for CCS research & development** (especially on BECCS)
- **New funding mechanism for early stage projects** (complementary to NER 400)

2020-2050:

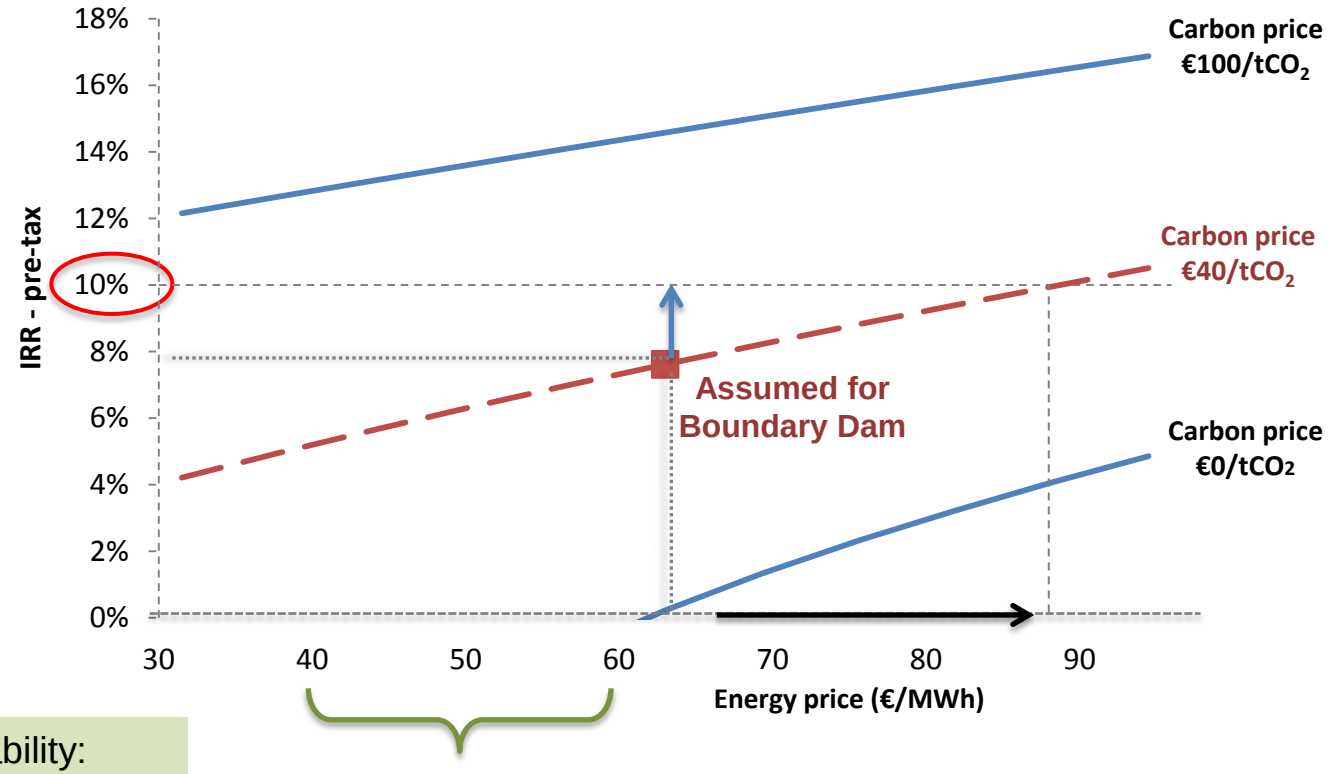
- **Carbon pricing** &
- **Financial incentives for CCS electricity generation**

- **Support from public financial institutions** to leverage private investment - to reduce cost of capital
- **Mandatory targets**
- **Private sector fund**
- **Tailored incentives for industrial CCS**

…Bankability depends on electricity and CO_2 prices

Sensitivity of IRR to carbon and electricity prices – based on Boundary Dam (coal)

We expect IRR>10% for a project to be bankable



EU power wholesale prices range: €40-60/MWh

To improve bankability:
- Raise carbon price
- Raise electricity price
- Both

Source: Authors, based on Boundary Dam

Ambitious and coordinated action

Piecemeal approach has failed to bring in 12 CCS plants by 2015:

Coordination at EU level or across 'coalition of willing' Member States.

Role for Member States:

- **Assess own potential for CO_2 capture and for storage**.

Role for European Commission (in collaboration with Member States):

- Ensure **coherence across national CCS policies**
- Facilitate **shared learning** on CCS innovation.
- Set **milestones** to measure progress
- Facilitate and support **infrastructure** planning and development

Improved legislation

Increased certainty over size of liability for CO_2 leakage:

revision of CCS Directive or alternative legislation

- **Initial cap on long-term liability for carbon dioxide leakage**, to be reviewed as risks become better understood and private insurance mechanisms develop.
- **Financial mechanism for damage remediation**, such as a liability fund or private insurance.
- **Special treatment of demonstration projects** through a public liability scheme.
- Reliance on the **Environmental Liability Directive**, rather than the EU ETS, to determine the size of remediation costs caused by leakage from CO_2 storage sites.

Centre for Climate Change Economics and Policy

Grantham Research Institute on Climate Change and the Environment

Conclusions

- CCS is crucial in the **EU Energy Roadmap 2050**
- **Progress so far has been too slow**
- Key barriers: **costs (e.g. electricity), financing, infrastructure and technology, inadequate policy and regulation**

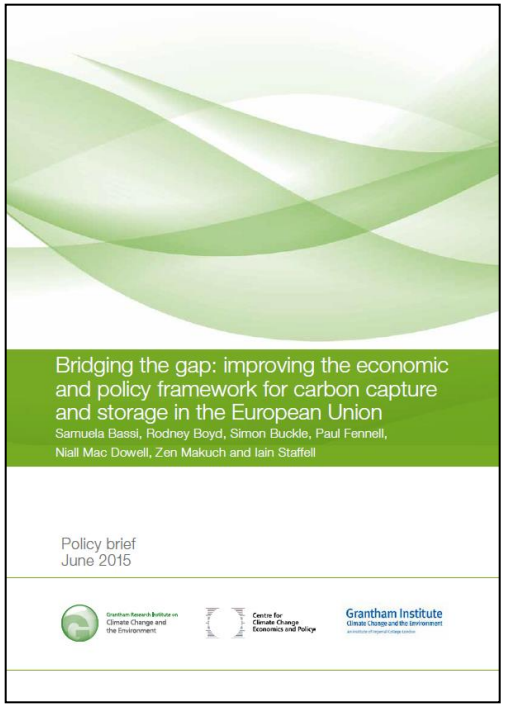
- Way forward: **a new EU strategy** to incentivise, coordinate and better regulate CCS action

Centre for Climate Change Economics and Policy

Grantham Institute
Climate Change and the Environment
An institute of Imperial College London

Grantham Research Institute on Climate Change and the Environment

Thank you.



For additional information please contact:

Samuela Bassi, Policy Analyst: s.bassi@lse.ac.uk
Rodney Boyd, Policy Analyst: r.boyd@lse.ac.uk
Chris Duffy, Policy Communications Manager: c.duffy@lse.ac.uk
Paul Fennell, Reader in Clean Energy: p.fennell@imperial.ac.uk
Niall Mac Dowell, Lecturer in Energy and Environmental Technology and Policy: n.mac-dowell06@imperial.ac.uk

The Institutes would like to thank their main funders:

The Grantham Foundation for the Protection of the Environment
E·S·R·C Economic & Social Research Council
EPSRC Engineering and Physical Sciences Research Council
UKCCS Research Centre
Research Councils UK Energy For a Low Carbon Future