Institute for European Environmental Policy

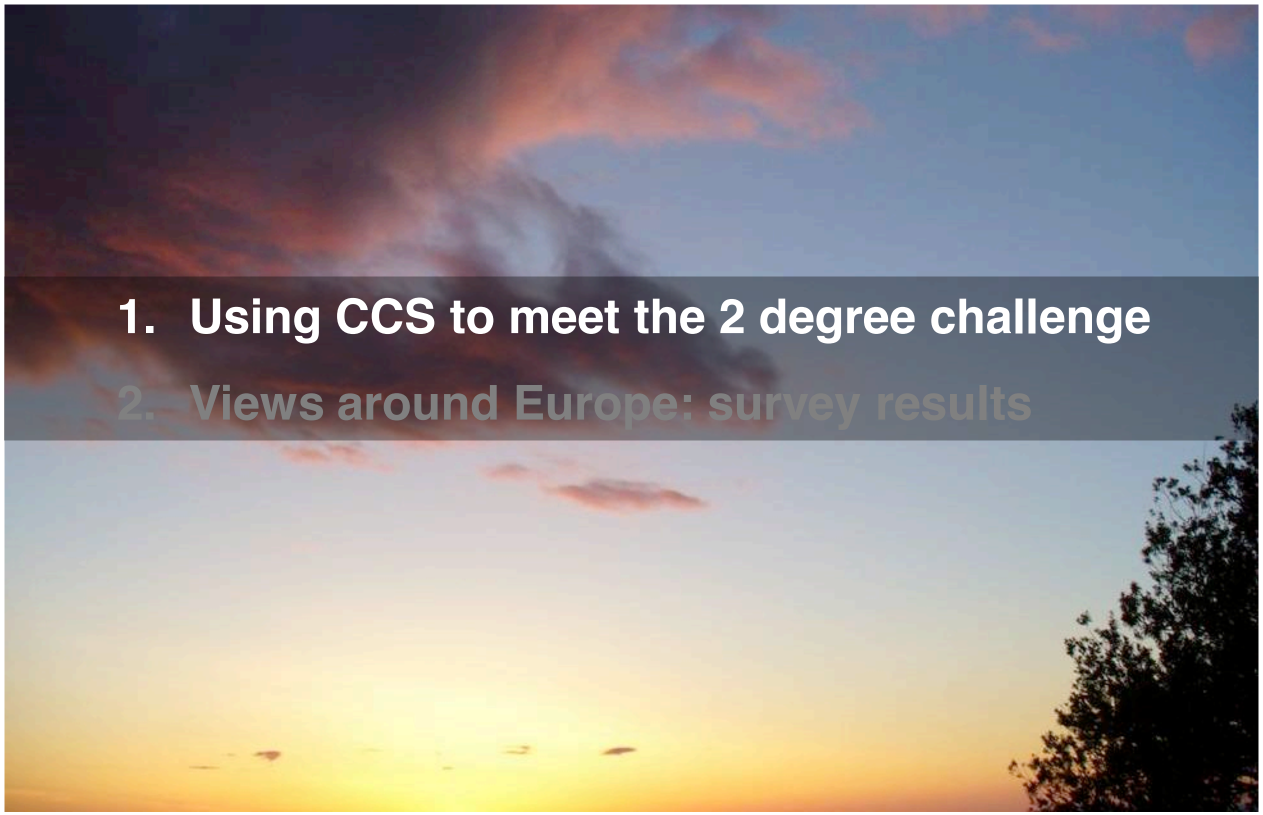
European policy and regulation of CCS

Jason Anderson, IEEP

Outline

- Background to EU interest
- Key questions informing EU policy
  - Is CCS necessary?
  - Is it safe?
  - Is it acceptable?
  - How do we make it happen? (If we want it)
- Proposed EU Directive on CCS

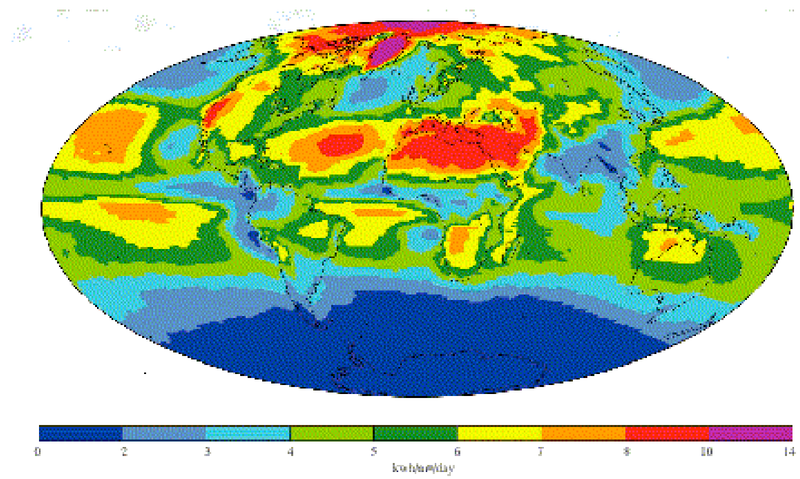
Background to EU interest



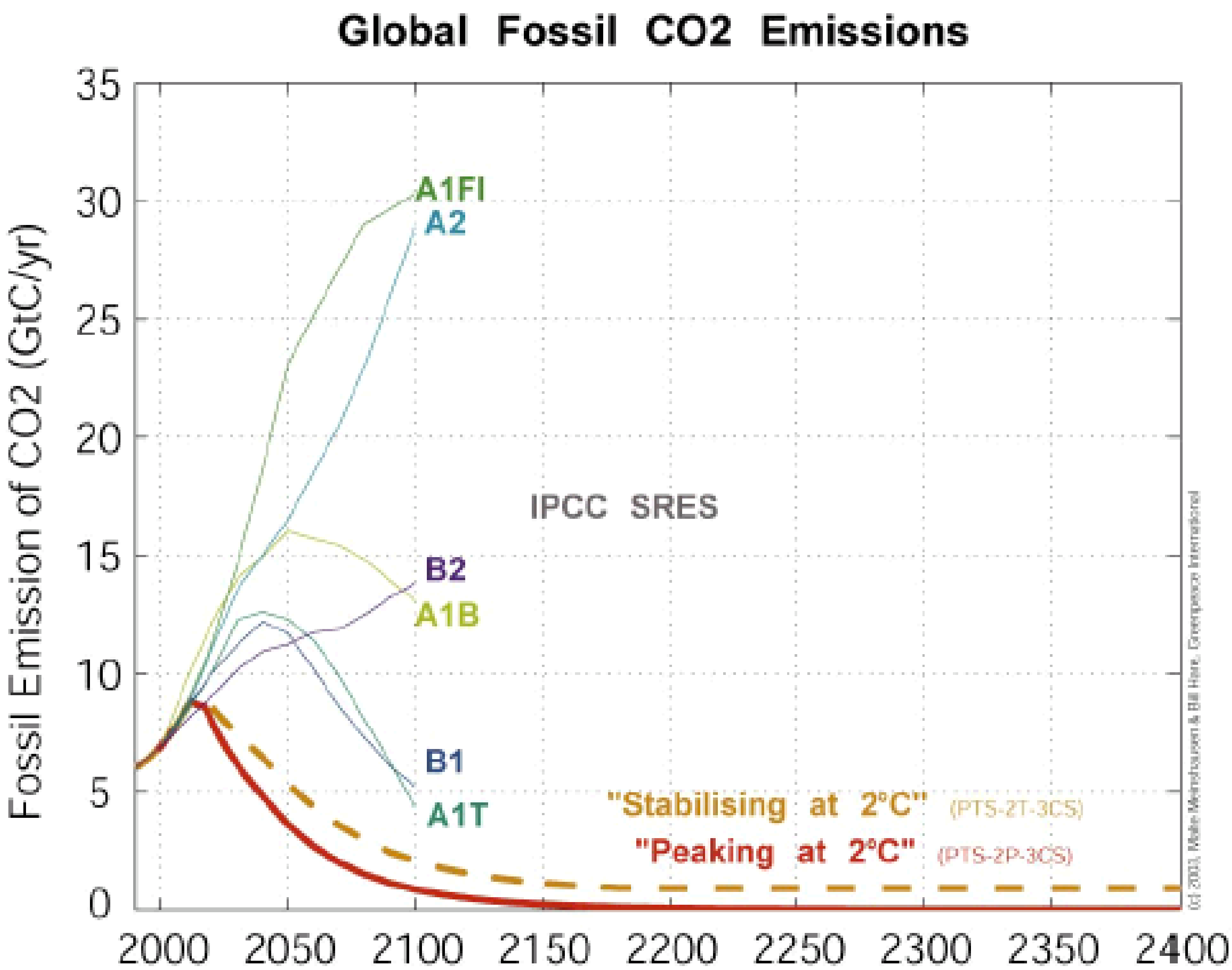
1. Using CCS to meet the 2 degree challenge
2. Views around Europe: survey results

The 2 degree challenge

A limit to global warming of 2 degrees Celsius above pre-industrial levels has been endorsed by the Council, Parliament and Commission, as well as many stakeholders

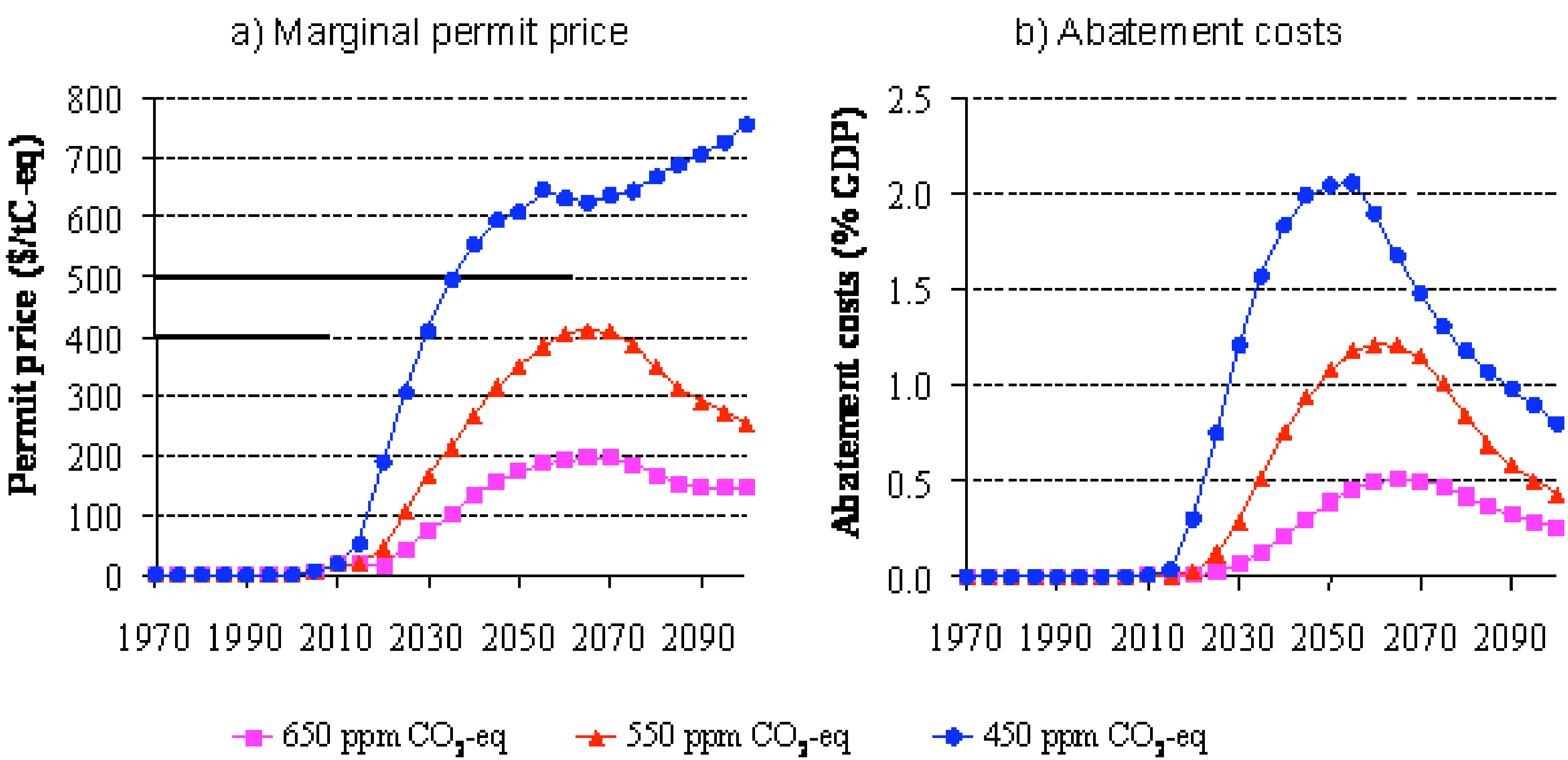


Emissions trajectories



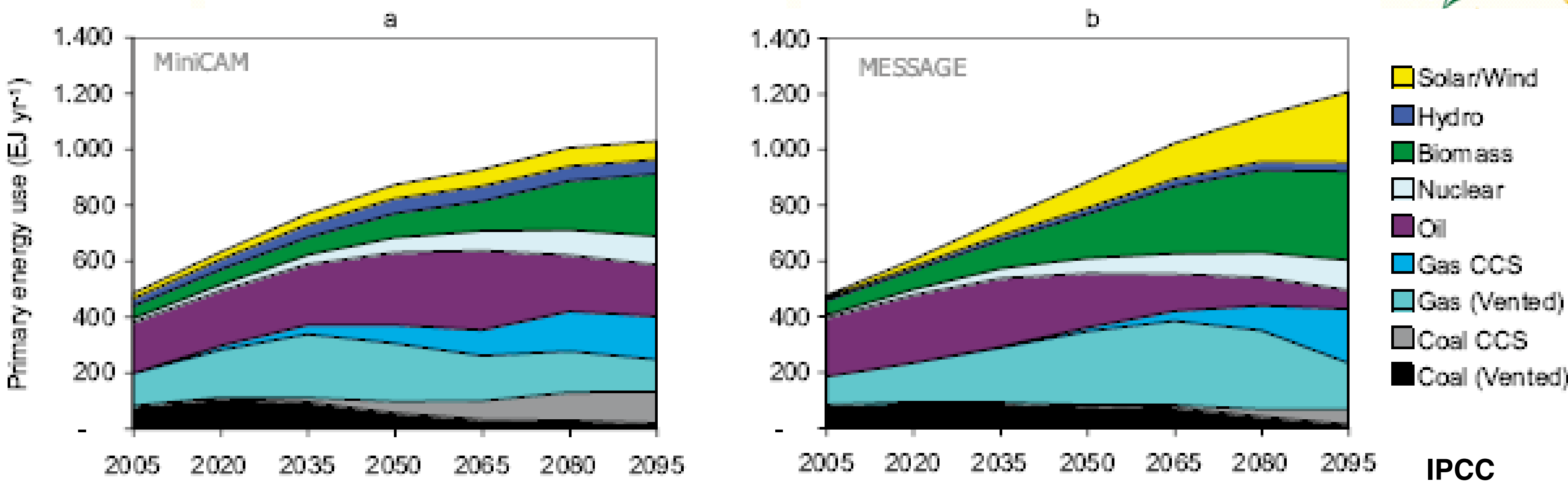
Source: Meinshausen, 2005

Costs to meet stabilisation targets

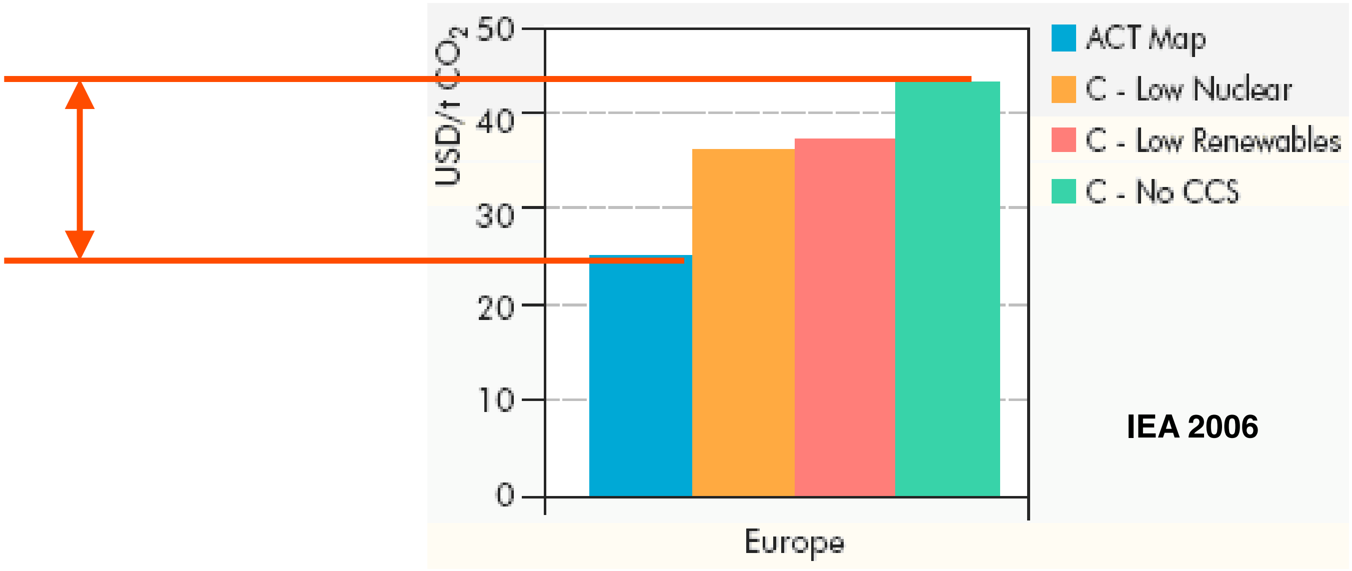


Source: Van Vuuren, in press

Economic modelling of CCS

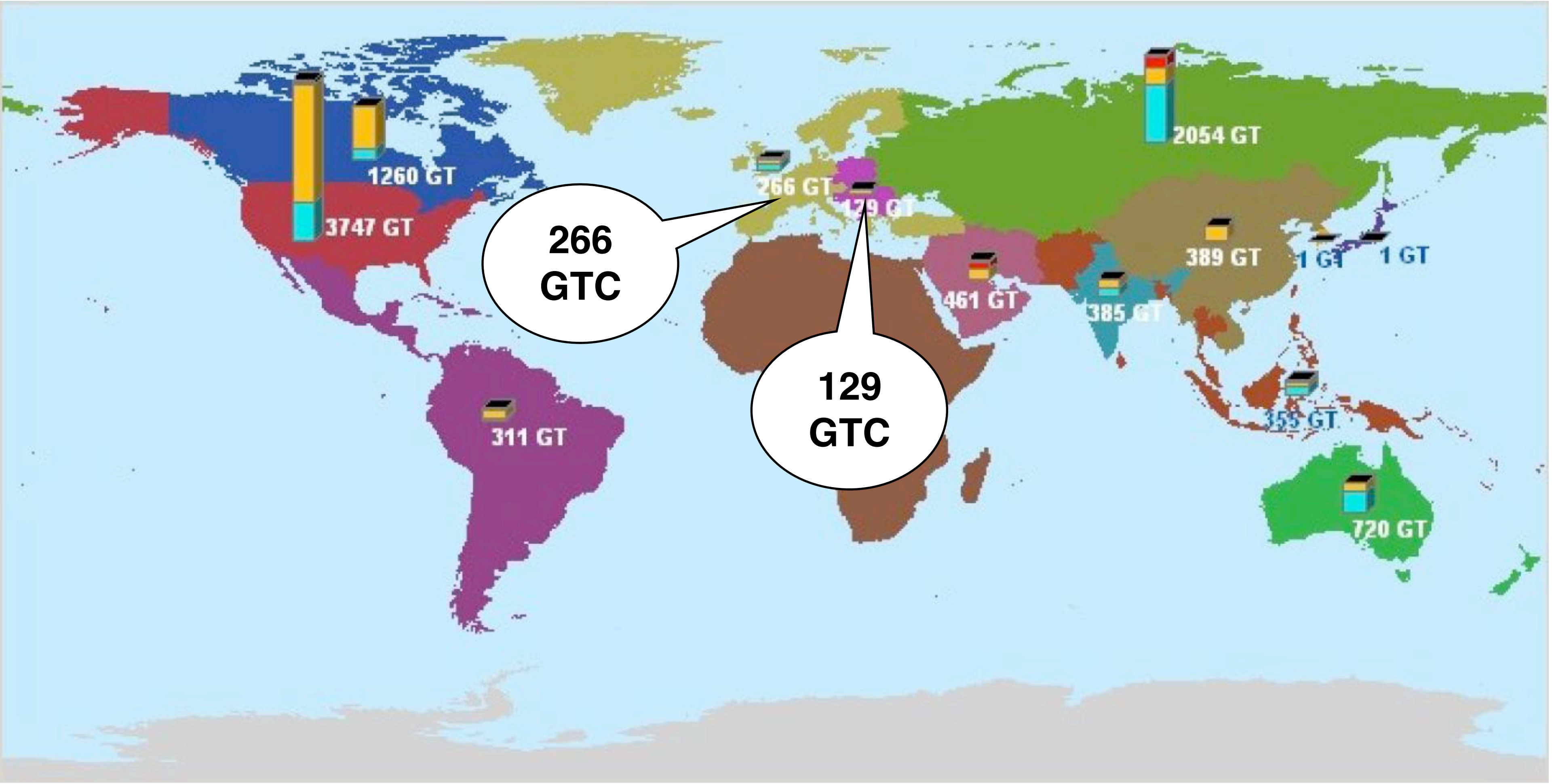


IPCC SRCCS, 2005



IEA 2006

Global storage capacities



As the Commission sees it

Why do we need CCS?

Climate change context

- Cannot reduce EU or world CO2 emissions by 50% in 2050 with energy efficiency and renewables alone
- Must also use the possibility to capture and store CO2
- Major fossil fuel use in the developing world must be addressed.

Potential of CCS

- Could contribute around 14% of all reductions needed by 2030
- by 2050 almost 60% of emissions from the power sector should be captured, compared with none today. More than 90% of all coal-fired electricity generation would be from plants equipped with CCS.
- After initial deployment in developed countries, rapid uptake in developing countries will follow.

Potential for long-term storage

- Most oil and gas fields have contained high-pressure CO_2 for millions of years (200 Mt trapped in Pisgah Anticline in the US for 65M years)

- Significant storage potential
  - Technical potential likely to exceed 2000 GT
  - Total CO_2 emissions currently around 24 GT/yr

- Detailed work on storage potential in Europe:
  - National geological surveys
  - Geocapacity FP6 project

- European Commission
  'believes that by 2020 all new coal-fired power plants should be built with CCS. Existing plants should then progressively follow the same approach'
  (Communication on Sustainable Power Generation from Fossil Fuels, 10 January 2007)

- Heads of State urge
  'Member States and the Commission ... developing the necessary ... regulatory framework to bring environmentally safe CCS to deployment with new fossil-fuel power plants, if possible by 2020'
  (European Council Conclusions, 9 March 2007)

Background to EU interest

1. Using CCS to meet the 2 degree challenge
2. Views around Europe: survey results

EU survey: ACCSEPT (FP6)

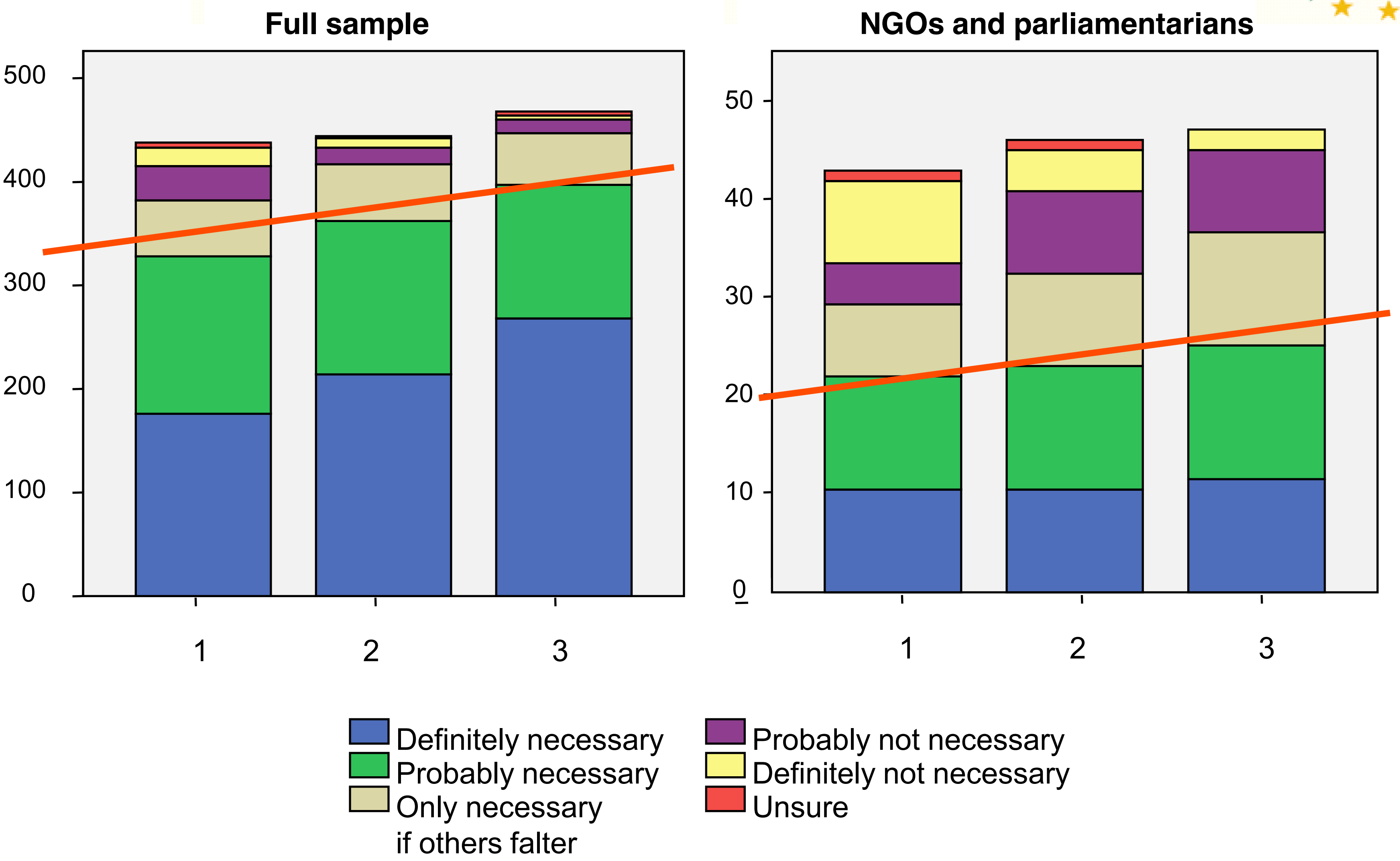
- 512 respondents from June-December 2006: Researchers (34%), Industry (28%), Government (13%), NGOs (5%) and Parliamentarians (4%).

20% UK
11% Germany
9% Netherlands
6% France, Italy, Sweden

5% Denmark, Spain, Norway
4% Belgium
3% Finland
20% in other MS

More information on www.accsept.org

Perceived need for CCS in own country (1), EU (2) and globally (3)



Perceived need for CCS

- **Norway, UK and Netherlands** most enthusiastic
- **Finland, Sweden and CEE** least supportive of CCS, but still in favour
- **Energy, government and research** stakeholders strongly supportive of CCS
- **NGOs** are more ambivalent regarding CCS, with **parliamentarians** largely supportive but with some scepticism

Role of CCS in the National Debate

- CCS is perceived to play a large or moderate role in the current national debate (57%)
- Significantly **larger role** of CCS in debate in **Norway, followed by Netherlands, UK, Germany**.
- **Smaller role** in debates in **Denmark, Finland, Sweden**
- Role of CCS is **generally increasing**

Key questions

1. Is CCS necessary?
2. Is CCS safe?
3. Is CCS acceptable?
4. How do we make it happen?

Received wisdom

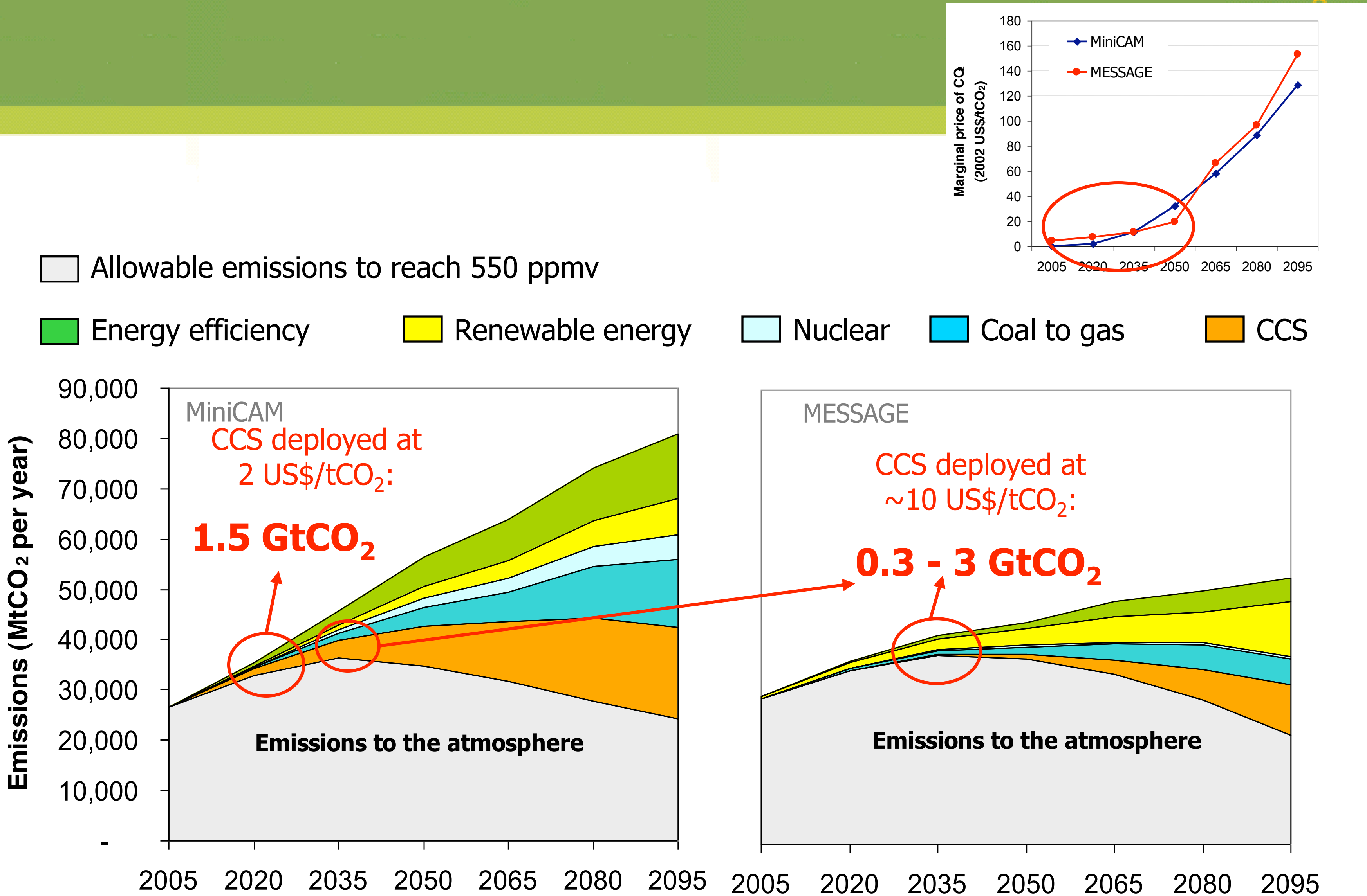
- Fossil fuels are dominant now and will be into the future
- Models indicate abatement with CCS in the mix is cheaper
- CCS could be a major source of mitigation in the coming decades
- It is obvious that renewable energy can't do it on its own

CCS costs

- Capture: $ 5 - 90 / tCO2 — $40-60 / tCO2 'typical'
  ↓ acid gas processing, hydrogen, ammonia
- Transport: $ 0 - 20 / tCO2 — depends on volume, distance, terrain
  ↓ on site storage
- Storage: $ 2 - 12 / tCO2 — depends on location/type of formation
  ↓ onshore, with infrastructure in place

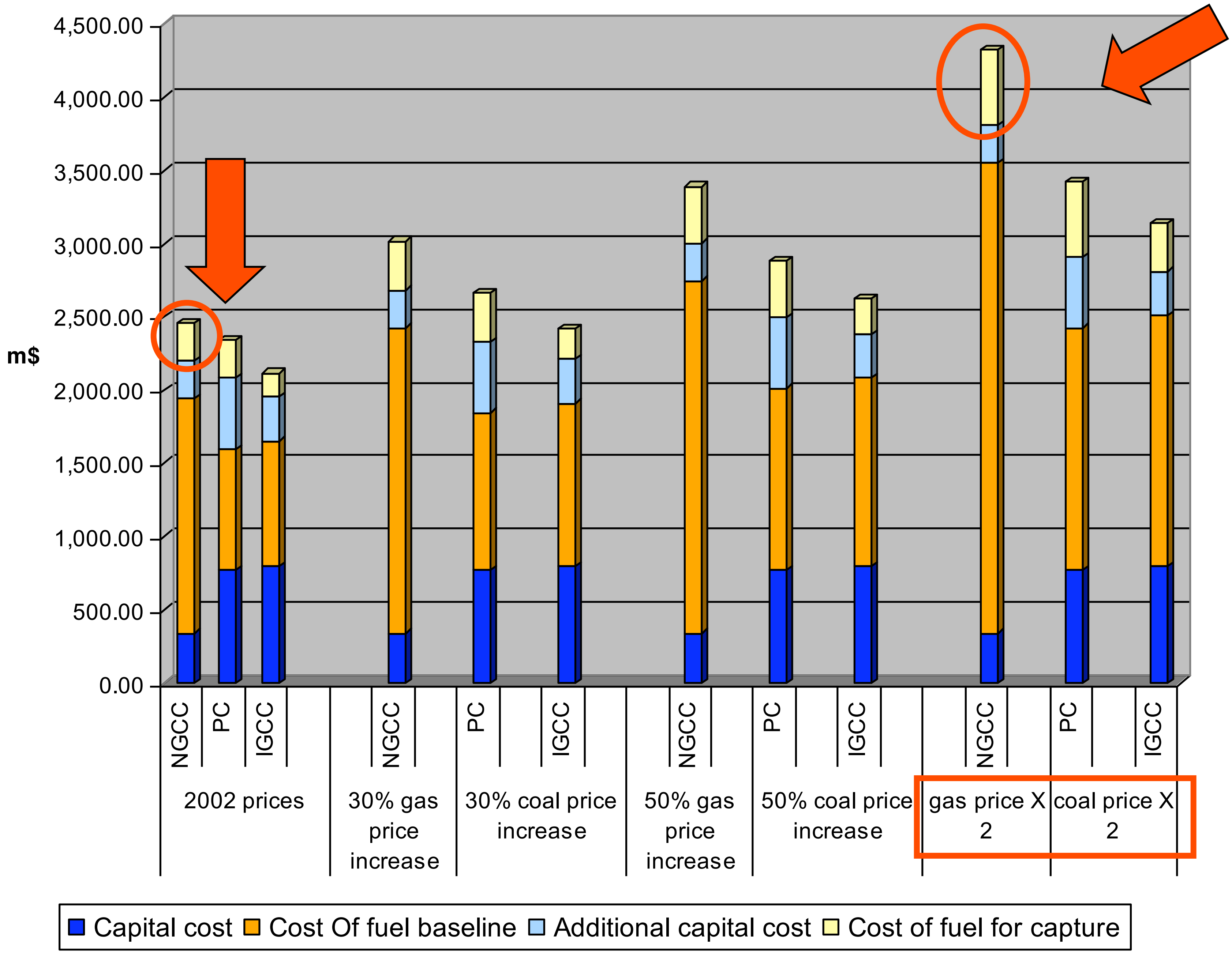
Future cost reduction potential: capture - 50%, others less

Source: Senior et al. 2004



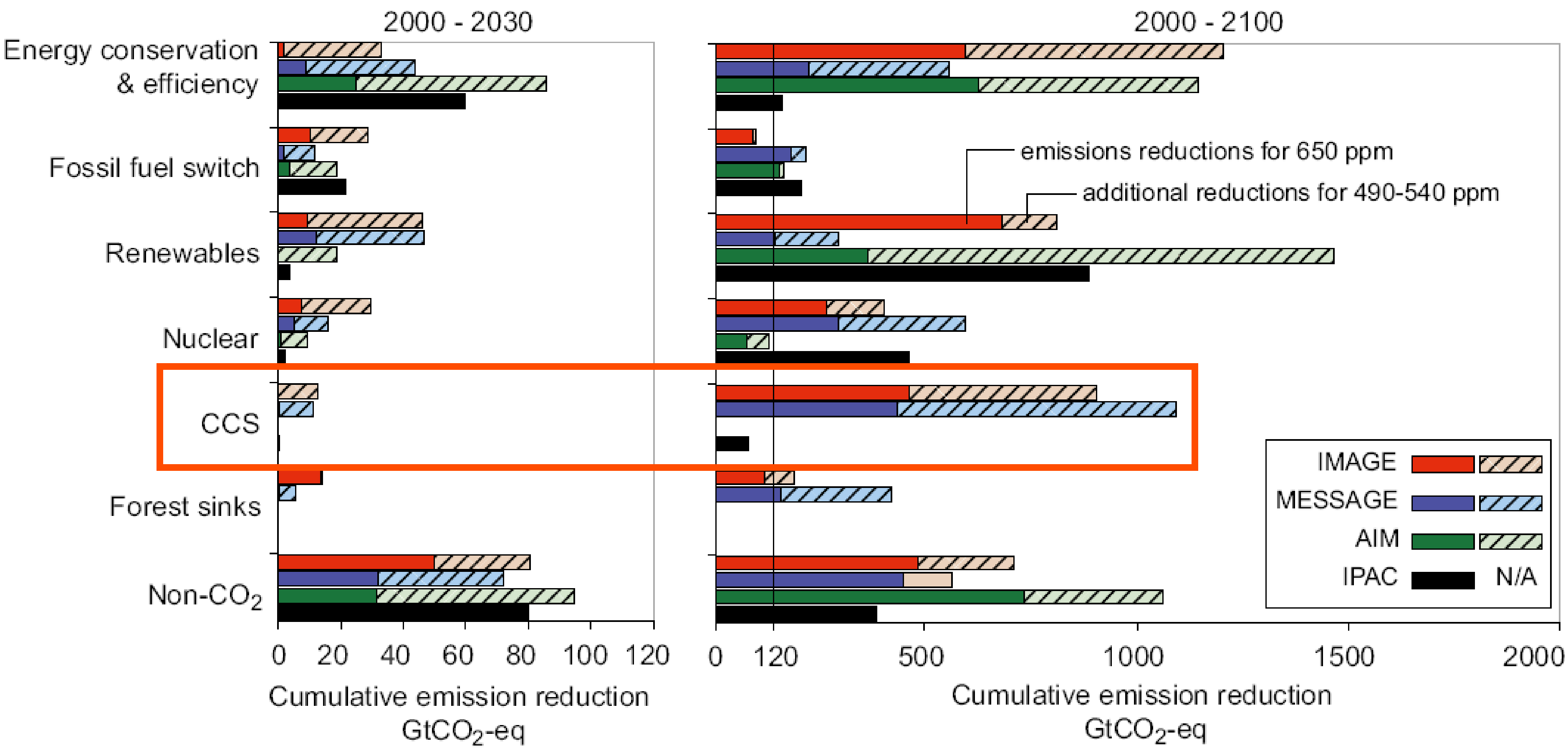
Cumulatively: 220 - 2200 $GtCO_2$ CCS used

Including CCS in the portfolio decreases overall mitigation costs by 30%



Source: IEEP analysis of IPCC special report

There is no *one* model

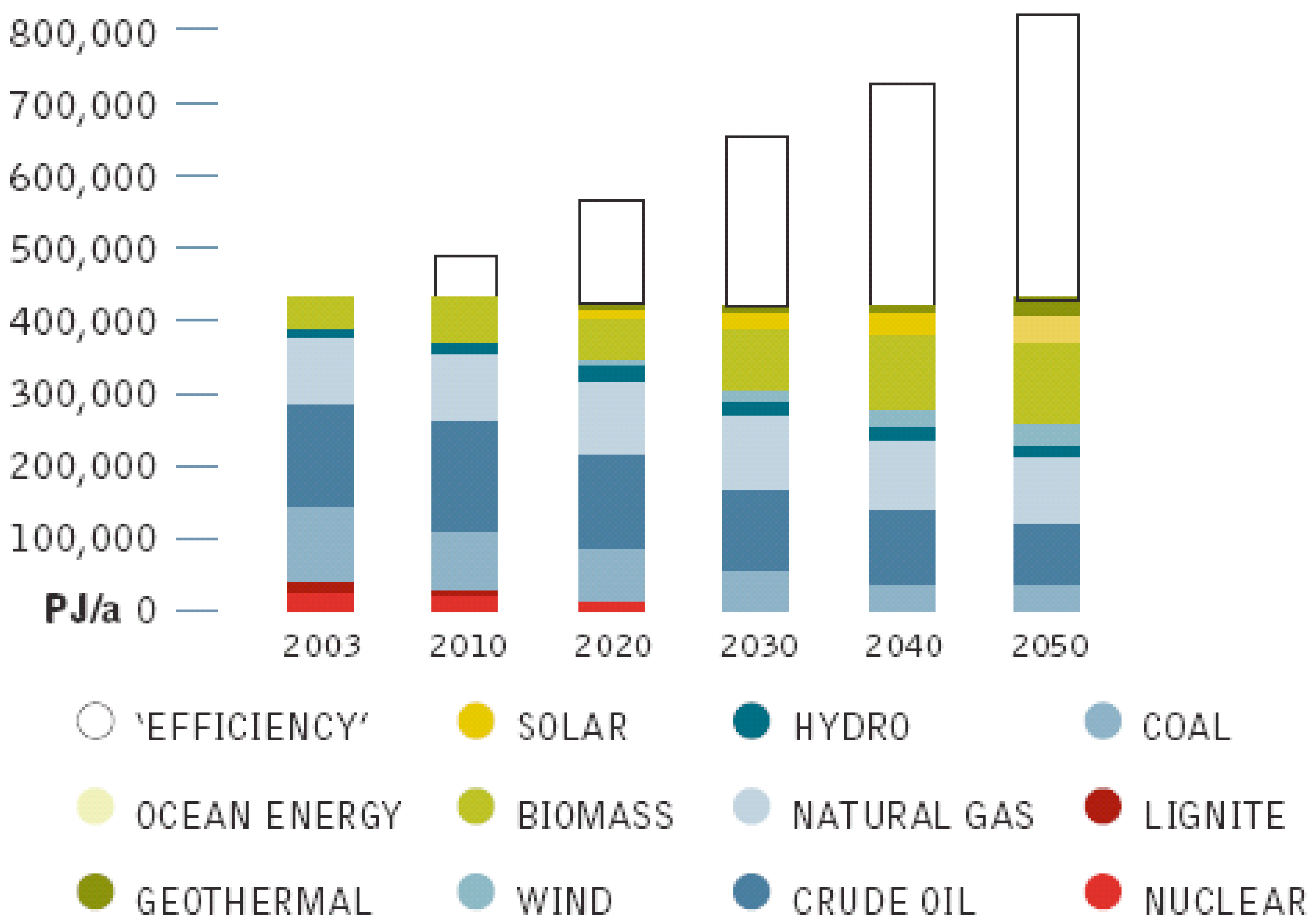


IPCC AR4, 2007

Shares of CO_2 emission reductions in 2050 by contributing factor (%)						
Scenarios	Map	Low Nuclear	Low Renewables	No CCS	Low Efficiency	TECH Plus
Fossil fuel mix in power generation	5.1	4.6	5.2	5.9	6.7	5.3
Fossil fuel generation efficiency	0.8	0.9	1.0	2.9	1.4	0.7
Nuclear	6.0	1.9	6.8	10.3	7.3	7.2
Hydropower	1.6	1.6	0.1	2.1	1.4	1.2
Biomass power generation	1.7	1.8	0.3	2.6	2.1	1.5
Other renewables power generation	6.1	6.6	4.5	11.3	7.2	7.2
CCS power generation	12.4	14.3	14.3	0.0	17.9	11.7
CCS coal-to-liquids	3.3	3.4	3.3	0.0	4.2	4.6
CCS industry	4.6	4.7	4.7	0.0	5.5	3.9
Fuel mix buildings and industry	7.7	7.5	7.4	5.5	9.6	7.3
Increased use of biofuels in transport	5.6	5.8	5.7	6.4	6.0	6.2
Hydrogen and fuel cells in transport	0.0	0.0	0.0	0.0	0.0	4.1
End-use efficiency	45.2	46.9	46.6	53.1	30.7	39.2
Total	**100**	**100**	**100**	**100**	**100**	**100**

IEA Energy technology perspectives, 2006

No CCS, no nuclear



Greenpeace energy [R}evolution, 2007

Primes model projections: 2030

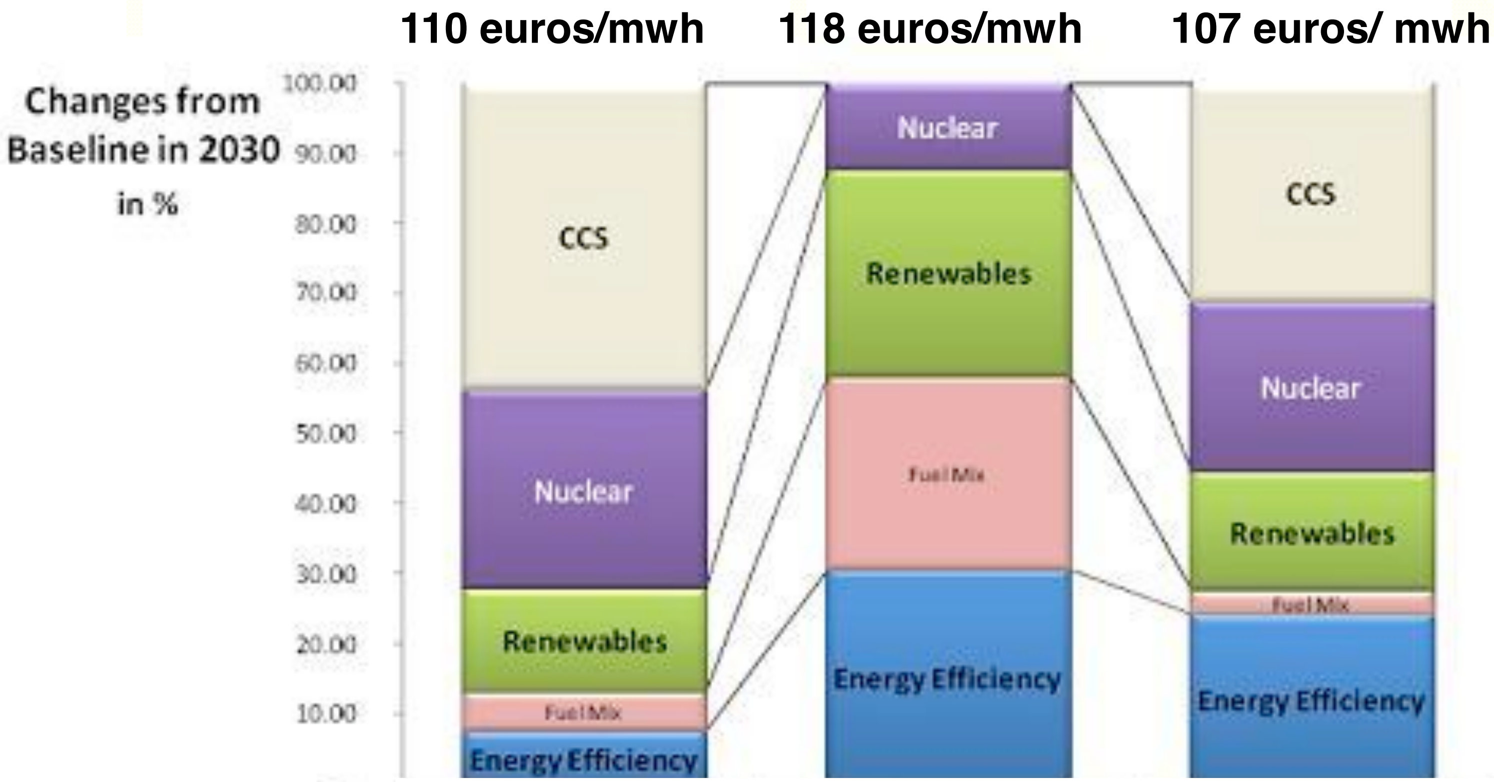
'Role of electricity' report (2007):

Four scenarios (Primes, Capros et al):

- Business as usual (BAU)
- A focus on efficiency and renewables (EffRES)
- A focus on nuclear and CCS (Supply)
- A balanced mix (Mix)

→ All three mitigation scenarios lead to 30% reductions

Sources of reductions

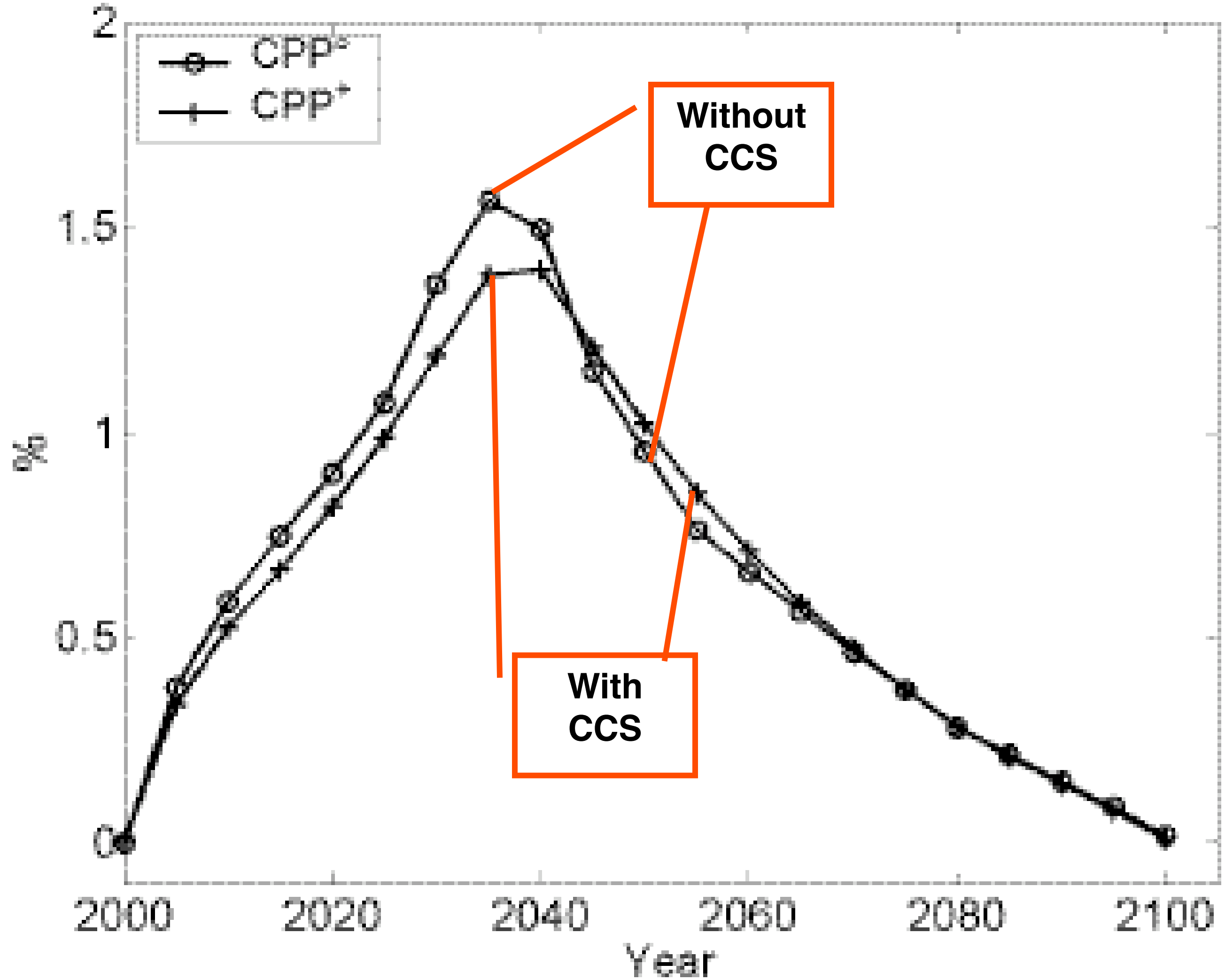


	Supply	EffRES	Mix
CCS	43.58	-	31.23
Nuclear	28.48	12.14	24.12
Renewables	14.55	29.57	16.96
Fuel Mix	5.74	27.42	3.42
Energy Efficiency	7.66	30.86	24.27

CCS Directive Primes model

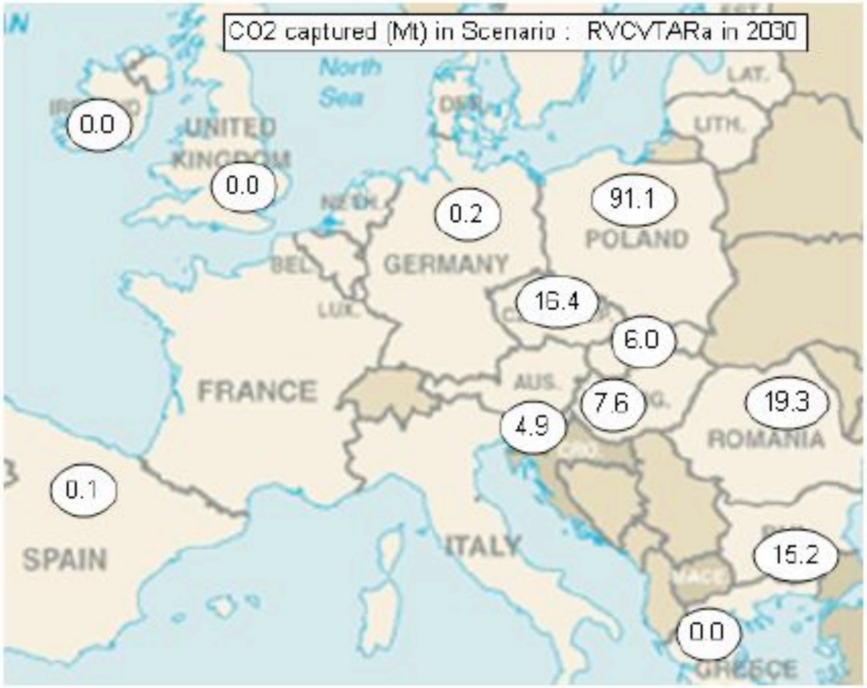
EU27	Scenarios	CO2 Captured (Mt/year)			CO2 captured as % of CO2 from Power and Steam			Total Energy Cost as % of GDP		
		2020	2025	2030	2020	2025	2030	2020	2025	2030
1	Baseline	0.0	0.0	0.0	*0.0*	*0.0*	*0.0*	9.57	9.26	8.95
2	Base-CCS1	0.0	4.3	62.0	*0.0*	*0.2*	*3.6*	9.58	9.28	8.99
3	Base-CCS2	0.0	5.0	90.5	*0.0*	*0.3*	*5.2*	9.58	9.28	8.99
4	CVtar-G	53.3	142.2	490.7	*4.0*	*10.1*	*32.5*	9.80	9.55	9.46
5	CVtar-A	27.2	150.5	483.3	*2.2*	*11.1*	*32.8*	10.19	9.94	9.75
6	RVCVtar-G	7.2	33.3	219.2	*0.6*	*2.7*	*17.5*	9.88	9.68	9.55
7	RVCVtar-A	7.0	19.7	160.7	*0.6*	*1.7*	*13.2*	10.14	9.93	9.75
8	RVCVtar-G-CCS1	7.2	33.1	300.7	*0.6*	*2.7*	*24.1*	9.88	9.69	9.59
9	RVCVtar-G-CCS2	7.2	52.1	424.3	*0.6*	*4.2*	*32.7*	9.90	9.70	9.63
10	RVCVtar-A-CCS1	6.9	20.6	266.9	*0.6*	*1.8*	*22.2*	10.14	9.94	9.79
11	RVCVtar-A-CCS2	6.9	26.5	391.3	*0.6*	*2.2*	*31.0*	10.15	9.95	9.81
12	RVCVtar-A-CCS1R	37.2	118.1	326.2	*3.2*	*10.0*	*26.9*	10.15	9.96	9.79
13	RVCVtar-A-CCS2R	75.0	176.5	517.1	*6.2*	*14.4*	*39.5*	10.17	9.99	9.82
14	RVCVtar-A-CCS2N	0.0	3.5	272.6	*0.0*	*0.3*	*22.7*	10.15	9.94	9.80
15	RVCVtar-A-CCS2Nuc	7.1	22.6	352.1	*0.7*	*2.1*	*29.7*	10.17	9.97	9.81
16	RVCVtar-A-noCCS	0.0	0.0	0.0	*0.0*	*0.0*	*0.0*	10.15	9.96	10.07
17	RVCVtar-A-subs	0.2	21.6	210.7	*0.0*	*1.8*	*17.3*	10.14	9.93	9.77

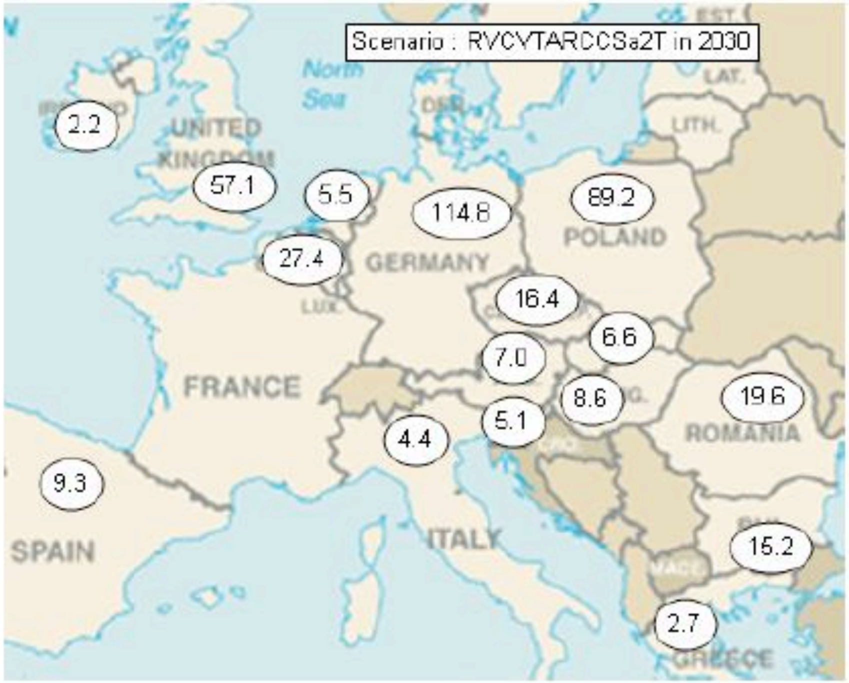
Mitigation GDP loss with and without CCS



Source: Bauer et al. 2004

Capture by country: 2030

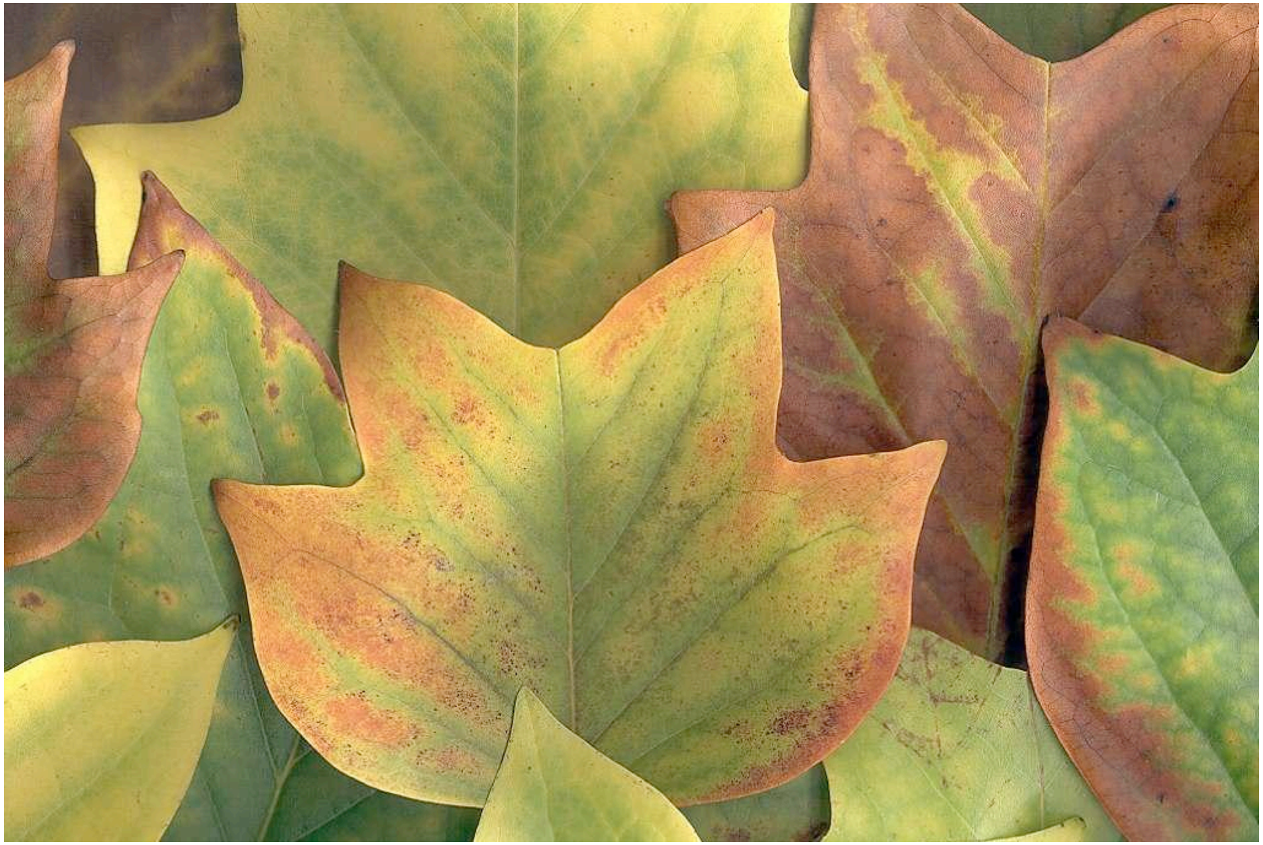




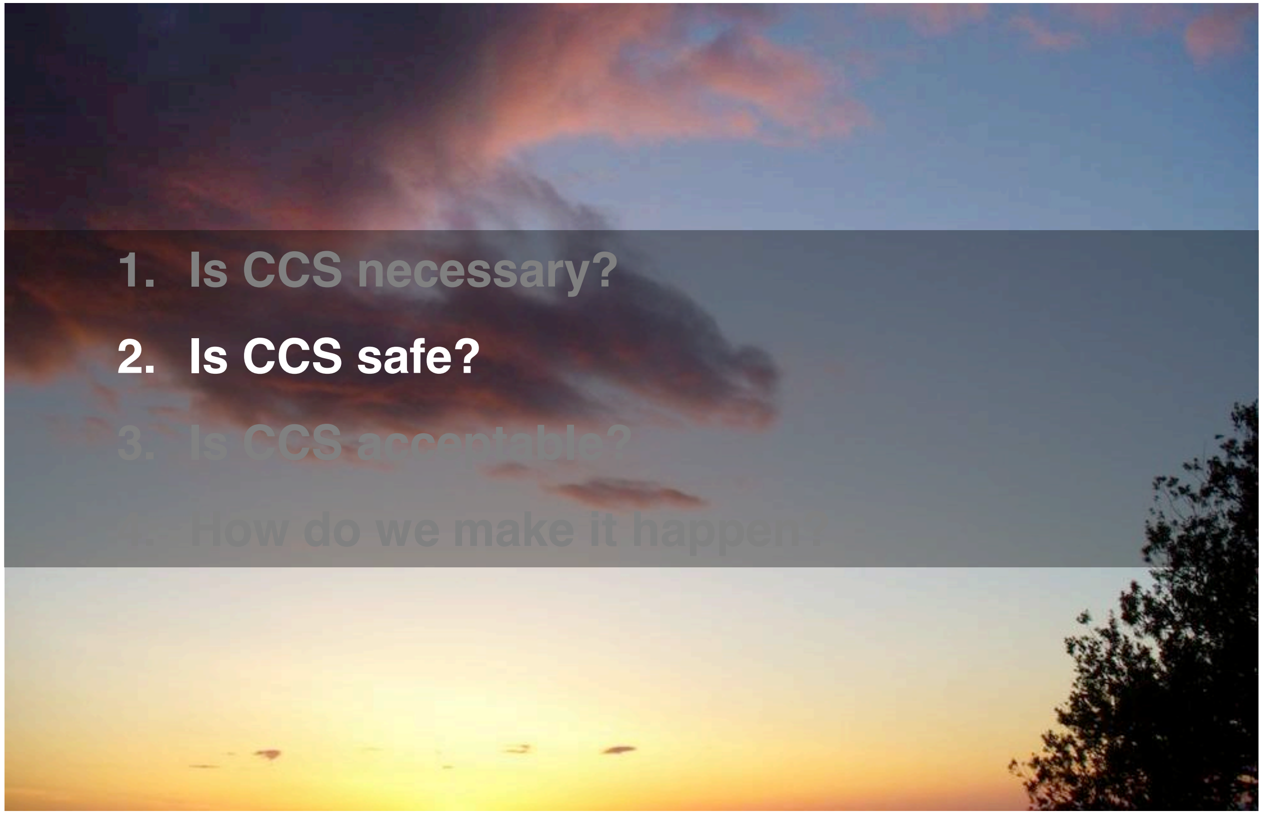
(France barely registers in any scenario)

Is CCS necessary?

- Aggregate figures can be misleading:
  - Need to know where and when specific challenges arise, e.g. new coal capacity – lock-in.
- Technical potential is not the best indicator of potential
  - Political will
  - Powerful constituencies
  - Public acceptance
  - Financial considerations
- Because there is no hard and fast answer the most important thing to avoid is *failure to act*



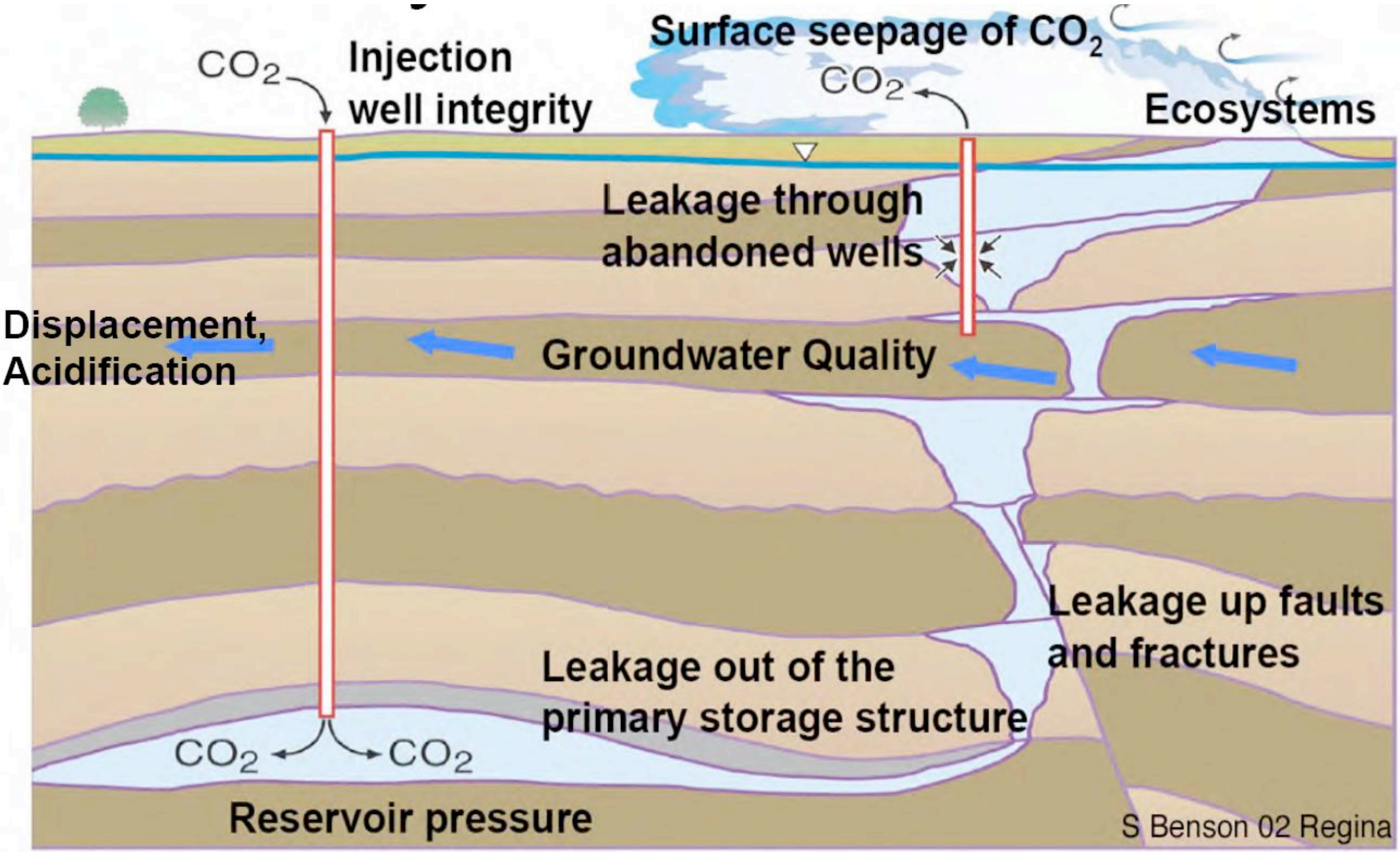
Key questions



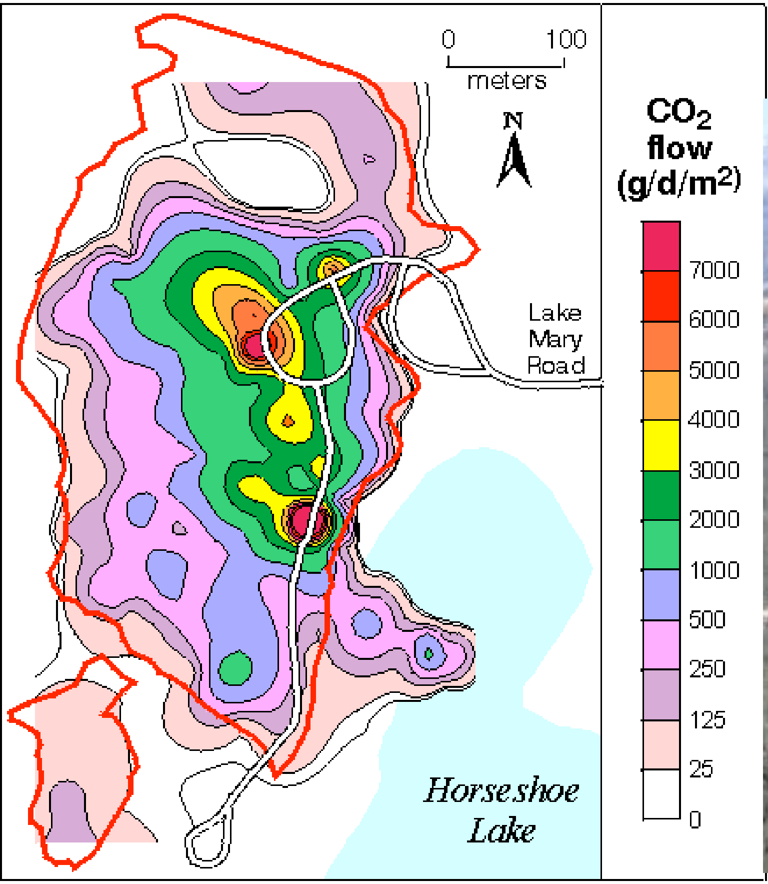
1. Is CCS necessary?
2. Is CCS safe?
3. Is CCS acceptable?

How do we make it happen?

Leakage pathways

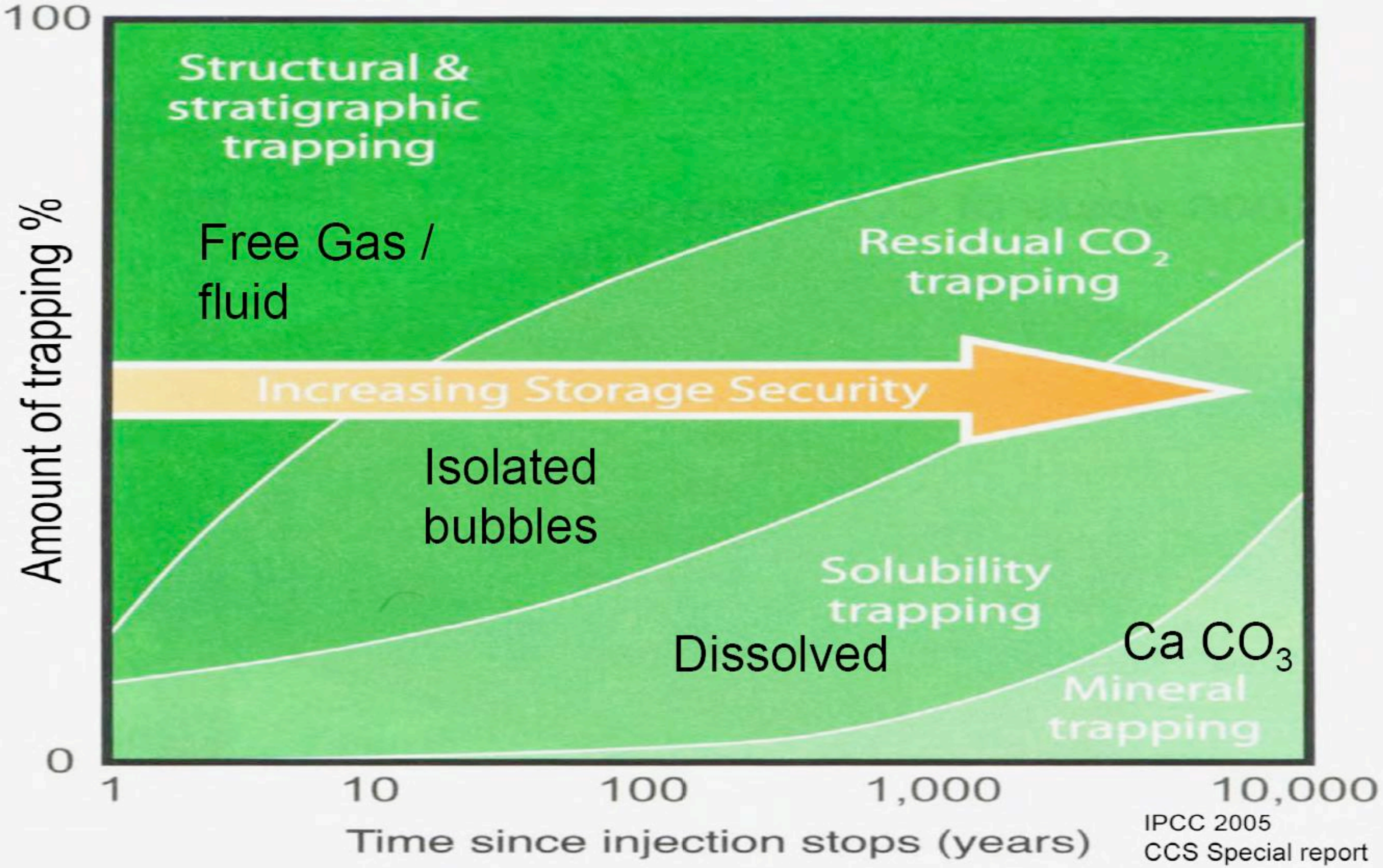


Local impacts



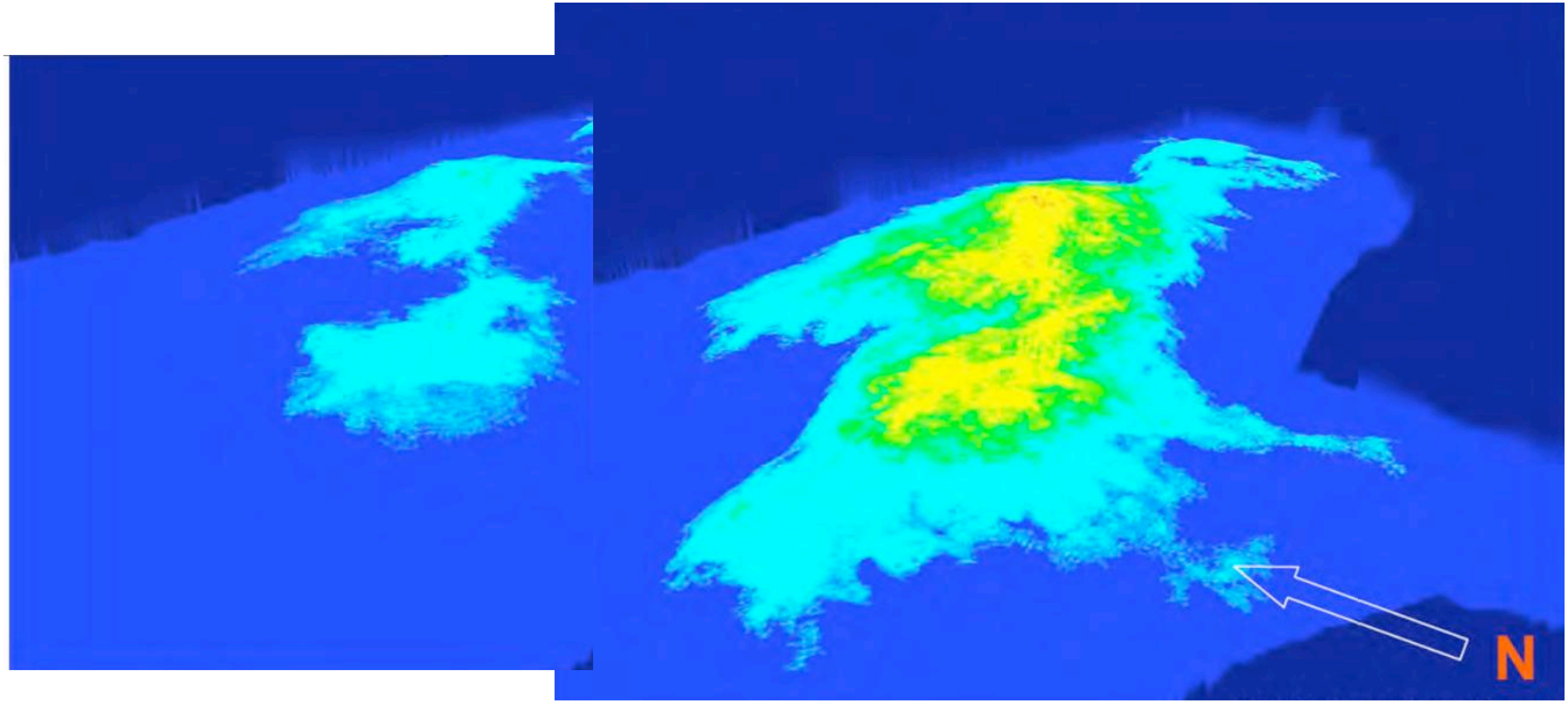
Graphic and photo: USGS

Trapping types over time

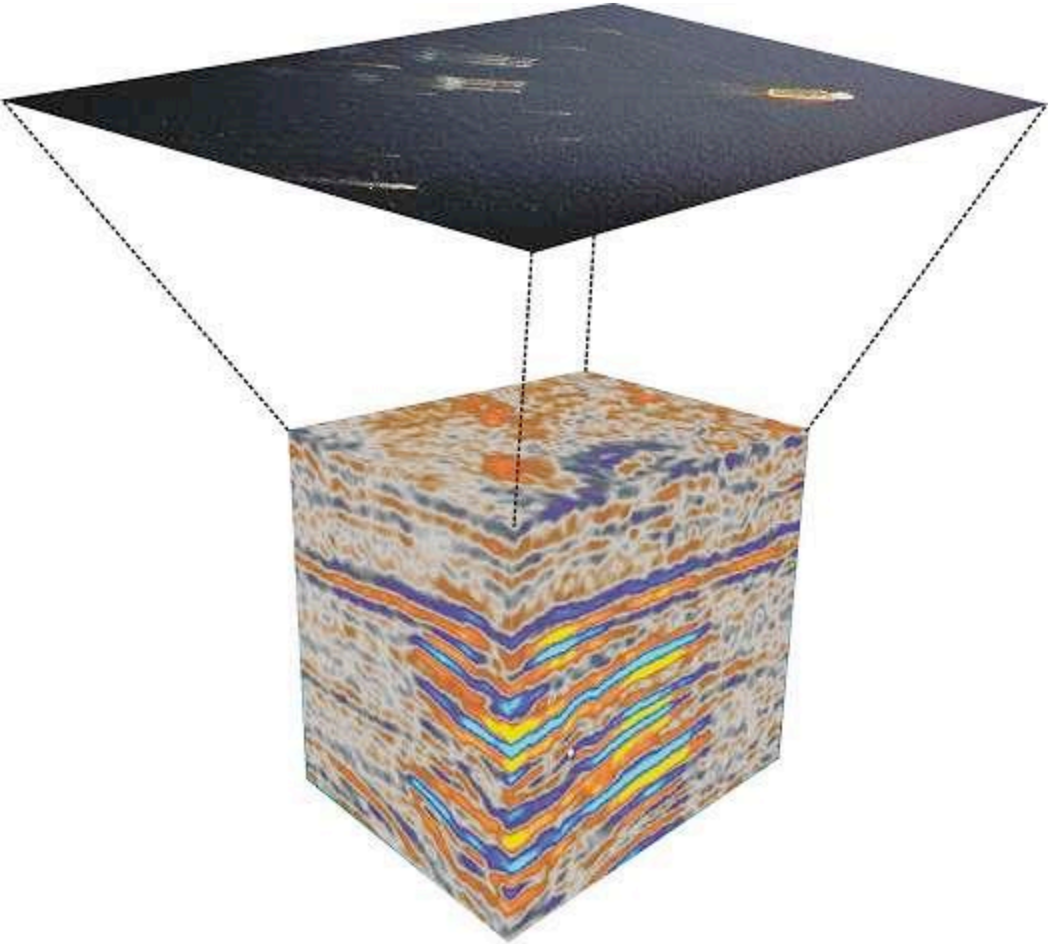


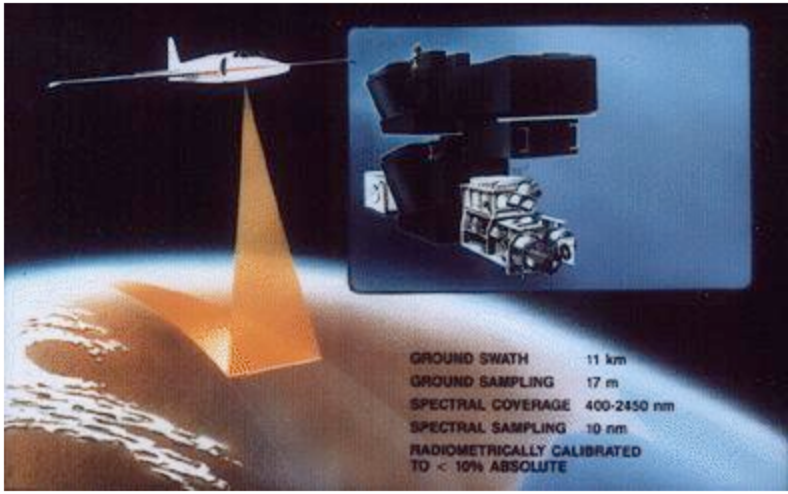
IPCC 2005
CCS Special report

Modelling and monitoring



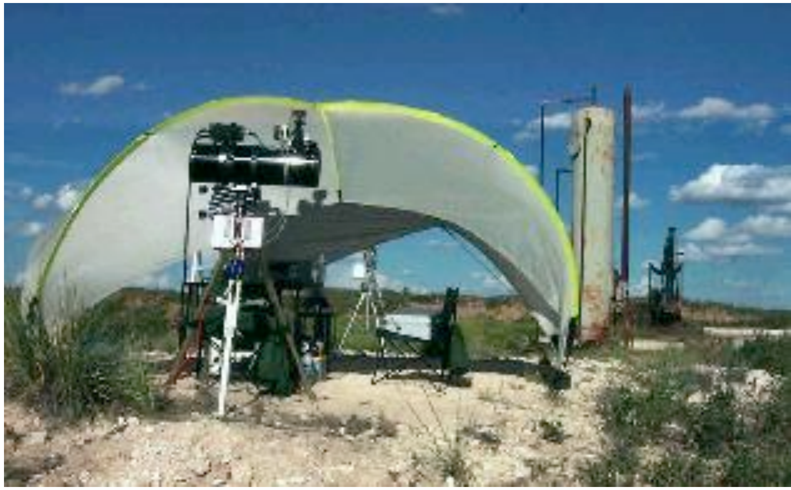
Source: S. Haszeldine, U. Edinburgh



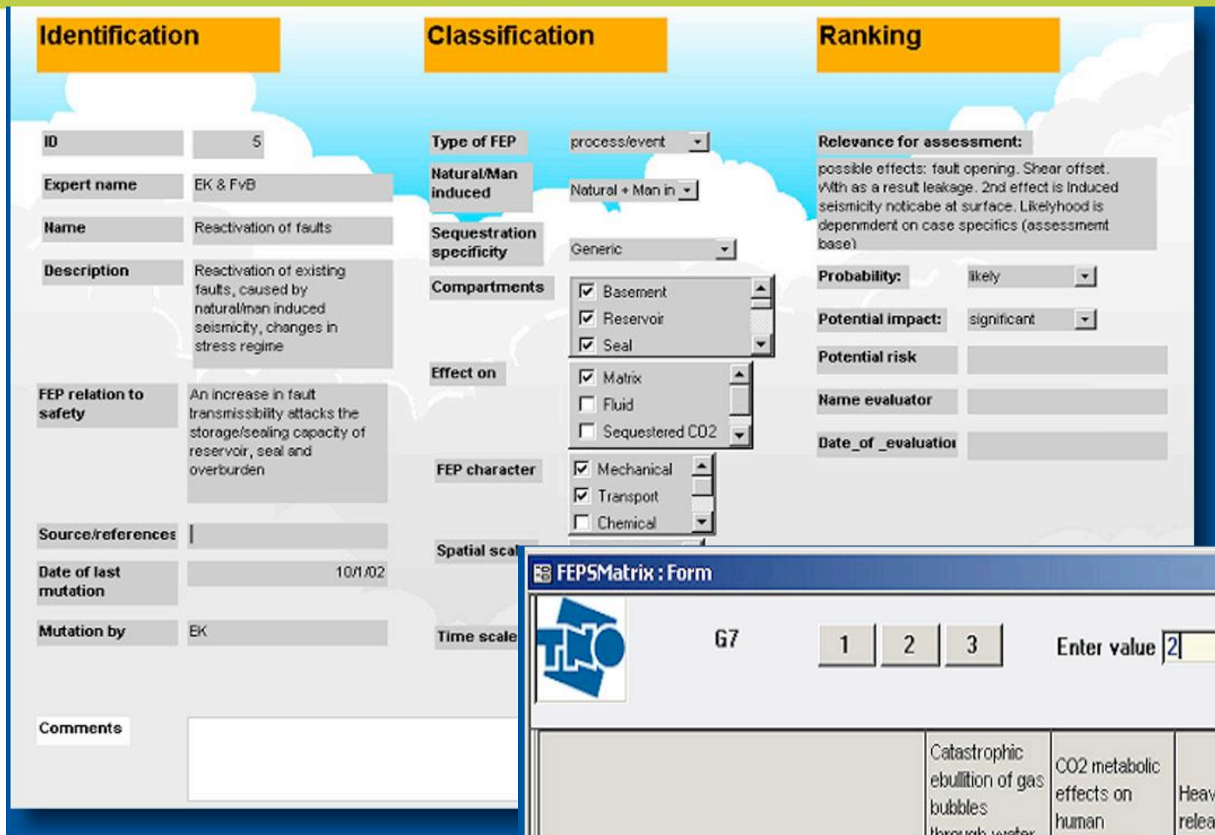


GROUND SWATH 11 km
GROUND SAMPLING 17 m
SPECTRAL COVERAGE 400-2450 nm
SPECTRAL SAMPLING 10 nm
RADIOMETRICALLY CALIBRATED TO < 10% ABSOLUTE

LI-7500



Risk assessment: FEP database, scenarios



Identification

ID: 5
Expert name: EK & FvB
Name: Reactivation of faults
Description: Reactivation of existing faults, caused by natural/man induced seismicity, changes in stress regime
FEP relation to safety: An increase in fault transmissibility attacks the storage/sealing capacity of reservoir, seal and overburden
Source/references:
Date of last mutation: 10/1/02
Mutation by: EK
Comments

Classification

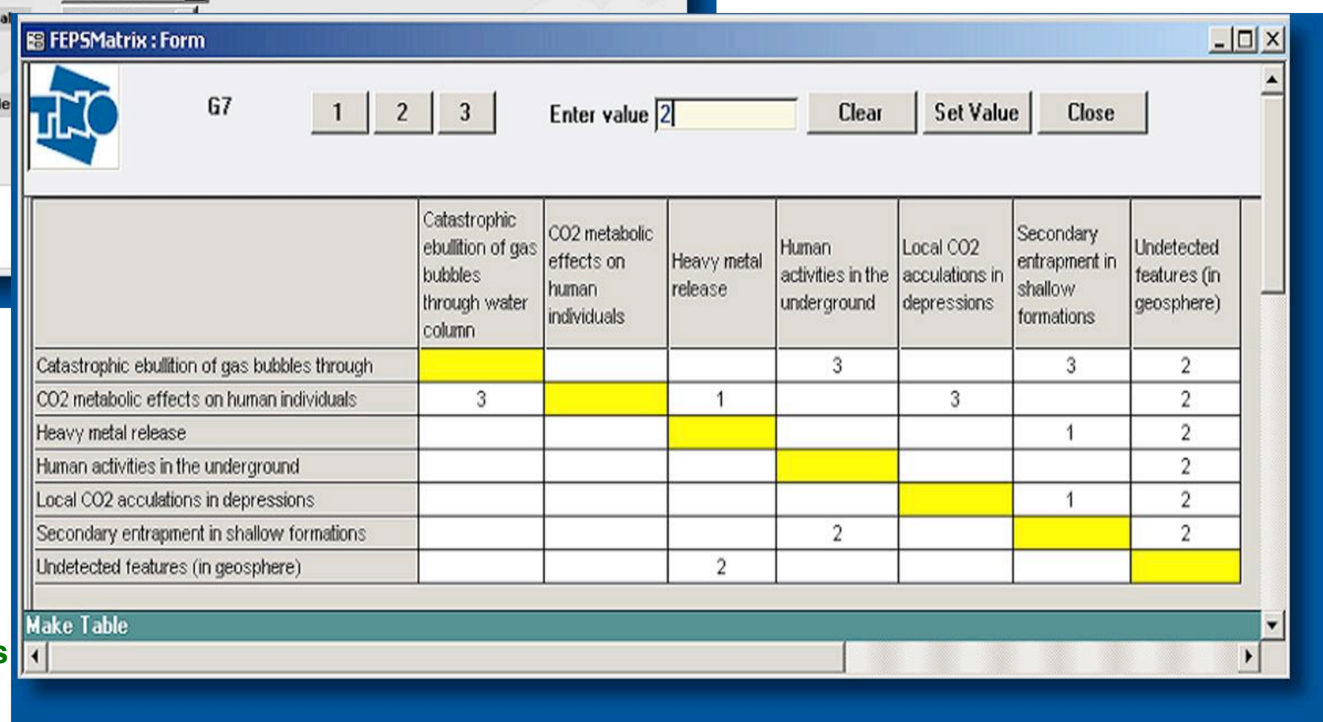
Type of FEP: process/event
Natural/Man induced: Natural + Man in
Sequestration specificity: Generic
Compartments: ☑ Basement ☑ Reservoir ☑ Seal
Effect on: ☑ Matrix ☐ Fluid ☐ Sequestered CO2
FEP character: ☑ Mechanical ☑ Transport ☐ Chemical
Spatial scal
Time scale

Ranking

Relevance for assessment: possible effects: fault opening. Shear offset. With as a result leakage. 2nd effect is Induced seismicity noticabe at surface. Likelyhood is depenmdent on case specifics (assessmemt base)
Probability: likely
Potential impact: significant
Potential risk:
Name evaluator:
Date_of_evaluatioi

Main ingredient: 'expert judgement'

Sources: Shell, TNO



FEPSMatrix : Form

G7 | 1 | 2 | 3 | Enter value 2 | Clear | Set Value | Close

	Catastrophic ebullition of gas bubbles through water column	CO2 metabolic effects on human individuals	Heavy metal release	Human activities in the underground	Local CO2 acculations in depressions	Secondary entrapment in shallow formations	Undetected features (in geosphere)
Catastrophic ebullition of gas bubbles through				3		3	2
CO2 metabolic effects on human individuals	3		1		3		2
Heavy metal release						1	2
Human activities in the underground							2
Local CO2 acculations in depressions						1	2
Secondary entrapment in shallow formations				2			2
Undetected features (in geosphere)			2				

Make Table

Uncertainties in Risk Assessment

Benchmarking exercise where 7 organizations using own methods and tools made independent risk assessment of the same Chemical Installation.

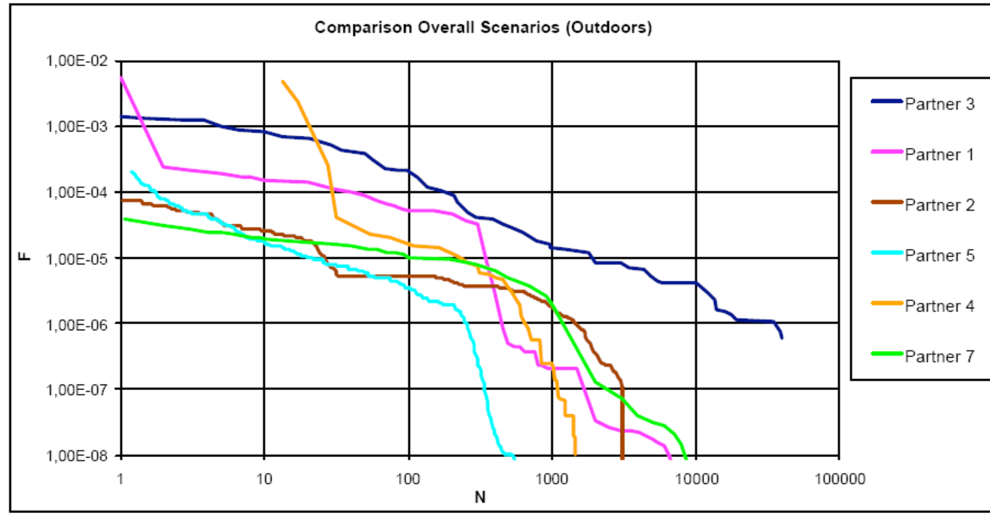


Figure 2. Discrepancy in societal risk calculations (based on fictitious population data)

Variations in individual societal risk calculations (based on fictitious population data).

Variations in individual safety distance calculations: Maximum and minimum distances for the isorisk curve 10-5 yr-1.

Source: Det Norske Veritas (DNV)

Risk perception and Communication

- People's beliefs and values influence the way they perceive risks and benefits.
- Risk is particularly tricky where there are subjective/ probabilistic elements.
- An early engagement strategy based on participation and dialogue is essential.
  - Communications must be clear and tailored
  - Communications must come through trusted sources
  - Communication should attempt to understand public's attitude toward 'acceptable' risks

The primary objective of risk communication is not to change public opinion about the size of the risk but rather to build trust about the corporate commitment to contain and control it.

– *AWMA Publications, http://gcisolutions.com/bertawma02.htm*

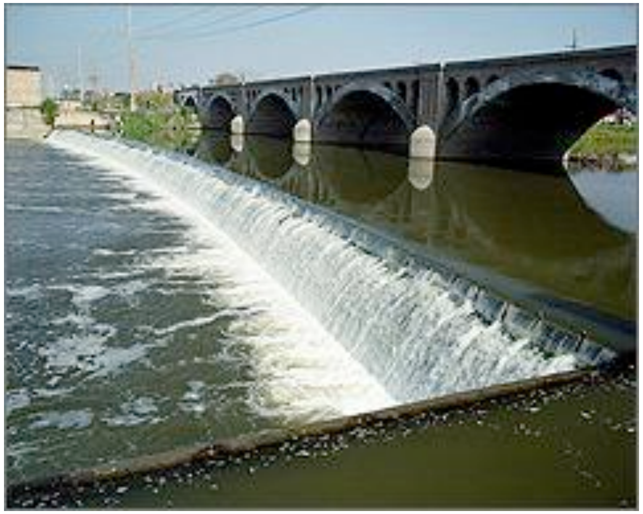
Is CCS safe?

- Short answer: probably
  - *Technically*: likely to be well within industry capabilities to control leakage.
  - *Main possible problem:* management failures, poor decision making.
- Compared to what?
  - Current coal emissions already a killer
  - Power industry, natural gas transport and storage are good analogues
- How can we prove it?
  - Experience with CO2 to date, natural analogues, natural gas
  - An element of uncertainty remains with storage
  - A barrier towards the public: communicating risk

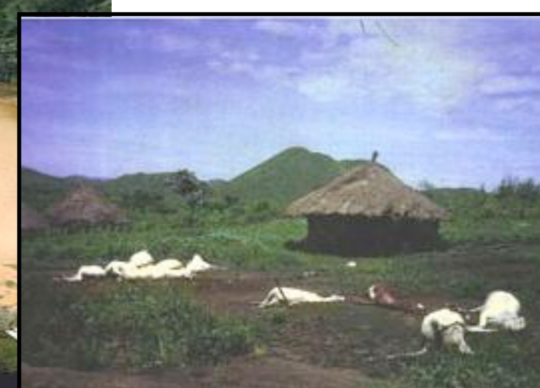
Key questions

1. Is CCS necessary?
2. Is CCS safe?
3. Is CCS acceptable?
4. How do we make it happen?

The model: renewables and efficiency…



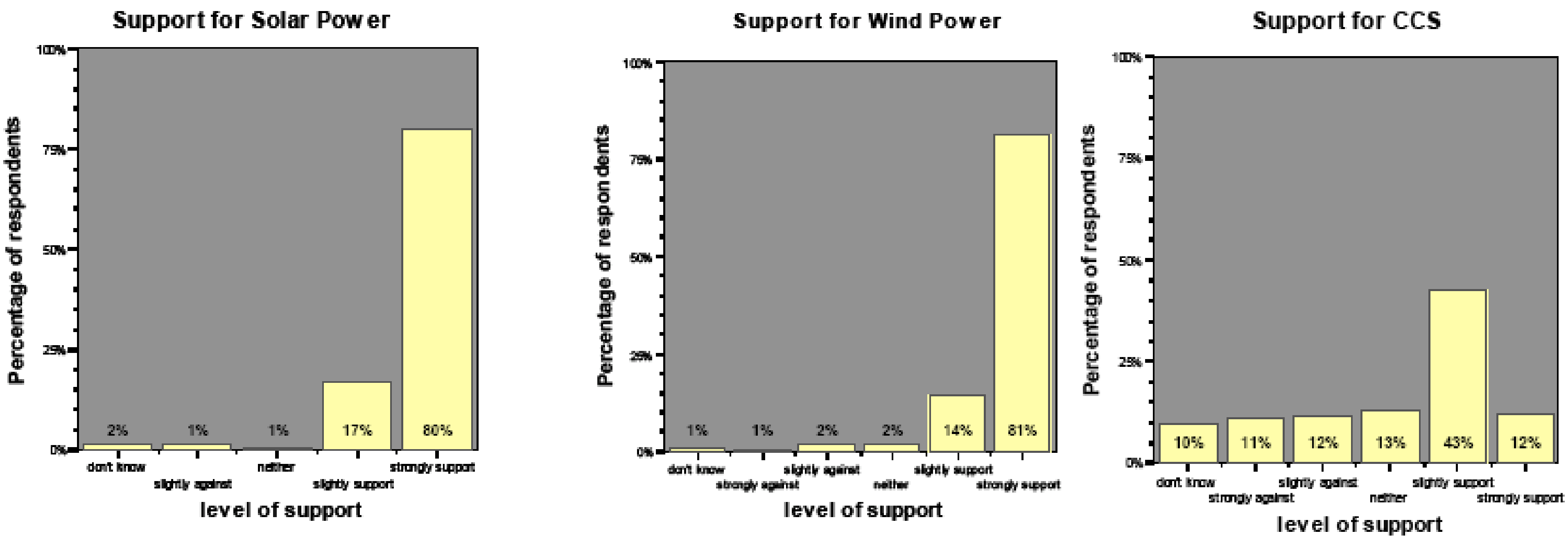
The warning…



Renewable energy sources and energy efficiency and conservation are proven, mature and environmentally friendly…CO_2 Capture and Storage must not divert public investments or political attention away from renewable energy and energy efficiency.

- CAN Europe position

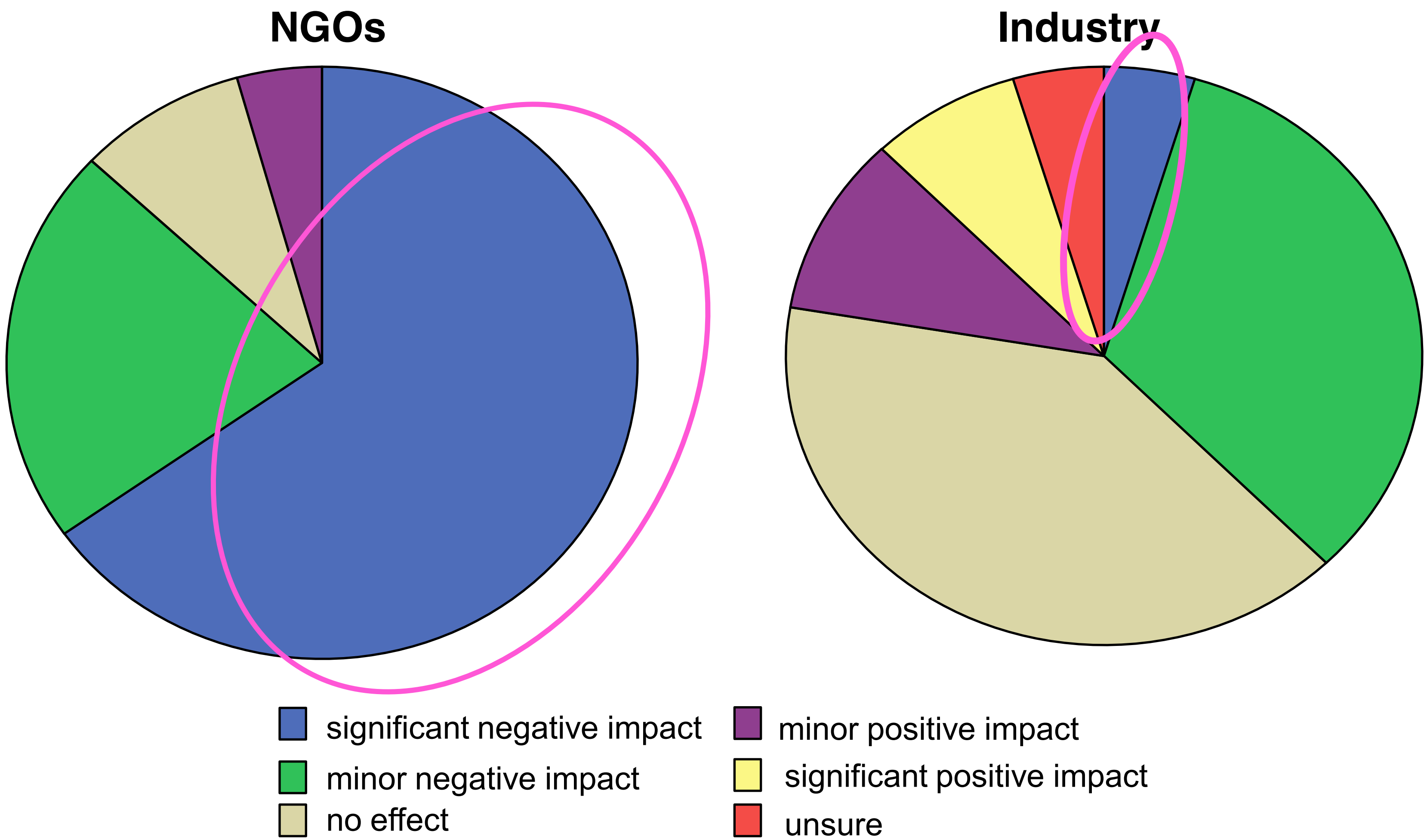
Renewables still most popular



Interviewee support levels after explanatory discussions on all technologies

Source: Tyndall Centre

ACCSEPT survey: Impacts of CCS on other low carbon technologies



If you are to exclude the use of nuclear you need to create a situation where fossil fuel power stations are made as carbon friendly as possible… If you have a choice to bury CO2 or plutonium, personally would prefer to bury CO2

- NGO interviewee

‘Hundreds of deaths caused by volcanic leaks of carbon dioxide from Cameroon to California are worrying experts seeking ways to bury industrial emissions of the gas as part of an assault on global warming.’

- Reuters article (8 July 2006)

Source: S. Haszeldine, U. Edinburgh

Leakage rates need to be near-zero or the benefits to the climate will be negligible…There is still a lack of experience to prove long-term storage and safety in a variety of locations

– CAN Europe CCS position

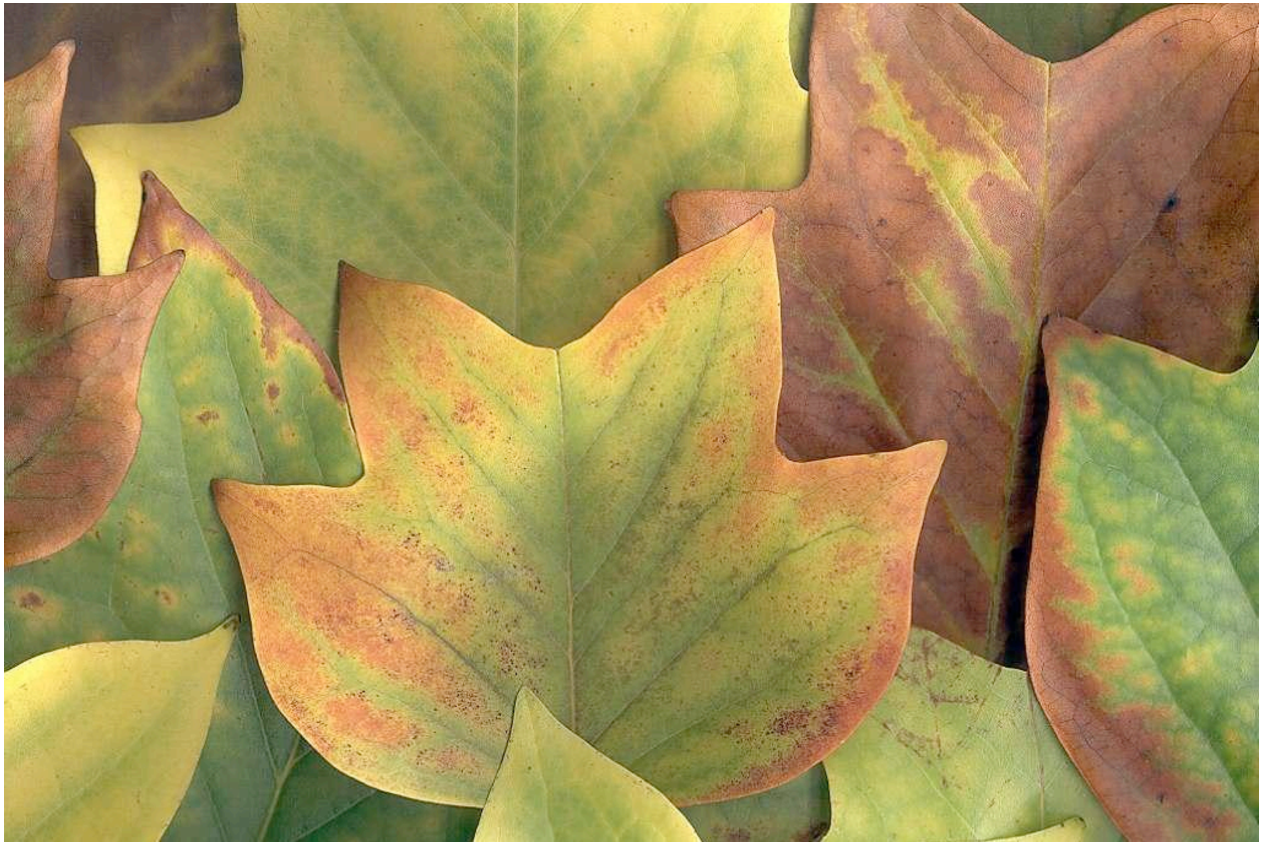
Prioritised stakeholder concerns

	R&D	Ind	Gov	NGO	P
Dangerous levels of leakage for humans			yellow	red	yellow
Impact on ecosystems			yellow	red	yellow
CO2 Pipeline Safety					
Impact on drinking water	yellow			yellow	red
Impacts on property values	yellow	yellow			yellow
Mineral rights / landowner approvals		yellow			yellow
Cost of Deployment	yellow	red *	green *	red	yellow
Scale of Deployment	yellow	yellow	yellow	red	
Importance of broader energy context in shaping attitudes			yellow	yellow	red
Are efforts to communicate adequate			yellow	yellow	yellow
Ability of CCS to reduce emissions dramatically in short term	green	green	green	yellow	yellow
Diversion of efforts from renewable energy			yellow	red	yellow
Possible competition with nuclear			green	green	green
Impact of EOR on extending oil market		green	green	yellow *	yellow
Impact of CCS on extending/expanding coal market		green		red	
Full cycle impact of fossil fuel use				red	
Differential acceptability of different kinds of CCS			yellow	red	yellow
Bridging or long-term?		green	yellow	red	yellow

Source: IEEP

Is CCS acceptable?

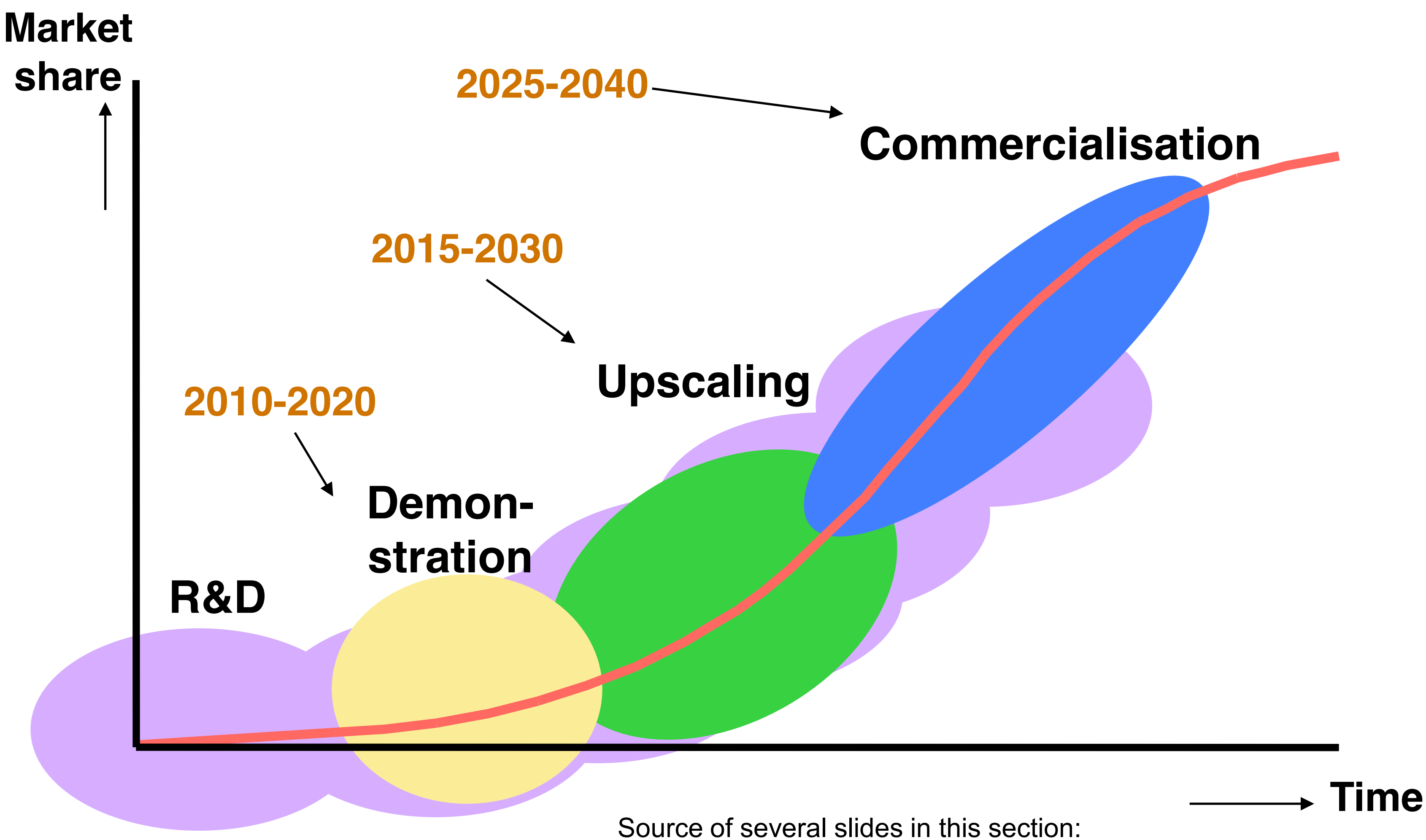
- To most stakeholders it is, although often as a second-best necessity
- Everyone is concerned about costs – they must show signs of being manageable
- Risk perception is as yet not fully formed and needs to be carefully managed
- Projects on the ground may mobilise new interest groups



Key questions

1. Is CCS necessary?
2. Is CCS safe?
3. Is CCS acceptable?
4. **How do we make it happen?**

CCS deployment curve



Source of several slides in this section:
Heleen de Coninck, ECN

EU Emissions Trading Scheme

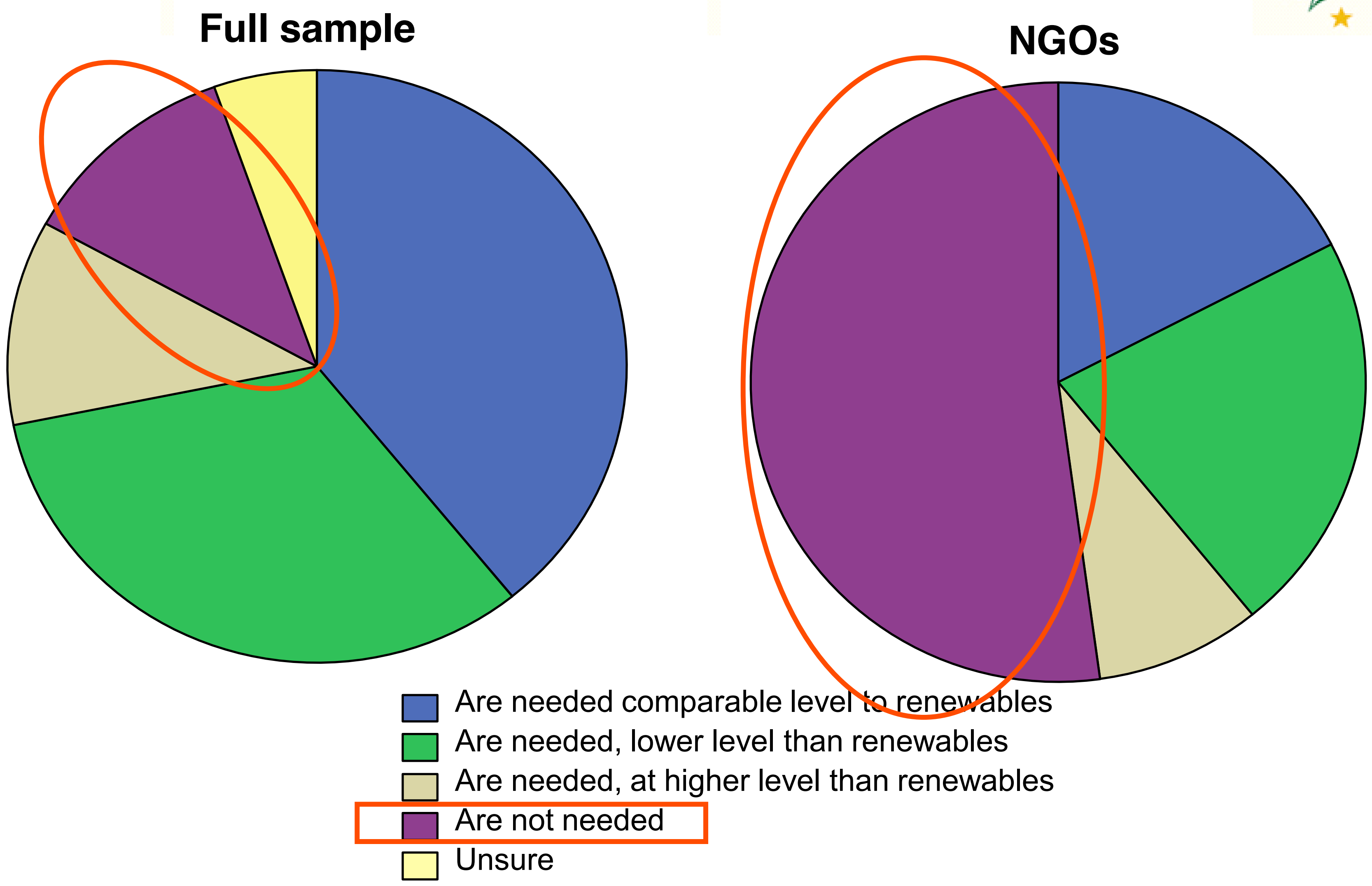
- The basic option already on the table
- Cost-effective instrument, if strong incentive given
- However, if EUA prices remain low:
  - Preference for low-cost abatement options
  - Innovation market failure
  - ETS unlikely to lead to CCS deployment

→ Need for complementary policies

Complementary policies

- Public financial support (most likely MS level)
  - Investment support
  - Feed-in subsidies
  - CO_2 price guarantee
- Low-carbon portfolio standard with tradable certificates (most likely EU level)
- CCS obligation (EU level)
- (Public-private partnerships)

Survey: financial incentives for CCS



Maximum value of FITs (c/kwh)

	Hydro	Geothermal	Onshore wind	Offshore wind	PV	Biomass	CHP
Austria	6.25	7	7.8	-	60	16.5	10
France	0.42	-	0.69	-	-	0.42	-
Germany	9.67	15	8.7	9.10	57.4	16.10	-
Luxembourg	-	-	10	-	10	10	10
Netherlands	6.8	-	4.9	6.8	6.8	6.8	-
Spain	6.49	6.49	6.21	6.21	39.6	6.85	-

Which is appropriate when?

	Demonstration 2010-2020	Up-scaling 2015-2030	Commercialisation 2025-2040
ETS (weak)	Yes	Yes	Yes
ETS (strong)	Yes	Yes	Yes
Investment support	Yes	No	No
Feed-in subsidy	Yes	Yes	No
CO_2 price guarantee	Yes	Yes	No
Portfolio + certificates	No	Yes	Yes
Obligation	No	Yes	Yes

Multicriteria analysis

	Effectiveness	Risk + cost burden	Consistency	Feasibility
ETS (low price)	-	0	+	+
ETS (high price)	+	+	+	+/-
Investment support	+	-	0	-
Feed-in subsidy	+	-	0	-
CO_2 price guarantee	+	-	0	-
Portfolio + certificates	+	+	0/-	+/-
Obligation	+	+	0/-	+

EU policy approach

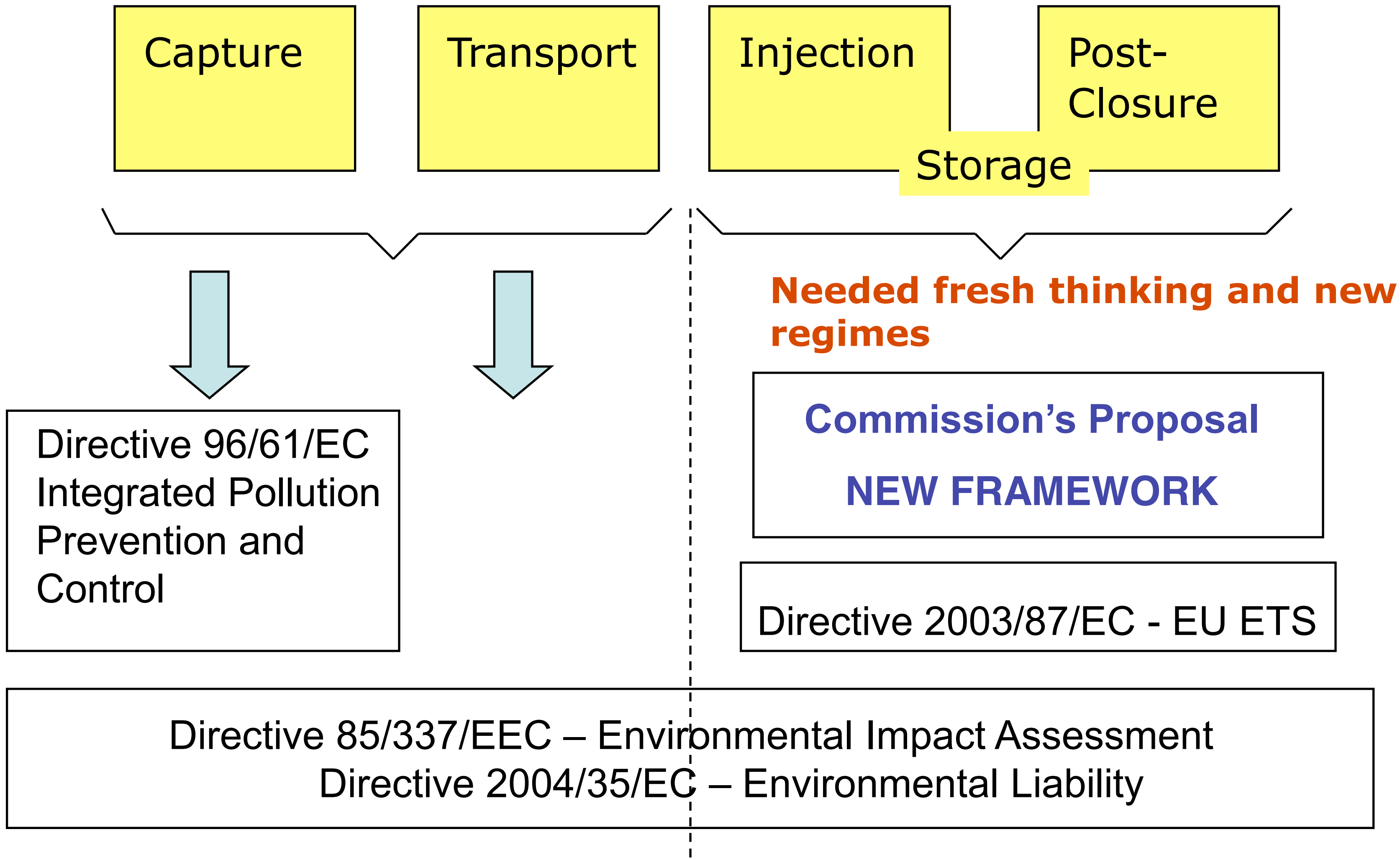
Basic requirements for successful regulation

- **Legal compliance, liability resolved, regulatory oversight established**
- **Agreed methodology for pre-injection site selection and risk assessment**
- **Monitoring and verification techniques agreed; long-term responsibility**
- **Public acceptance using participatory methodology**

And additionally:

- **Ensuring that it happens**

On 23 January 2008 the Commission proposed a Directive to enable CCS in the EU.



Regulatory structure

- Current restrictions cleared up – waste, landfills
- Existing regimes used for most aspects: IPCC, EIA, Liability Directive
- Capture:
  - addition of eligibility for EU ETS, and obligation to make good leakage
  - Obligation to leave space for future capture – ‘capture ready’ – and to investigate future storage options
- Storage:
  - New regulatory approach
  - Exploration and storage permit requirements spelled out
  - Operation, closure and post-closure obligations
  - Member States rule on permits; EU has advisory role
  - Transfer of liability to State after process determines a closed site is no longer a risk
  - Third party access facilitated

Storage: requirements for a suitable regime and EU proposal

- **Agreed methodology for pre-injection site selection and risk assessment**
  - Member States can determine the areas from which storage sites can be selected
  - Environmental Impact Assessment Directive applies
  - Suitability of storage site determined by site characterisation and assessment pursuant certain criteria (Annex I)
- **Legal compliance, liability resolved, regulatory oversight established**
  - Exploration subject to permit requirement and financial security
  - Corrective measures in case of significant irregularities or leakages
  - Storage permit can be withdrawn by competent authority
  - Competent authority taking over responsibility for storage site and recovering any costs incurred from former operator
  - Penalties applicable to infringements

Elements of EU proposal cont'd

- **Monitoring and verification techniques agreed; long-term responsibility**
  - Monitoring Plan according to certain criteria
  - Closure and post-closure obligations
  - Hand over of liability to the state once criteria are met

- **Public acceptance using participatory methodology**
  - Consultation process: meetings under the 2nd European Climate Change Programme Working Group III on CCS + Public internet consultation + stakeholder meeting
  - Public participation under the EIA process

Underlying logic:

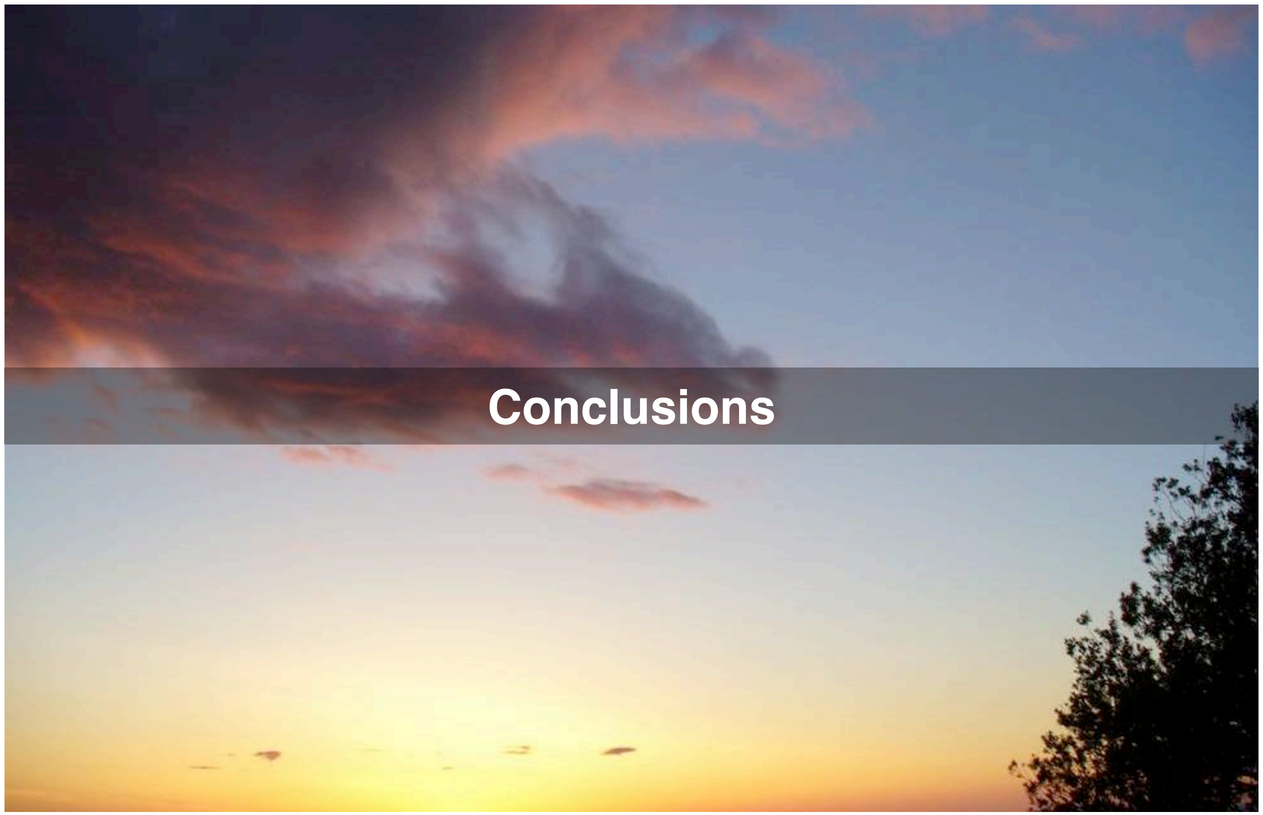
"for properly selected, managed and decommissioned sites, the risk of leakage, and a fortiori of irreversible consequences, is in fact low" (IPCC Special Report)

Support to develop CCS

- Inclusion in the ETS – CCS will not have to buy allowances at auction
- DG Research continues support
- Member States encouraged to put forward funding – e.g. part of the 20% of auctioning revenue suggested to be put toward clean technology
- Possibility for more EU support considered by the end of 2008

What *hasn't* been done

- Commission, Council and industry have called for 'up to' 12 demonstration plants by 2020: no EU commitments, few firm Member State commitments
- Commission initially proposed *mandatory* CCS by 2020:
  - Backed down in proposal after opposition
  - Impact assessment shows it's feasible
  - Parliamentary rapporteur interested


Conclusions

Conclusions

- Economics:
  - The *potential* to be high-volume, low cost
  - Capture has room for improvement – how do we model it?
- Safety:
  - Technical potential to store safely
  - Management/ regulatory oversight will be key
  - Proving safety and convincing the public *may* be more difficult
- Stakeholder opinion:
  - No *a priori* opposition, but support is contingent
  - Division over approach (caution vs. enthusiasm) is problematic
- European Regulation:
  - Rationalizes current legislative restrictions (e.g. waste, landfills)
  - Uses existing regulations where possible – IPCC, EIA
  - EU ETS eligibility and obligation to make good leakage
  - Site selection and management requirements in new package
  - Other than 'capture readiness' no specific requirements

My view…

- Don’t allow CCS to be promoted as hype – it should either contribute or get out of the way. The failure of CCS is entirely likely if not forced in; the failure of alternatives is entirely likely if CCS is not forced out.
- If it is to be an option you can’t sit on the fence: make it prove itself by devoting public funding (which leverages private money).
- Subject demonstrations to defined timetables and goals.
- Create a kind of requirement: emissions standard or mandatory CCS rather than leaving it to the ETS market alone – price uncertainty and future political will are too uncertain.
- A requirement will make alternatives to CCS even more attractive because the counterfactual probably isn’t solar energy but coal pollution.

Thank you

Contacts

London Office
28 Queen Anne's Gate
London SW1H 9AB
UK
Tel: +44 (0)207 799 2244
Fax: +44 (0)207 799 2600

Brussels Office
55 Quai au Foin/Hooikaai
B-1000 Brussels
Belgium
Tel: +32 (0) 2738 7482
Fax: +32 (0) 2732 4004

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