

Geological deep storage of CO₂ : the problem

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EU storage
North Sea
Trans-boundary

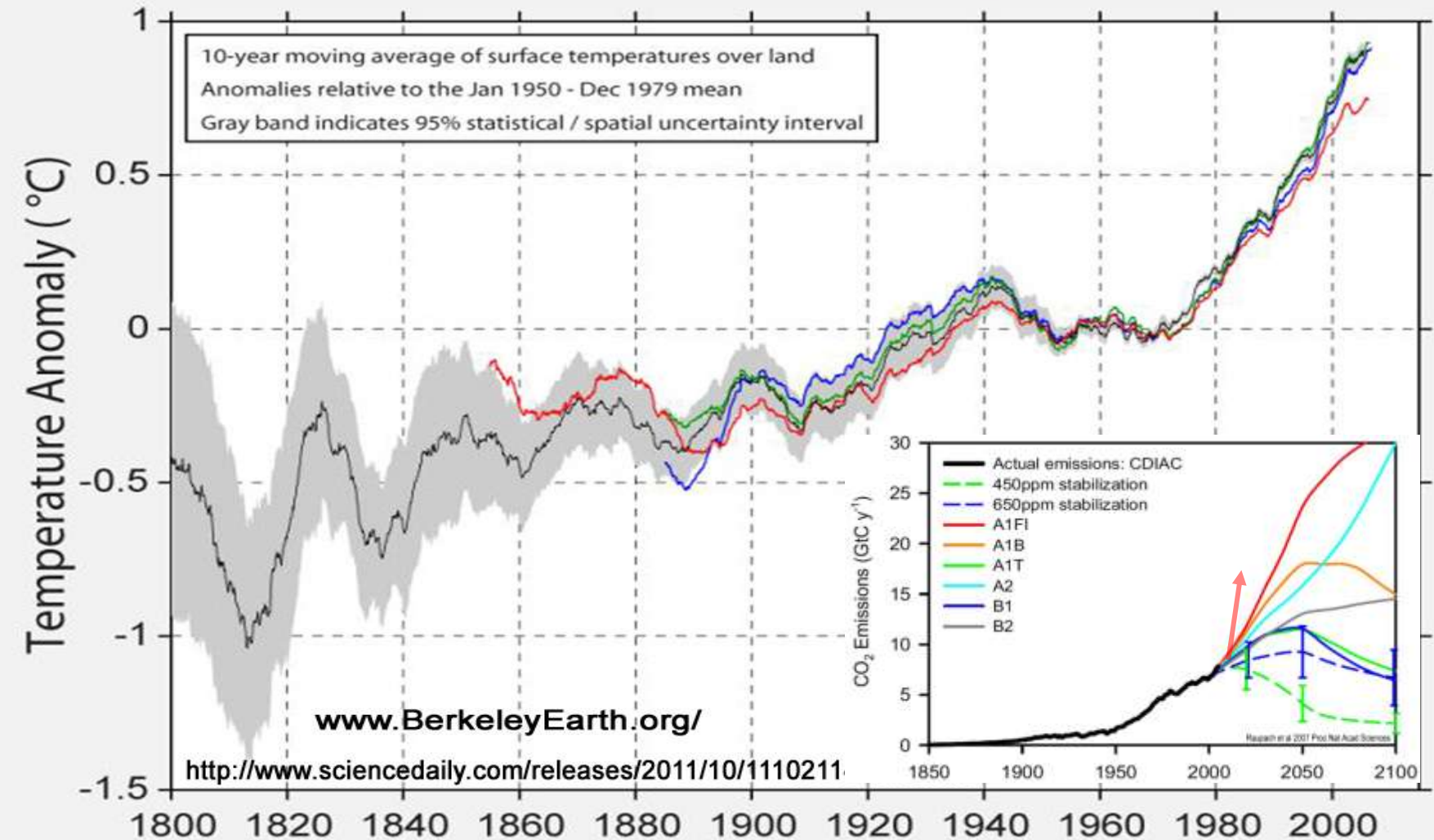


www.geos.ed.ac.uk/sccs/



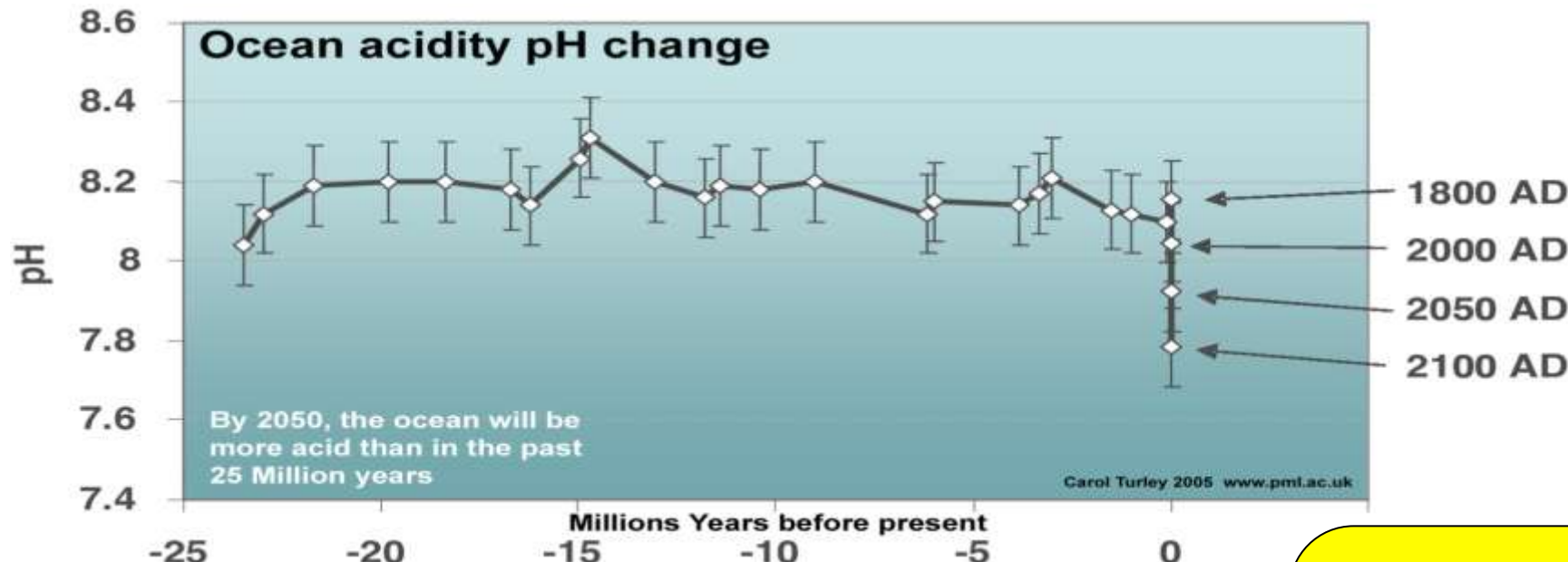
Its getting hotter

Decadal Land-Surface Average Temperature



11 yr trend **Faster** than the worst IPCC projection

Ocean acidity: measured & predicted



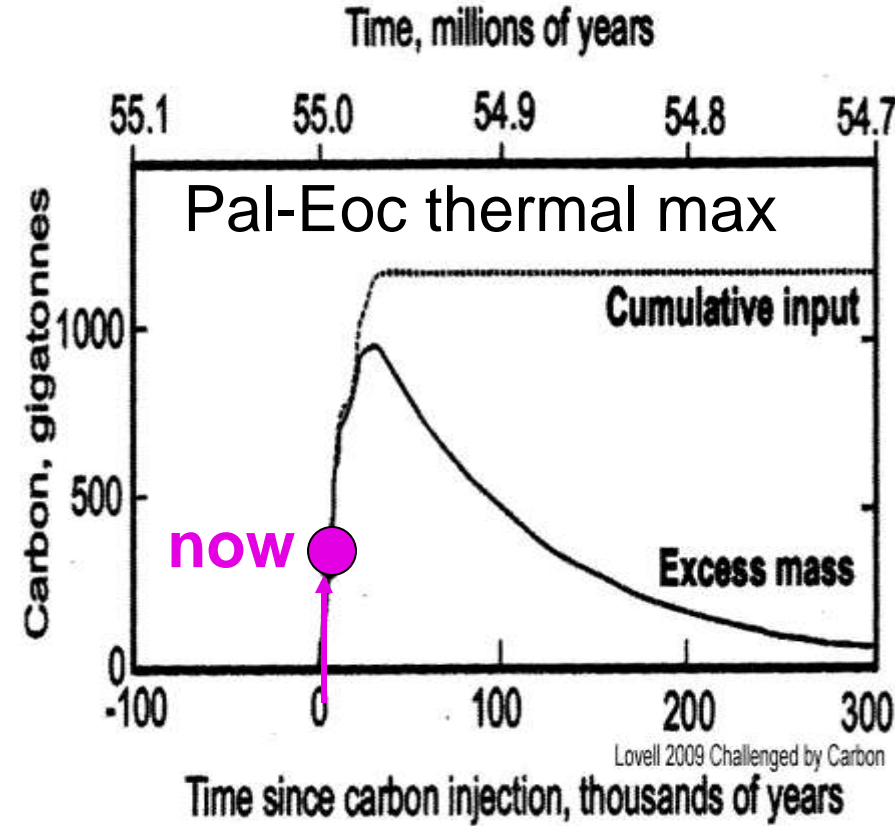
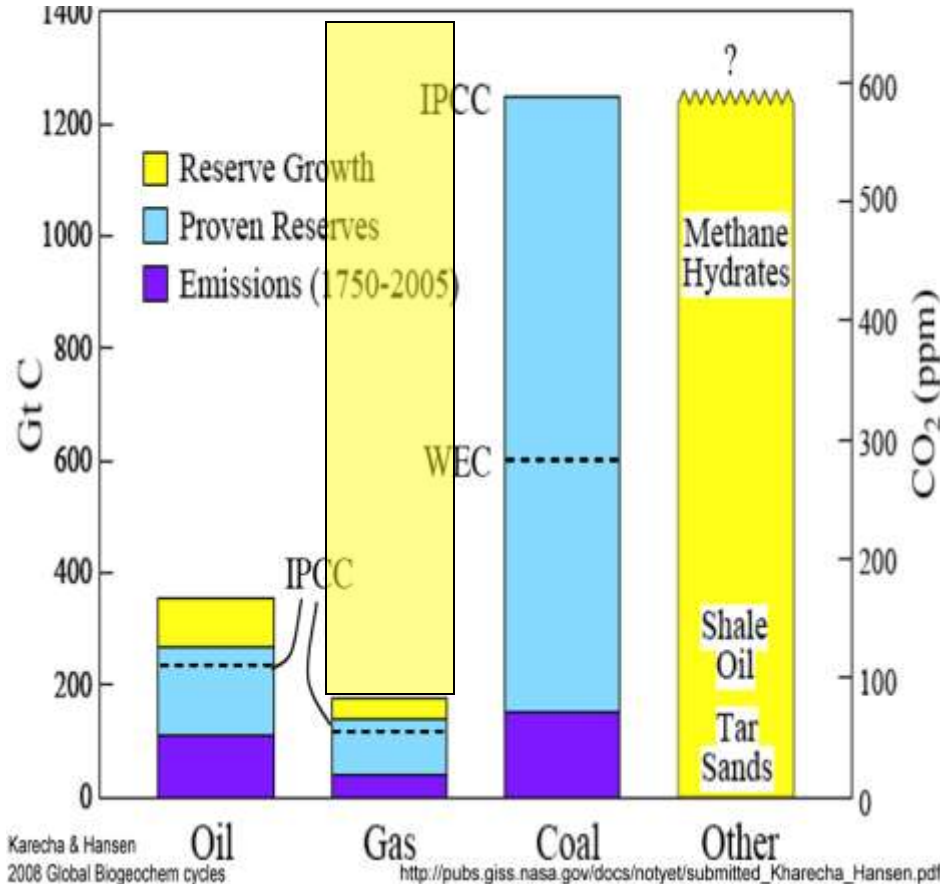
Today



With CO2

Modern CO2 seeps:
Sicily
Tyrrhenean sea
Greatly reduced diversity

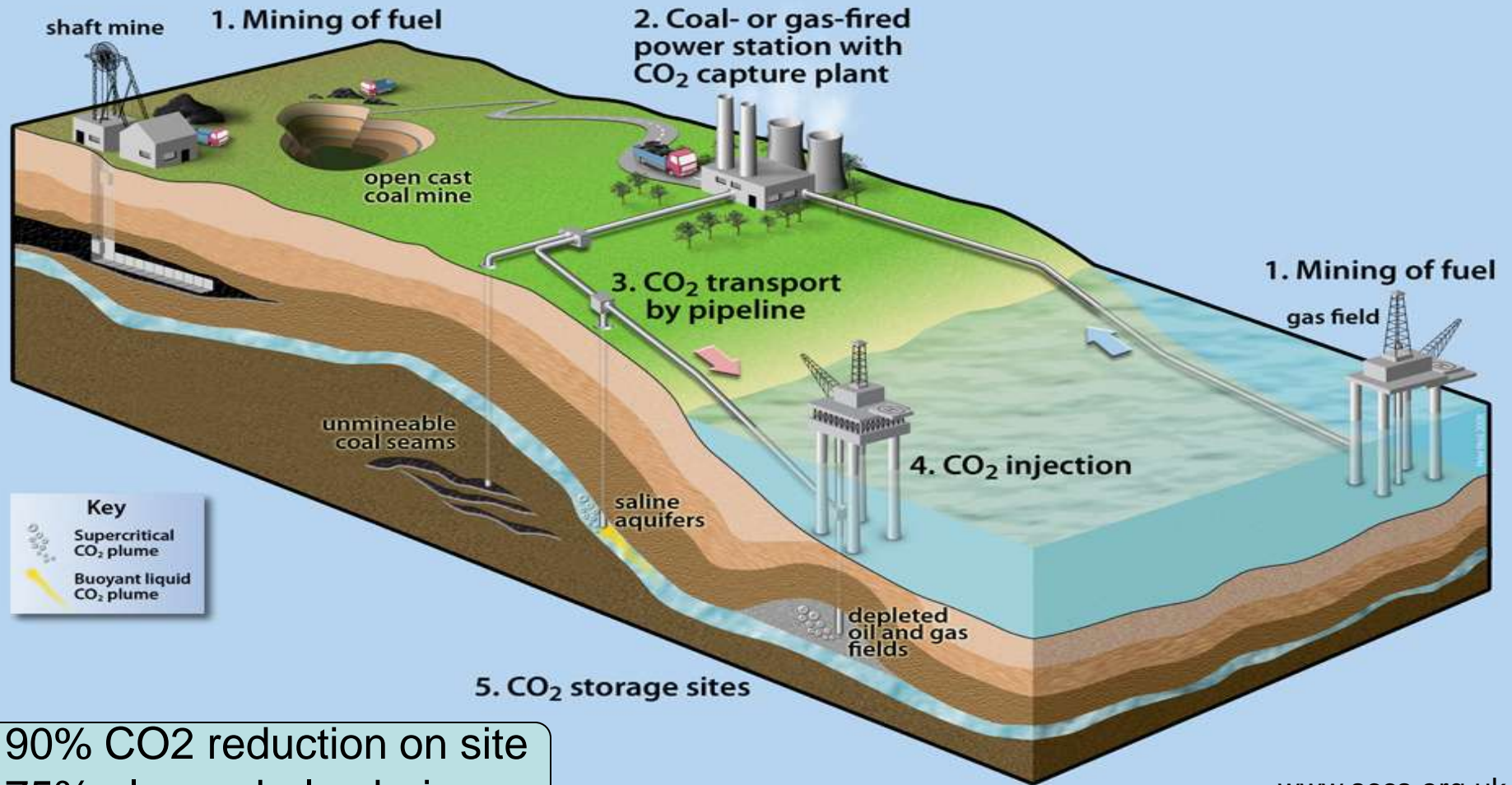
Fossil fuel : 90% remains to burn



**Only 10% fossil resource
already used
Lots of coal, and GAS**

**Geological history
shows 5 high CO₂
examples - ALL have
same effects: Heating,
extinction, ocean death**

Carbon Capture and Storage



90% CO₂ reduction on site
75% along whole chain

www.sccs.org.uk

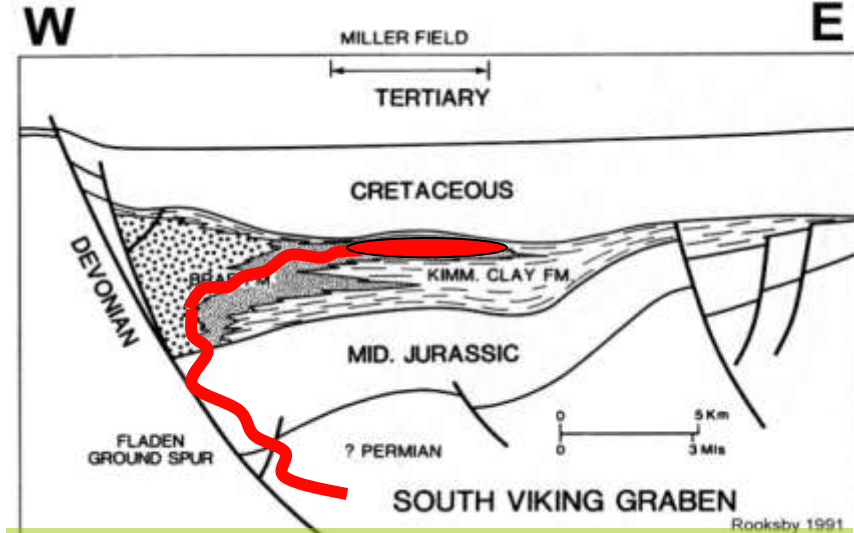
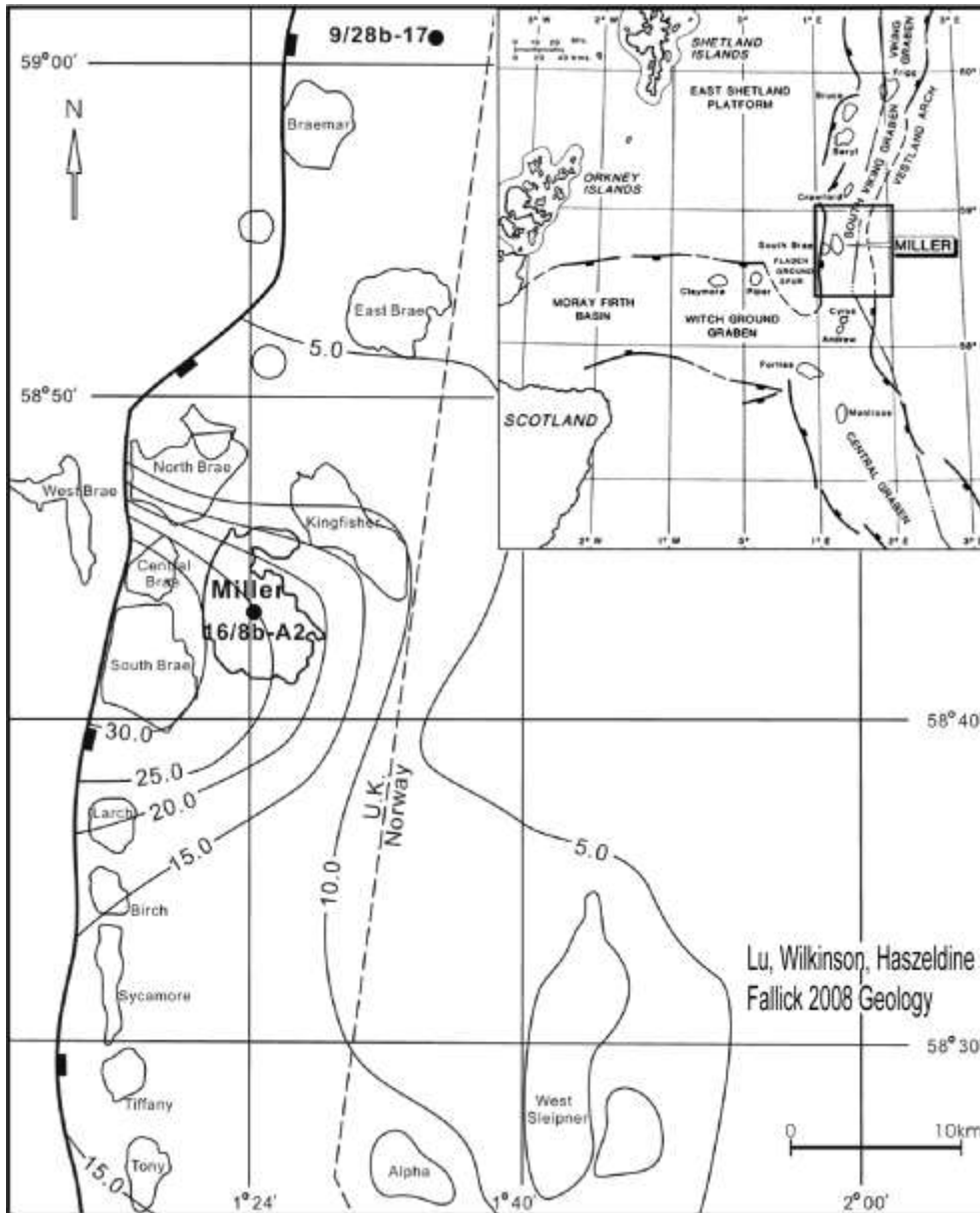
+ direct Carbon reduction, existing energy system, EPS, cheap
- emerging not proven, Big cash funds, coal mining?

Natural analogues

CO₂ Leakage: Natural analogues show what a worst case would be

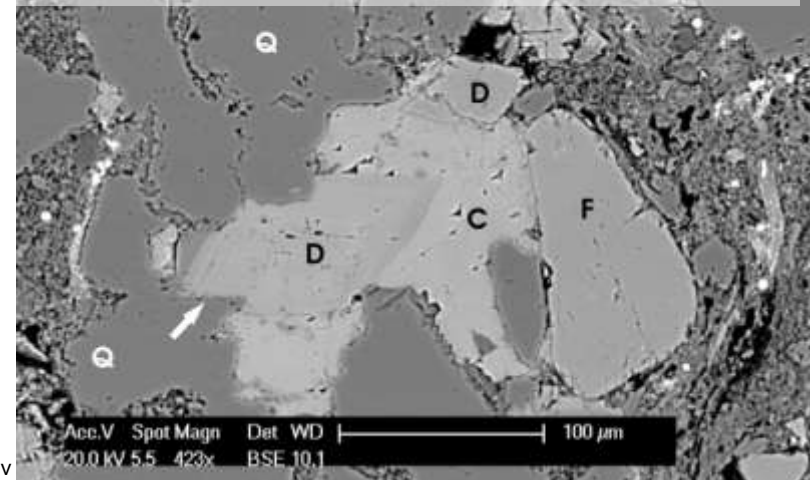


Seal integrity

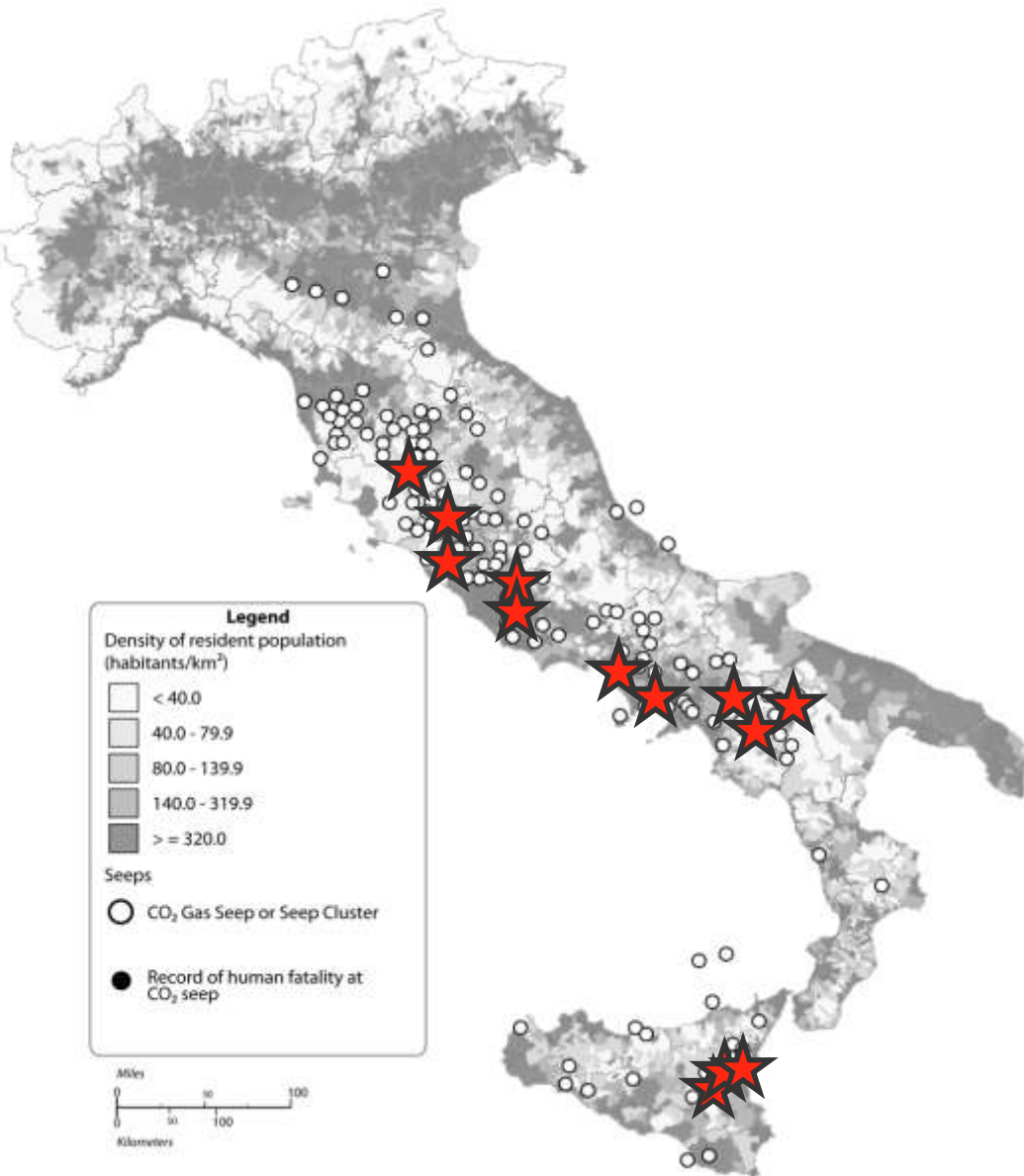


**Miller field seal 60Ma CO₂
10m mudrock interaction**

**calcite cement (C) along beds,
younger than dolomite (D) quartz (Q)**



Mortality at Italian CO₂ Seeps



★ = human fatality

19 deaths in
50 years.

13 seeps

11 deaths in 20 years
≡ “full” record

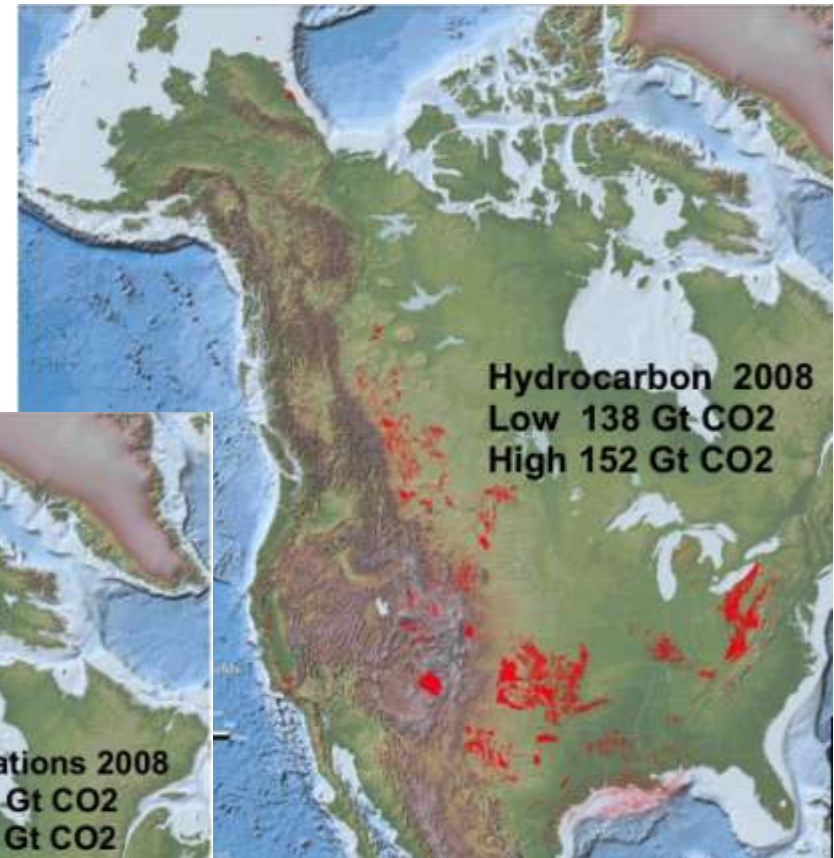
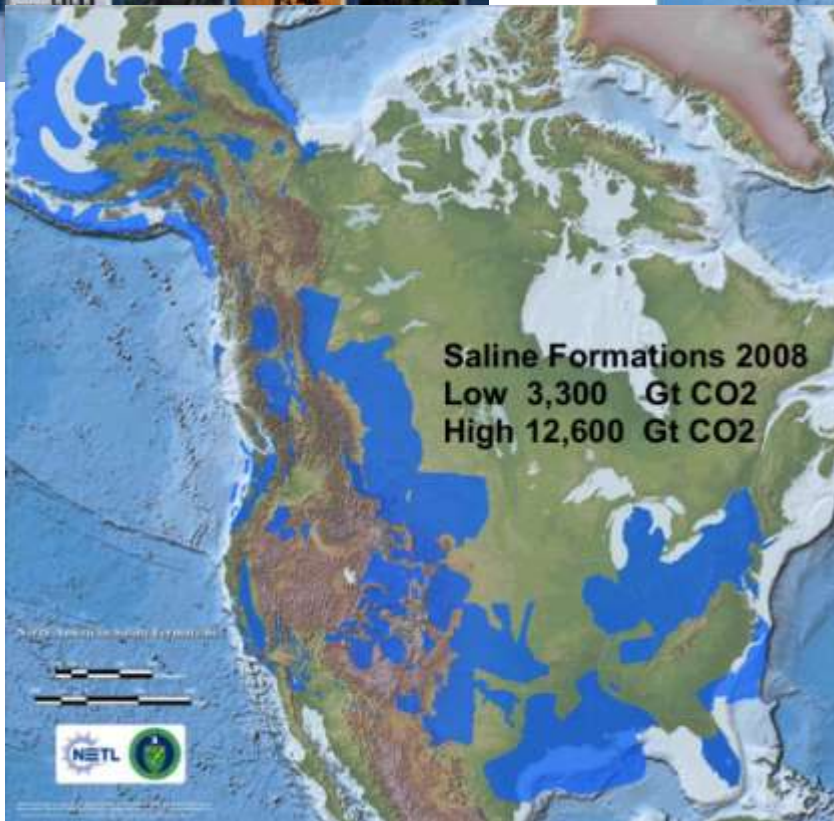
If no death year recorded -
assumed > 20 yrs.

Risk of fatality 2.8×10^{-8}
1: 36,000,000

Roberts Wood Haszeldine PNAS 2011

Storage

Storage assessment



Lots of storage
POTENTIAL
Mostly aquifers
DoE Phase III proving

CO2 storage offshore of UK

Onshore storage blocked
by public onshore Europe

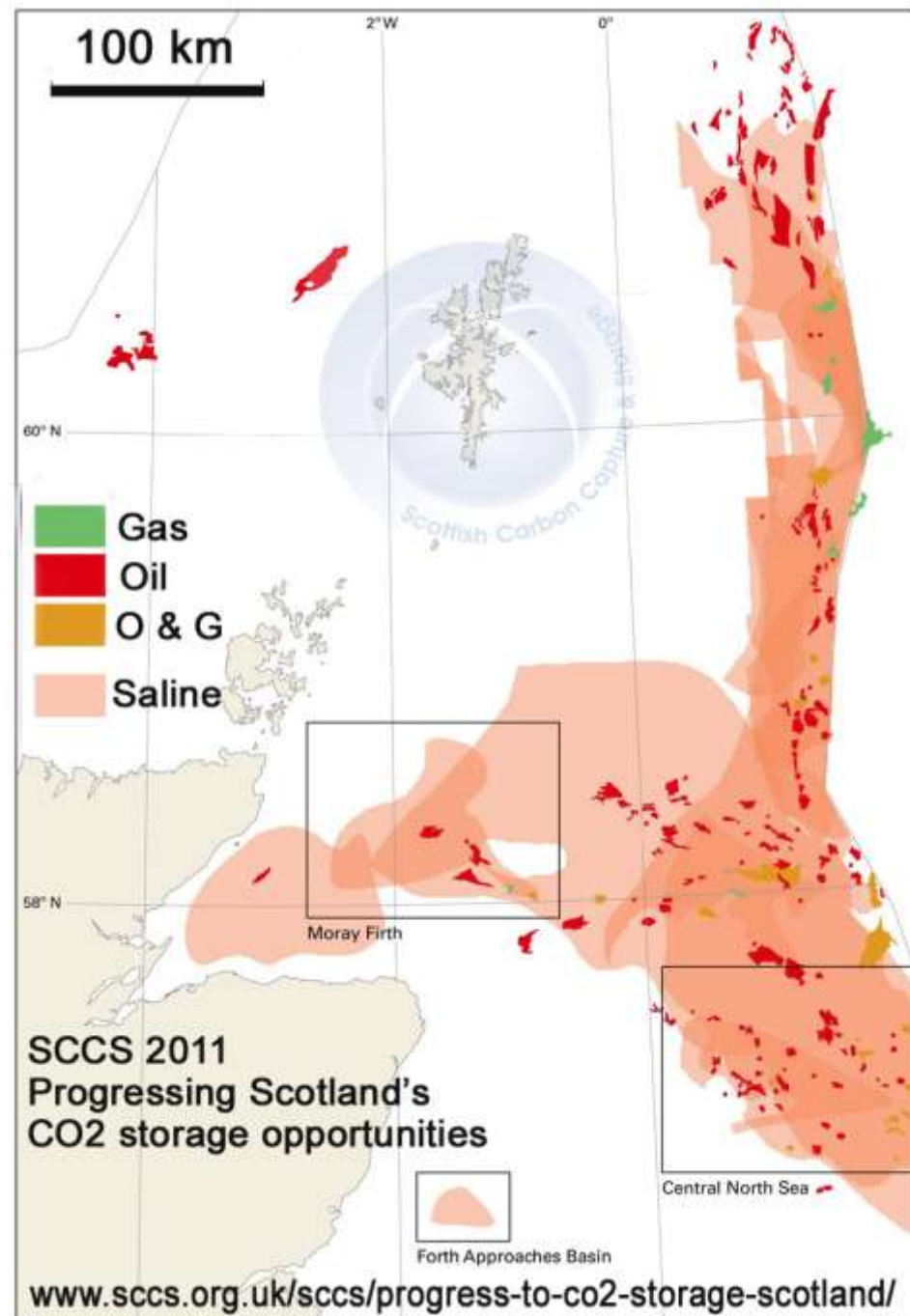
UK North Sea:
100yrCO2

60-70 Gt
storage potential

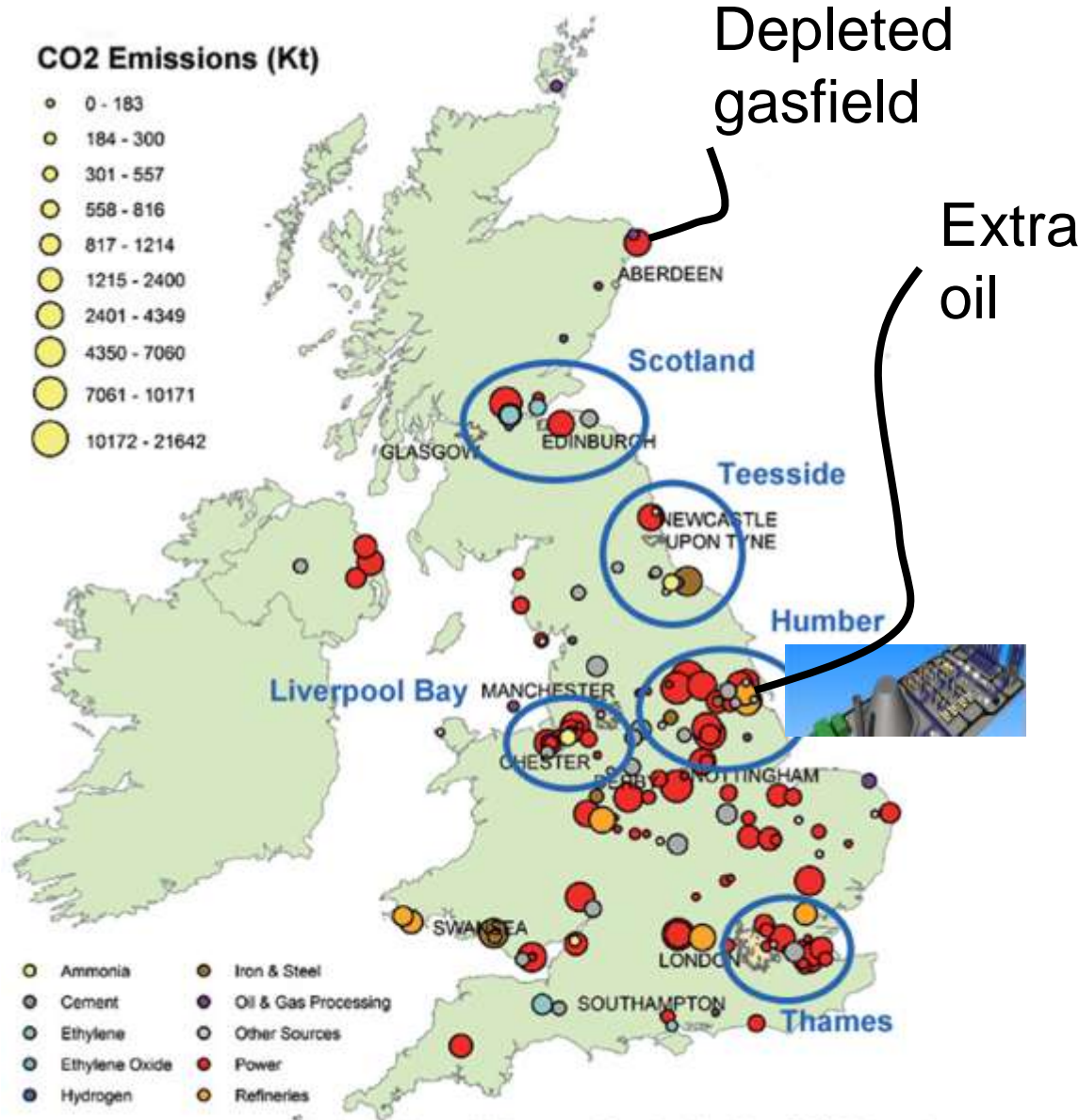
Oilfields 10Gt

NEED to develop aquifers

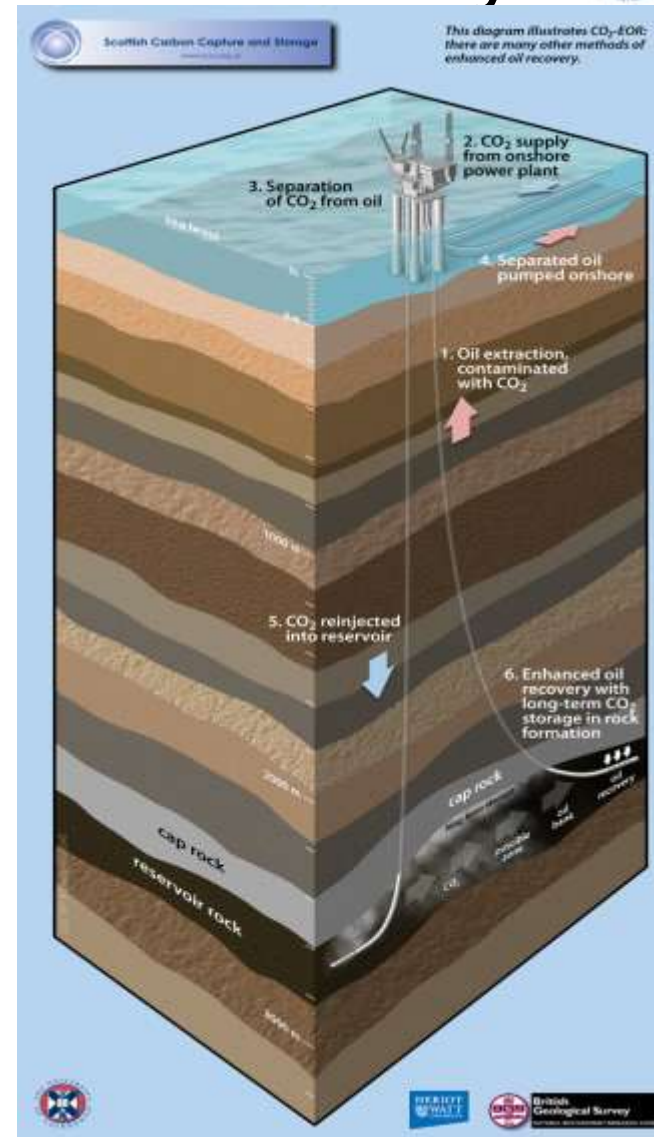
Gasfields and EOR first



CO2 Improved / Enhanced Oil Recovery



www.nationalgrid.com/uk/EnergyandServices/NonRegs/CCS/Projects/
 Basemap data taken from Digital Chart of the World (Scale 1:1 million)



Unproven

3-7 Bn bbl

Storage: EU 27

Update, fill in gaps,
extend geographic
coverage, spread
aquifers regionally

NEW:

North Sea - large

Ireland

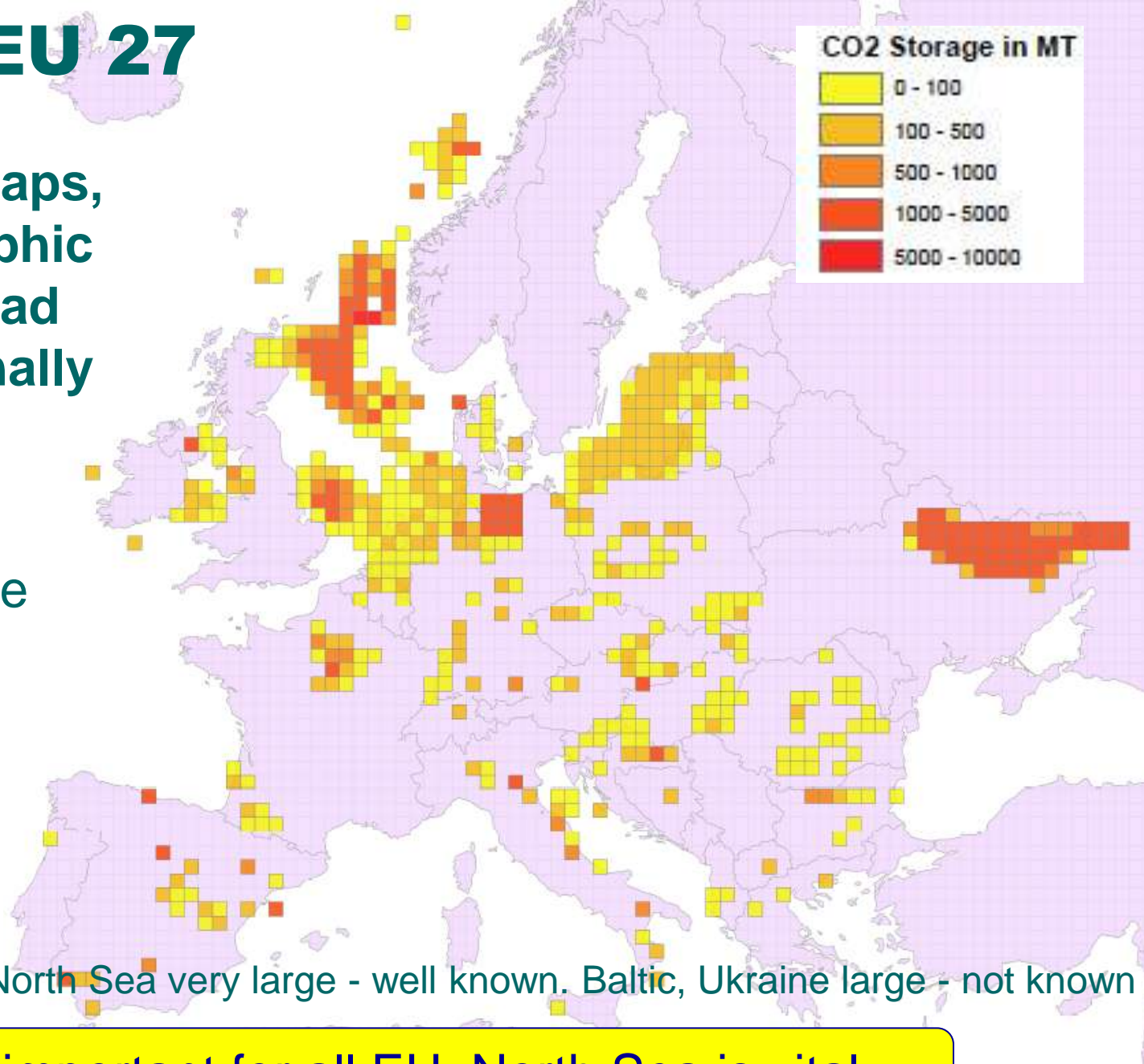
Austria

Switzerland

Baltic

Ukraine

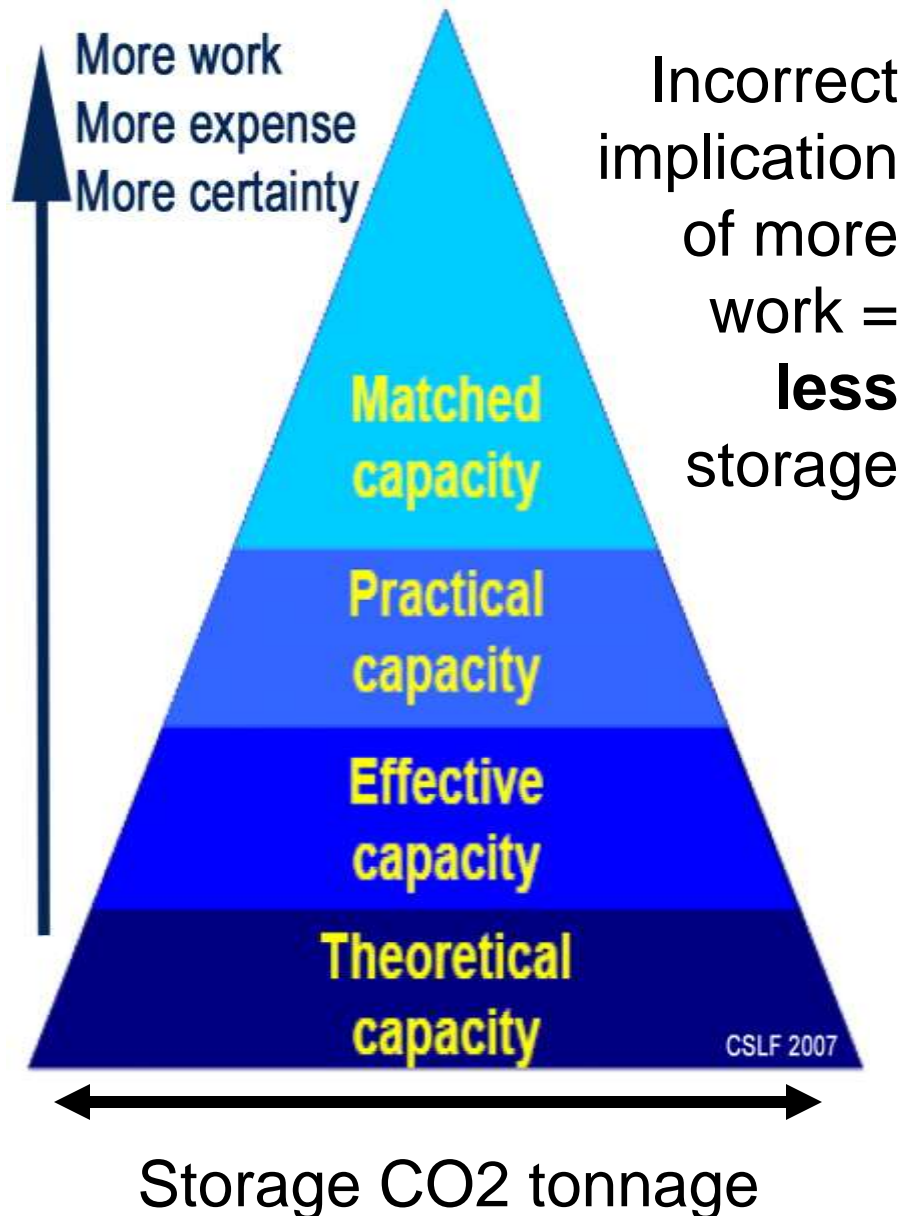
Onshore well spread. North Sea very large - well known. Baltic, Ukraine large - not known



Offshore is important for all EU; North Sea is vital

Methods of assessing storage

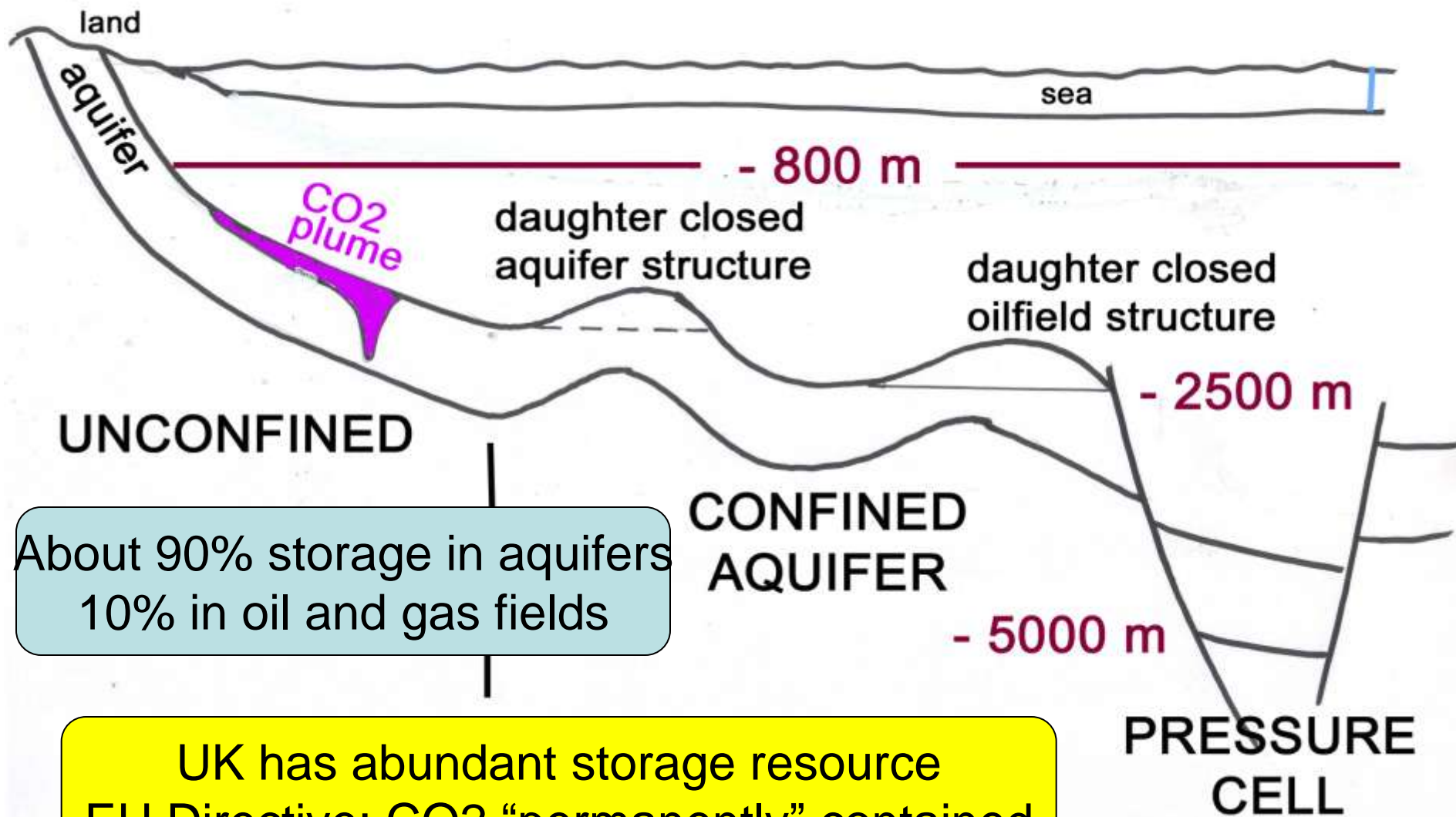
Storage capacity needs work



Acquires data...
Reduces uncertainty,
Correct implication of more work = **more** storage

Data shortage \neq Risk

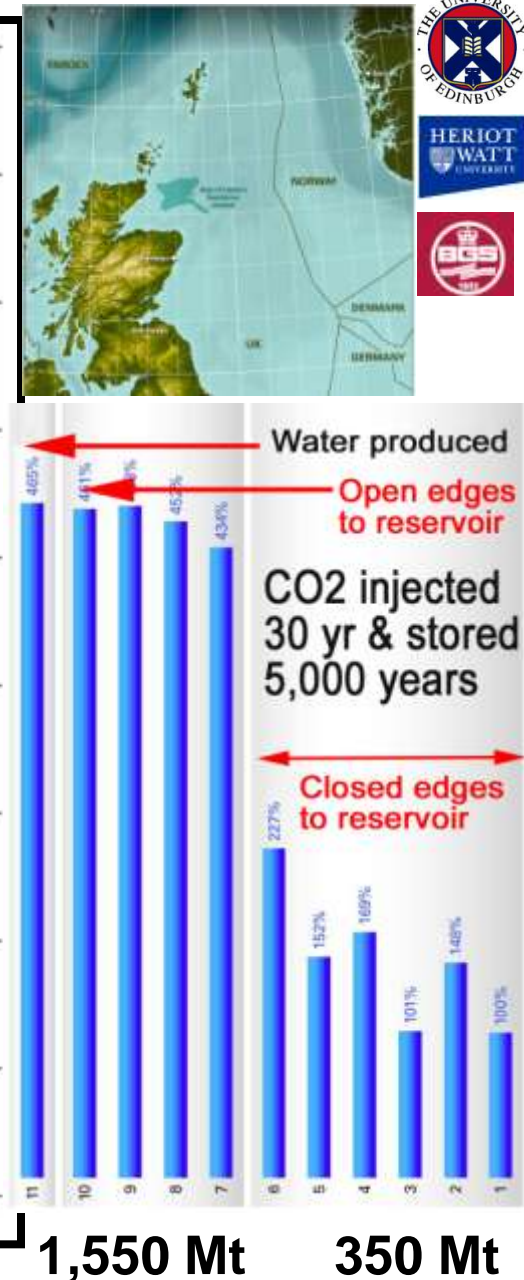
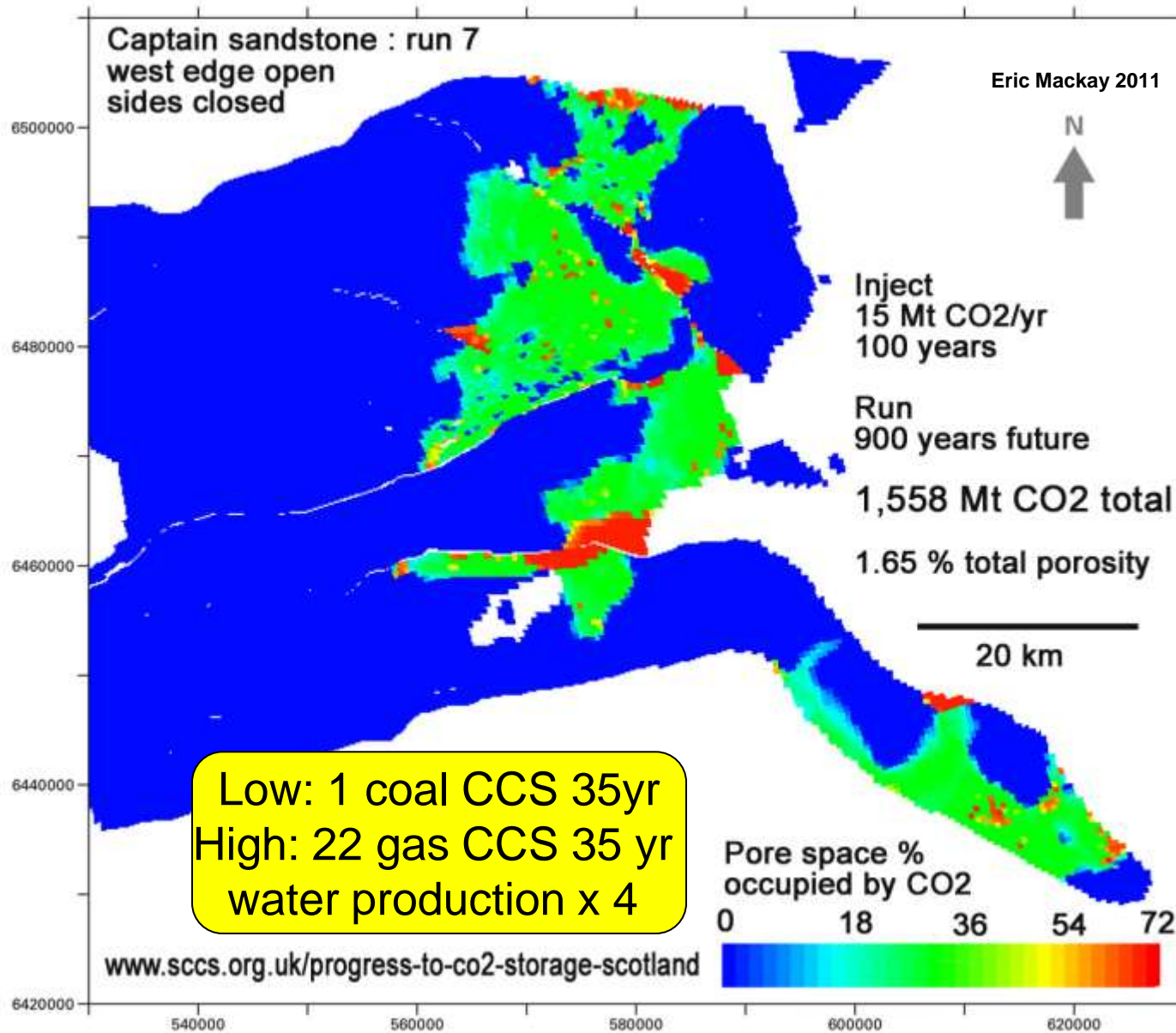
UK storage: 3 types



About 90% storage in aquifers
10% in oil and gas fields

UK has abundant storage resource
EU Directive: CO2 “permanently” contained

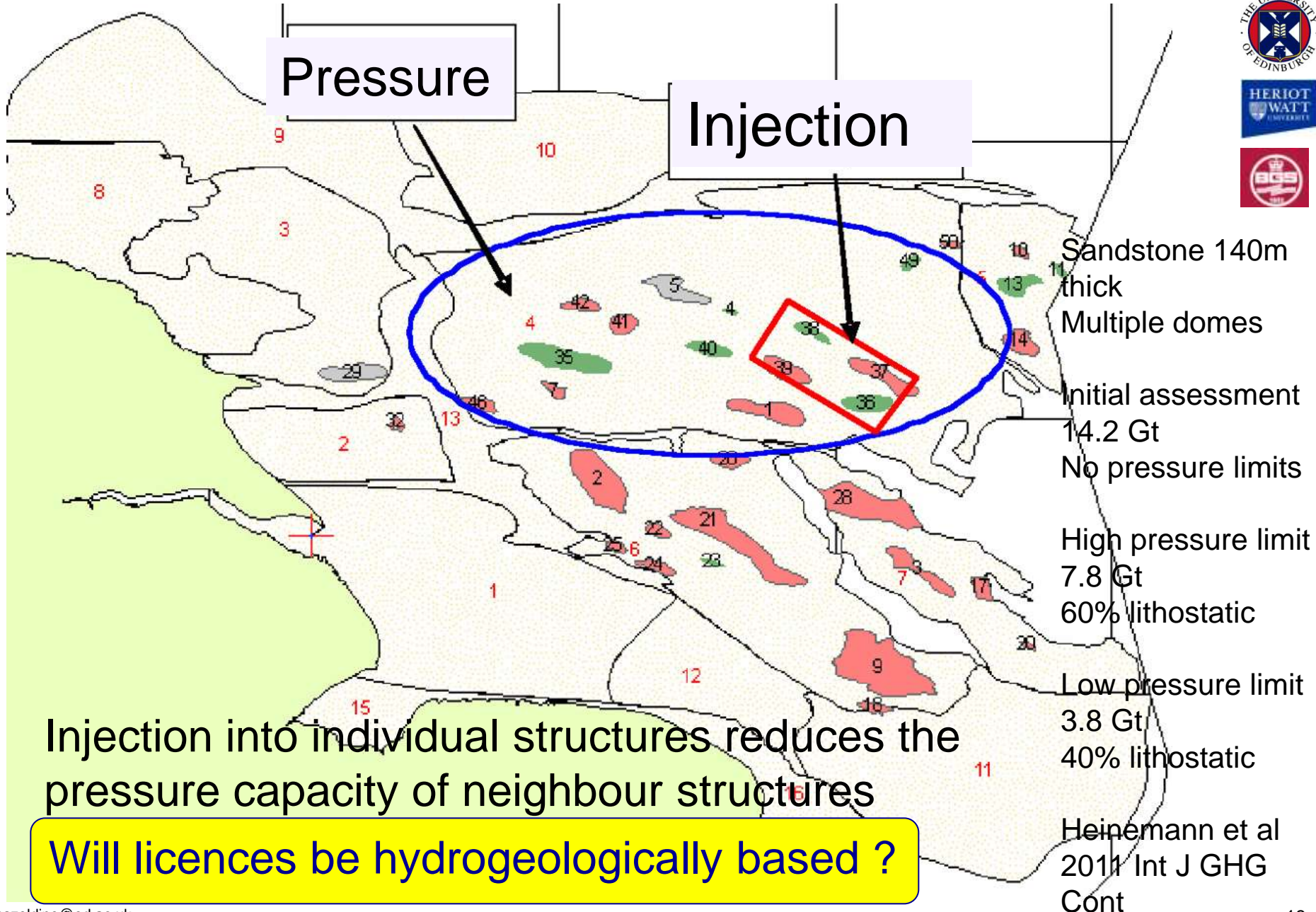
Total CO2 stored: produce water



Pressure limits

Pressure

Injection

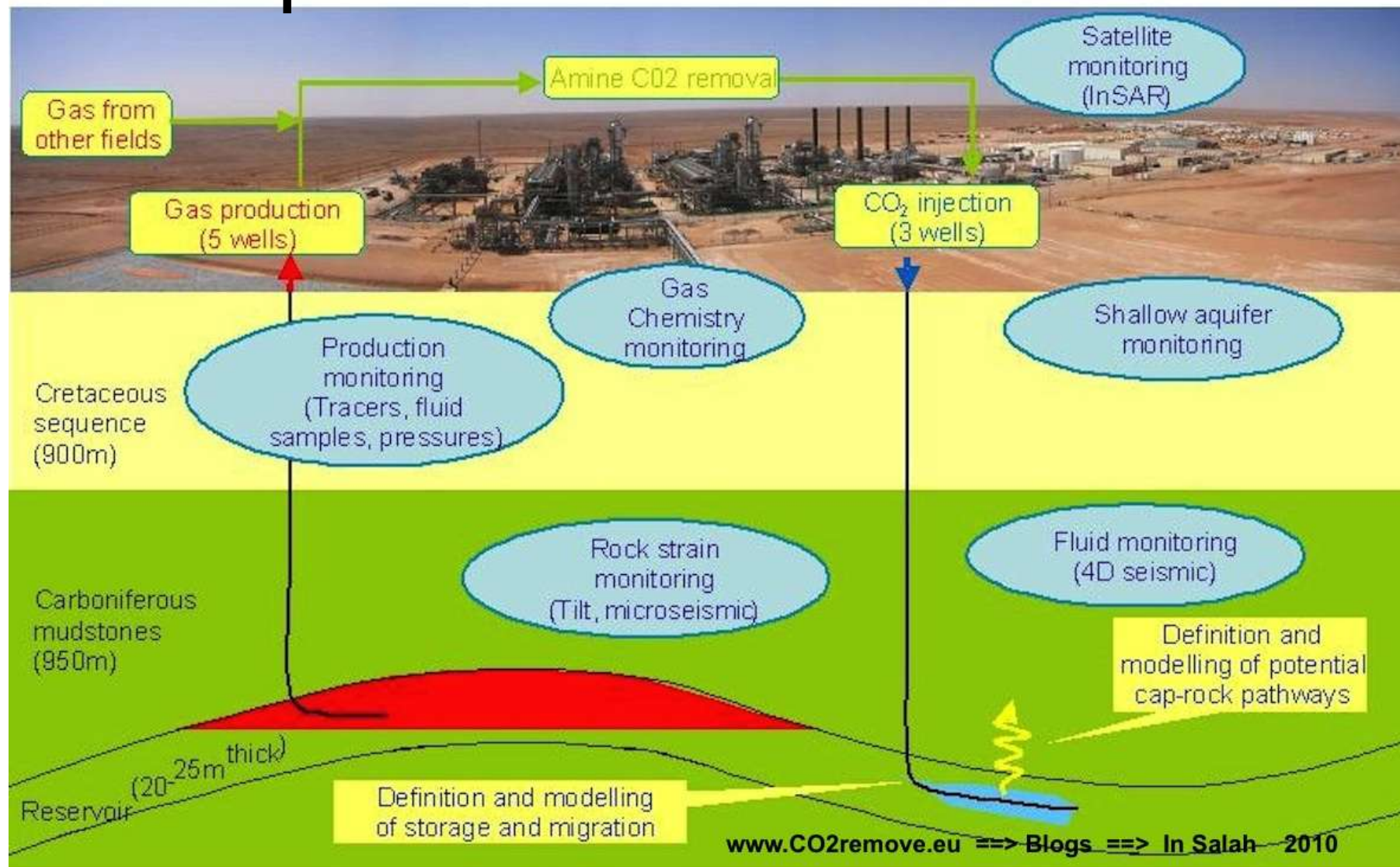


Injection into individual structures reduces the pressure capacity of neighbour structures

Will licences be hydrogeologically based ?

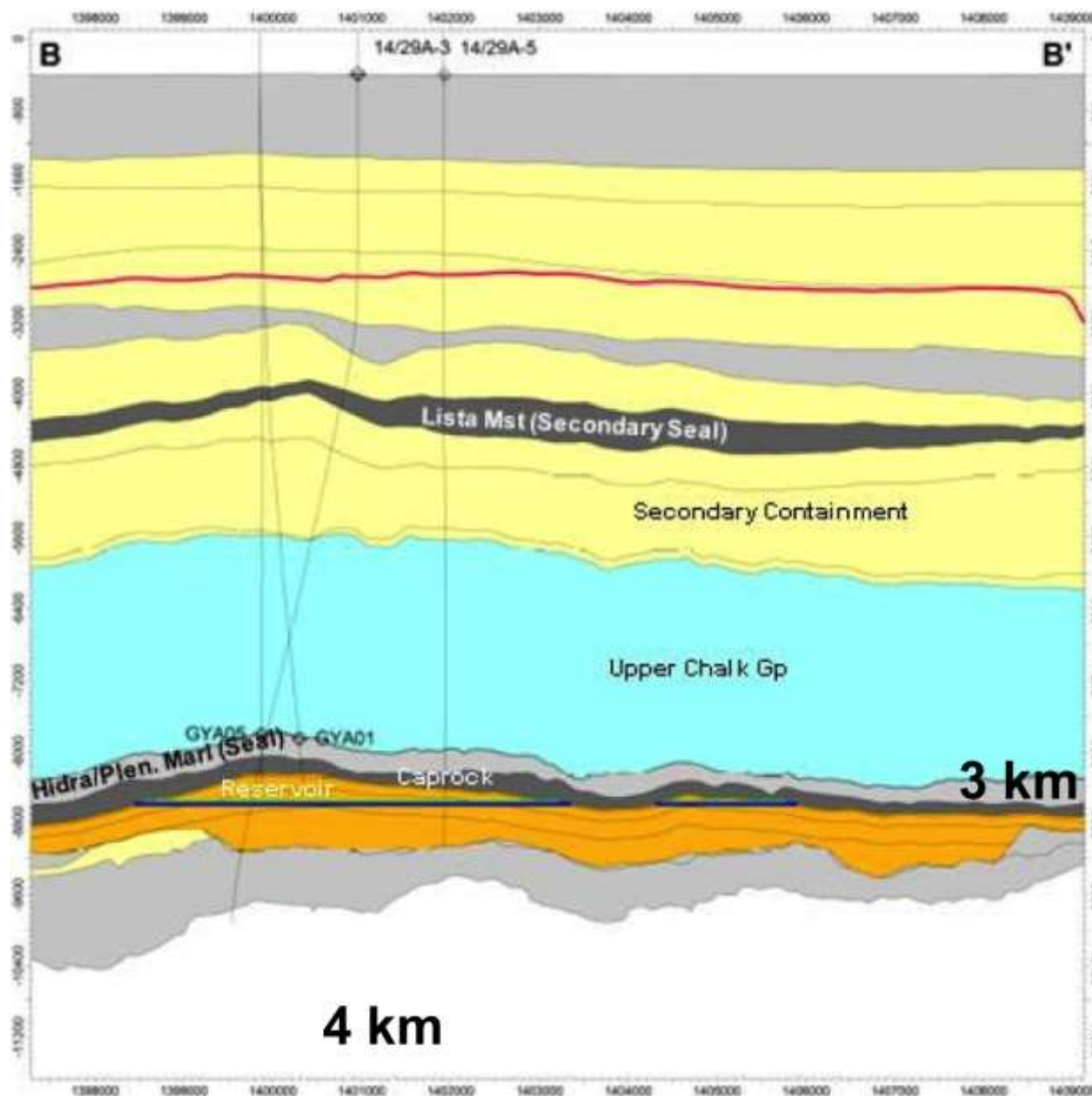
Monitoring

Experimental site: In Salah



Multiple techniques evaluated: ground tilt, seismic, fluid tracers ..

Real marine site : Goldeneye



5 wells,
2 or 3 injectors
1 monitor Well

Now 200 bar
Inject 310 bar
Finish 260bar

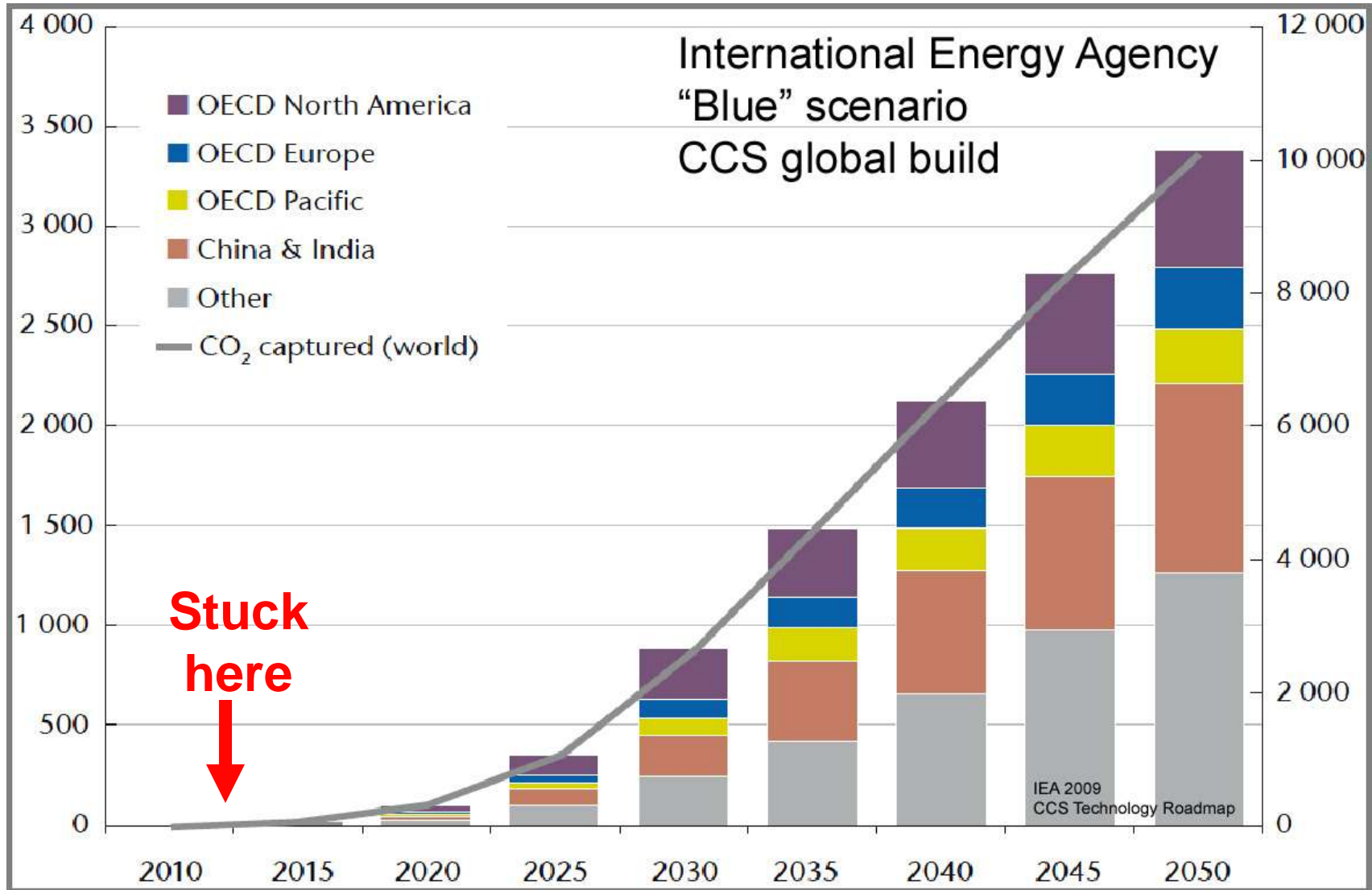
MONITOR

- Seabed
- Seismic 3D, 4-8yr
- Borehole fluid samples, saturation logs, pressure

Very few techniques

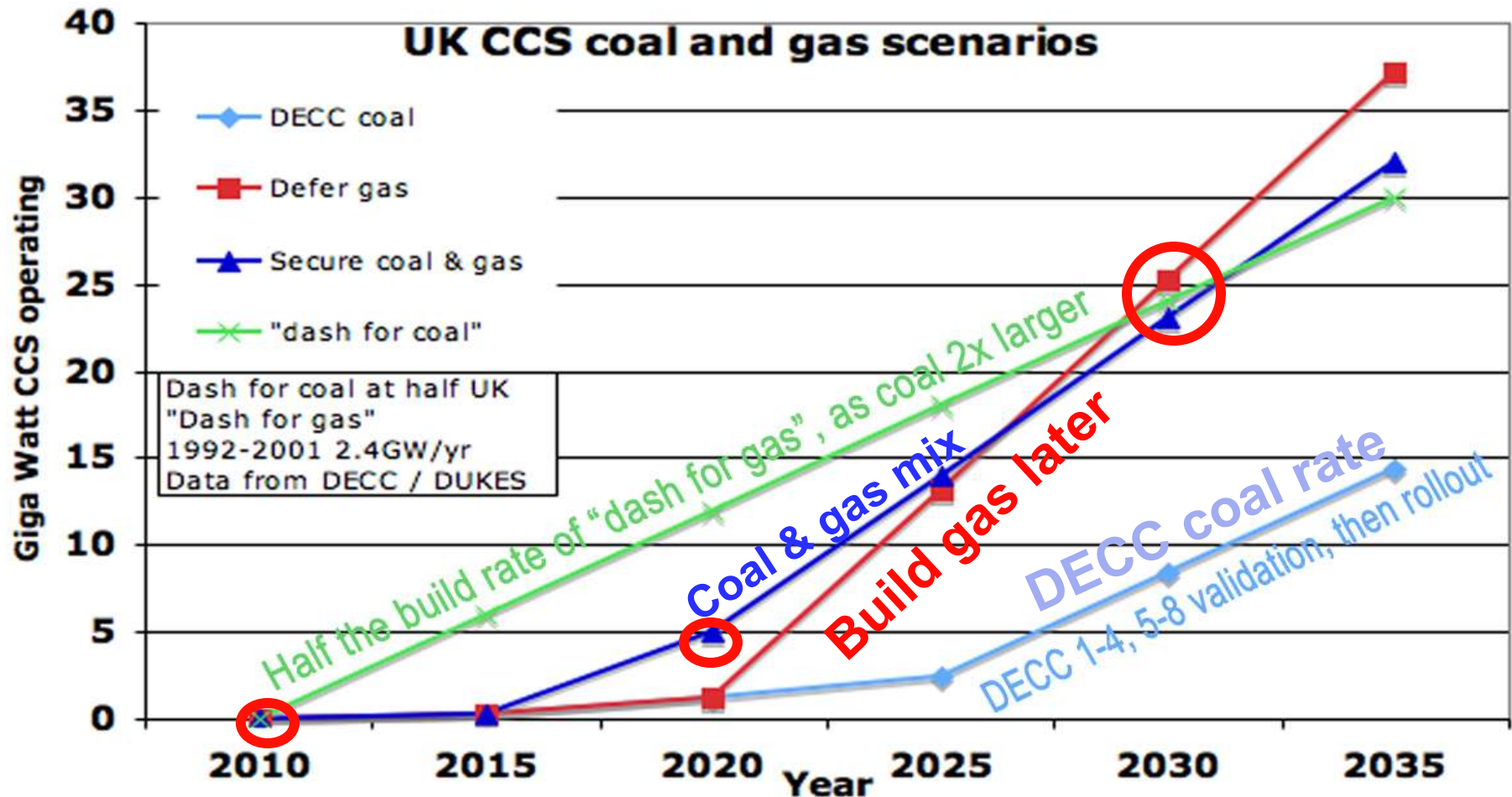
Trajectory and pace

Potentially a global industry (but not yet)



Daily fluid transport volume similar to oil&gas. Less than water

Build Rate: needs ambition

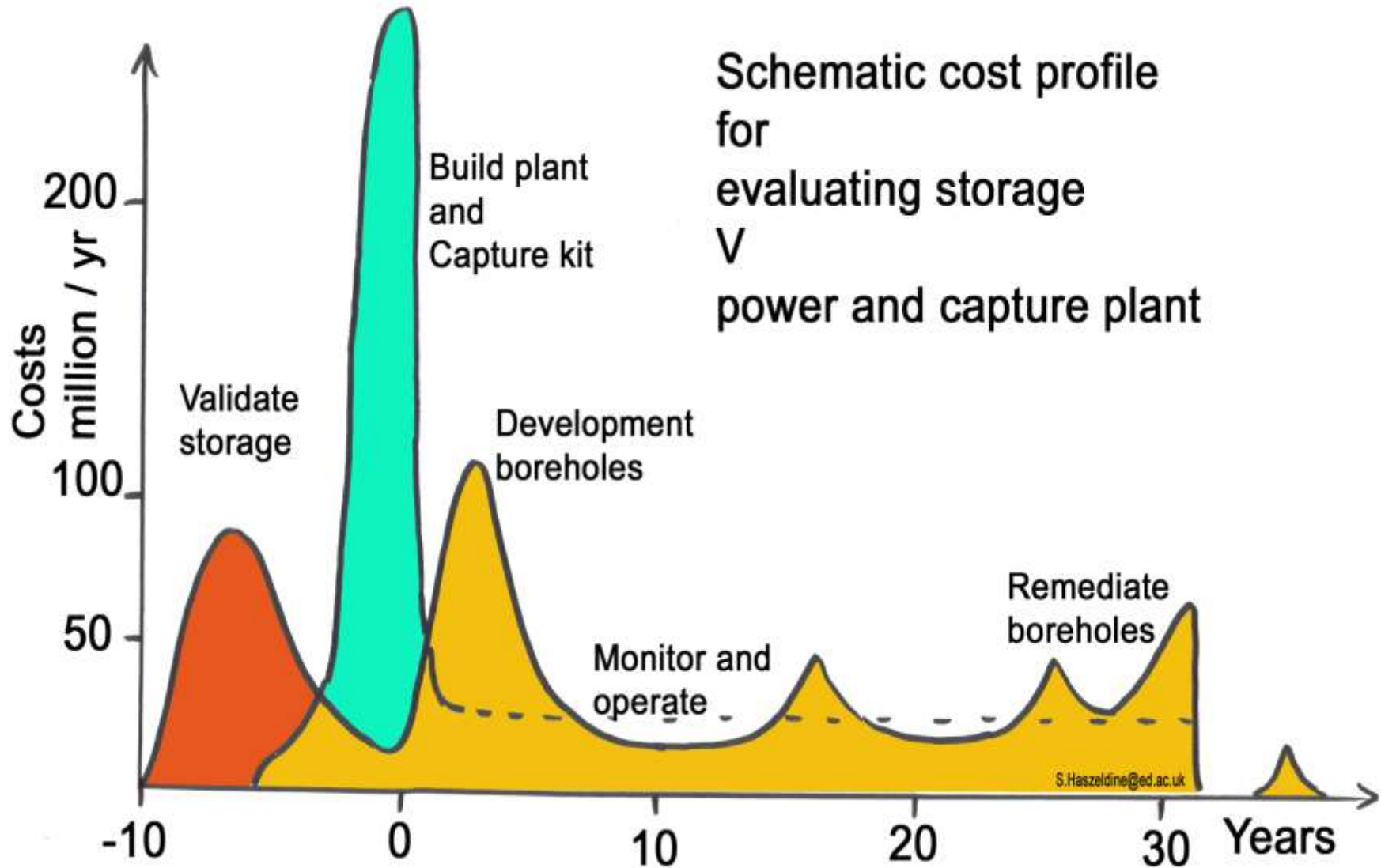


AIM: 25GW fossil fuel plant with CCS by 2030

ASSUME: Coal is half build rate of dash for gas

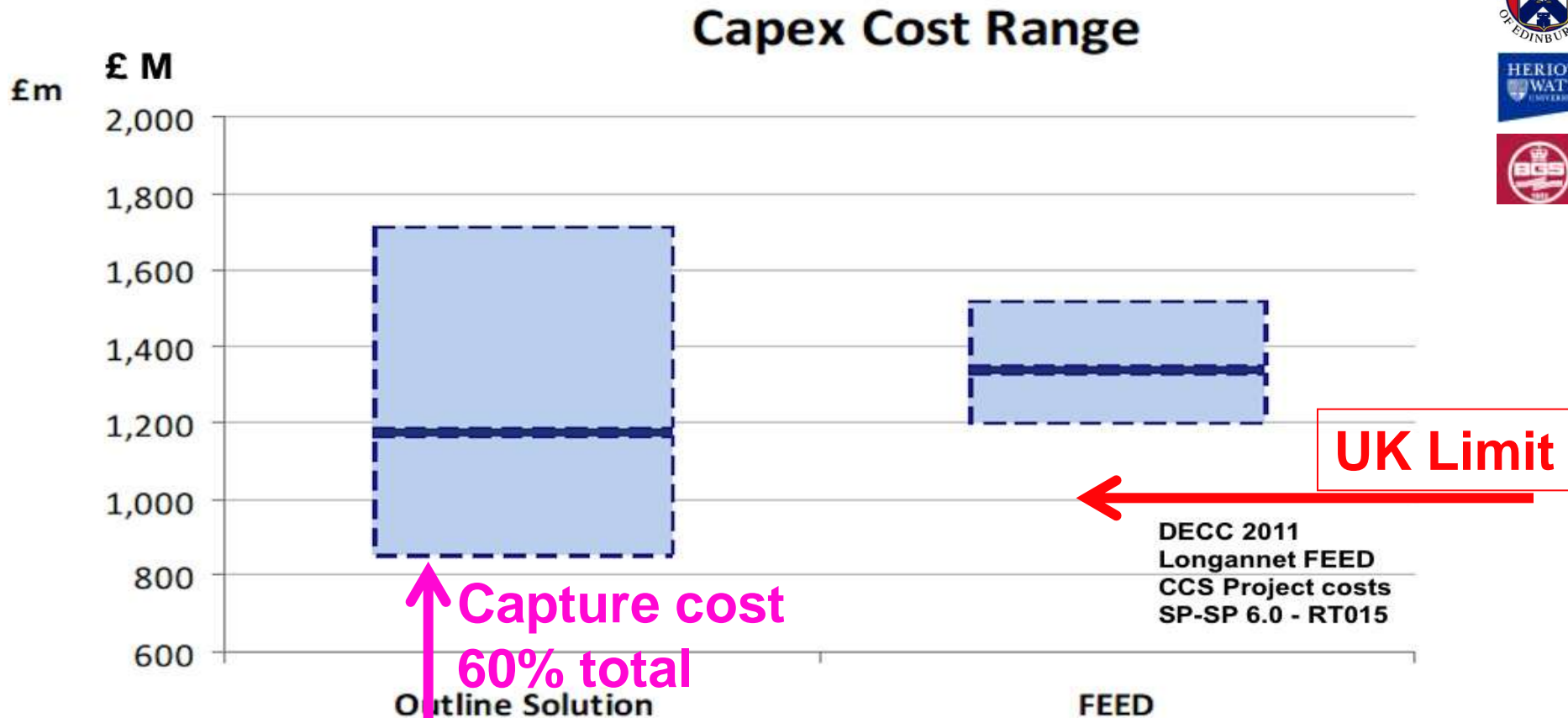
If CCC target and coal in mix, need to operate 5GW CCS by 2020 – NO !

Storage work offshore: 10 yr ahead



Storage costs comparable to powerplant - but in advance

Pre-FEED, Post-FEED costs



£40 M FEED raised costs £170M, reduced error $\pm 15\%$

- Expensive to fit an existing coal plant, not CCS ready
- Potential cost over-run allocated to Developers

Paying and insuring



- Offshore is the EU publicly agreed zone

- Drilling after Macondo
£10, 20, 40M ...

- Legacy boreholes
V
Legacy pipes

Who pays ?

Liability

EU Directive on CO2 “Permanent storage”

USA nuclear (Price Anderson)

- Joint liability by operators
- \$110 M from 120 plant
- Waste in care of State
- No-fault insurance.

Prevents multiple claims

UK nuclear

- Immediate state care
- £70 Bn funding
- Stored for many decades

Risk: 1 death in 1,000,000

UK and EU CCS

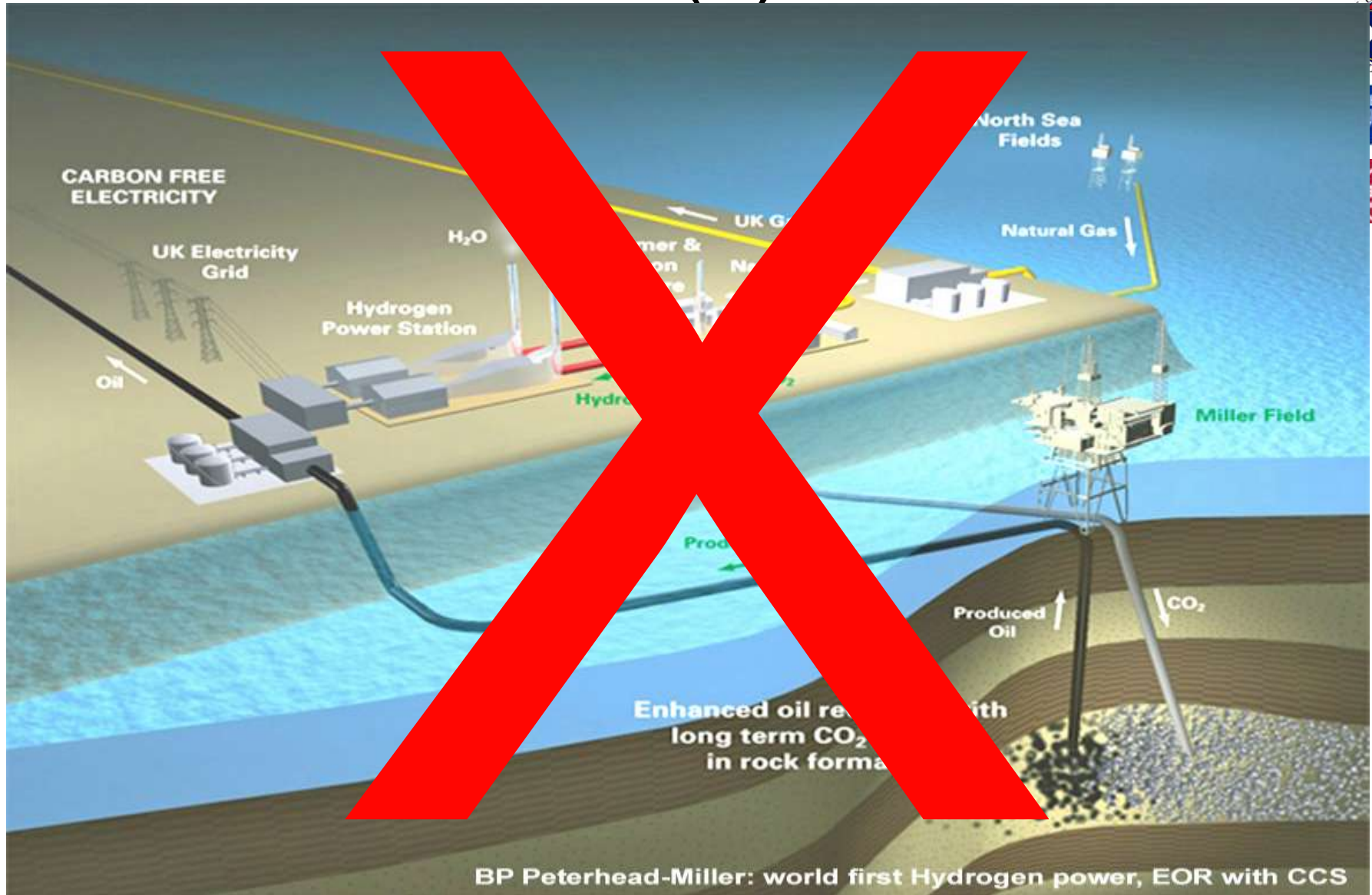
- CO2 owned by storage operator
- Storage operator liable, to ensure disposal of CO2
- Others in chain liable too
- 100% leakage assumed
- Delayed state takeover
- £ 1 Bn funding

Risk: 1 death in 30,000,000

Liability too onerous for CCS: Needs State underwriting & partnership



Peterhead (1) No more



G8 2005 ==> Budget 2007, DECC competition 2007 → end

Longannet - no more



DECC Competition "clarification" - not survivor → end
Expensive £190/MWh, "pipes too long" → RISK
not taken by Government, may be multiple accounted

Where is the UK value ?

Capture:

Expensive, creates construction jobs, mobile

Transport:

Need a developer, or state control (like gas)

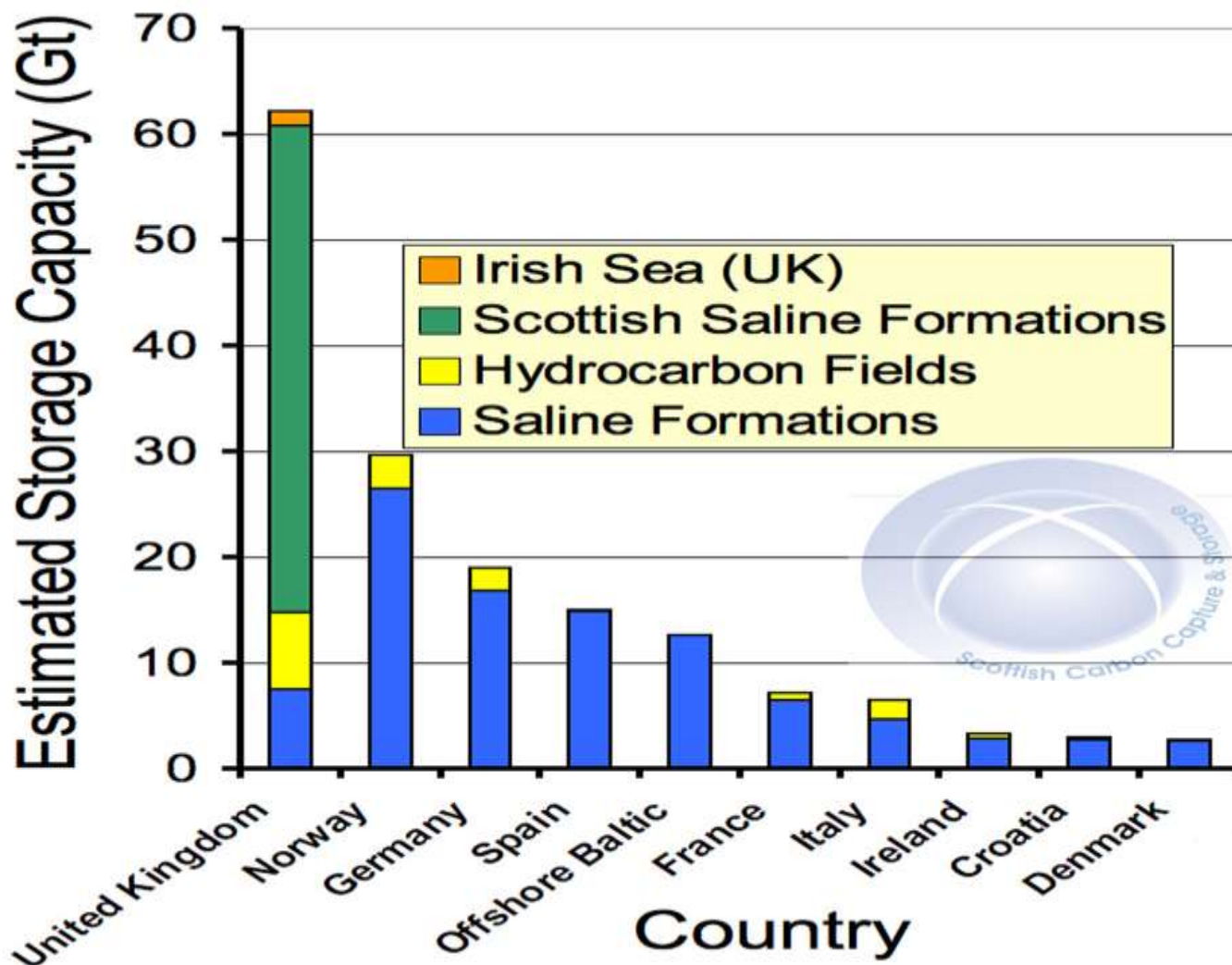
Storage:

Long term, offshore supply and jobs,
£300,000,000,000 of EOR
Cannot be relocated



Top ten EU storage

(static un-risked capacity potential)



EU Annually
1Gt/yr CO₂
**>150 Gt
storage**

**UK has 35%
of ALL EU27
storage**

UK long term value is EU27 OFFSHORE storage

How to promote storage ?

Need:

A long term organisation, prepared to invest for UK benefit.
Multiple skills and cross-connected to onshore energy and offshore users



Good as enabler, not as long term developer



Creates business framework, not as long term developer



Commercial business of sustainability, energy, offshore, onshore, communities



BaU CO₂
by 2030

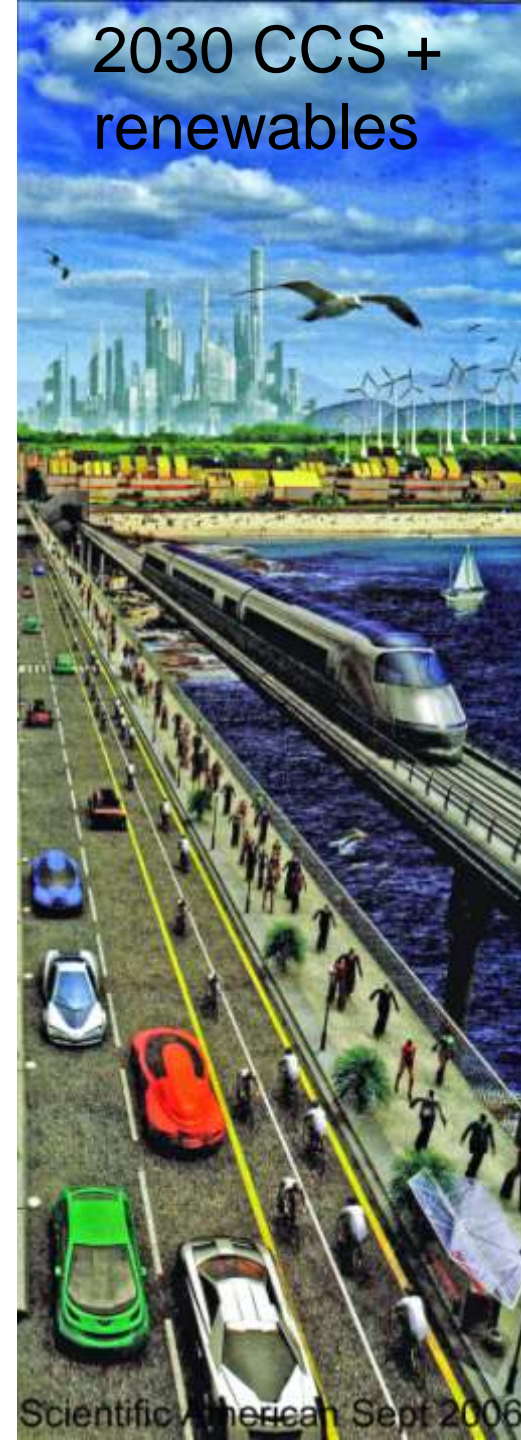
Summary

- Fossil fuel use ≠ climate
- Global CO₂ storage potential
- CCS chain technically possible
- Engineering and EOR can increase storage
- Monitoring offshore is hard
- Complex licensing. And early investment. May need new expert unifying organisation
- UK and world activity too slow

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Geological Society, London 22 Nov 2011

2030 CCS +
renewables



Scientific American Sept 2006