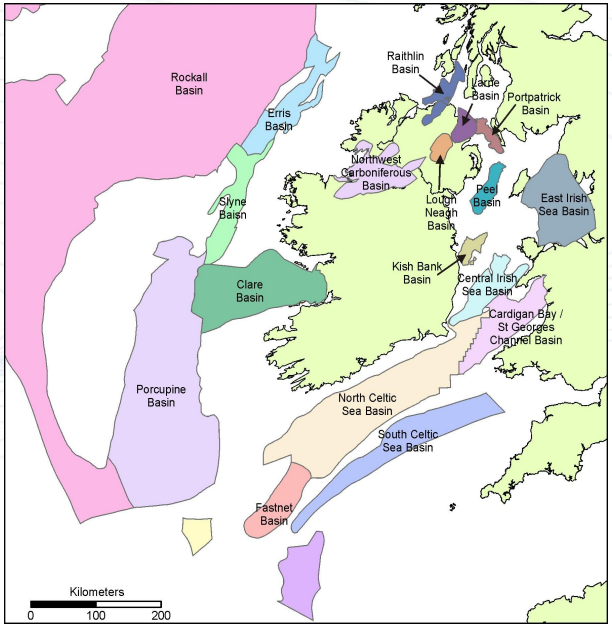
EU Directive 2009/31/EC
on the Geological Storage of CO_2



Implications for Geoscience in Ireland

Dr Deirdre Lewis
SLR Consulting Ireland
12 May 2010

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TODAY'S PRESENTATION

- What is CCS?
- Why CCS?
- EU CCS Directive *2009/31/EC*
- Implications for Geosciences in Ireland

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Carbon Capture & Storage (CCS)

3-phased process:

1. **Capture of CO_2 at combustion source, typically large point sources (power, cement, gas production…)**
   - **Compression of gas to dense fluid phase**

2. **Transport by pipeline (or ship) to storage site**

3. **Geological Storage by injection to depths > 700m, *where CO_2 remains in supercritical fluid phase, thus less buoyant***

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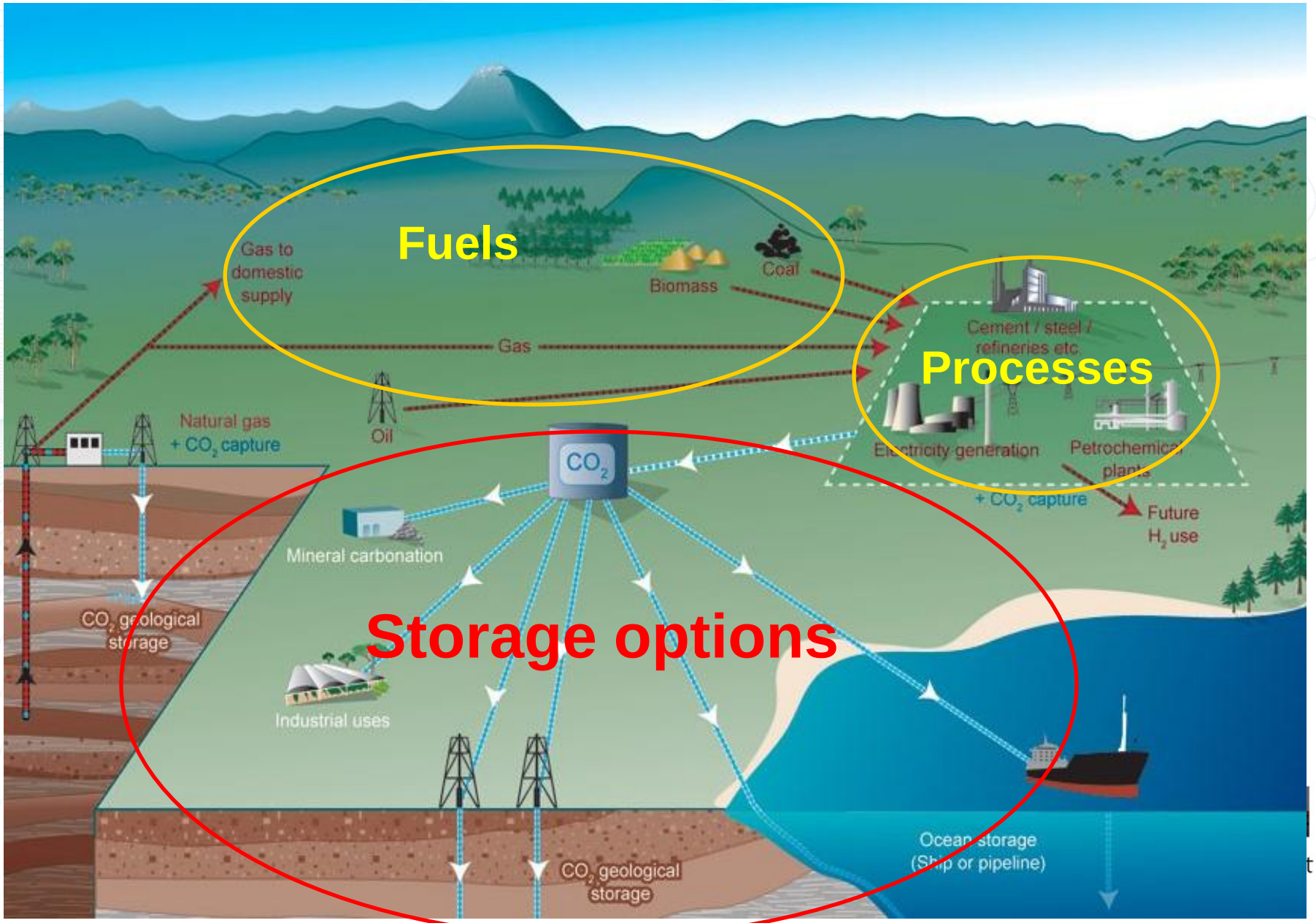
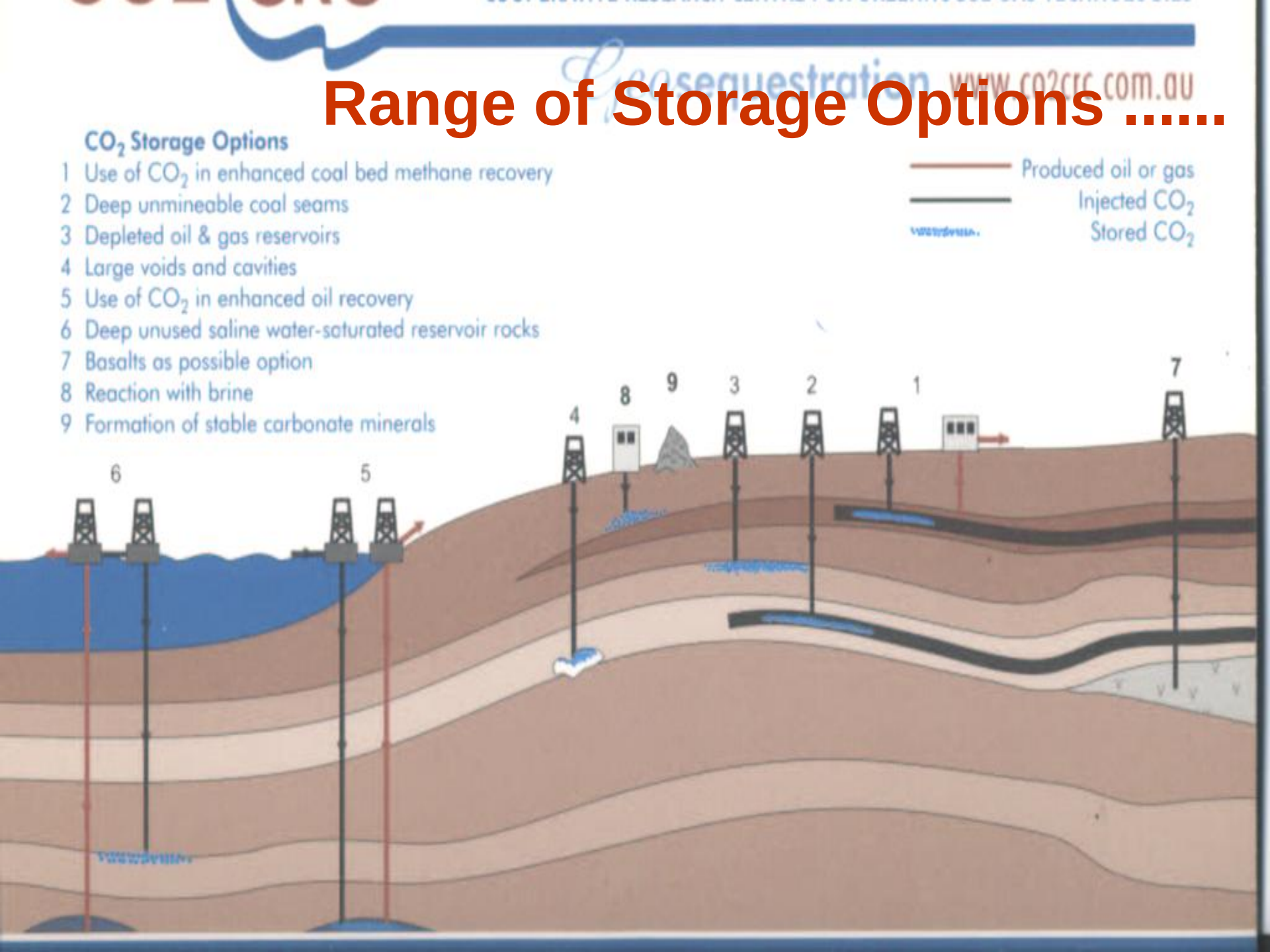
Carbon Capture & Storage



Range of Storage Options .....



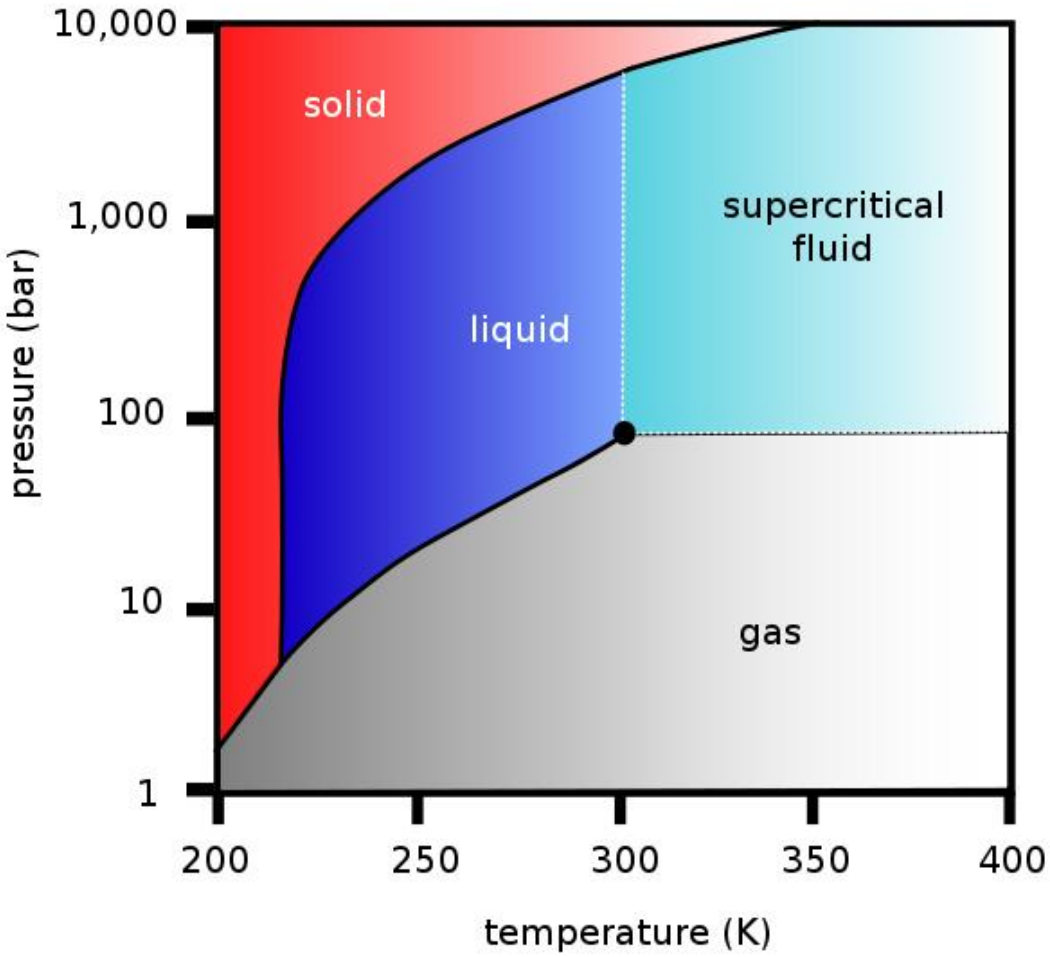
GEOLOGICAL CHARACTERISTICS

Geology – suitable rocks?	**Tectonic Setting**
Reservoir/ Seal pair?	**Potential for Oil and Gas??**
Structures – folding/ faulting/ orientation	**Containment** **Compartmentalisation**
Size of available Basins	**Volumes available**
Depth	**> 700m**
Hydrogeology	**Porosity & Permeability (*CRITICAL!*)**
Pressure / Temperature	**Geothermal Gradient**
CO_2 : wall rock interaction	**Potential for occlusion**
Recharge of reservoir	**Water/ Depletion driven?**
?? Total Volumes available	**Long term Safe Storage??**

NON-GEOLOGICAL CHARACTERISTICS

Proximity to 'capturable' CO_2 sources	Will affect fundamental economics of geological storage project Economies of scale (capture hubs?)
Accessibility	Proximity to shore Water depth
Infrastructure	Production/ pipeline transport infrastructure in place?
Environmental Integrity	Proximity to major population centres Potential for leakage/ explosion Lifelong monitoring Public perception & acceptance
Legal **Insurance**	Regulation Long term liability Insurance costs

CO_2 PHASE CHANGES



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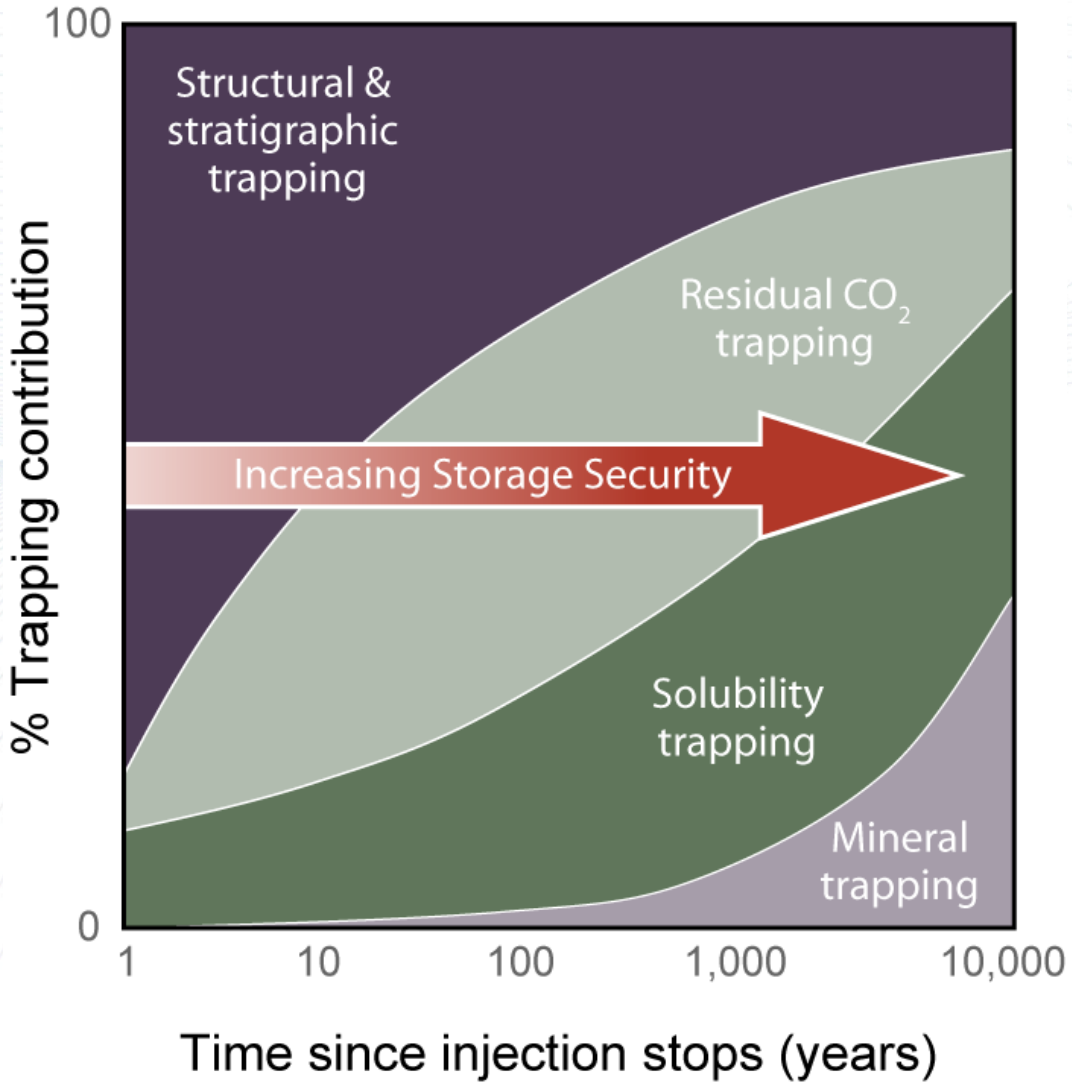
IPCC – Risk of leakage decreases with Time



The fraction of CO_2 retained in well managed geological reservoirs is 'very likely' to exceed 99% over 100 years, and is 'likely' to exceed 99% over 1,000 years[1].
Local risk of geological storage can be comparable to risks of current activities such as commercial gas storage in SW Kinsale in a local sense or EOR projects in the USA/ Canada.

[1] *'Likely" is a probability between 66 and 90% and "very likely" of 90 to 99%.*

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TODAY'S PRESENTATION

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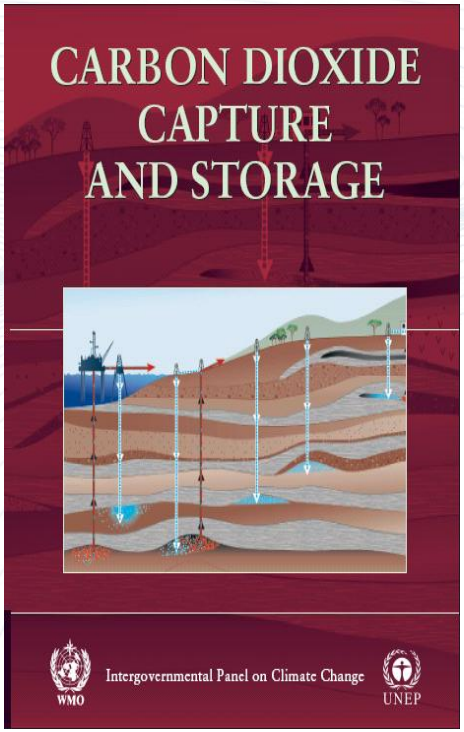
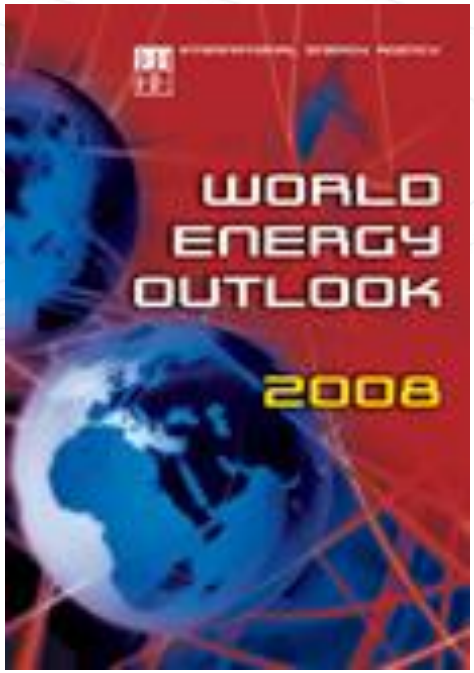
EVERYONE IS TALKING ABOUT CLIMATE CHANGE





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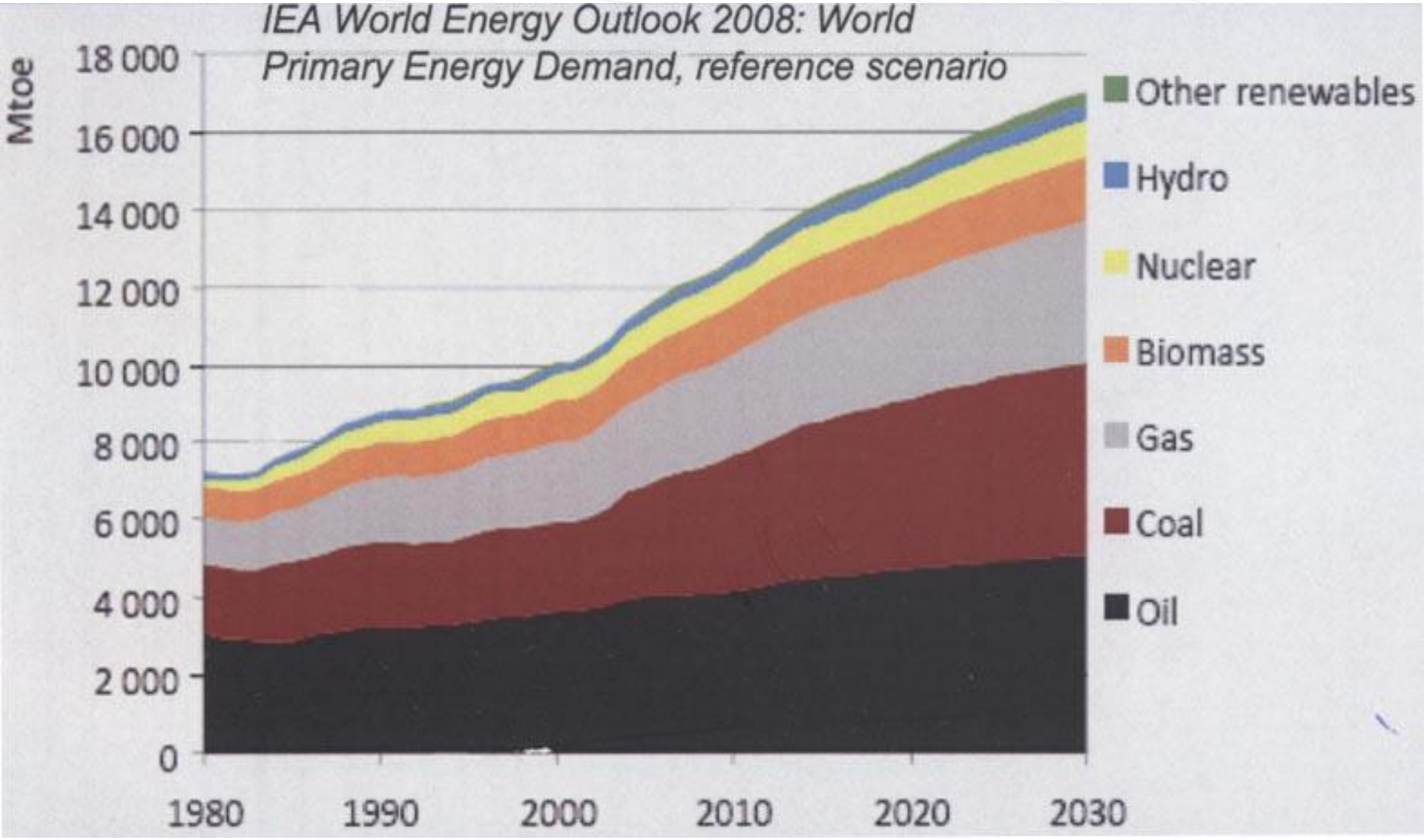
ENERGY DEMAND – predicted x 2 (1980-2030)



CO_2 Atmospheric Concentrations…..

- [CO_2] pre-industrial levels 280ppm reached 379ppm by 2005 - aiming to keep it below 450ppm, or….catastrophe?
- Combined 2007 emissions USA & Canada = 6 Gt
- CO_2 emissions China likely to be higher than USA by 2030 if planned coal fired electricity continues – up to 8 Gt pa
- Ireland's CO_2 emissions ~ 47Mt pa
  - relatively small, but high in per capita terms.

- **CCS offers a <u>bridging strategy</u> over the next 20-100 years to sequester carbon from the atmosphere, until performance and uptake of renewable and clean energy technologies improves**

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So what are we going to do about it?

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EU leading the way…Climate Mitigation

- 70% reduction on 1990 GHG by 2050

- 12 CCS plants operational by 2015
  - 7 Mt CO_2 stored by 2020 ; 160 Mt by 2030
  - CO_2 avoided could be 15% of total EU reductions
- Non-mandatory CCS
  - Market-driven (Emissions Trading System: ETS)
  - Amend existing Directives to permit CCS
  - Amendments to London/ OSPAR Agreements

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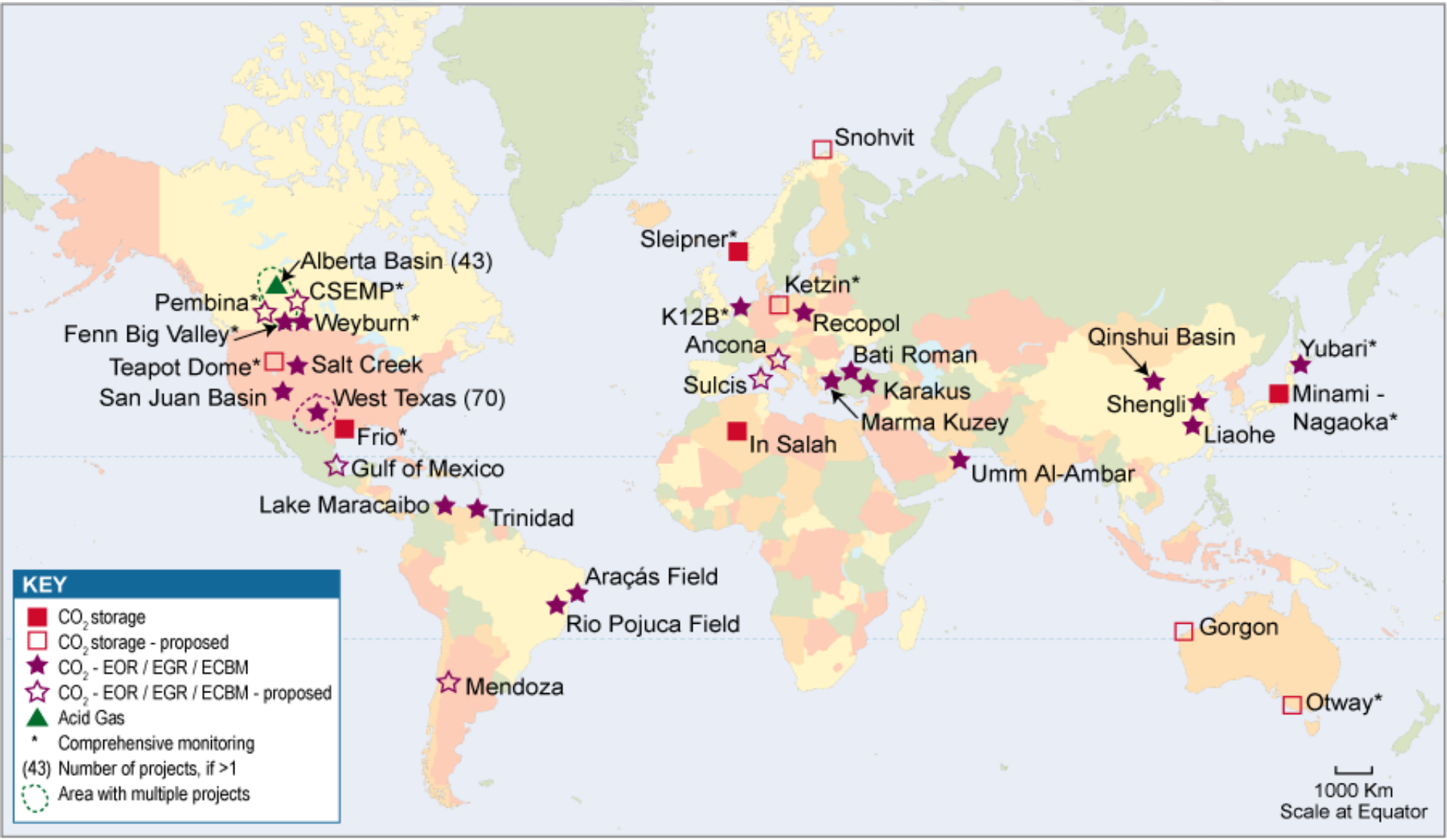
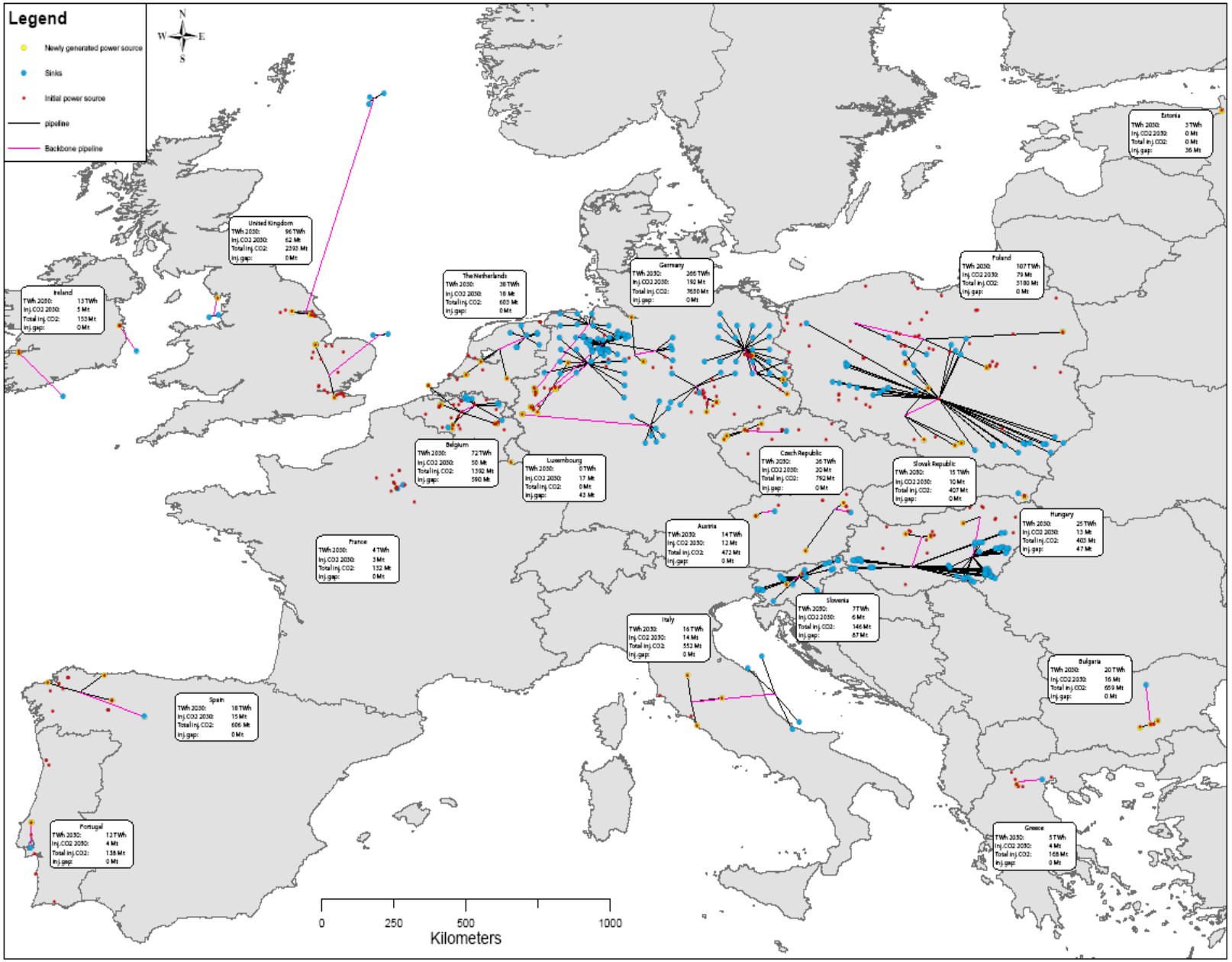
International CCS Projects (Current/ Planned)



EUROPE: MS PLANNED CCS PROJECTS



TODAY'S PRESENTATION

- What is CCS?
- Why CCS?
- EU CCS Directive *2009/31/EC*
- Implications for Geosciences in Ireland

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EU Directive *2009/31/EC*

- **Entered into force in June 2009**
  - **Must be transposed into MS laws by 25 June 2011**
- **8 Chapters, 2 annexes**
- **Guidance on responsibilities of:**
  - **EC**
  - **Member States**
  - **Competent Authorities**
  - **Site operators**
- **CCS is non-mandatory at this stage, given the uncertainties in costs/ technologies & storage But…is coming…..**

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Member State (MS) obligations

- Competent authority (CA) to be appointed
- MS should assess storage capacity of territory
- Identify geologically suitable zones; assess seismicity
- Storage only in zones of low risk of leakage
- Environmental data must be made public*
- Maintain records / registers of CCS projects

- Grant exploration / site storage permits
- Monitor CO_2 streams/ transport, link to EIA, M&V
- Conduct regular and random inspections of sites
- Communicate decisions to EC

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EU Directive *2009/31/EC*

- **Chapter 1 – Scope & definitions**
- **Chapter 2 – Selection of Storage Sites & Exploration Permits**
- **Chapter 3 – Storage Permits**
- **Chapter 4 – Operation, Closure, Post-Closure**
- **Chapter 5 – Third Party Access**
- **Chapter 6 – General provisions**
- **Chapter 7 – Amendments to existing Directives**
- **Chapter 8 – Final Provisions**
- ***Annex I*** ***Criteria for Storage Site Characterisation***
- ***Annex II*** ***Criteria for establishing Monitoring Plan & Post Closure Plans***

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Chapter 2 Storage Site Selection & Exploration Permits

- **Site Selection (based on MS assessment)**
- **Site Characterisation – *guidelines set out Annex 1***
- **Must be no risk of leakage**
- **No significant risk to environment/ human health**

- **Exploration Permits**
  - **Clear criteria for issuance**
  - **Sufficient time to assess site**
  - **Clear geo-spatial limits to site to be assessed**
  - **Sole rights of permit holder to access site**

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Chapter 3 Storage Permits

- Storage permit – clear procedures & guidelines
- Storage volumes & timeframe clearly set out
  - Injectivity, injection rates, measures to prevent 'irregularities', content & project volumes of CO_2 streams
- Monitoring plans, with mitigation measures
- Provisional Post-Closure Plans
- Site Operator
  - Competent, technically & financially
  - Must comply with associated Directives
- EC will review Draft Storage Permit applications; make non-binding recommendations
  - If CA deviates from EC, must be able to justify

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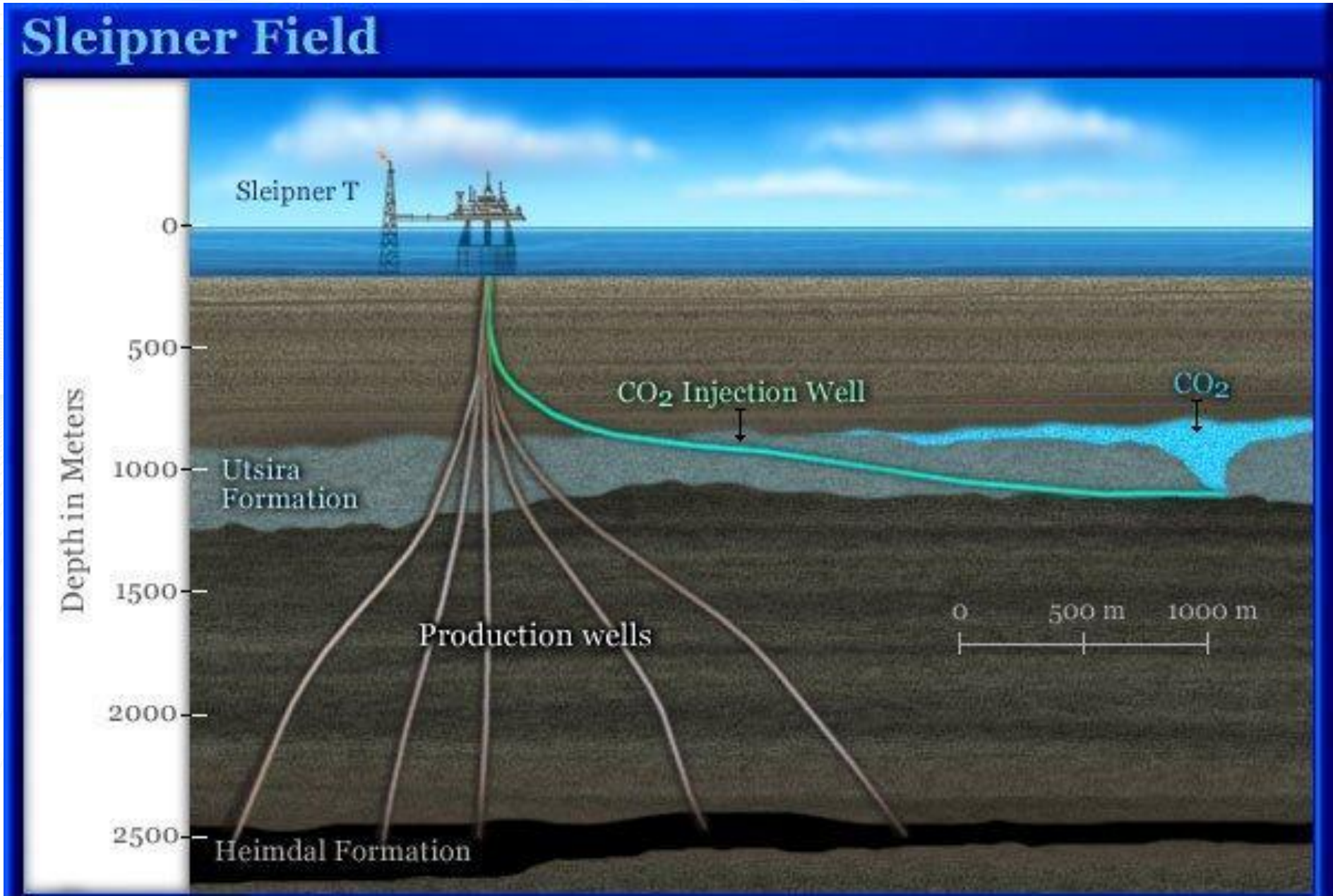
SLEIPNER STORAGE PROJECT



Chapter 4 Site Operation, Closure & Post Closure

- **Focus on Monitoring (injection, storage & surrounds)**
  - Actual vs Modelled behaviour, updated every 5 yr
- **Annual records & reports by Operator to CA**
- **Inspections by CA at least 1 pa (operating stage) &**
  - every 5y (post-closure) until transfer site to CA
  - Data publicly available 2 months later
  - Corrective measures must be taken if 'irregularities'

Post-Closure Obligations

- **Post Closure Plan**
- **Only permit closure if all obligations are met**
- **All remedial actions must be taken, as per CA**

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Chapter 4 Transfer of Responsibility to CA

- CO_2 must be demonstrably permanently contained
- Min. period before transfer to CA = 20 years
  - Site must be sealed, injection facilities removed
  - Financial sureties in place
- FINAL REPORT by Operator >> must demonstrate
  - actual vs model; absence of leakage; long term stability
  - CA must pass Report to EC within 1 month
  - CA prepare Draft Decision of Approval to transfer liability
  - Notify EC, who rule within 4 months;
  - Should comply with EC ruling; if not, why not
- Post-Transfer inspections, every 1-5 years
- Ongoing monitoring costs for 30 yr borne by Operator

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Chapter 5 - Third Party Access

- Access to transport network for 3rd Parties
- Access to storage sites for 3rd Parties
- Can refuse but decision must be transparent

  e.g lack of storage capacity, or technical incompatability e.g. of CO_2 stream

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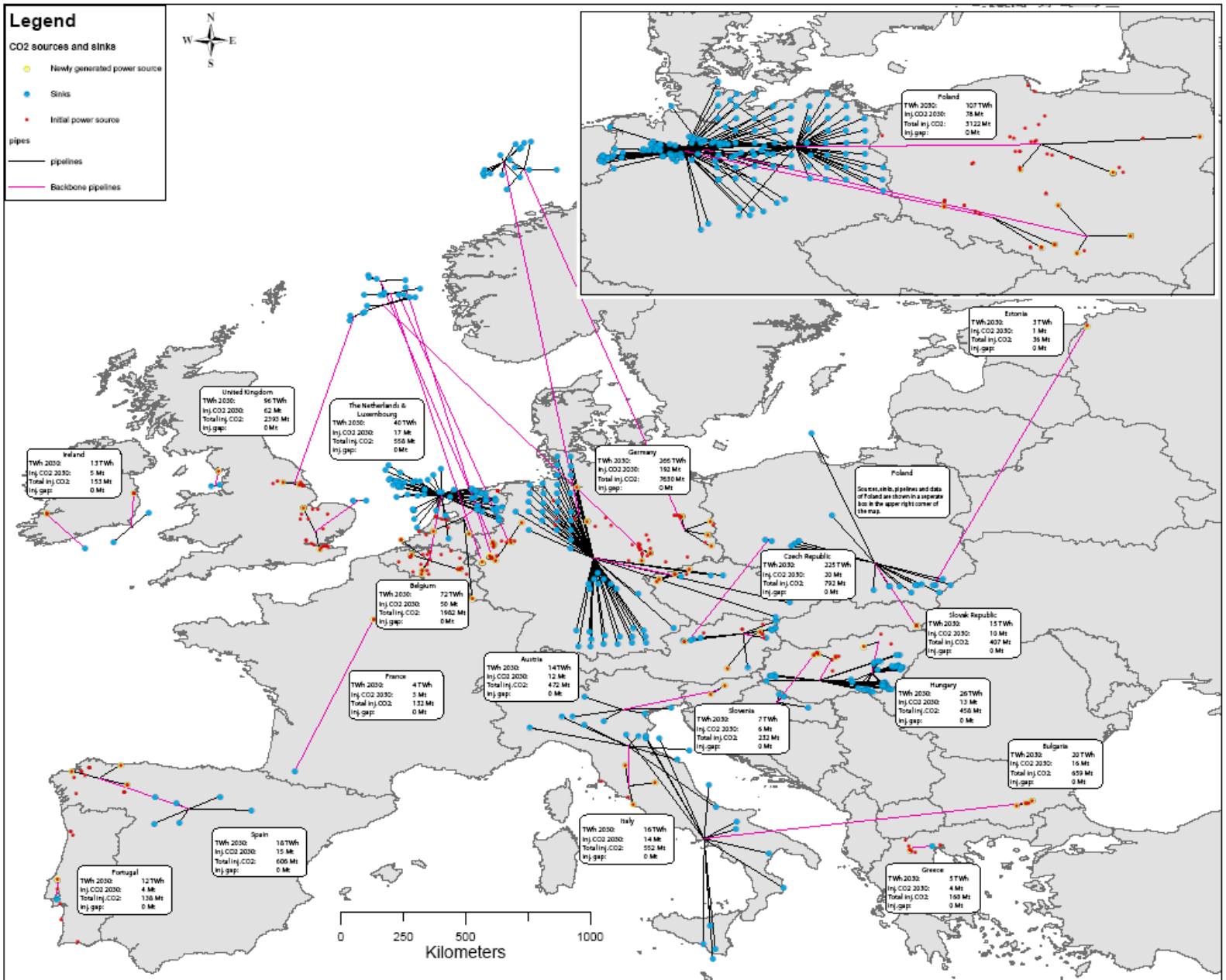
EUROPE: Integrated CCS Projects 2030 ?



Chapter 6 General Provisions

- CA may be more than one entity, but must be single Coordinating Authority in each MS
- Registers must be maintained by MS on all CCS activities
- Reporting: MS first report on implementation of the Directive is due 30 June 2011
- Penalties may apply

- ONEROUS OBLIGATIONS ON MS / CA

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Chapter 8 - Final Provisions

- **EC must report to Eur Parliament within 9 months of receipt of all MS June 2011 reports**
- **May make recommendations for amendments**
- **May suggest what is required (if any) to establish a mandatory framework for emissions performance standards for new large electricity-generation installations**

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In Summary

- **Enabling legal framework sets out liabilities covered**
  - Corrective measures for CO_2 leakage (geological storage directive)
  - Surrender of allowances under ETS to cover any leaked emissions
  - Liabilities under the Environmental Liability Directive (2004/35/EC)
- **Site transfers to the MS when injection has ceased and site has progressed towards safe condition:**
  - Criterion: all available evidence indicates that stored CO_2 will be completely and permanently contained
  - Must be approved by EC/ independent body
- **Post-Closure Liability of Operator:**
  - Minimum period before transfer of 20 years unless condition for transfer met earlier
  - Financial contribution to cover at least post-transfer monitoring for 30 years

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TODAY'S PRESENTATION

- What is CCS?
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THE POLICY CONTEXT

"...we will build on analysis by SEI on costs, benefits and future potential for Ireland of CCS Strategies. Subject to developments, the Government would envisage the commercial operation of a new clean coal power generation plant before 2020"

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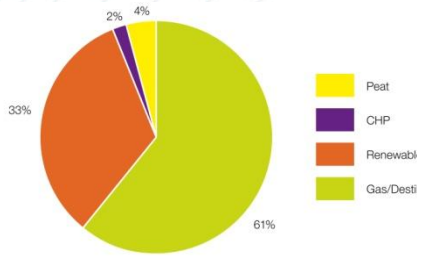
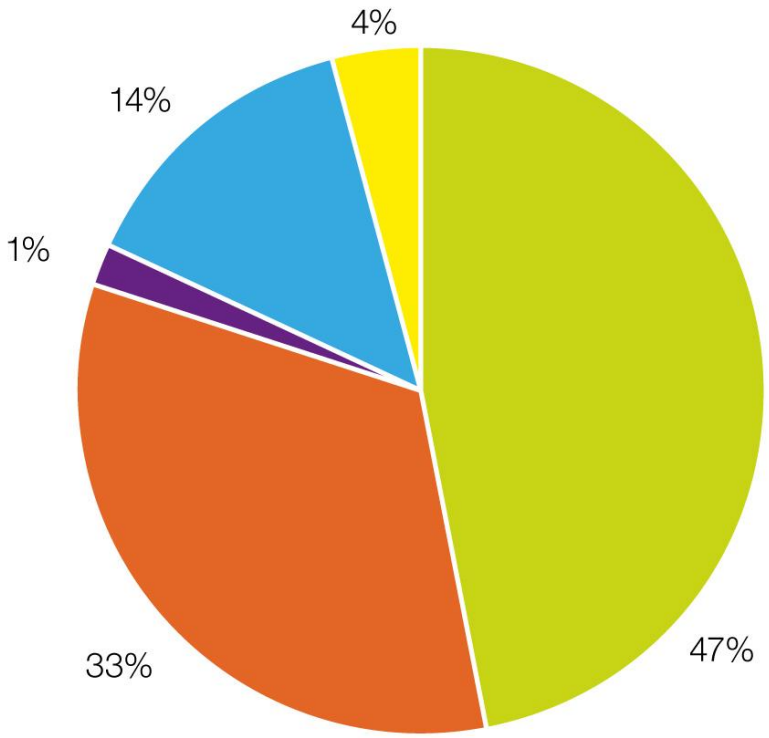
GENERATION PORTFOLIO 2020 : Coal in the mix to secure supply?





Peat
Coal
CHP
Renewable
Gas/Destillate

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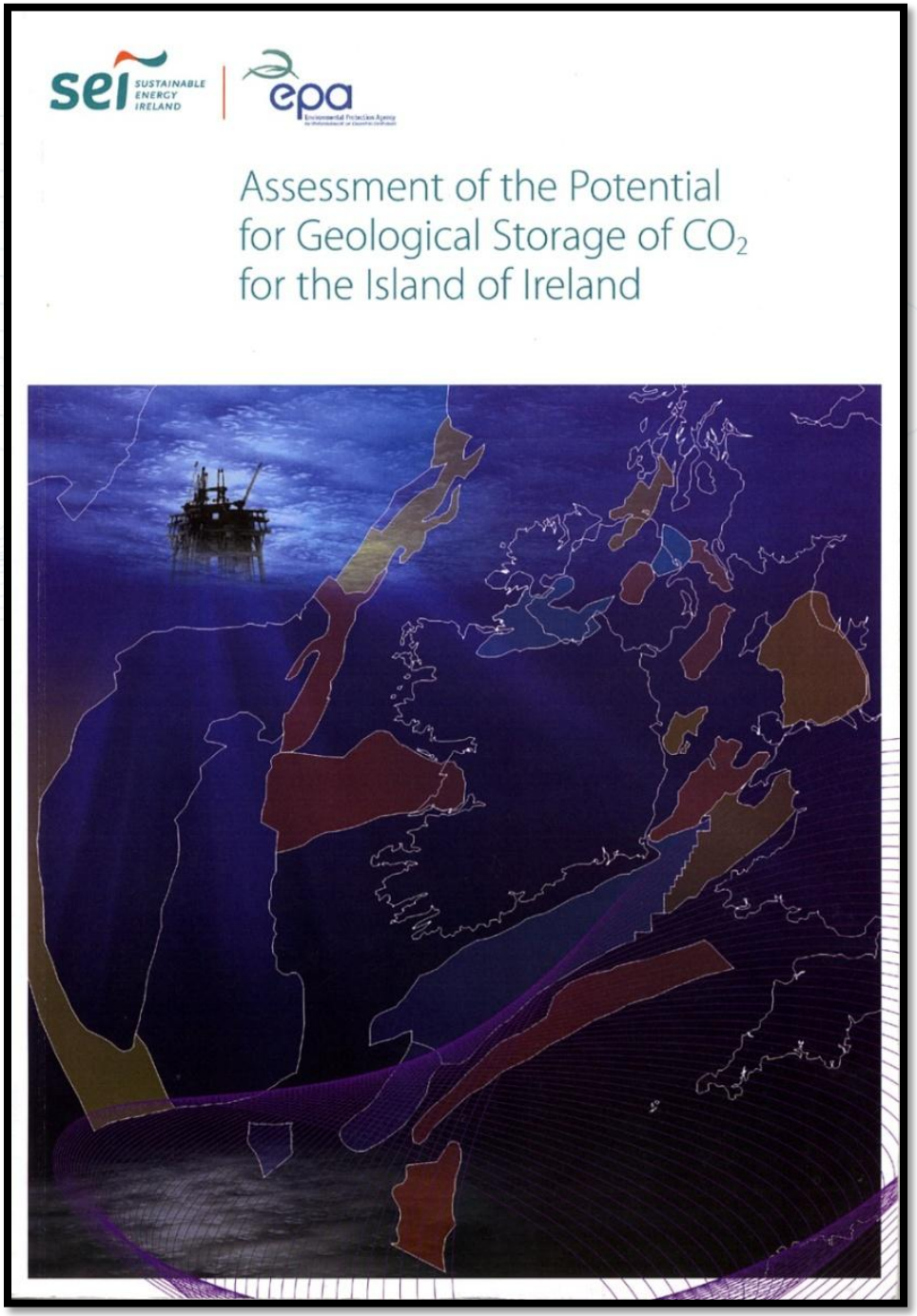
Island of Ireland (2008)

Regional Assessment of potential for geological storage of CO_2

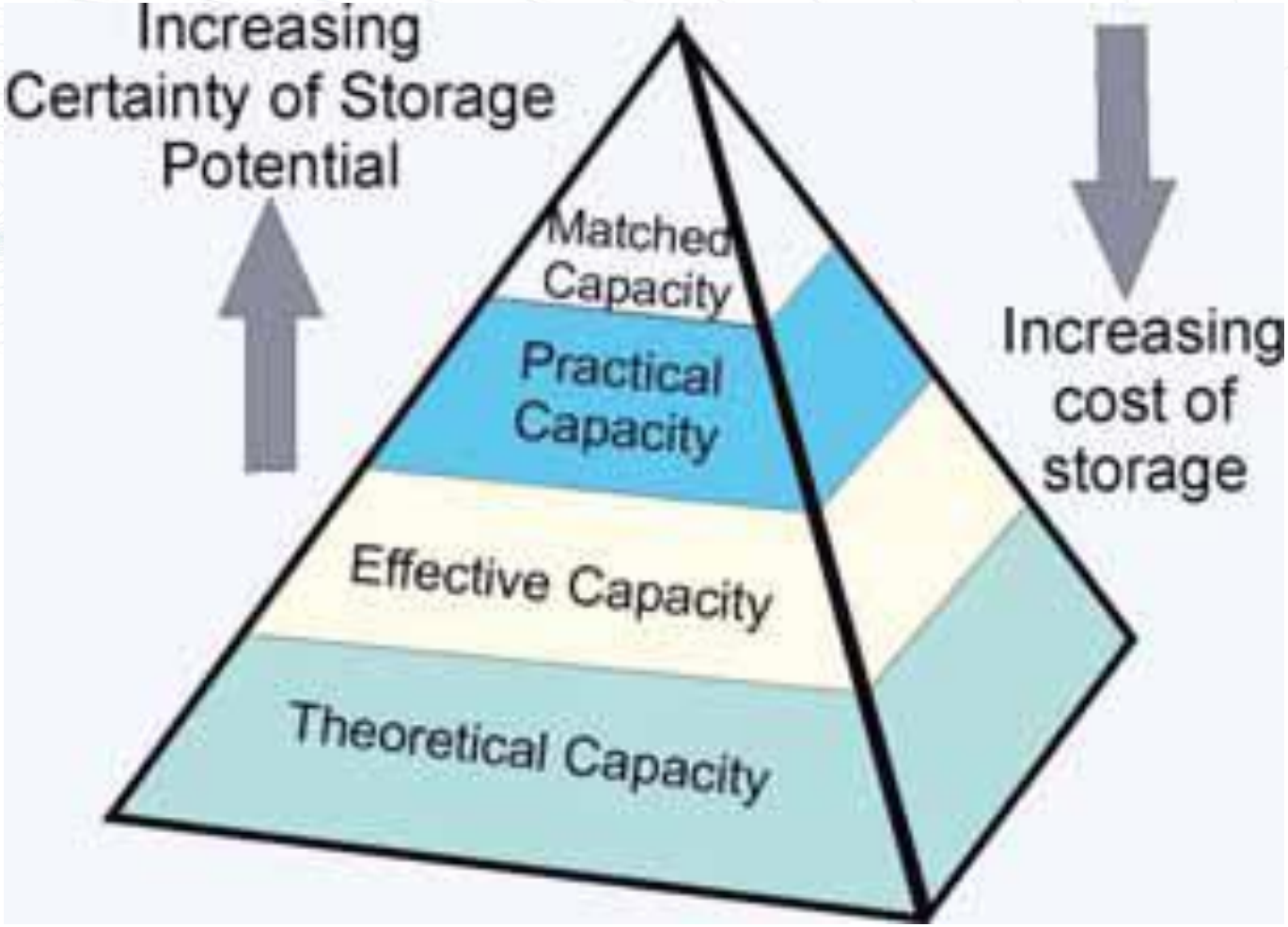
http://www.sei.ie/Publications/Emerging_Technologies/



International Best Practice & Standards:

TECHNO-ECONOMIC RESOURCE PYRAMID

Carbon Sequestration Leadership Forum 2007



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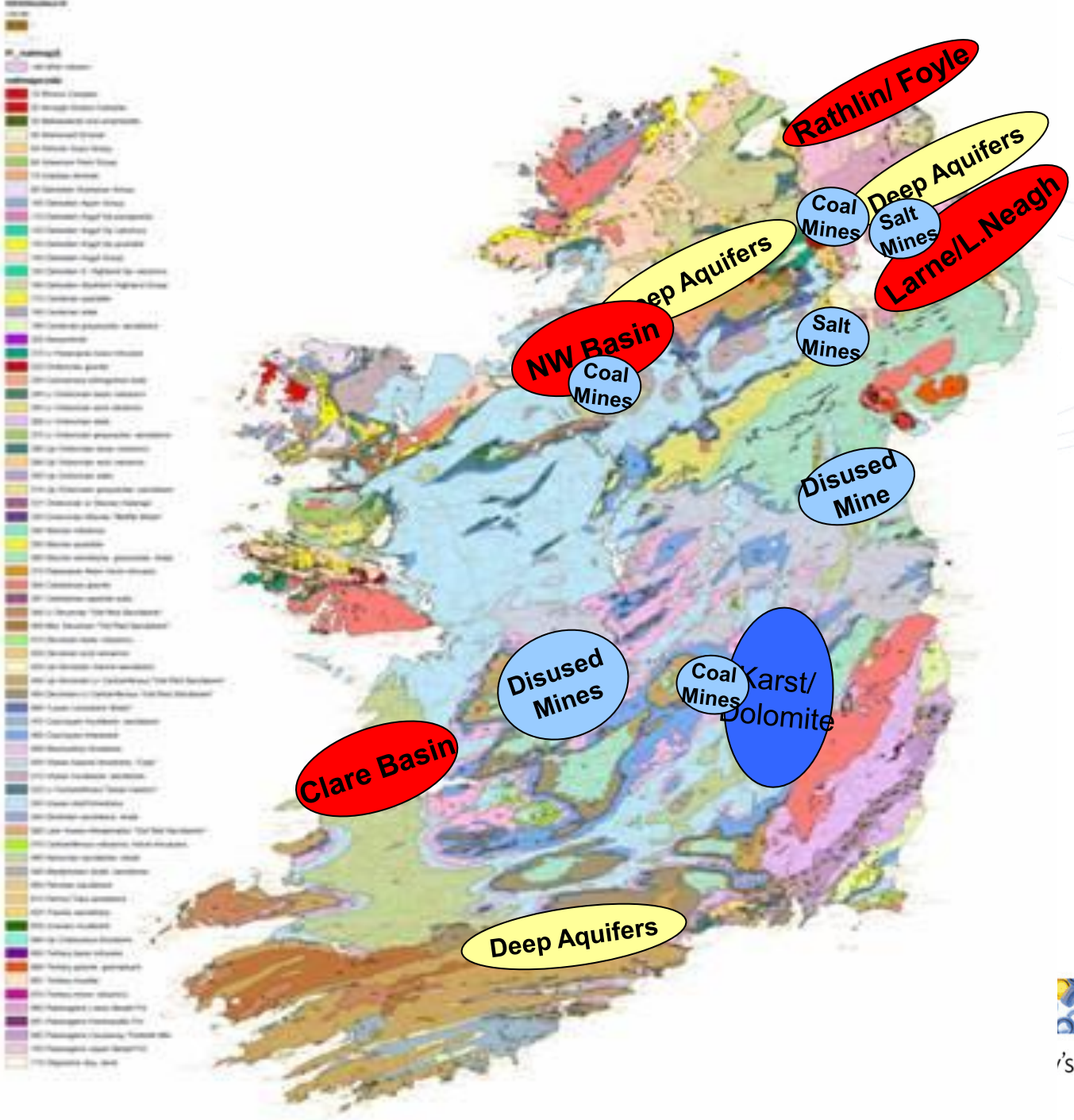

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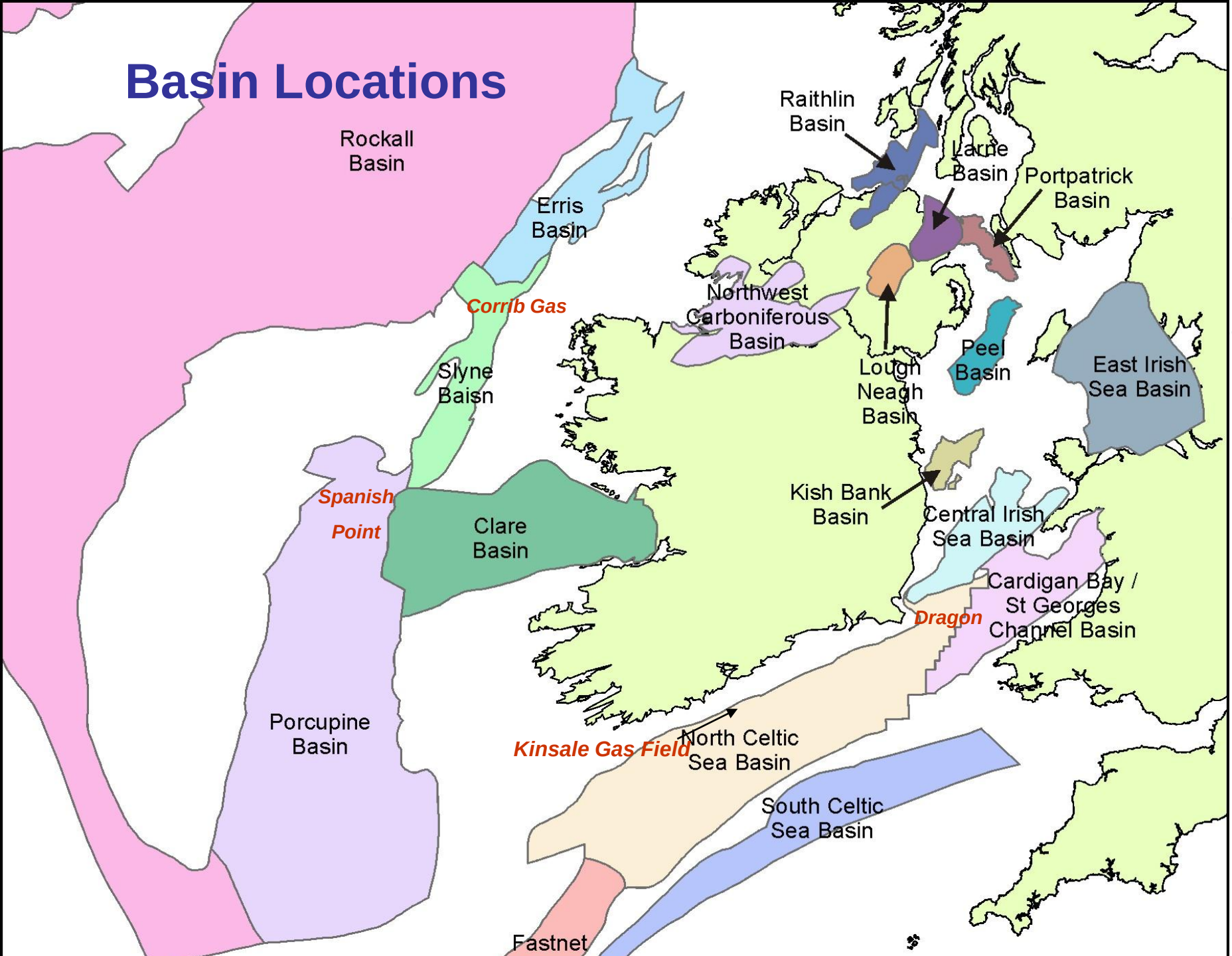
Basin Locations
Rockall Basin
Erris Basin
Raithlin Basin
Larne Basin
Portpatrick Basin
Corrib Gas
Northwest Carboniferous Basin
Slyne Baisn
Lough Neagh Basin
Peel Basin
East Irish Sea Basin
Spanish Point
Clare Basin
Kish Bank Basin
Central Irish Sea Basin
Cardigan Bay / St Georges Channel Basin
Dragon
Porcupine Basin
Kinsale Gas Field
North Celtic Sea Basin
South Celtic Sea Basin
Fastnet

SUMMARY: CO_2 Storage Opportunities

- **Practical Storage capacity** **1,505 Mt**
- **Effective Storage capacity** **3,500 Mt**
  (***of which 667Mt is subset of Theoretical capacity***)
- **Theoretical** **88,770 Mt**

>> Total (all-island): 93,115 Mt

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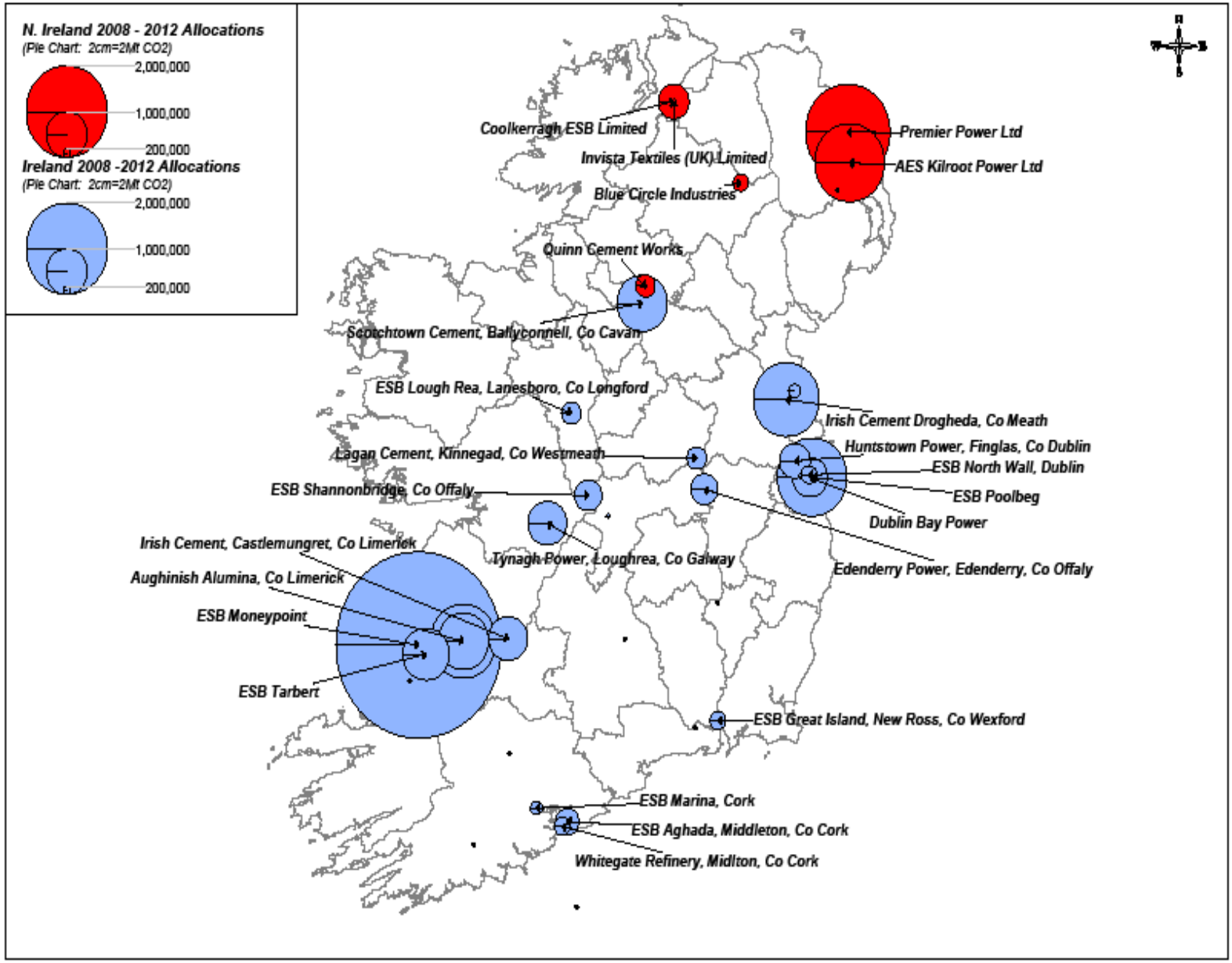
All-Island CO_2 Allocations (NAP)



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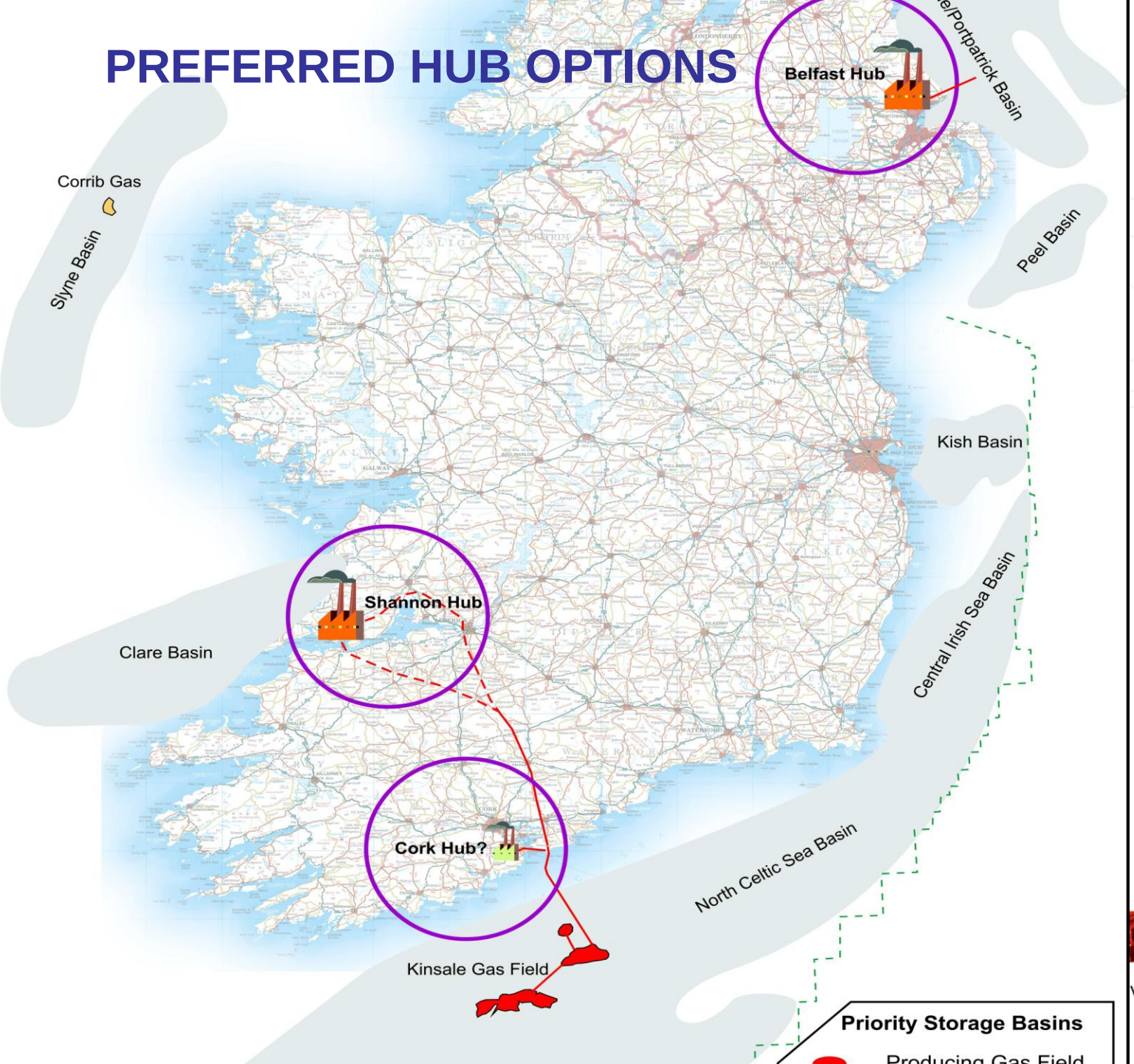
PREFERRED HUB OPTIONS



vironment

Ireland: Geological Storage of CO_2

- Kinsale Head Gas Field - window of opportunity
- Clare Basin onshore – too shallow/ too tight (TNO/ Aurum, 2010)
- Offshore : Spanish Point/ North Celtic Sea
- Site specific modelling required
  - 3-D Static modelling
  - Dynamic modelling
- Industry/Academic linkages must be fostered

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CCS - Any questions?