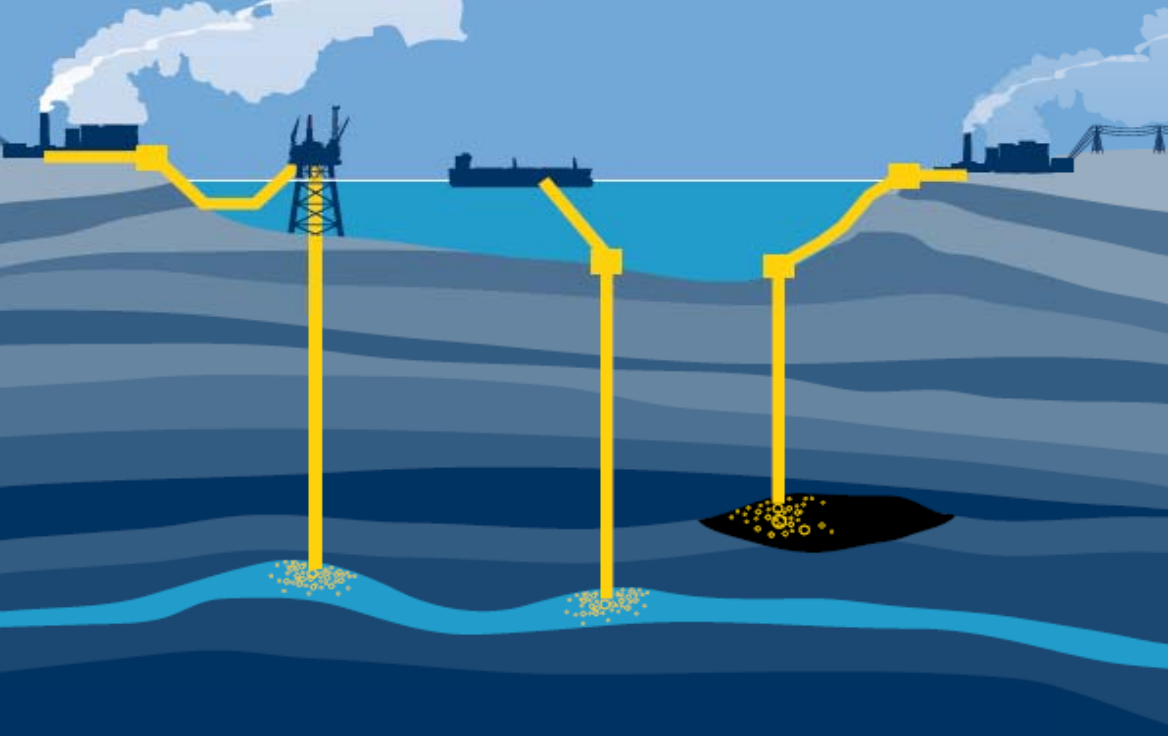


One North Sea

A study into North Sea cross-border CO₂ transport and storage



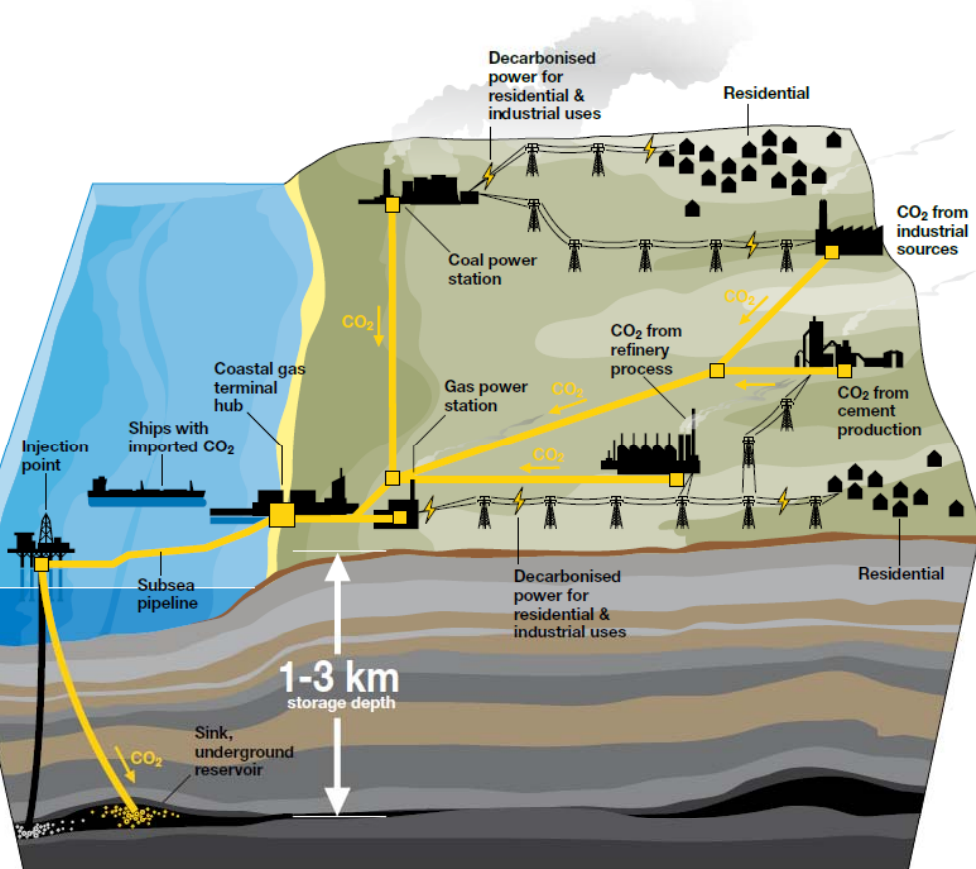
North Sea Cross-border CO₂ transport and storage

Eva Halland
Project Director CO₂ Storage
Norwegian Petroleum Directorate

Outline

- Objective
- Database
- The Vision
- Approach
- Results
- Recommendations

One North Sea – objective



graphic: © www.paulweston.info 2010

- ◆ **Initiated** by the Norwegian and UK Energy Ministers in May 2009
- ◆ **Identify** the storage potential for CO₂ in the North Sea
- ◆ **Estimate** a likely CO₂ storage need for Europe
- ◆ **Identify** plausible matches of sources and sinks
- ◆ **Identify** challenges with regard to transport of CO₂ across countries
- ◆ **Optimize** CO₂ transportation infrastructure

UNITED KINGDOM

The UK has a legally binding target of at least an 80 % cut in greenhouse gas emissions by 2050, to be achieved through action in the UK and abroad, as well as a reduction in emissions of at least 34 % by 2020.¹

The UK is one of the first countries to undertake a CCS competition to demonstrate 300MW net post-combustion capture on a coal power plant in 2014.

The UK has also implemented a Carbon Capture Readiness policy for new large combustion plant and is undertaking consultations on:

Proposals for a framework for the development of clean coal, including inter alia providing financial support for up to four commercial-scale CCS demonstrations in Britain, requiring any new coal power station in England and Wales to demonstrate CCS on a defined part of its capacity, and requiring new coal power stations to retrofit CCS to their full capacity within five years of CCS being independently judged technically and economically proven.

Proposals for an offshore carbon dioxide storage licensing regime. Regional consortia are examining CCS infrastructure potential for the Yorkshire and Humber region and for Scotland.

against a 1990 baseline.

NETHERLANDS

The Ministries of the Environment and Economic Affairs have published "An agenda for 2007-2020 to make CCS work". In June 2009 the Cabinet of Ministers sent a CCS Policy Letter to Parliament on the usefulness and necessity of CCS for climate change policy and financial issues and CO₂ infrastructure.

ATO and CATO-2, co-ordinated by Utrecht University and TNO, are ambitious research and development programmes on all aspects of CCS.

The Rotterdam Climate Initiative has carried out an analysis for a full business case and network approach for CCS.

Realising one of the European CCS demonstration projects, the northern Netherland presented an Action Plan in February 2009. Three techniques for capturing CO₂, combined with transport and exploration of storage possibilities, have been presented in an integrated business case.

INTERNATIONAL COORDINATION

The Task Force is developing recommendations on site risk assessment and qualification, and on monitoring, verification, accounting and reporting guidelines.

Task Force countries are working closely together on international activities to optimise CCS deployment. These include the Carbon Sequestration Leadership Forum (CSLF), the International Energy Agency (IEA), the Global CCS Institute (GCCSI), as well as

Europe-wide initiatives including the EU Zero Emissions Power plant (ZEP) Technology Platform, the GeoCapacities study on storage, the Fossil Energy Coalition (FENCO) and the ACCCEPT study on public engagement. The Task Force members have worked closely with the OSPAR Commission and London Convention to develop rules for safely storing CO₂ beneath the seabed.

NORWAY

Norway's ambition is to reduce its greenhouse gas emissions by the equivalent of 30% of its own 1990 emissions by 2020.

The Sleipner and Snøhvit CCS projects are separating and injecting CO₂ into deep saline aquifers for long-term monitoring and storage.

The Ministry of Petroleum and Energy has established the CLIMIT Programme and the Gassnova company to stimulate CCS research and deployment.

The European CO₂ Technology Centre Mongstad (TCH) is under construction. The primary objective is to develop, test and qualify new CO₂ capture technologies with the aim to reduce costs and risks associated with large-scale CO₂ capture plants.

The Norwegian Petroleum Directorate is mapping possible storage sites on the Norwegian Continental Shelf.

Det Norske Veritas is investigating common standards and specifications for CCS infrastructure.

GERMANY

The state of development and perspectives of CCS-technologies in Germany were summarized in a cabinet report published in September 2007.

Support for further research and development including demonstration projects is given by the "Integrated Energy and Climate Package" which aims to deliver a cut in CO₂ emissions against a 1990 baseline of at least 30%.

Two research and development programs – COORETEC (CO₂-reduction technologies, www.cooretec.de) and GEOTECH-INNOLOGEN (www.geotechnologien.de) – are focused on the development of low emission power plants based on fossil fuels. COORETEC is focused on power plant technologies including CO₂ capture. GEOTECH-INNOLOGEN focuses on the long-term safe and environmentally friendly CO₂-storage and corresponding storage technologies.

Several pilot plants are already testing capture technologies (Oxyfuel and Postcombustion) at small scale. Storage is tested within the European research project CO₂SINK (www.co2sink.org) at the Katzin test site in Brandenburg and the storage potential is analyzed by the Federal Institute for Geosciences and Natural Resources (BGR) and the Geological Surveys of the Federal States. National partners and BGR commenced in 2008 the project "Geo-Potential of the German North Sea sector" which includes a detailed estimation of storage capacities.

Norwegian Petroleum Directorate

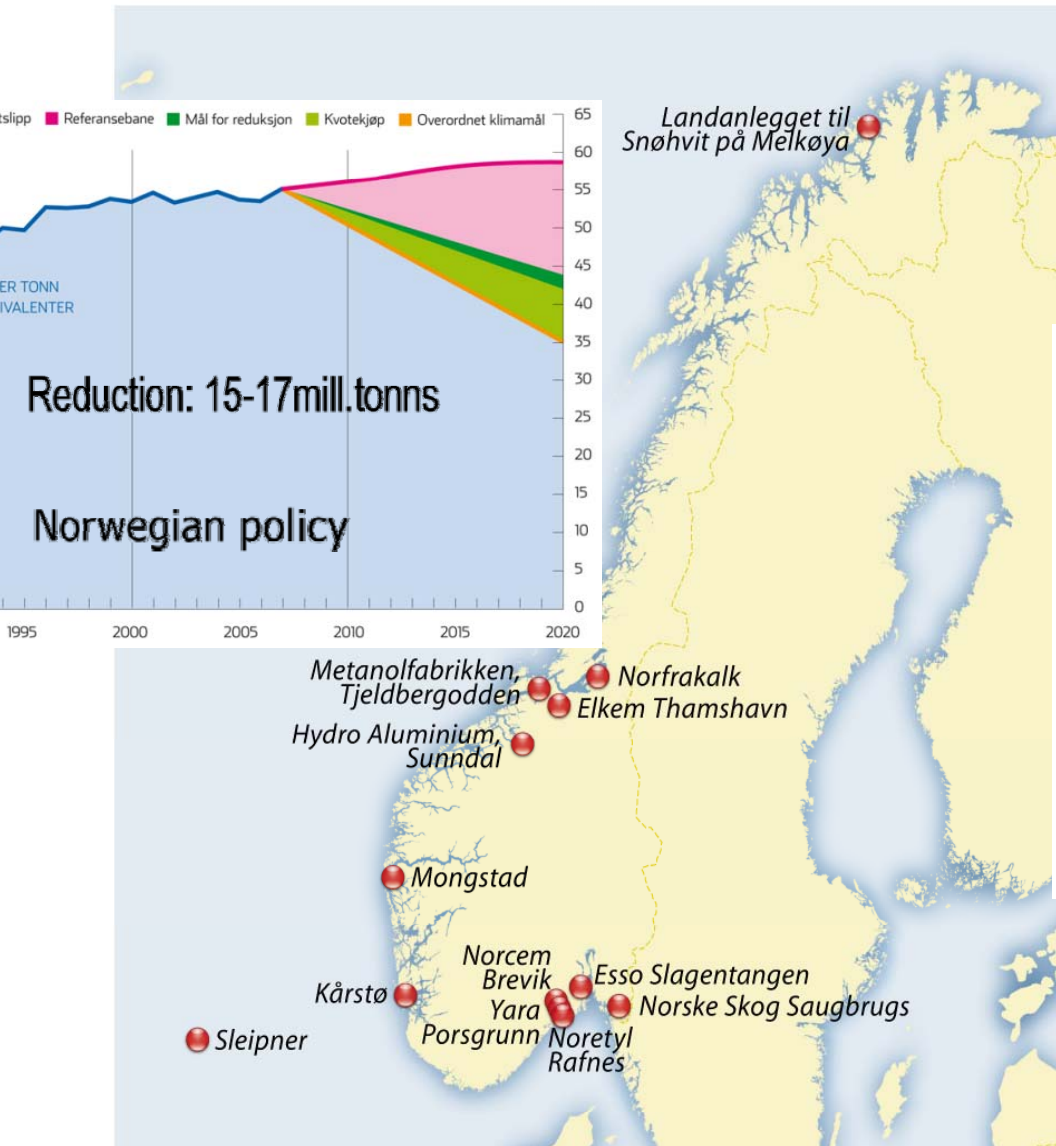


- ◆ Subordinate to the Ministry of Petroleum and Energy (MPE)
 - ◆ Advisory body to the MPE
 - ◆ Exercise management authority
- ◆ Established 1972 in Stavanger
- ◆ 220 employees; – engineers, geologists, economist etc

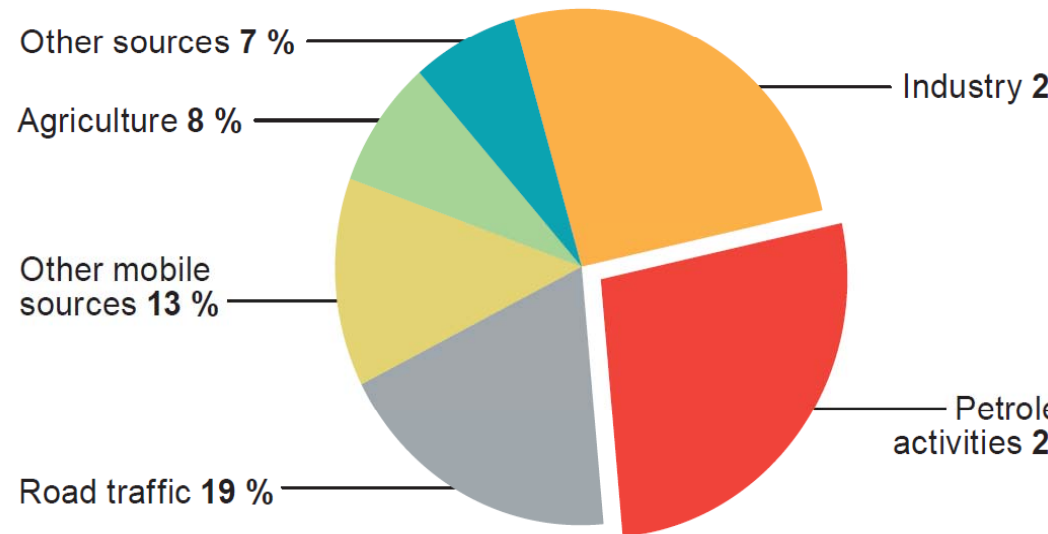
The Norwegian Petroleum Directorate will contribute in **creating the greatest possible value for society from oil and gas activities by means of prudent resource management**, based on safety, emergency preparedness and safeguarding the natural environment.



CO₂- emissions from Norwegian sources

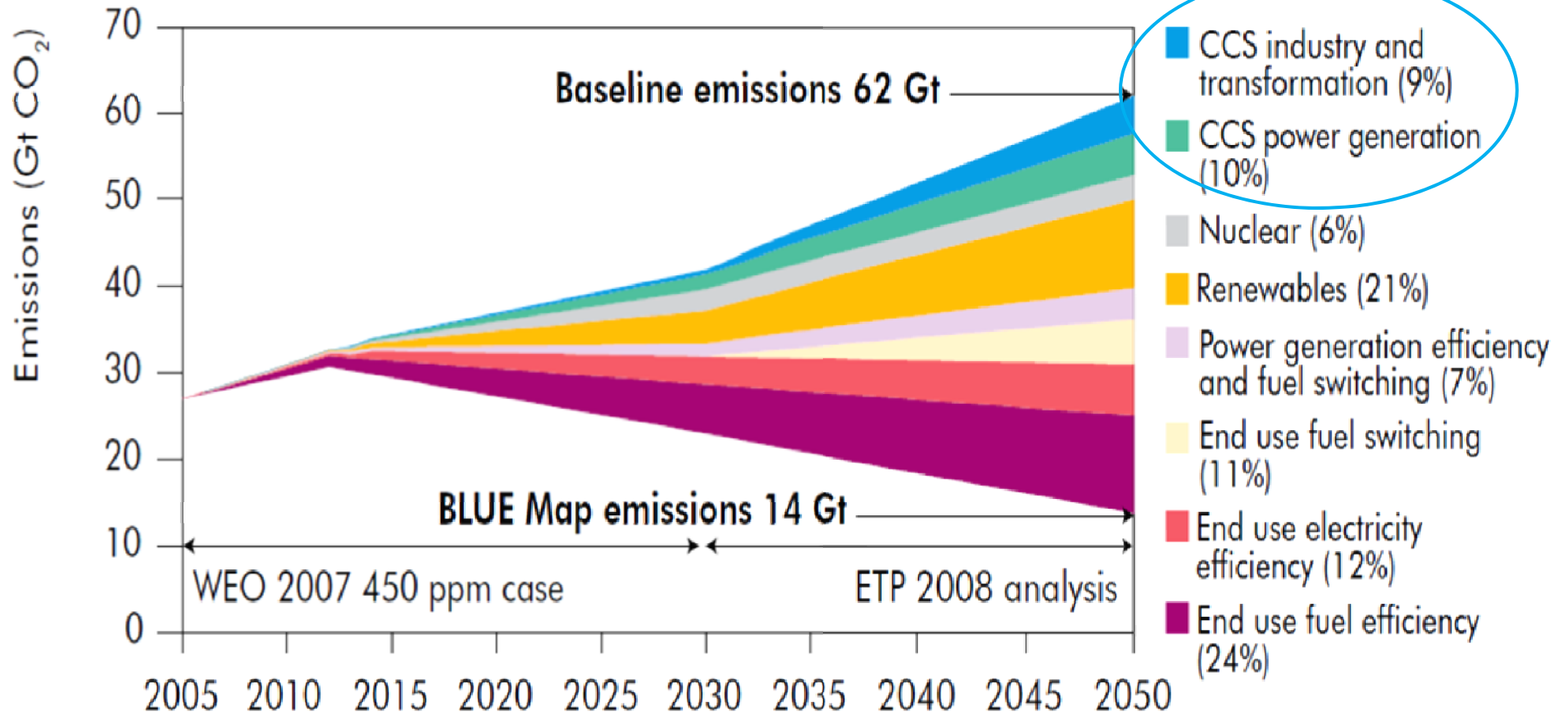


Sources of Norwegian CO₂ emissions, 2008



Total CO₂ emissions
ca. 45 million tonns/year

WHY?



World Energy Outlook 2007

Internationally



The Global CCS Institute formally launched at G8/Major Economic Forum in Italy 9th July 2009

Testimonial

"If we want to reduce our greenhouse gas emissions by 80% in 2050, we certainly need Carbon Capture and Storage" (Andris Piebalgs, EU Energy Commissioner)

The European Council has called for a demonstration programme of up to 12 large-scale CCS projects to be operational by 2015



"We strongly support the recommendation that 20 large scale CCS demonstration projects need to be launched globally by 2010, with a view to supporting technology development and cost reduction for the beginning of broad deployment of CCS by 2020."

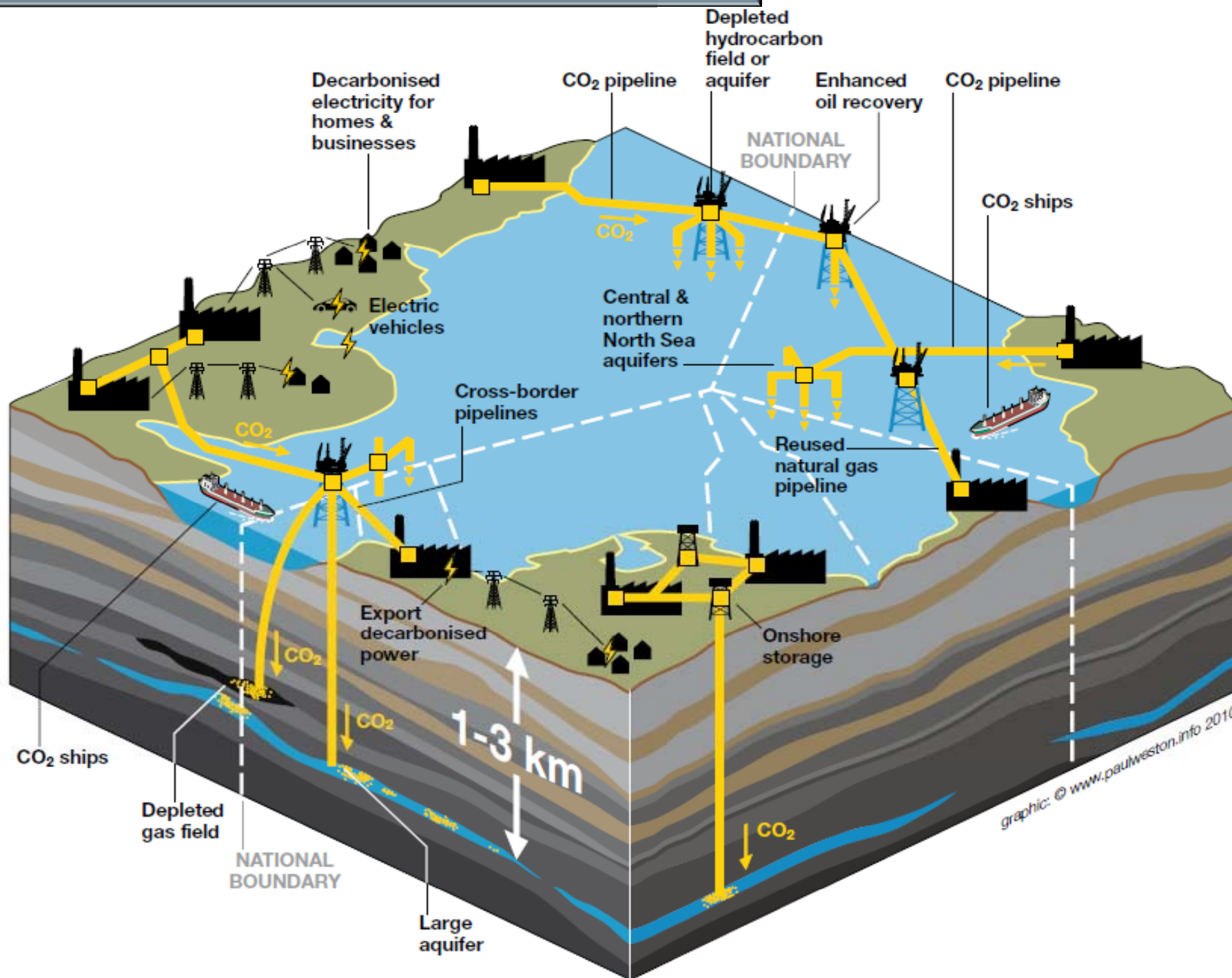
G8 Statement of June 2008

"One North Sea" database

- ✓ Storage capacity: based upon Geocapacity project and data from Norwegian Petroleum Directorate
- ✓ Policies and initiatives to support CCS at EU level and within Norway, UK, the Netherlands and Germany
- ✓ Economic modelling of CCS demand
- ✓ Analysis of legal and regulatory barriers
- ✓ Scenarios of investment in capture, transport and storage in 2030 and 2050
- ✓ CO₂ transport and storage scenarios and network
- ✓ Several stakeholder meetings



A 'One North Sea' vision



Summary of the market and policy combinations in 2030 used as inputs for the Classic Carbon model

Driving force	Mandatory	Competitive	Fragile
Power demand	High	Business as usual	Business as usual
Renewables	90% of 2020 target	90% of 2020 target	100% of 2020 target
CO ₂ cap	30% reduction relative to 1990	40% reduction relative to 1990	25% reduction relative to 1990
CCS costs	35% reduction relative to 2008	25% reduction relative to 2008	20% reduction relative to 2008
CCS efficiency penalty	6% gas, 8% coal	8% gas, 10% coal	8% gas, 10% coal
Gas prices	\$19/MWh	\$22/MWh	\$27/MWh
Coal prices	\$70/tonne	\$70/tonne	\$70/tonne
Nuclear	Known investments only	Known and new investments	Known investments only
Mandatory CCS	New investments from 2020	None	None

Modelled Mt CO₂ storage capacity in depleted hydrocarbon fields in the GIS database with 30Mt filter

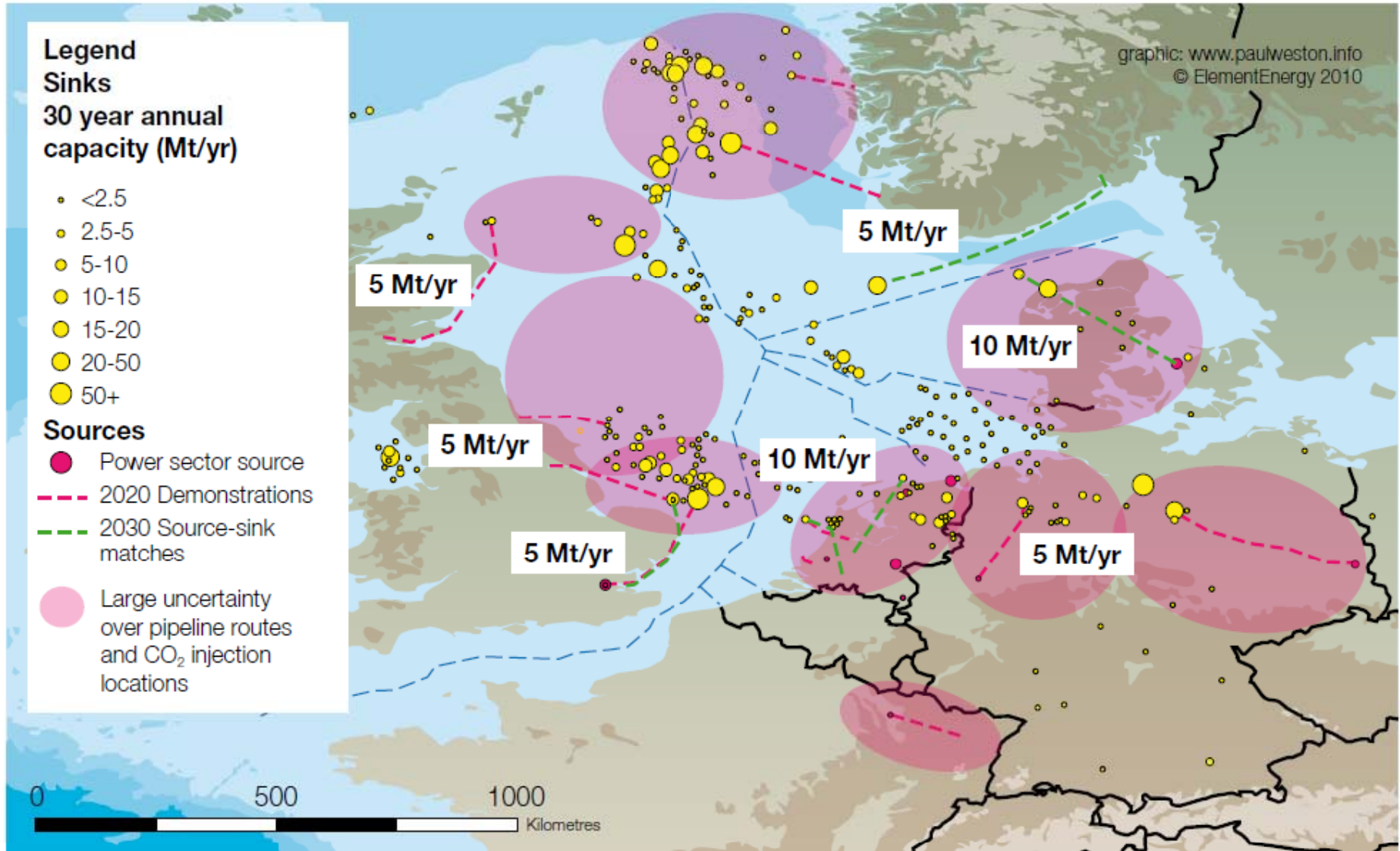


Country	2030 storage (Mt)	2050 storage (Mt)	Reference
Denmark	753		GeoCapacity
Germany	1816		GeoCapacity
Netherlands	1532		GeoCapacity
Norway	4283	6302	NPD
UK	7141	7910	GeoCapacity
TOTAL	15525	18313	

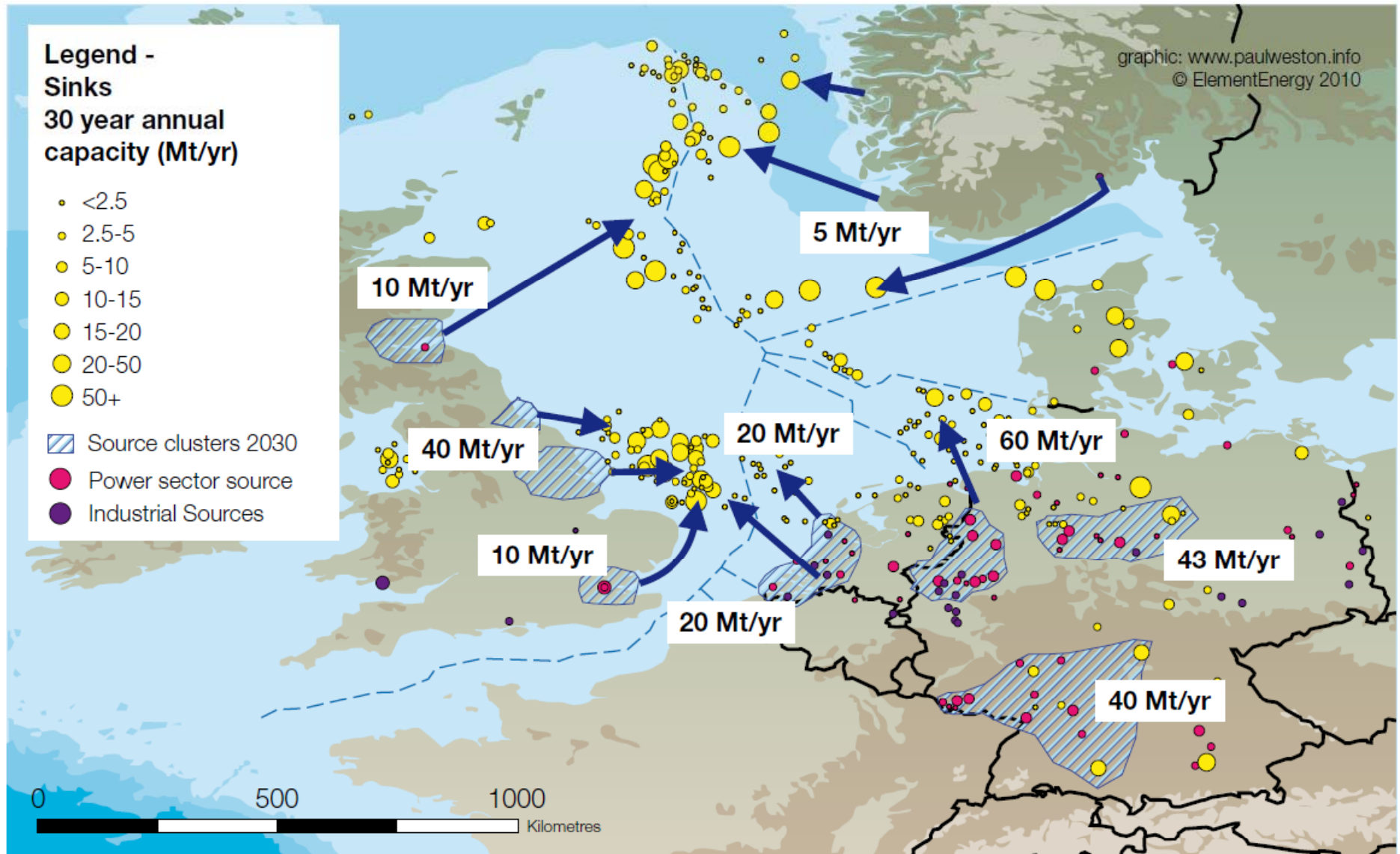
Modelled Mt CO₂ storage capacity in saline aquifers in the GIS database

Country	2030 storage (Mt)	2050 storage (Mt)	Reference
Denmark	16672		GeoCapacity
Germany	27120		GeoCapacity
Netherlands	428		GeoCapacity
Norway ²⁰	48488	97059	NPD
United Kingdom	60971		GeoCapacity and SCCS (2% efficiency)
TOTAL	153689	202260	

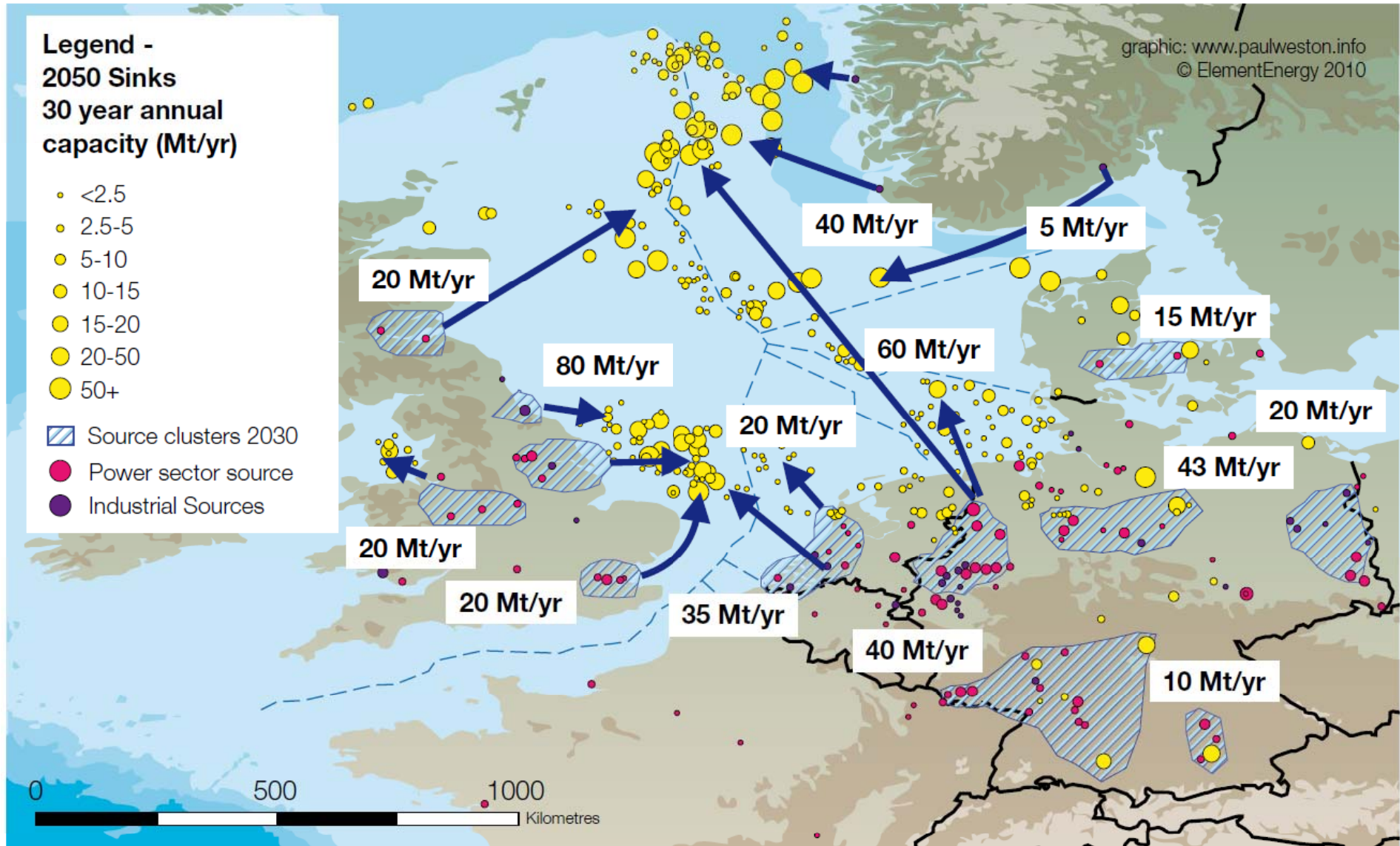
Map of source-sink connections in 2030 – 'Medium' Scenario



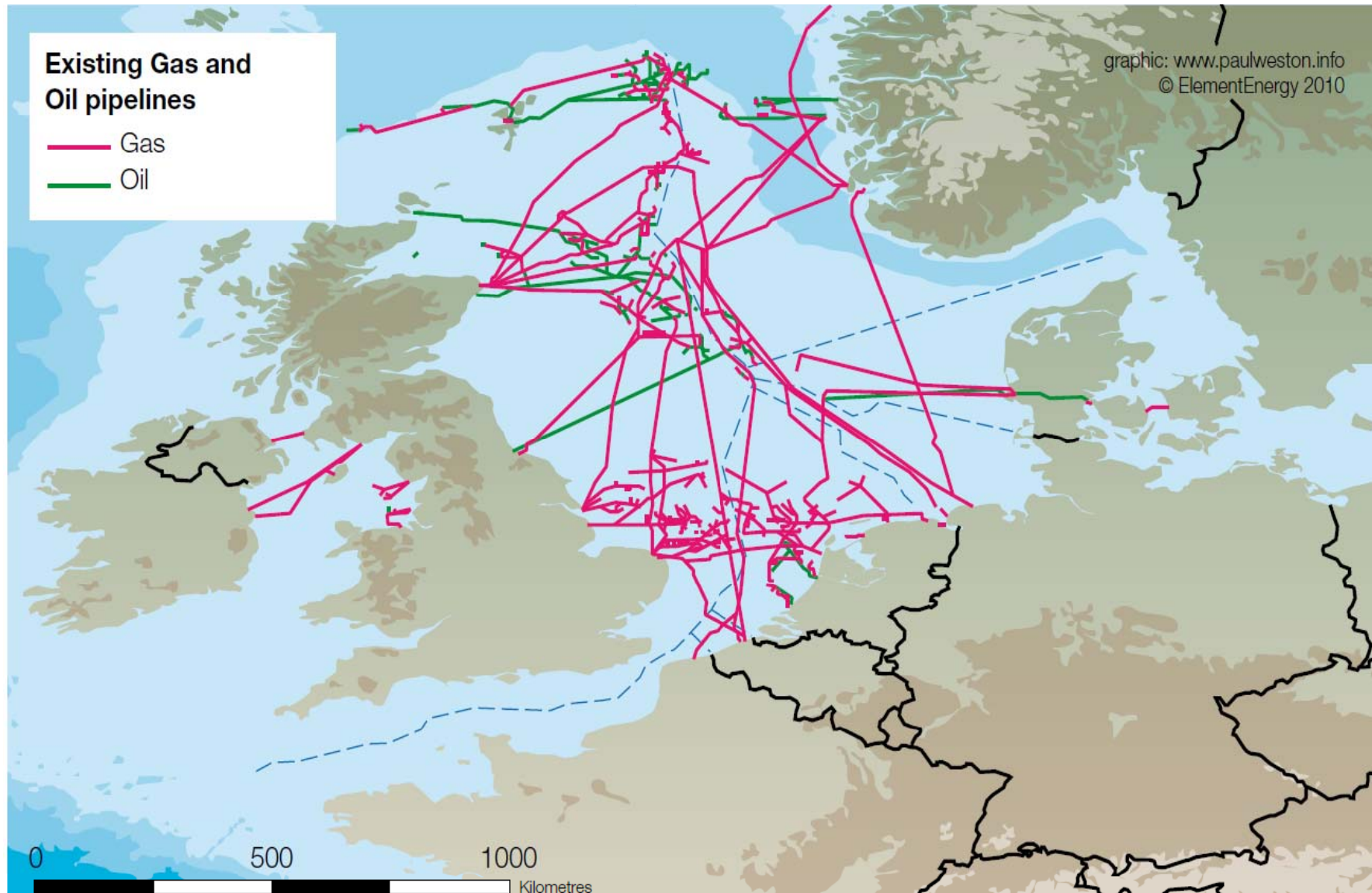
Map of CCS transport and storage in 2030 – ‘Very high’ scenario



CO₂ transport in 2050 – Very High Scenario. (No restrictions on transport or storage)

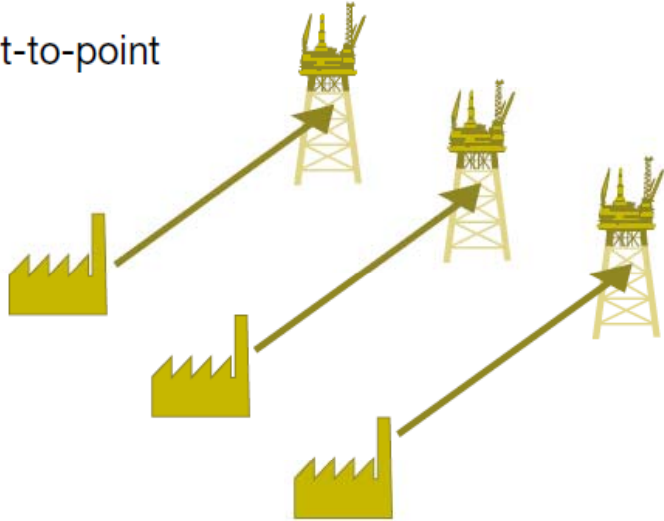


Existing gas and oil pipelines in the North Sea

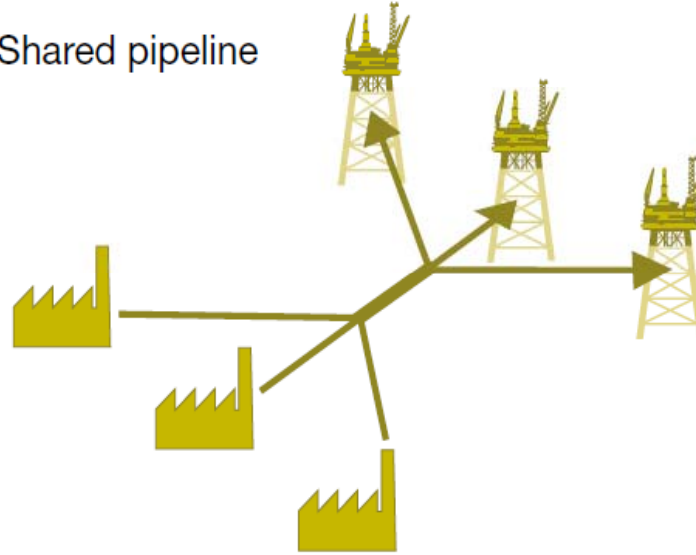


Transport network topologies

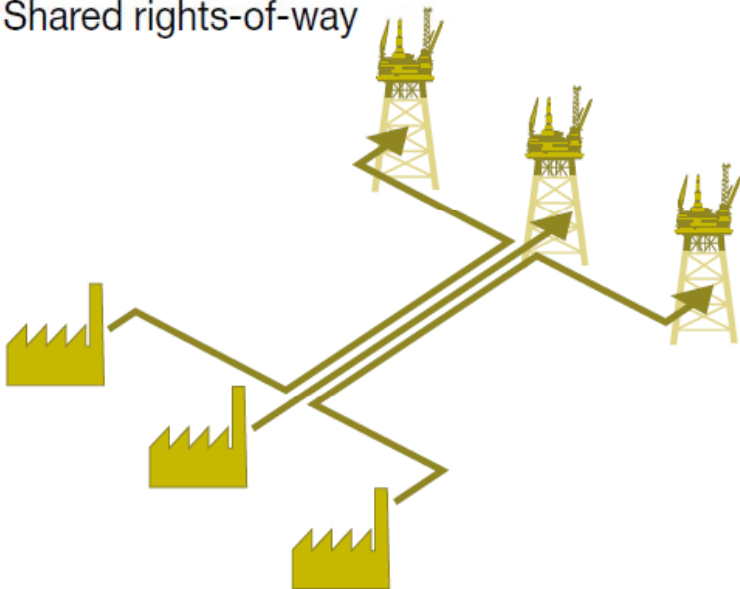
A) Point-to-point



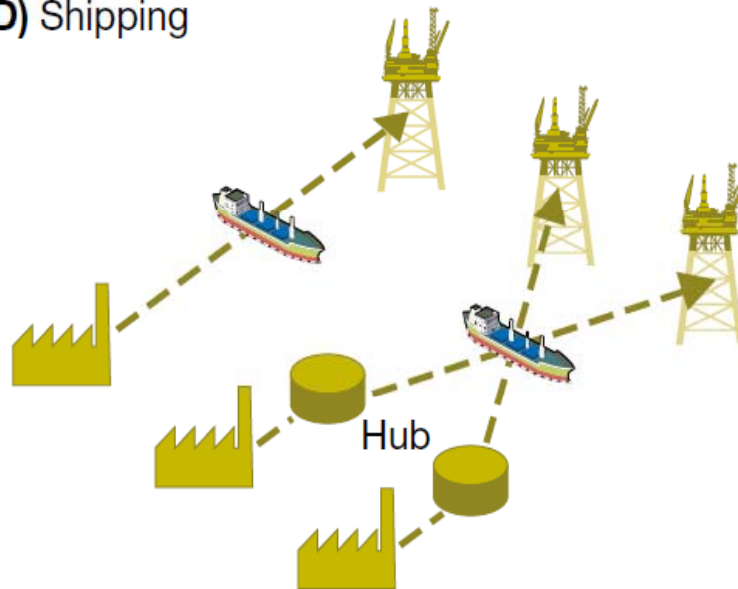
B) Shared pipeline



C) Shared rights-of-way



D) Shipping



Legal and regulatory issues



EU CCS Directive
National regulations

Cross-border challenges

- ◆ Legal rights to transport CO₂ across borders
- ◆ Regulation of cross-border transport of captured CO₂
- ◆ Storage complex spanning national boundaries
- ◆ Cross border impacts from storage operation
- ◆ Emissions accounting
- ◆ Mechanism to facilitate cross-border project development

Picture: iStockphoto © William Maher

Cross-border issues

1. Cross-border pipeline

ISSUES

- Long term liability impact
- Pipeline management

2. Cross-border sink

ISSUES

- CO₂ migration
- Pressure changes
- Allocation rights

3. Cross-border impacts

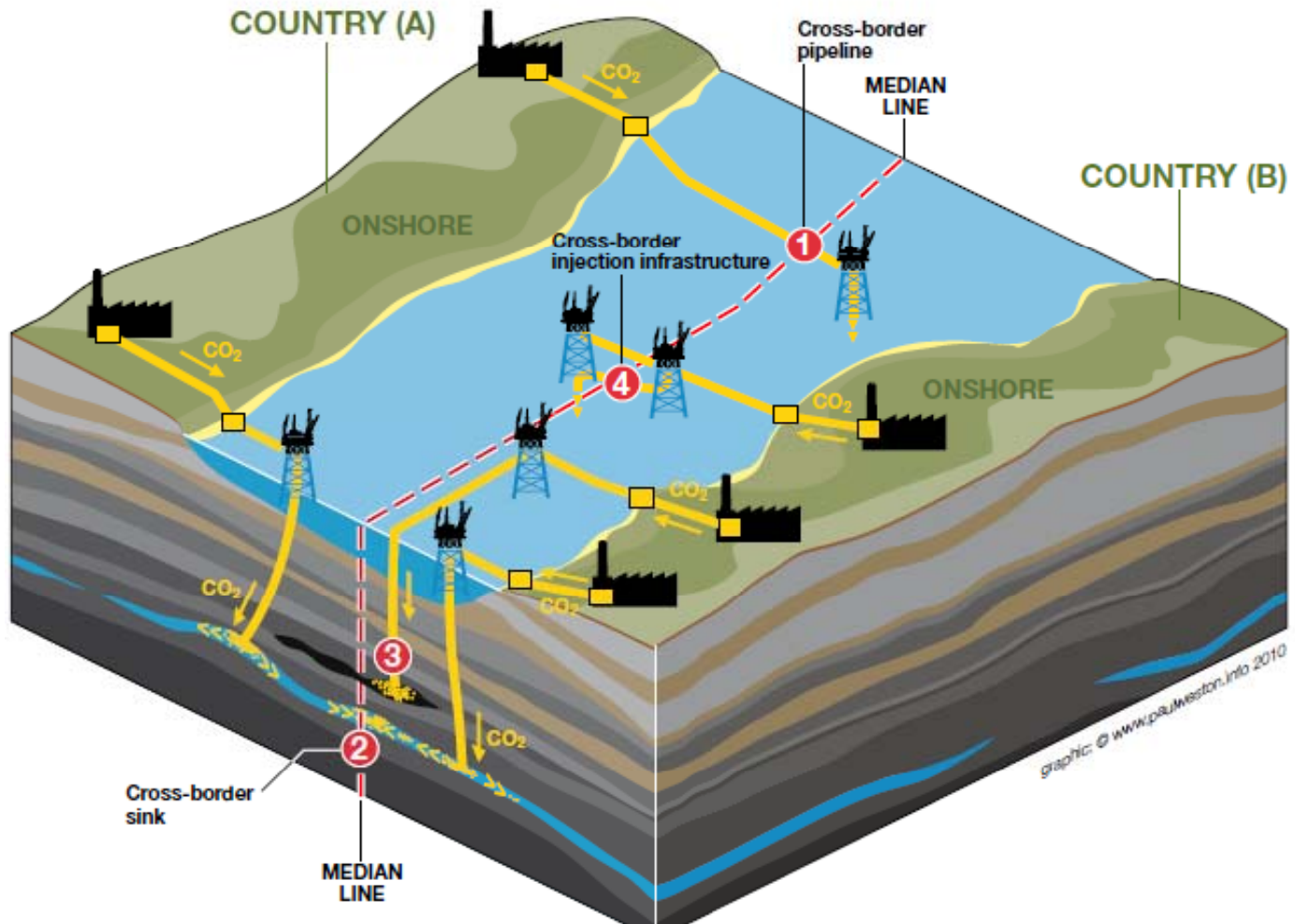
ISSUES

- Possible compromise of nearby hydrocarbon reservoir

4. Cross-border injection infrastructure

ISSUES

- Infrastructure management





Thank you for your attention.