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ENVIRONMENTAL SCIENCE FOR THE EUROPEAN REFINING INDUSTRY

Potential for CO_2 Capture and Storage in EU Refineries

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CONservation of Clean Air and Water In Europe

Concawe was established in 1963 to conduct research on environmental issues relevant to the European petroleum refining, distribution and marketing industry

1963–2013 concawe 50 years delivering science for Europe

Objectives:

- To acquire adequate scientific, economic, technical, and legal information on HSE issues
- To communicate the findings in order to improve understanding of these issues by the industry, authorities, and consumers

Operating principles:

- Sound science
- Cost-effectiveness of options
- Transparency of results

Our research reports are available at www.concawe.org

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Membership of the Association

- 42 members, representing ~100% of European refining capacity
- Open to companies owning refining capacity in the EU

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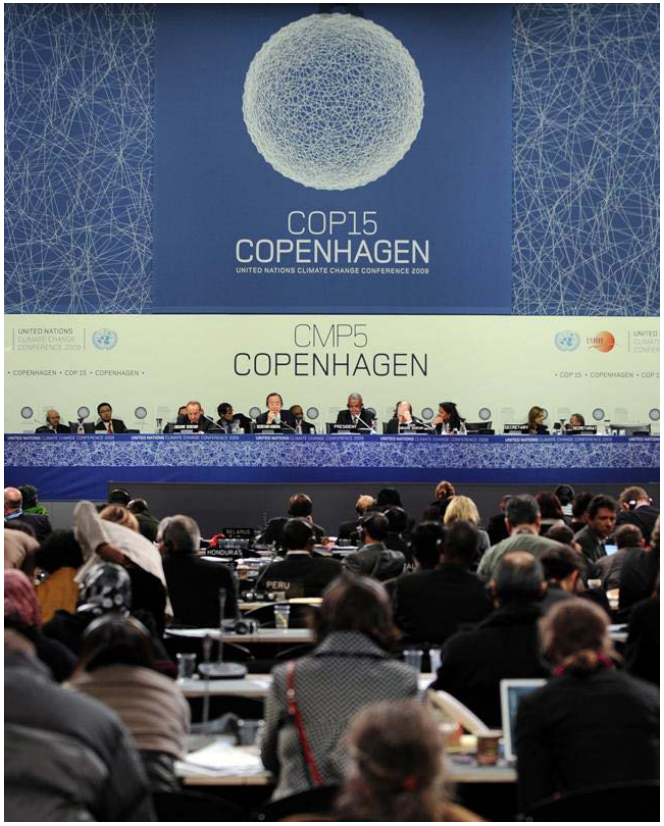
Climate change

- Climate change is a challenge for governments, industry and consumers alike
- Cancun consensus: need to keep global temperature rise below 2°C
- Different scenarios target deep CO_2 reductions: 80 % CO_2 reduction by 2050 (a.o. IEA 450 scenario and blue map)
- Regulators target **large emission sectors**



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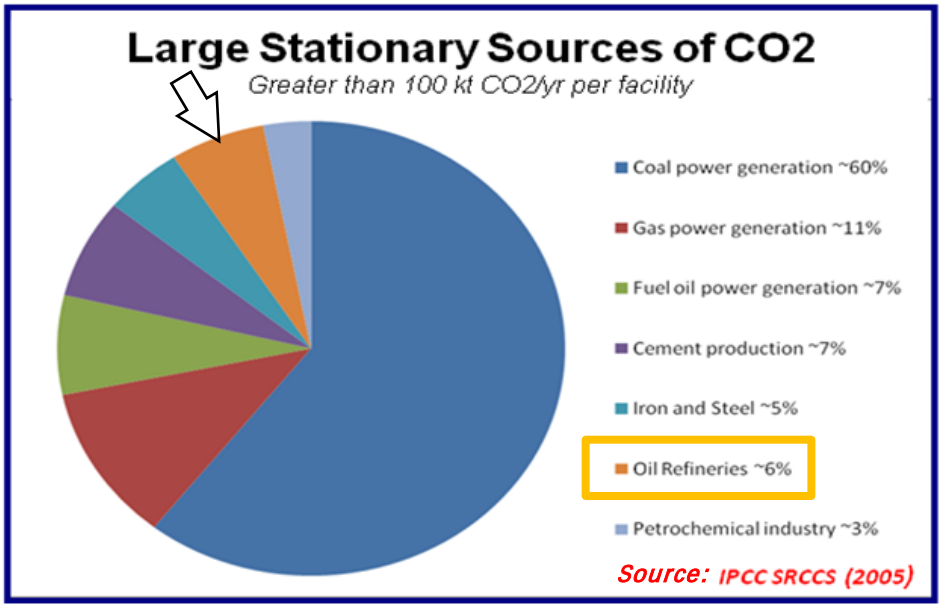
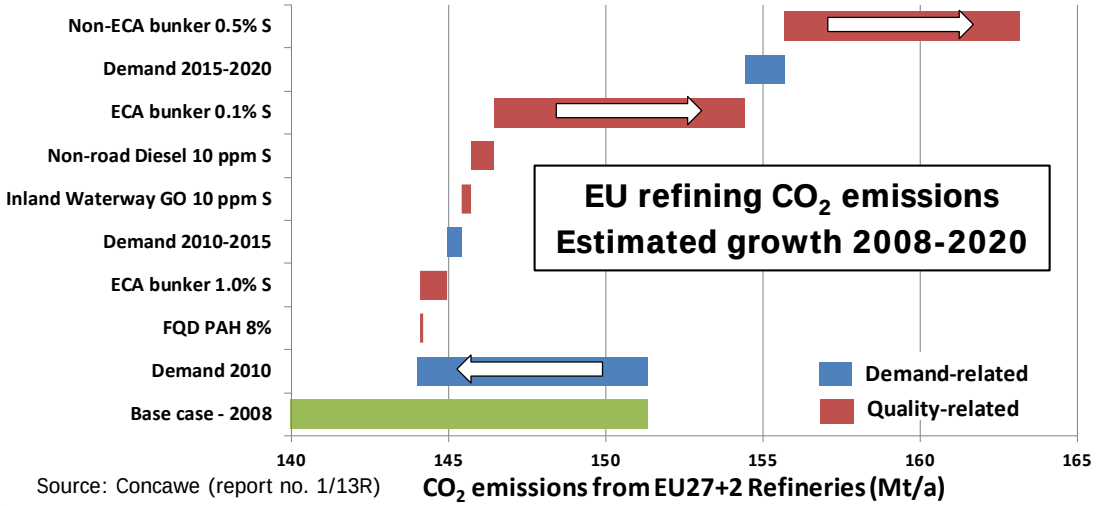
Refining is one of the large CO_2 emission sectors

- Power generation sector
  - Coal
  - Gas & fuel oil
- Industry sector
  - Cement
  - Iron and steel
  - Refining
  - Petrochemicals
- EU Refining CO_2 emissions could grow from 144 Mt/a in 2010 to 165 Mt/a in 2020





Source: Concawe (report no. 1/13R)

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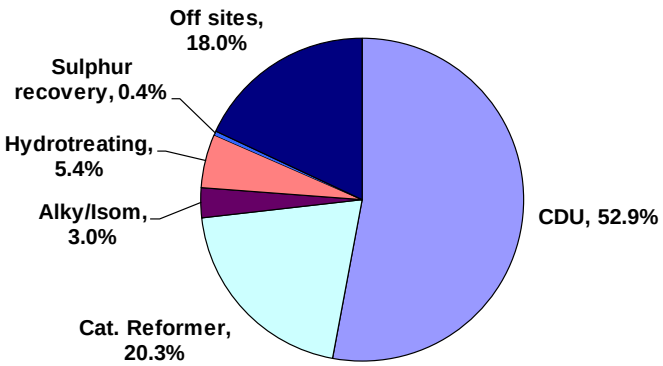
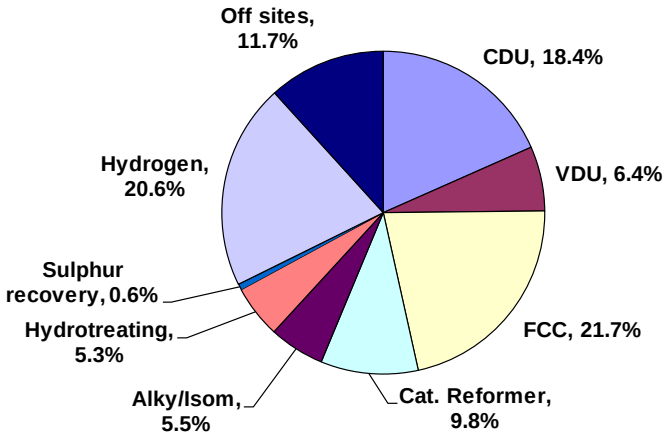
Refineries have multiple CO_2 sources





Source: Concawe (report no. 7/11)

- Refineries have multiple CO_2 emission sources
  - Fuel combustion to supply energy for refining processes
  - Production of Hydrogen for internal use (hydrocracking and hydrodesulphurisation)
- Big differences in emissions between refinery types and locations
- Emissions (and no. of sources) increase with refinery complexity

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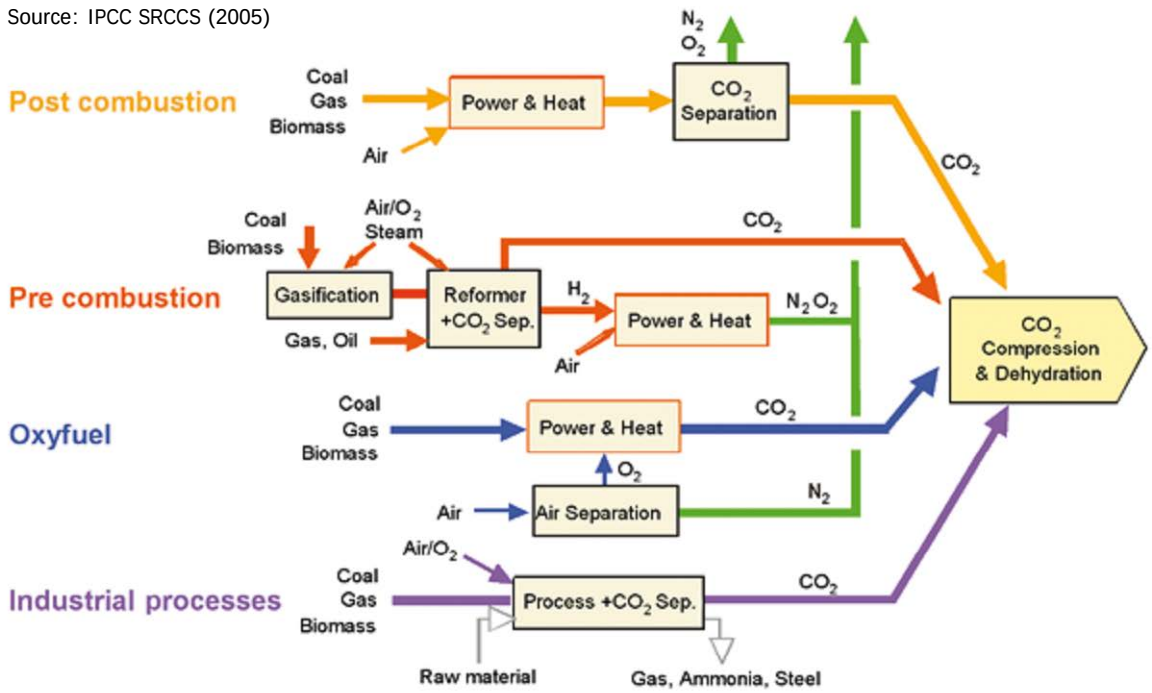
Refinery sources & capture technologies (1)

Source: IPCC SRCCS (2005)



- CO_2 Capture from most refinery sources is technically feasible
  - Though scale up and demonstration is needed
- Different Capture technologies
  - Post combustion
    - Amine-based CO_2 separation technologies are known to refineries
  - Pre combustion
  - Oxyfuel firing

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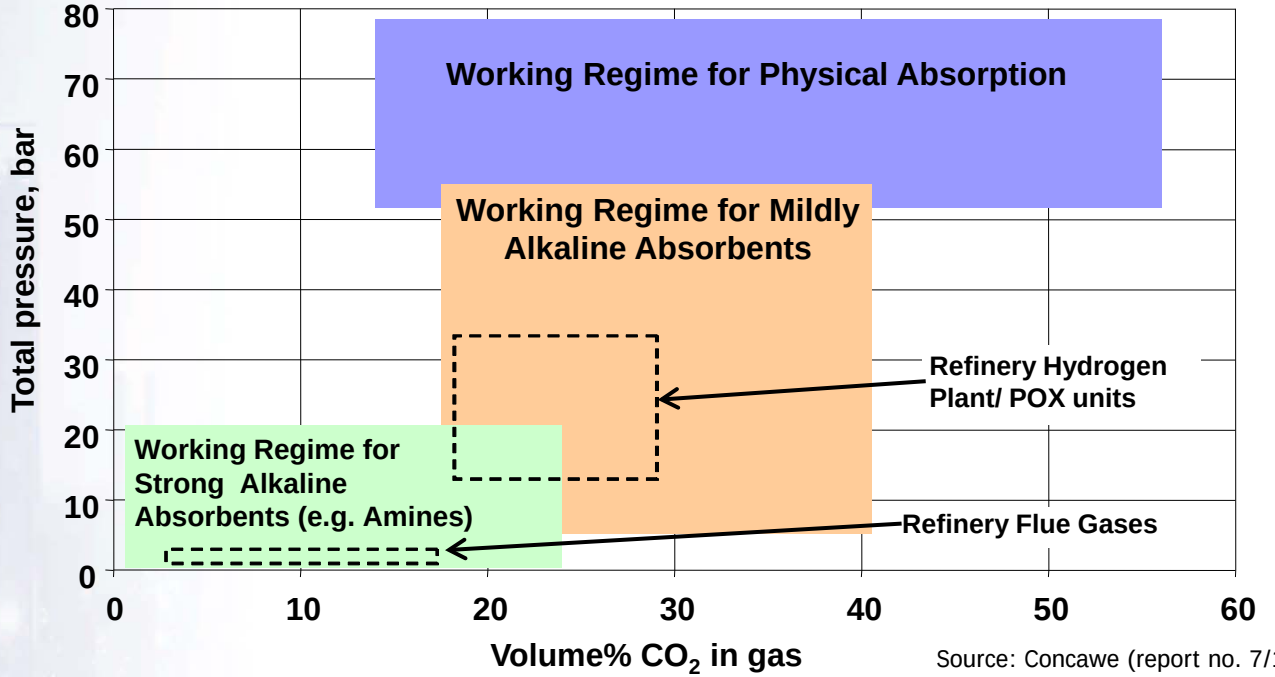
Refinery sources & capture technologies (2)



Source: Concawe (report no. 7/11)

- Various CO_2 concentrations and pressures in refineries
- Cost trade-off between options:
  - Maximisation of CO_2 concentration of certain sources (e.g. oxyfuel) vs. simple large scale capture at lower CO_2 concentration
- Physical constraints for retrofits (e.g. plot space limitations)
  - May drive technology choice
  - May limit final capture rate
  - Will add to costs

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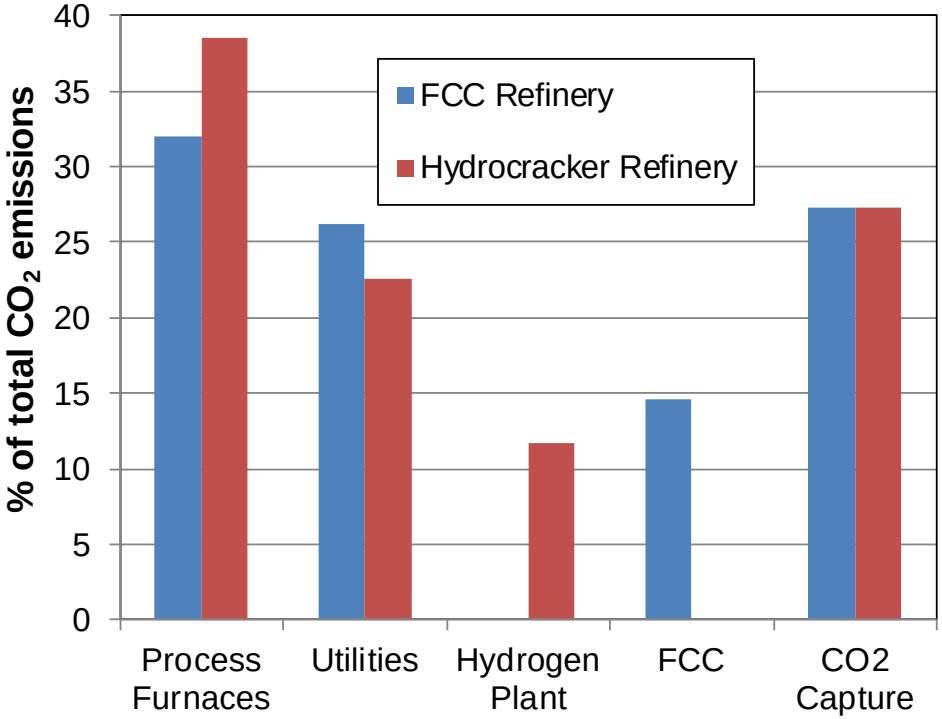
CO_2 Capture needs extra energy ⇒ added cost

- CO_2 capture units need power for CO_2 compression and heat for capture solvent regeneration
- For refineries with balanced utilities power and heat need to be generated by additional utilities
  - Of which the CO_2 emissions (15% to 30% of total) also need to be captured
    - **t CO_2 captured > t CO_2 avoided**
  - Which has a "roll-up" effect
    - Incremental CO_2 from utilities requires more energy to capture, which requires more energy production by utilities, etc…
  - Which increases the cost of capture

Source: Concawe (report no. 7/11)



- Compression for CO_2 transport also requires additional energy
- Irrespective of the technology selected, CCS will significantly increase the energy footprint of the refinery

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CCS Costs for refineries

- Cost of capture per ton CO_2 avoided in refineries will be much higher than the 40-60 €/t quoted for coal power and considerably higher than current ETS market prices.
- Why?
  - **Scale**: Reduced economy of scale (0.5 to 2.0 Mt/a CO_2 versus 5+ Mt/a CO_2)
  - **Distributed & diverse sources**: Requires ducting and fans to connect to capture facility
  - **Range of concentrations**: Requires more complex capture system
  - **Utilities**: Additional CAPEX for dedicated utilities equipment
  - **Brownfield projects**: Retrofits involve higher project complexity and costs
  - **Fuel costs**: Higher OPEX for natural gas as capture plant marginal fuel (instead of coal)
  - **Economic premises**: Refineries operate in a more volatile, less predictable market requiring higher discount rates and capital charges, making annualised investment costs higher

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CCS Costs for refineries

- Refinery specifics may result in large differences in capture costs between refineries
  - Specifically between deep conversion (complex) and hydroskimming (simple) refineries
- Capture costs will add significantly to overall refinery CAPEX and OPEX
  - The impact on margins needs to be clarified, along with how these costs can be transferred
- Significant cost uncertainties since the technology has not been built to similar scale in a refinery application.
- Cost of transport and storage to be included (about 15-20% of total CCS cost)
- A project is in progress to estimate the cost of retrofitting CO_2 capture technologies in refineries
  - Project participants are IEAEPL, Concawe and SINTEF Energy Research
  - Completion expected in December 2016

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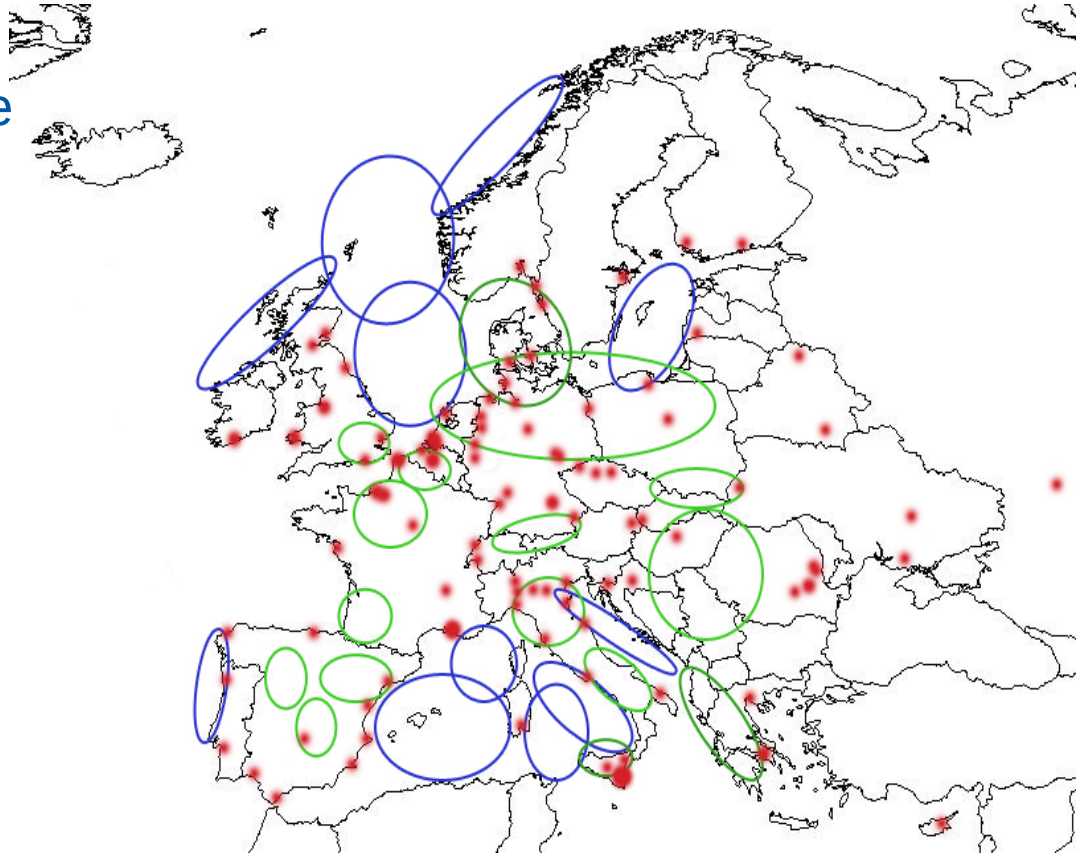
CO_2 Storage

- Refinery CO_2 sources need to be matched with CO_2 Storage sites
- Depleted Oil and Gas fields
  - Known, limited volume
- Deep Saline Aquifers
  - Larger potential volume but needs exploration
- Onshore and Offshore
  - Offshore at higher costs
- Sharing of storage sites with different industries will yield scale advantage

Location of EU Refineries and Potential CO_2 Storage Areas



Source: The European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP)

Legend: Red dots are refineries, blue and green bounded areas are potential offshore and onshore storage areas

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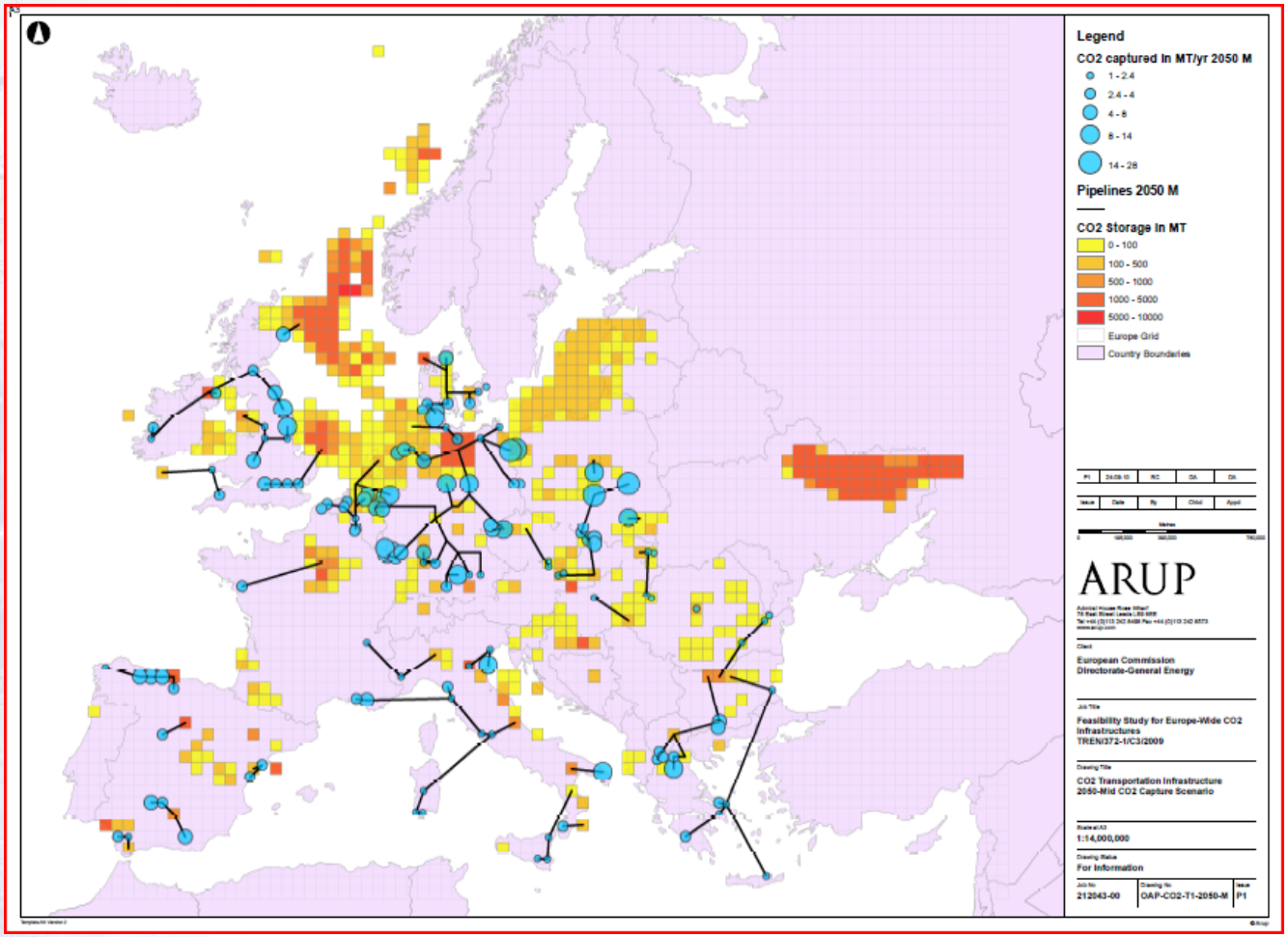
CO_2 Transport

- CO_2 needs to be transported to storage locations by pipelines (or ships)
- Shared transport networks between capture facilities, for scale advantage



Source: ARUP/DG-ENER Feasibility Study for Europe-wide CO_2 Infrastructures, October 2010

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Conclusions

- CCS is technically feasible to reduce refinery CO_2 emissions
  - But needs scale up and demonstration
- Refinery retrofit CCS will be complex and expensive to implement
  - Specifically when compared with CCS in new-build power plants
- There are significant uncertainties with CCS cost estimates, since the technology has not been built to similar scale previously
- Cost of CCS per ton CO_2 avoided in refining will be significantly higher than the current ETS CO_2 market prices and the 40-60 Euro per ton CO_2 cost quoted for coal power
- For refiners deep CO_2 reduction (greater than 90%) may be physically impossible or impractical due to multiple source types and capture efficiency limits
- Piggybacking on a larger CO_2 transport network will be crucial
- *Watch this space for results of the IEAGHG/Concawe/SINTEF project to estimate the cost of retrofitting CO_2 capture in refineries*

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For More Information

Our technical reports are available at no cost to all interested parties

Concawe Website:

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Thank you for your attention

Any questions?

Picture: ExxonMobil

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