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How Could Carbon Capture and Storage Work for Refineries?

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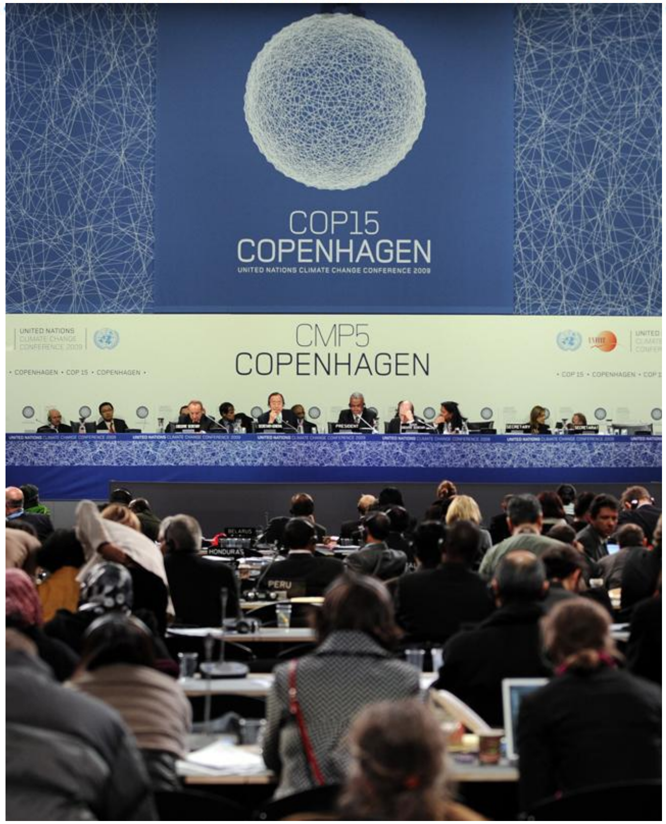
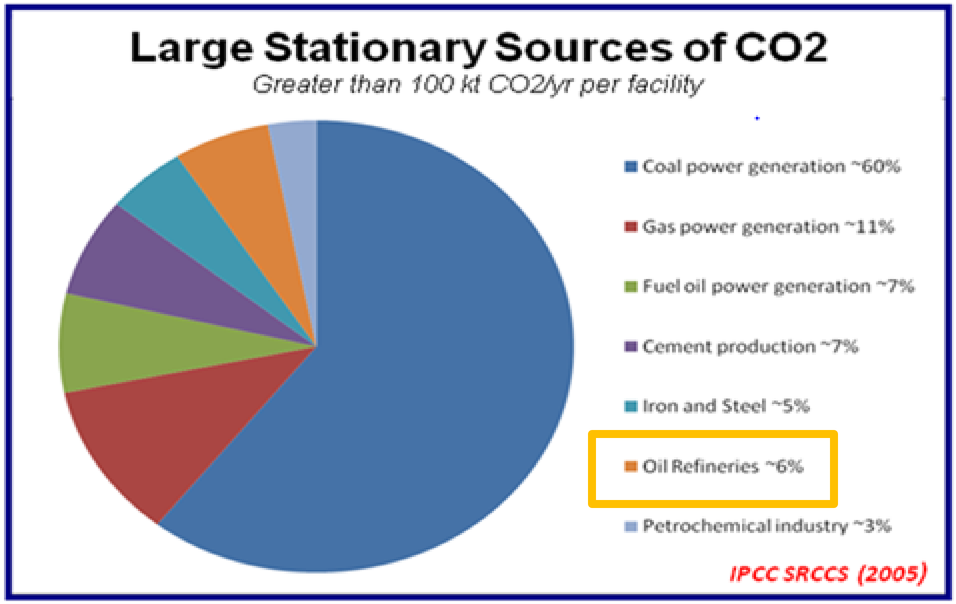
Climate change

- 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

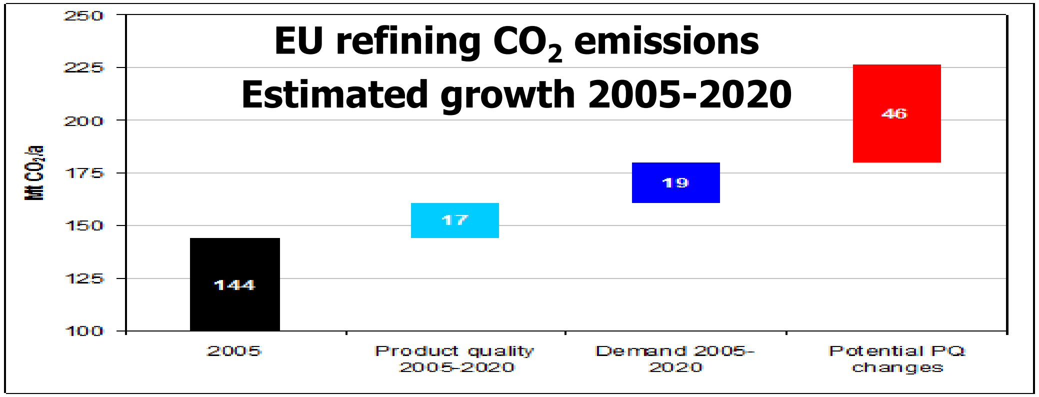


Refining is one of the large emission sectors

- Power sector
  - Coal
  - Gas & fuel oil
- Industry sector
  - Cement
  - Iron and steel
  - Refining
  - Petrochemicals
- EU Refinery emissions could grow from 144 to 226 Mt CO_2/a



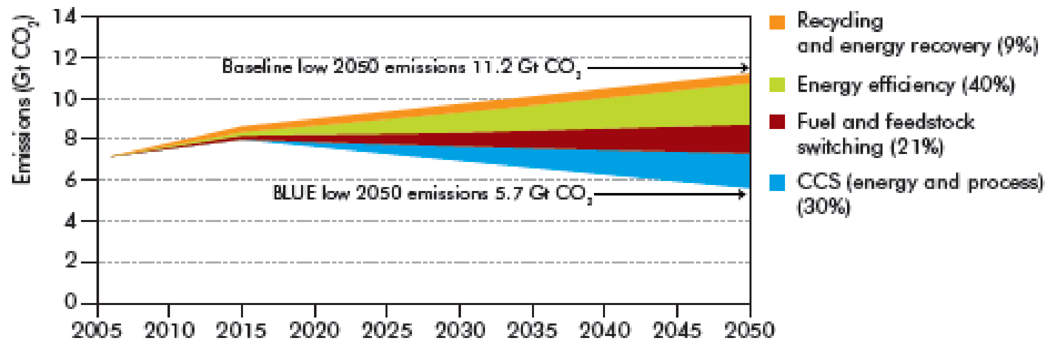
Source: IPCC SRCCS (2005)



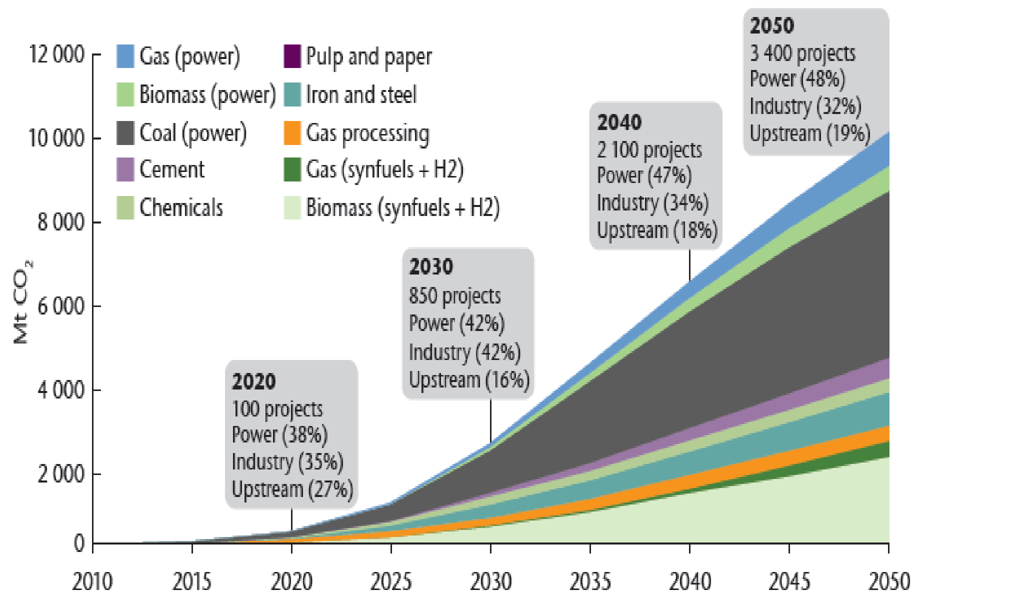
Source: CONCAWE (report no. 8/2008)

CCS FOR INDUSTRY: A PATHWAY

- Efficiency and fuel/feedstock switching are early responses for energy-intensive industries
- Refiners have taken actions with offering CO2 (from POX) for food, greenhouses and CCS
- For deeper decarbonisation CCS is the only option
- The IEA CCS roadmap shows an ambitious pathway
  - CCS contributions mainly from power
  - Significant contributions from industrial sector

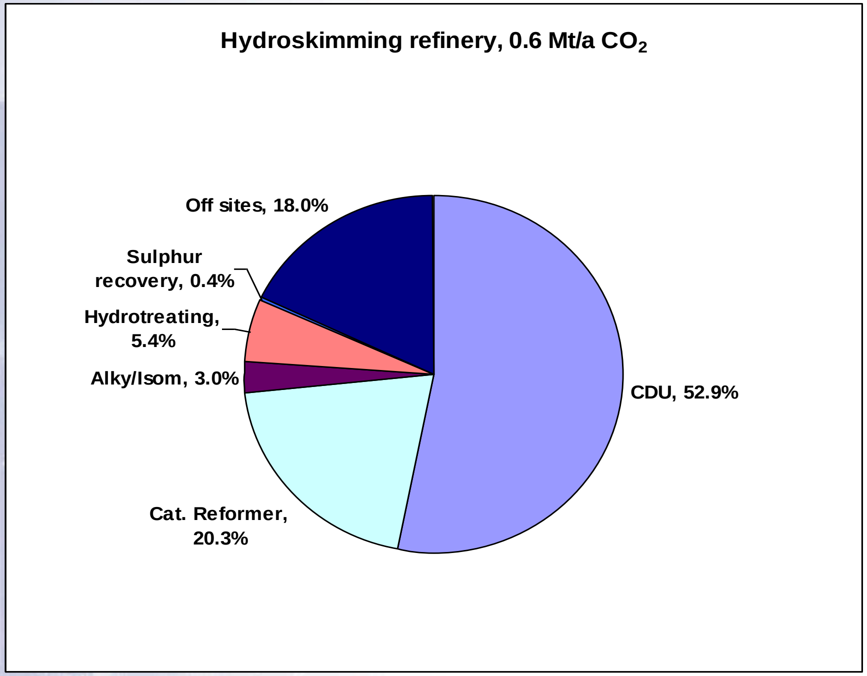


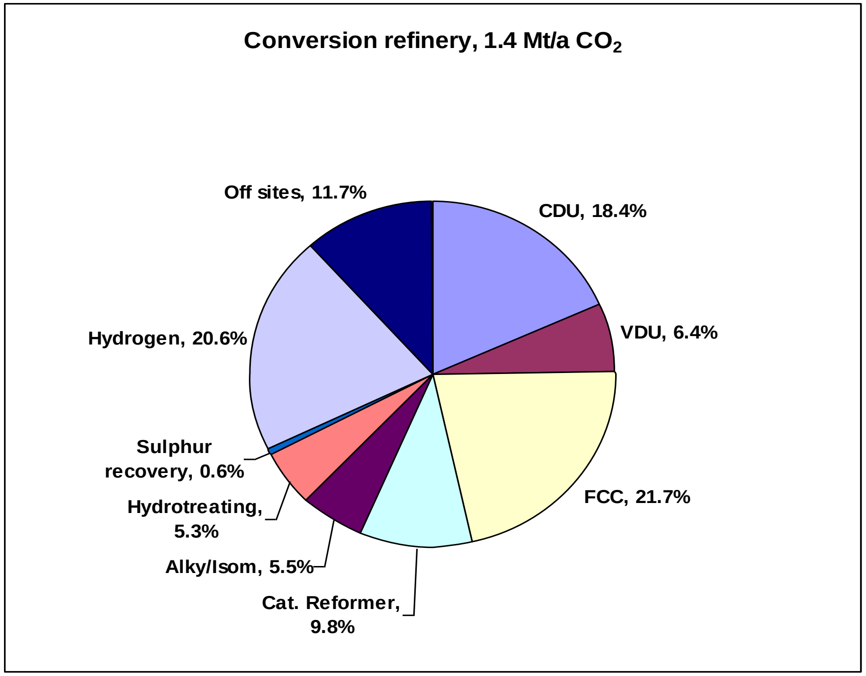
Source: IEA Blue scenario 2009



Source: IEA Technology Roadmap. Carbon capture and storage 2009

Refineries have multiple CO2 sources



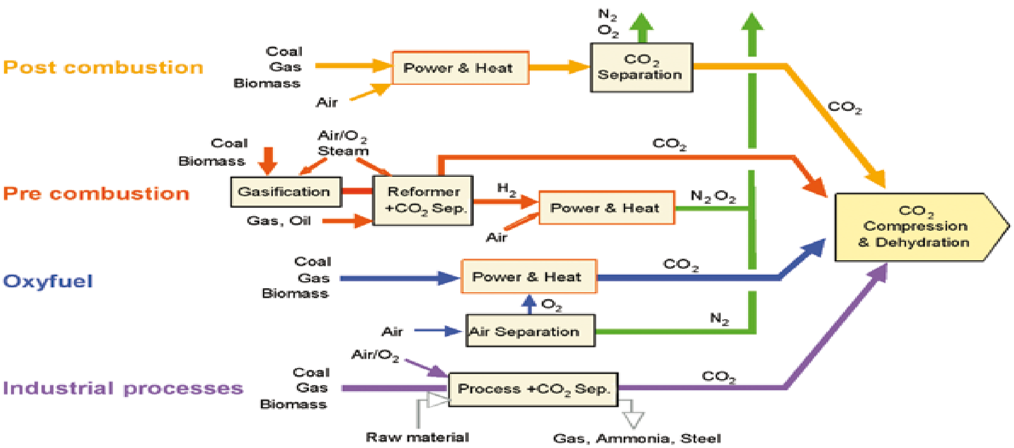


Source: CONCAWE internal study

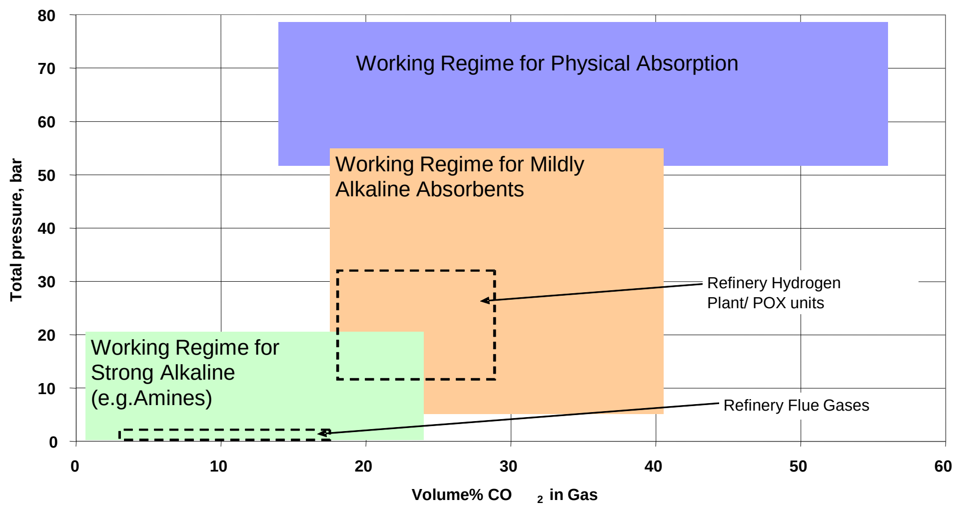
- Refineries have multiple emission sources
- Large differences between refinery types and variations between individual refineries and locations
- Emissions (and number of sources) increasing with complexity

Refinery sources & capture technologies

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



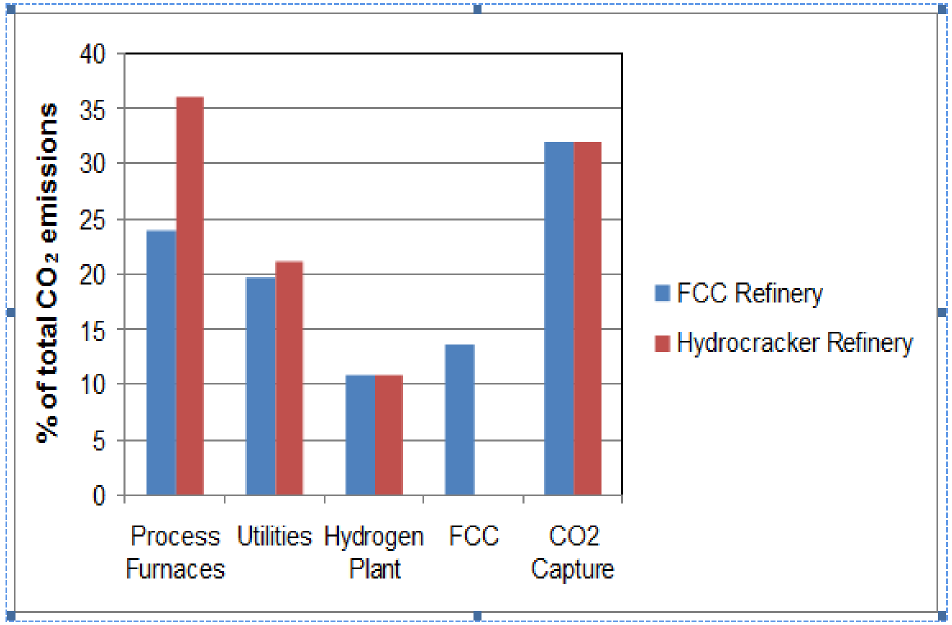
Source: IPCC SRCCS (2005)



Source: CONCAWE internal study

CO2 Capture needs energy -> “parasitic” CO2

- 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 an additional utilities block
  - Of which the CO_2 emissions (15% to 30% of total) also need to be captured
    - CO_2 avoided < CO_2 captured
  - 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 (Opex and Capex) of capture



Source: CONCAWE internal study

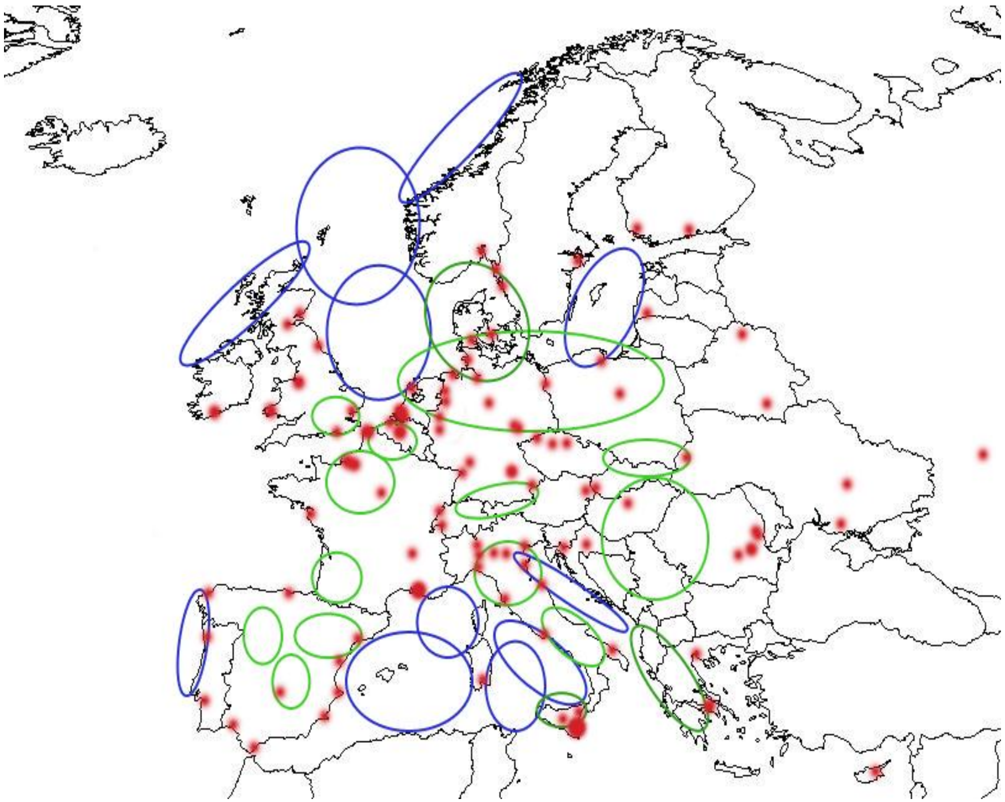
CCS Costs for refineries

- Refinery Cost of CCS per ton CO_2 avoided will be significantly higher than the 40-60 Euro per ton CO_2, quoted for coal power and current ETS market prices:
  - Connecting all the distributed sources (instead of one source)
    - E.g. extensive ducts with fans to capture unit
  - Capex for sub-optimal size CCS utilities plant (instead of shared utilities)
    - Of which the emissions need to be captured too
  - Opex with fuel for capture plant at Natural Gas value (instead of coal)
  - Less economy of scale (1-2 vs 5 Mt/a)
  - Brownfield integration impact with e.g. extension of shut down periods
  - Residual lifetime of refinery to be taken into account
- Refinery specifics may result in large differences in CCS costs between refineries
  - Specifically between deep conversion (complex) and hydroskimming (simple)
- Cost to apply CCS at a refinery will add significantly to overall refinery CAPEX and operating costs
  - 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 (<15-20% of total CCS cost)
- *Watch this space for the CONCAWE CCS ad hoc workgroup to deliver their report*

CO2 Storage

- The 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

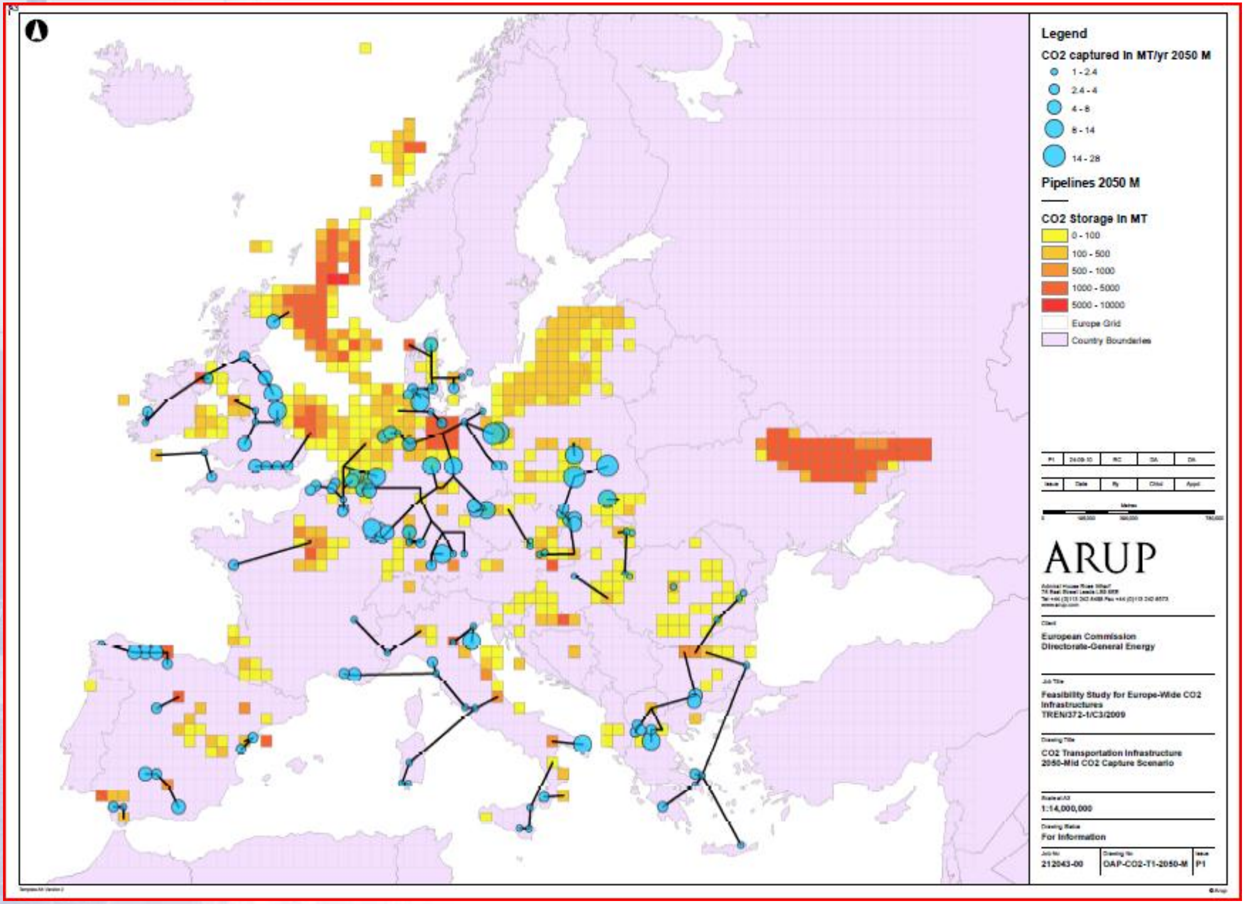


Source: The European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP)

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

CO2 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

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
- Refiners need to progress the options to potentially deploy CCS in response to alternative approaches to CO_2 market mechanisms
  - Learn from demonstrations

Thank you

for your attention