How Could Carbon Capture and Storage Work for Refineries?

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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 CO₂ reductions: 80 % CO₂ 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)
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

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Refineries have multiple CO2 sources

- 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

Source: CONCAWE internal study
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 known 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
CO₂ Capture units need power for CO₂ 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 CO₂ emissions (15% to 30% of total) also need to be captured
    - CO₂ avoided < CO₂ captured
    - Which has a “roll-up” effect
      - Incremental CO₂ 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
Refinery Cost of CCS per ton CO₂ avoided will be significantly higher than the 40-60 Euro per ton CO₂, 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
The refinery CO₂ sources need to be matched with CO₂ 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

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
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
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