Potential for CO$_2$ Capture and Storage in EU Refineries

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1. What is Concawe?
2. Refining CO₂ emissions compared to other sectors
3. Capture sources and technologies
4. Costs
5. Storage and transport
6. Conclusions
Concawe was established in 1963 to conduct research on environmental issues relevant to the European petroleum refining, distribution and marketing industry.

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](http://www.concawe.org)
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 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 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

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Refineries have multiple CO₂ 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

Source: Concawe (report no. 7/11)
CO₂ Capture from most refinery sources is technically feasible
- Though scale up and demonstration is needed
- Different Capture technologies
  - Post combustion
    - Amine-based CO₂ separation technologies are known to refineries
  - Pre combustion
  - Oxyfuel firing
Various CO₂ concentrations and pressures in refineries

Cost trade-off between options:
- Maximisation of CO₂ concentration of certain sources (e.g. oxyfuel) vs. simple large scale capture at lower CO₂ 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\textsubscript{2} capture units need power for CO\textsubscript{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\textsubscript{2} emissions (15% to 30% of total) also need to be captured
- t CO\textsubscript{2} captured > t CO\textsubscript{2} avoided
- Which has a “roll-up” effect
  - Incremental CO\textsubscript{2} from utilities requires more energy to capture, which requires more energy production by utilities, etc…
  - Which increases the cost of capture

Compression for CO\textsubscript{2} transport also requires additional energy

Irrespective of the technology selected, CCS will significantly increase the energy footprint of the refinery
CCS Costs for refineries

- Cost of capture per ton CO₂ 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 CO₂ versus 5+ Mt/a CO₂)
  - **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
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 CO₂ capture technologies in refineries
  - Project participants are IEAEPL, Concawe and SINTEF Energy Research
  - Completion expected in December 2016
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- 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\textsubscript{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\textsubscript{2} Infrastructures, October 2010
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Conclusions

- CCS is technically feasible to reduce refinery CO₂ 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 CO₂ avoided in refining will be significantly higher than the current ETS CO₂ market prices and the 40-60 Euro per ton CO₂ cost quoted for coal power
- For refiners deep CO₂ reduction (greater than 90%) may be physically impossible or impractical due to multiple source types and capture efficiency limits
- Piggybacking on a larger CO₂ transport network will be crucial
- Watch this space for results of the IEAGHG/Concawe/SINTEF project to estimate the cost of retrofitting CO₂ capture in refineries
Our technical reports are available at no cost to all interested parties

Concawe Website:

www.concawe.org

Thank you for your attention

Any questions?

Picture: ExxonMobil