International Energy Agency

Overview of 2012 CCS in Industry Workshop (1) and key messages

Carbon Capture and Storage: *Options for Energy Intensive Industry, Beijing, 2nd Workshop*

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Carbon capture and storage

CCS in Energy Intensive Industry – Why, Where and When?

Why ?

- **CO_2 would have been emitted from commercial facilities outside the power sector.**

- **Beyond Energy Efficiency, CCS Enables energy-intensive industries to significantly reduce CO_2 intensity.**

Where?

- **In some sectors (iron and steel, cement, chemicals) process emissions and existing technologies prevent emissions reductions below ~25% unless CCS is applied.**
  - **$CaCO_3 \rightarrow CaO + CO_2$**
  - **$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$**
  - **$C + H_2O \rightarrow CO + H_2$ / $CO + H_2O \leftrightarrow H_2 + CO_2$**

When?

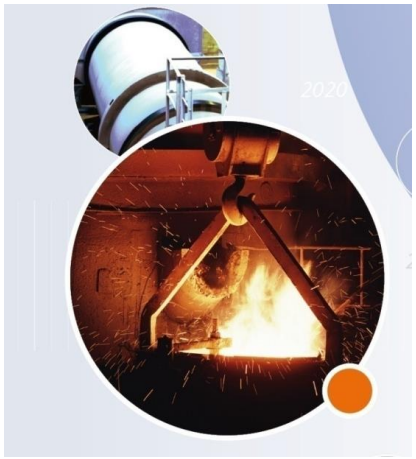
- **Process emissions may have minimal capture cost → excellent early opportunities**

Technology Roadmap: CCS in Industrial Applications 2011

- **Key sectors:**
  - **Biomass/Pulp and Paper**
  - **High-purity**
  - **Iron and Steel**
  - **Refineries**
  - **Cement**
  - **Enhanced Oil Recovery**
  - **Sources and sinks matching**

http://www.iea.org/roadmaps/ccs_industrial_applications.asp

CCS Industry roadmap conclusions



- **A varied picture, many sectors, no one-size-fits-all policy possible**
- **But if all emissions are treated equally, high purity CO_2 emissions are the best opportunities**
- **Industrial agglomerations and clusters - several CO_2 sources to be matched with a suitable sink or reutilisation opportunity, reducing costs**
- **Total investment of USD 3 trillion 2010-2050**

Recommendations:

- **Variety of incentive mechanisms for varying maturities of technologies**
- **Improve data on emissions, technologies and costs**
- **Public research and development programmes are required to bring more information in the public domain**
- **Governments need to ensure adequate funding for CCS demonstration projects in industrial applications**
- **Continue analysis of business opportunities**

CCS in Energy Intensive Industry Workshop Series Objectives

- Increase understanding of the CCS option in industrial applications to consider beyond power
- Consider sectors at different stages of development with different policy instruments and CCS technical approaches
- Generate knowledge of CCS in industrial applications in the near term
- Identify options to support cost-effective propositions in longer-term
- Building capacity and shaping expectations/options now

Industry Stakeholder Views: Where are the Challenges? And Opportunities?

Challenges

- Exposure of a sector in a given country to international trade must consider sensitivity to international competitiveness
- Relative impact that CCS would have on production cost
- Intra and inter-sectoral coordination and first-mover challenges
- Regulatory dilemma – more mature technologies permit regulation
- Perceptions of responsibility/timing
- Inter-regional misalignment of climate policy and capacity expansion

Opportunities

- Integrated into complex industrial sites
- It is not necessary for every country to test every technology at scale, but learning must be shared

After power and steel industry, cement industry in China emits the largest amount of CO_2 - Dr. Shen Lei, Institute of Geographic Sciences and Natural Resources Research, CAS, Secretary-general of China Society of Natural Resources

China Iron and Steel Industry Stakeholder Views

- Outdated/inefficient Iron and Steel processes/sites
- Need to improve energy efficiency and employ low-carbon fuels leveraging S&T progress
- Extend steel mill's functions to circular economy
- Encourage use of high-performance steel and increase its operational efficiency
- No two steel mills are alike... Steel is produced w/different processes w/different grades
- Blast Furnace Technology is near theoretical efficiency limit
- Amount of CO2 captured per site far greater than a single site of coal fired power plant
- Emissions from Integrated Steel Mills may have multiple sources and indirect emissions - dependent on how you define Boundary Limit
- In addition to direct use of fossil fuels, emissions strongly dependent on By-Product Gases

Cement Industry Stakeholder Views

- Since 1985, China's the largest cement producer in the world, today more than 50% of world production.
- Increasing CO2 emissions yearly, with 10% China's total CO2 from coal use
- Approximately 6.6% of total energy consumption in China
- Requirements based on rapid social and economic development/buildings sector, Residential structures increase significantly
- Investment into infrastructure and urbanization is speeding up
- National cement production in 2010 approaching upper limit, and likely will not exceed 2 billion tons in 2020.
- Due to technology improvements, clinker ratio will decrease to 0.55, with the clinker scale in 2020 lower than in 2010.
- Due to new drying methods and process optimization, power consumption per unit of production has descended.
- CO2 mineralization/calcium-based industrial solid waste are emerging

Chemical Industry Stakeholder Views

- For purification process, higher CO2 concentration(>95%) which is ready for storage
- Lower CO2 concentration and high flow rate for purge gas
- Direct coal liquefaction project of 1 million tons/y emits 10 million tons of CO2
- Polyolefin project of 60 million tons/y emits over 360 tons of CO2
- Coal to natural gas project of 2 billion tons/y will only emit nearly 6 million tons of CO2

Highlighted trends in these sectors…

- Large-scale reduction of industrial solid wastes and CO2 emission and recycling will require new systems in the iron and steel and cement industries.
- Discharged gases from non-power industry usually have higher CO2 concentration (20~100%), and more complicated compositions.
- CO2 production is not restricted to fuel combustion like in power generation, the conversion of C to CO2 is flexible , such as gasification.
- Lower energy penalty and cost can be achieved in some processes with higher CO2 concentration (early opportunity for CCS.)
- Accounting of CO2 emissions for comparability is essential for deployment of CO2 Capture Technology in Iron and Steel and other sectors.
- Globally consistent methodology needed for normalised CO2 emissions comparable between regions and better benchmarking (CO2 Avoidance Cost).
- Establish MRV systems of CO2 emissions and standardized monitoring

Workshop perspectives on costs

- CO2 may be captured at cement plants - Post-combustion capture may be low risk option and well suited for retrofit but costs are high
- Cement plants need to be close to other CO2 sources to minimise transport costs (CO2 captured is 0.5-1.0 Mt/y ~ 100-200 MWe coal fired power plant)
- Pre-combustion capture is not easy to achieve, but could be more cost competitive in longer term
- Post Combustion/retrofit advantages for cement plants – Plant is unaffected as long as transport and space is available, stringent flue gas cleaning may be required
- Disadvantages - large quantity low pressure steam needed for solvent stripping = on-site CHP required
- Oxy-combustion in cement similar costs to capture at large power plants
- Most cement production in developing countries where abatement costs may be lower, and plants often larger
- Imports of cement from countries w/out CO2 abatement may be a concern

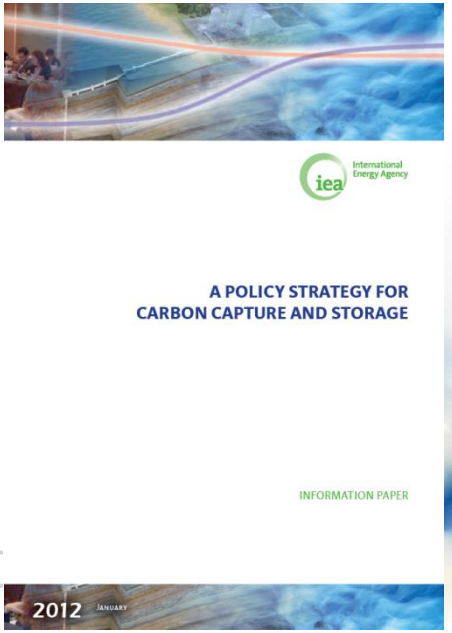
Generating knowledge

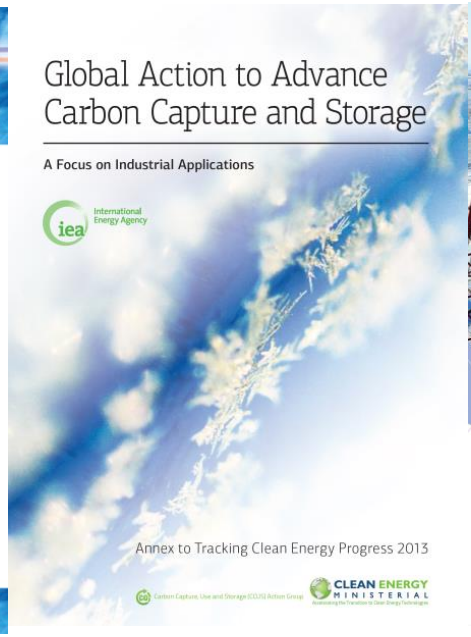
- Importance of shared experience with integrated projects
- Ammonia, methanol, steam reformers, ethanol, gas processing, gasifiers
- Deliver knowledge of integration and pre-commercial storage sites
- Ready for deployment with storage site monitoring and demonstration by next decade
- More pilots to exploit synergies/crossover knowledge
- Blast furnaces, cement kilns, cat crackers, process heaters

Examples of collaboration

- ULCOS (Ultra-Low CO2 Steel), since 2004
  - Evaluated technologies to reduce CO_2 intensity by >50%; 2 pilot tests
  - Up to 2010, funded by 48 industry members (60%) and EC (40%)
  - Patents owned and managed by inventor firm, but use rights shared
- ECRA (European Cement Research Academy), since 2003
  - Considers CO_2 capture designs and economics, including lab-scale test
  - 40 cement producers (3 of 4 main global equipment suppliers)
  - No public funding
  - IPR waived by members, who share all results
- Plus: COURSE50, CO2 Capture Project
  - But, EU sectoral roadmaps are sceptical about CCS (steel, cement, paper)

More to come…





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