CO₂ Capture and Use (CCU)

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> How much CO$_2$ can be mitigated by CCU
> What are the technological challenges
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> What boundary conditions must be fulfilled
Basic routes of CO₂ utilization

- Direct use
- Chemistry
- Chem. energy storage
- Biotechnology
- Biology
These basic technologies can open up numerous product lines

Product lines
- technical gas
- synthetic gas
- basic chemicals
- plastics
- specialty chemistry
- fuels
- synthetic natural gas
- biogas
A scenario of a possible future CO₂ utilization reveals a potential up to 10 Mio. t/a in Germany

- **Industrial gas**
  - Market: 1 Mio. t CO₂/a

- **Synthetic gas**
  - C-Input from fossil fuels: ~ 15 Mio. t
  - (CO₂-equivalent: 50-60 Mio. t)
  - possible C-Input via CO₂: 5-10 Mio. t CO₂/a

- **Basic chemicals**
  - Scale analog to biodiesel: 2.5 Mio t (2008)
  - CO₂-based fuels: 7 Mio. t CO₂/a

- **Plastics**
  - Scale analog to biogas generation: 2 Mrd. m³ CH₄
  - CO₂-based CH₄: 3.5 Mio. t CO₂/a

- **Special chemicals**
- **Fuels**
- **Natural gas/biogas**

**Basic potential limitations:**
- Natural gas and chemical products: product market
- Particularly fuels and gas: enough regenerative energy (CO₂-Footprint)
Market for industrial CO$_2$

- CO$_2$ used as:
  - Dry ice for cooling or cleaning, fertilizer in greenhouses, carbonation of drinks, refrigerant, solvent, EOR, fire extinguisher, …
  - Usually high purity CO$_2$ exhaust streams are sources for supplying the market
  - Technical gas market limited in comparison to power plant emissions

Power plant operators have the capability to supply the market with CO$_2$
What are the technological challenges for use of CO₂ in chemical processes

- Development of suitable catalysts
- Efficient provision of pure CO₂
- CO₂-free production of an energy-rich reaction partner (in most cases H₂)

Interdisciplinary partnerships
Role of power plant operator
Example: R&D project "DreamProduction"

Lignite-CO$_2$ as a resource for the production of polyurethane

- Efficient capture of CO$_2$ out of flue gas
- Conditioning of CO$_2$ in order to provide high CO$_2$ purity for catalytic reactions
Applications for polyurethane

**Hard foams**
- construction foam
- thermal insulation of buildings
- ...

**Soft foams**
- mattresses
- car seats
- ...

**Specials**
- household goods
- footballs
- ...

*VORWEG GEHEN*
Role of power plant operator
Example: R&D project "CO₂RRECT"

Lignite-CO₂ and renewable power for the chemical production

Consortium led by Bayer (BTS)

Provision of electricity/hydrogen based on fluctuating renewable electricity feed-in
Electricity industry: 
CO$_2$ is a component to enable long-term storage of renewable excess energy

In the future temporarily over-supply of wind and solar power

Use of stored energy in windless times

Simple, in large quantities and permanently storable energy source: methanol, methane (synthetic natural gas), …
Biology und Biotechnology for CO₂ utilization

Biology

- Algae pilot plant
- Microbial CO₂ conversion

Biotechnology

- Biomass direct use
- Biomass conversion
- Bulk chemistry
- Fine chemicals

Power plant Niederaussem
RWE Power

Flue gas
Microbial CO₂ conversion
(R&D cooperation with B•R•A•I•N)

R&D cooperation to study CO₂ conversion from power plant flue gas using micro-organisms

> Project goal: Development of "carbon capture bacteria" to produce biomass and chemicals on the basis of coal-derived CO₂

> Product examples: Bio-polymers / bio-plastics for
- food packages
- consumer products
- automotive industry (car interior)
Also for CO₂ utilization, the CO₂ must be transported

- standard for large quantities of CO₂ (e. g. > 2 mill. t/a)
- in case of short distances also for smaller quantities of CO₂

- standard for medium quantities of CO₂ (e. g. < 1 mill. t/a)

- small quantities of CO₂
- short distances
- short period

The economical choice of transport option depends on the amount of CO₂ and the transport distance
CCU is a technology to reduce \(\text{CO}_2\) emissions
EU ETS must recognize CCU as CO$_2$ reduction

The utilization of CO$_2$ as a carbon source is a very promising approach because it combines a new source of raw material with CO$_2$ reduction and substitutes oil- and natural gas-based production.

**But,** the current EU ETS legislation (EU ETS monitoring regulation\(^1\)) does not recognize CCU as CO$_2$ reduction technology:

Only CO$_2$ captured for the purpose of *long-term geological storage* can be subtracted from the overall CO$_2$ emissions for which CO$_2$ certificates need to be purchased.

(wheras the EU monitoring guidelines\(^2\) still define CCU as CO$_2$ reduction like CCS)

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\(^1\) 4\(^{th}\) draft of the Commission Regulation on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council

\(^2\) Commission Decision of 8 June 2010 amending Decision 2007/589/EC as regards the inclusion of monitoring and reporting guidelines for greenhouse gas emissions from the capture, transport and geological storage of carbon dioxide
Conclusions

> The utilization of CO₂ as a carbon source is a very promising approach because it combines a new source of raw material with CO₂ reduction

> Research and development focus on
  - new CO₂-based production routes
  - new products based on CO₂

> Support programs for research and development

> Interdisciplinary collaborations are indispensable

> In view of the realistic potential is to be noted:
  In terms of CO₂ emissions, CCS is the main approach for CO₂ reduction

> Establishment of acceptance in the implementation (CO₂ transport)
  => Ensure positive public communication for CO₂

> Recognition of CCU as an emissions reduction (CO₂ emissions trading, consideration in TEHG)

> Successful examples:
  - gypsum from flue gas desulfurization
  - ash as building material for road construction