CO_2 quality specifications – only a matter of CO_2 purity?

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COORAL

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CO2 GeoNet

Directive 2009/31/EC

(38) Access to CO_2 transport networks and storage sites, irrespective of the geographical location of potential users within the Union, could become a condition for entry into or competitive operation within the internal electricity and heat market, depending on the relative prices of carbon and CCS. It is therefore appropriate to make arrangements

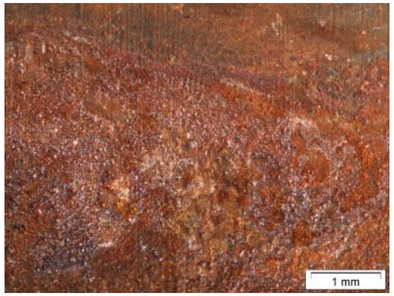
- **How to define "…reasonable minimum composition thresholds…" ?**
- **Which reasonable CO_2 purity / impurity levels may be viable in practical application ?**

legal instruments and to Community legislation intended to be met through CCS. Pipelines for CO_2 transport should, where possible, be designed so as to facilitate access of CO_2 streams meeting reasonable minimum composition thresholds. Member States should also establish dispute settlement mechanisms to enable expeditious settlement of disputes regarding access to transport networks and storage sites.

Key questions

What are optimum proportions of CO_2 and impurities in separated CO_2 streams to

- ensure long-term, safe geological storage,
- control corrosion of equipment and pipelines,
- keep costs of CO_2 capture, transport and geological storage economically acceptable,
- maximise contribution of CCS operation to climate protection,
- use pore space most efficiently (cf. other subsurface uses)?



Corrosion risk

Corrosion risk: Oxyfuel, (Post Combustion) > Pre Combustion

→ PreC: limit water content (<60% rel. humidity);
→ PostC, Oxyfuel : prevent formation and condensation (!) of acids - in particular H_2SO_4 - by limiting contents of at least one of **H_2O, SO_2**, NO or **O_2**.

⇒ Generally limit water content of CO_2 streams to ≤ 50 ppm_v for pipeline transportation ↔ dehydration of CO_2 streams necessary.

⇒ Analyse transport chain for temperature gradients.

Pipeline design – recommendations for CO_2 purity

Relative to pure CO_2 case, at impurity level of >1.5 vol% presence of impurities starts to significantly impact design and costs of transportation system.

$\Rightarrow$ CO_2 purity of $\geq$ 95 vol.% recommended for pipeline transport.

Geochemical reactions in storage reservoirs – key factors

- Specific minerals & specific impurities → specific processes
  ⇒ detailed knowledge of mineral composition of reservoir rocks.
- Amount of impurities available in storage reservoir → extent of mineral reactions
  ⇒ spatial & temporal distribution pattern of impurities in storage reservoir important.
- Redox reactions potentially important.

⇒ Site-specific assessments of impacts of impurities necessary.

Natural "siderite" in experiment with CO_2 + 4% O_2

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CCS clusters – additional challenges

- Potentially more diverse CO_2 stream compositions / lower CO_2 purity (depending on CO_2 emitters);
- variable CO_2 stream composition and mass fluxes.

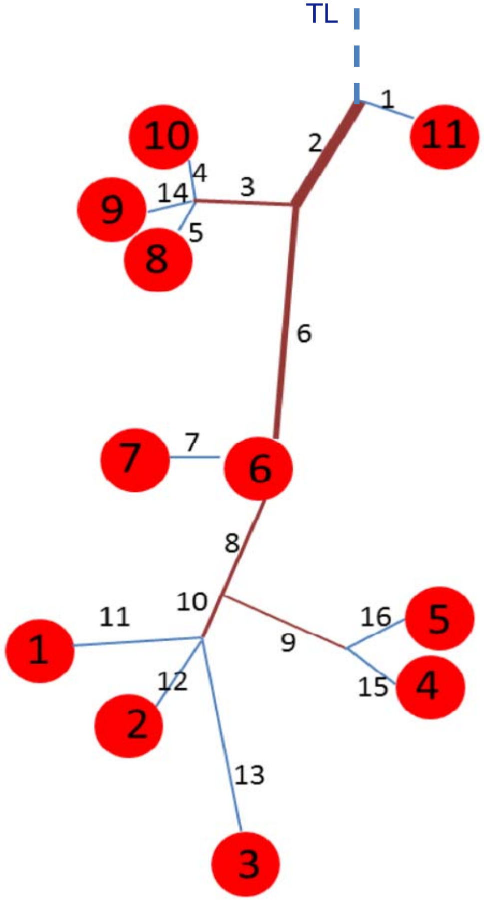
⇒ Impacts of dynamics on various processes in CCS chain;

⇒ set up of CO_2 stream mixing schemes and facilities;

⇒ potential need for interim CO_2 storage arising from coupling of process steps of different flexibilities and loading capacities;

⇒ consider chemical reactions in CO_2 streams.

CLUSTER – Scenario



CO_2 emitters

- 7 power plants (coal, lignite, natural gas),
- 2 cement plants,
- 1 steel mill,
- 1 refinery

⇒ max. annual amount of captured CO_2: 19.35 Mio t

Transport

- Pipeline transport and ship transport,
- transport distance (trunk line, TL): 300 km onshore, 100 km offshore

Storage reservoir

- saline aquifer (Buntsandstein),
- offshore,
- depth: 1600 m

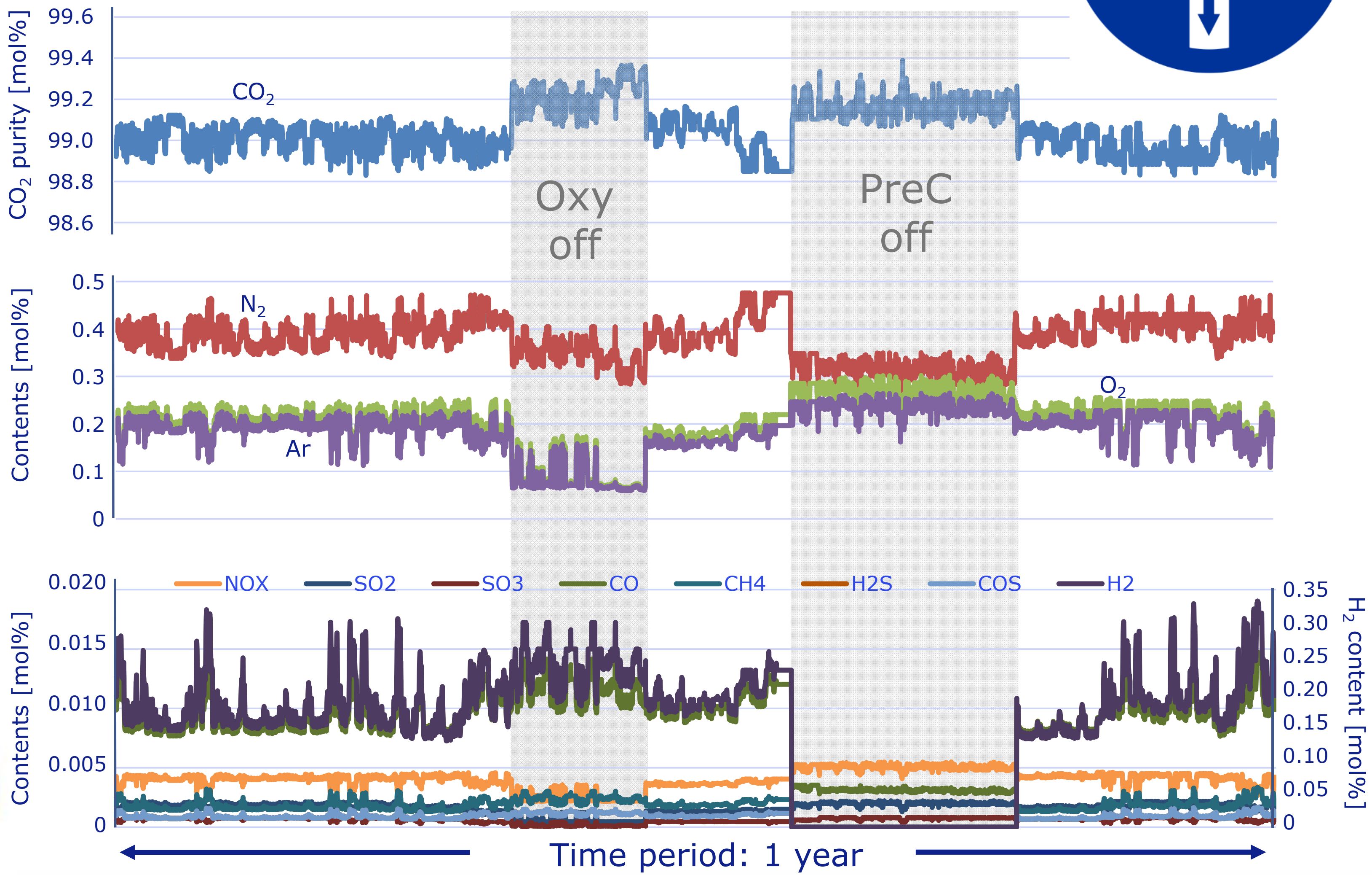
CO_2 stream composition of different emitters

(Contents in mol%; H_2O content: 50 ppm_v)

	CO_2	N_2	O_2	Ar	NO_x	SO_2	SO_3	CO	H_2	CH_4	H_2S	COS
C/L-Oxy	98.003	0.710	0.670	0.590	0.010	0.005	0.002	0.005				
C/L/G-Post	99.931	0.023	0.015	0.023	0.002	0.001	0.001	0.001				
L-PreC	98.004	0.900		0.030				0.040	1.001	0.010	0.005	0.005
Cem-Post	99.931	0.023	0.015	0.023	0.003			0.001				
Cem-Oxy	98.005	0.840	0.590	0.540	0.010			0.010				
Steel-Post	99.931	0.023	0.015	0.023	0.002	0.001		0.001				
Ref-Post	99.931	0.023	0.015	0.023	0.002	0.001		0.001				

L: Lignite, C: Coal, G: Natural gas, Cem: Cement plant, Steel: Steel mill, Ref: Refinery

CO_2 stream composition (in TL) – annual dynamics



Chemical reactions in CO_2 streams

Interplay between NO_x, SO_x, O_2:

$2\ NO + O_2 \rightarrow 2\ NO_2$
$2\ NO_2 + O_2 \rightarrow 2\ NO_3$

$NO_2 + NO \leftrightarrow N_2O_3 \xrightarrow{+H_2O} HNO_2$
$2\ NO_2 \leftrightarrow N_2O_4 \xrightarrow{+H_2O} HNO_2 + HNO_3$
$NO_2 + NO_3 \leftrightarrow N_2O_5 \xrightarrow{+H_2O} 2\ HNO_3$

$2\ SO_2 + O_2 \rightarrow 2\ SO_3$ (very slow)
$SO_2 + NO_2 \rightarrow SO_3 + NO$ (faster alternative)
$SO_2 + H_2O \rightarrow H_2SO_3$
$SO_3 + H_2O \rightarrow H_2SO_4$

⇒ **How will reducing impurities modify this interplay?**

Conclusions

- CO_2 quality specifications are not only a matter of CO_2 purity (i.e. CO_2 content).
- The "rest" also matters, in particular contents of reactive impurities affecting material corrosion and rock alteration.
- Also chemical reactions in CO_2 stream to be considered, in particular when combining CO_2 streams of different compositions.

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