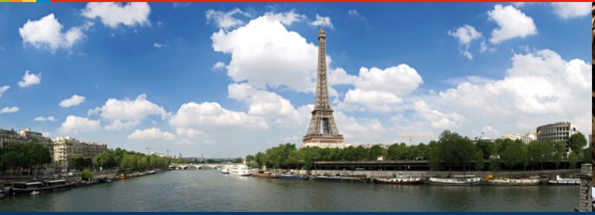
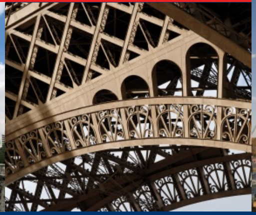
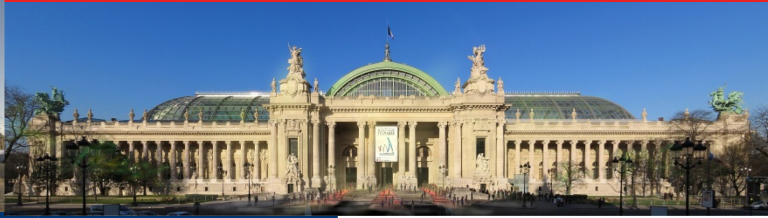
26th World Gas Conference

1 – 5 June 2015, Paris, France

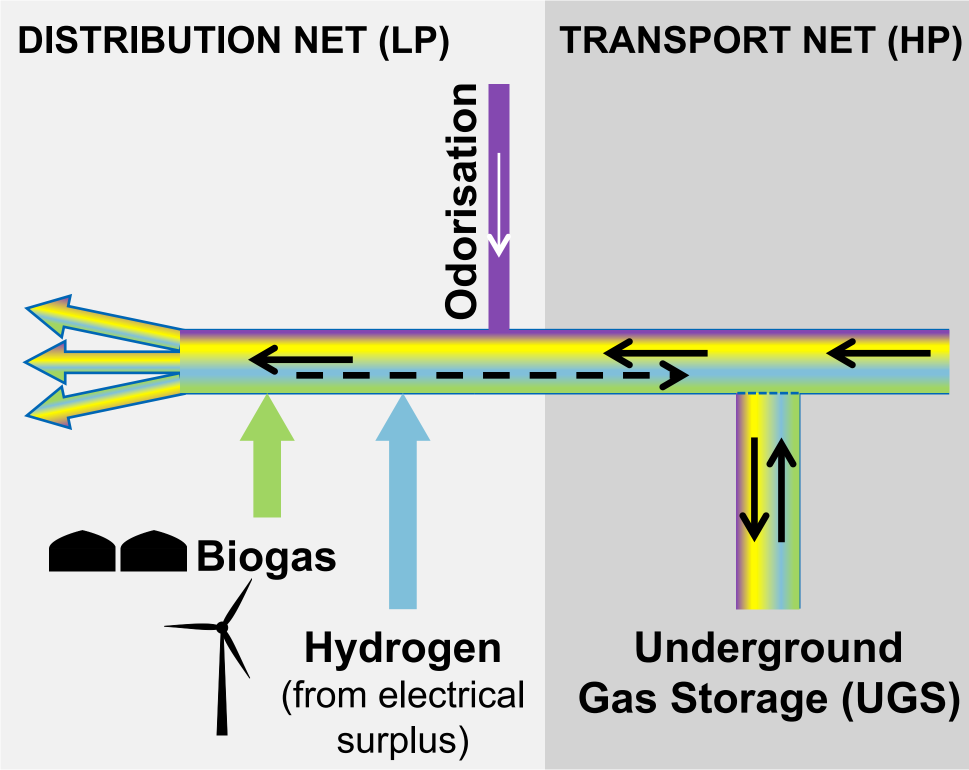


COMPATIBILITY OF NATURAL GAS SUBSTITUTES FROM RENEWABLE ENERGY SOURCES WITH UNDERGROUND GAS STORAGES

Kai Schulze
DEA Deutsche Erdoel AG

WGCPARIS2015
WORLD GAS CONFERENCE

The gas transport and storage framework is changing



	Biogas	Hydrogen (H_2)	Draft EN Standard
O_2 [mol% (ppm)]	≤ 3 (30,000)	-	0.001 (10)
CO_2 [mol%]	≤ 5	-	2.5
H_2 [mol%]	-	≤ 100	-
Sulphur [mg/sm^3]	≤ 6 not odorised	≤ 6 not odorised	20
Odorisation	odorised	odorised	not odorised
Microbio.	-	-	-

Underground gas storages vital for secure supply in EU

Microorganism, Sulphur Compounds and Odorants

- Microbiology sufficiently treated biogas similar to natural gas
- Potential problems by sulphur components & odorants
  - Unless storage of odorised gas is current practice
    - Water treatment and disposal
    - Glycol degeneration and odor issues
    - Need for gas additional gas purification steps
    - Potential H_2S liberation by well workovers and stimulations

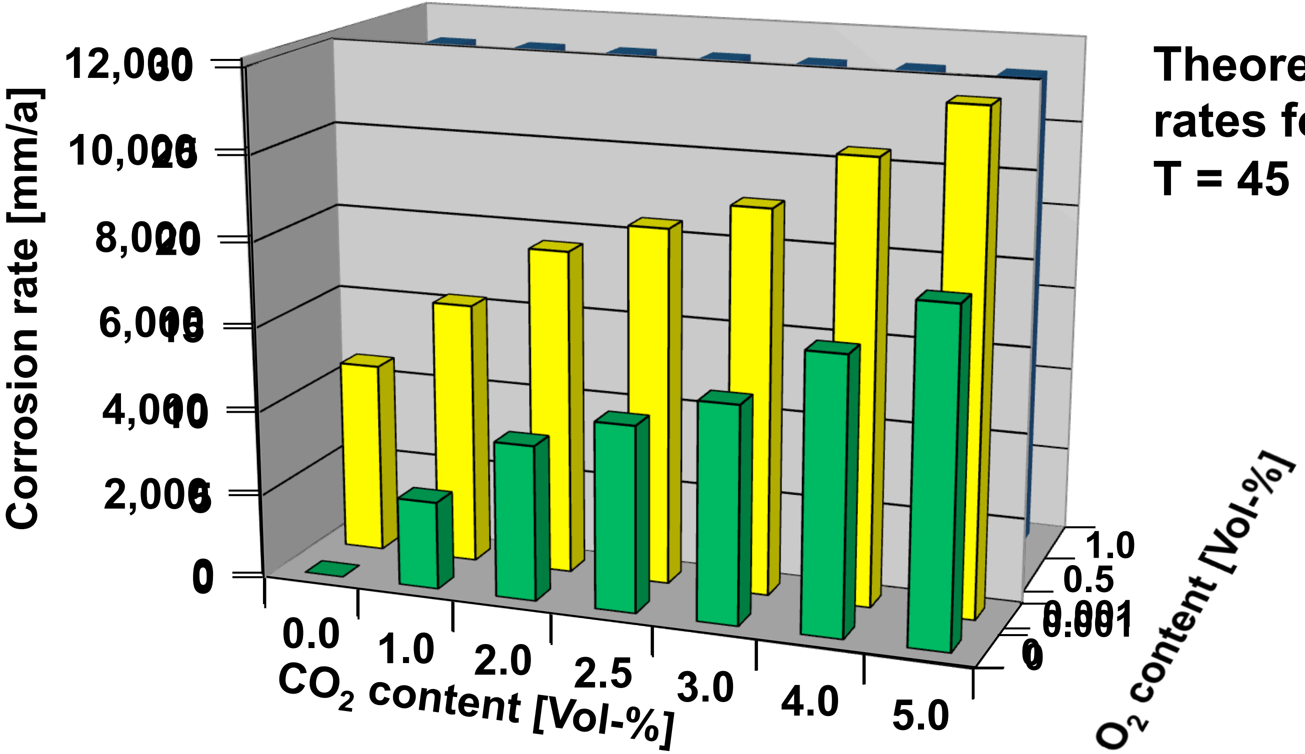
➔ Sufficient treatment of microbiology of biogas

➔ No odorised gas in UGS if this is current practise

➔ Keeping up existing limits for sulphur compounds

DEA

Carbon dioxide (CO_2), Oxygen (O_2) and Corrosion



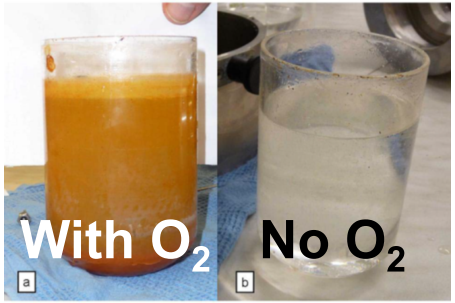
Theoretical corrosions rates for carbon steel
T = 45 °C, p = 250 bar

➔ Keep existing limit for CO_2 of 2.5 mol%

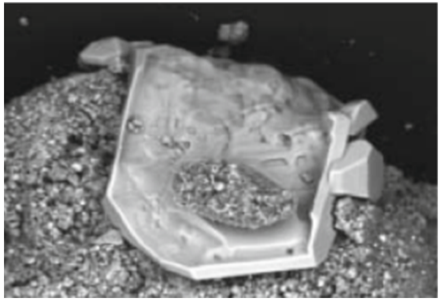
➔ Keep existing limit for O_2 of 10 ppm (0.001 mol%)

O_2 and Damage in Formations and Installations

- Sulphur precipitation by O_2 in valves
- Pore blocking induced by O_2 – porous rock storages only
  - Mineral transformation & precipitation, e.g. $Fe^{2+} \rightarrow Fe^{3+}$
  - Sulphur formation & deposition



Fe^{2+} - solution



S-crystal by O_2

S-scale in valve

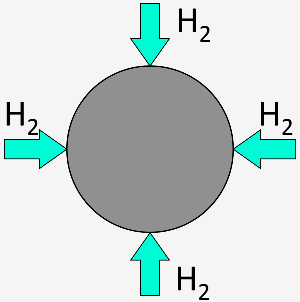
Corr. by S-deposit

DEA

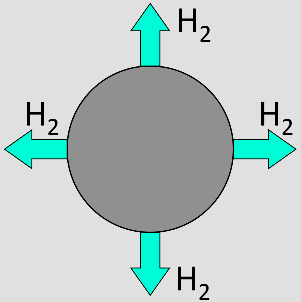
➔ Keep existing limit for O_2 of 10 ppm (0.001 mol%)

H_2 and potential Loss of Integrity of UGS

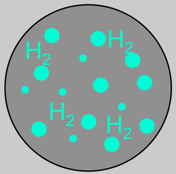
- Cap rock integrity – risk for porous rock storages
- Conventional cementations not made to prevent H_2 diffusion
- Steel installations with strength ≥ 800 MPa at risk
- Risk of fracturing of elastomer based seals (e.g. packers) by rapid pressure release



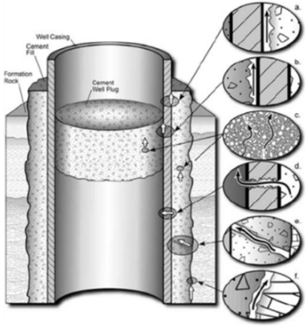
High pressure charging with H_2



Innerfracturing by H_2 release



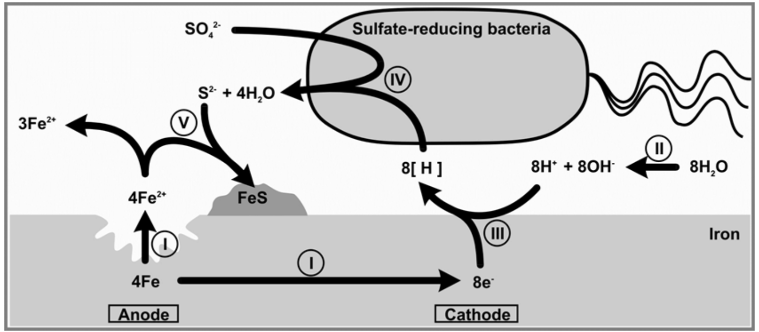
Decompression and H_2 oversaturation

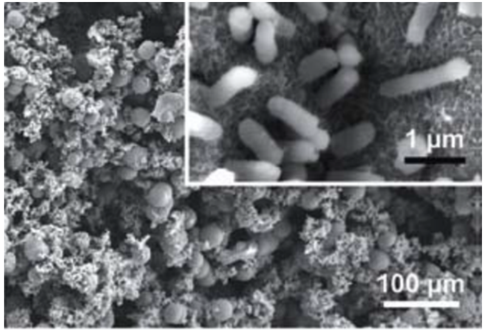


H_2 – Food for Microorganisms

- Many detrimental reactions by microorganism
  - $4H_2 + SO_4^{2-} + 2H^+ \rightarrow H_2S + 4H_2O$ ➔ Corrosion, safety
  - $2CO_2 + 4H_2 \rightarrow CH_3COOH + 2H_2O$ ➔ Corrosion
  - $4H_2 + CO_2 \rightarrow CH_4 + 2H_2O$ ➔ Energy loss

  ➔ Pore blockage by bacteria (porous rock storages)
- 99.9 % loss of H_2 observed for town gas





Conclusions

- UGS can facilitate structuring & expansion of renewables
- Renewables welcomed in UGS, but damage to be prevented
- ➔ **Biogas**
  - Keeping the existing limit values
  - Sufficient treatment of microbiology
- ➔ **Hydrogen (H_2)**
  - So far no limit values in place
  - Need for research to establish limit value
  - e.g. ‘Underground Sun Storage’ project

DEA

Special gratitude to the co-authors

• Joachim Wallbrecht	Gas Storage Consultancy
• Stephan Bauer	RAG Rohöl-Aufsuchungs AG
• Thomas Höcher	VNG Gasspeicher GmbH
• Christoph Kersten	DEA Deutsche Erdoel AG

DEA

Contact

Compatibility of Natural Gas Substitutes from Renewable Energy Sources with Underground Gas Storages

- Contact:
  Kai Schulze
  kai.schulze@dea-group.com
  +49 5146-89240

DEA

Thank you for your attention!

Limit values for regenerative gases vs. natural gas

	Biogas	Hydrogen (H_2)	EASEE-Gas
O_2 [mol% (ppm)]	≤ 3 (30,000)	-	0.001 (10)
CO_2 [mol%]	≤ 5	-	2.5
H_2 [mol%]	-	≤ 100	-
Sulphur [mg/sm^3]	≤ 6 not odorised	≤ 6 not odorised	30
Odorisation	odorised	odorised	not odorised
Microbiology	-	-	-

- Risks for UGS? Reservoir, installations, gas treatment?
- 5 independant literature initiated studies to get clarity

DEA

H_2 and microorganisms

- No experience natural gas - hydrogen mixtures but town gas
- Significant microbiological activity observed

Tabelle 10: Gasqualitätsänderung im Horizontalmodell

1. Einlagerung: 7. 12. 84 - 8. 2. 85 63 Tage

Gasvolumenänderung: eingesetztes Stadtgasvolumen 400 ml

Gasverbrauch: 195 ml = 48,75 %

Restgas 205 ml

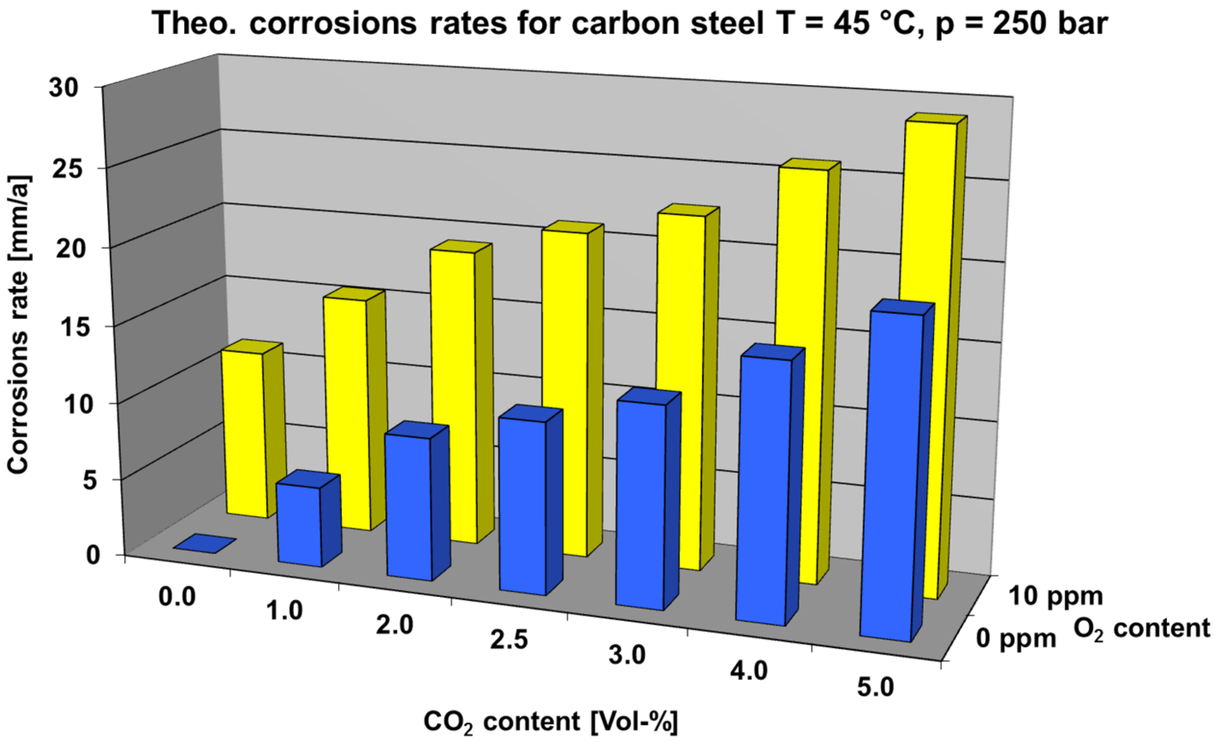
Komponenten	Einspeisegas		Ausspeisegas		Gasvolumen-änderung	
	%	ml	%	ml	ml	%
CH_4	29,5	118	34,2	70,11	-47,85	-40,55
C_2H_6	0,37	1,48	0,36	0,738	- 0,742	-50,01
C_3H_8	0,044	0,176	0,026	0,053	- 0,123	-69,89
i C_4H_{10}	0,0041	0,016	0,0021	0,004	- 0,012	-75,0
n C_4H_{10}	0,0055	0,022	0,0016	0,0033	- 0,019	-86,36
22 PM Pr	0,001	0,004	0,0005	0,001	- 0,003	-75
i C_5H_{12}	0,0012	0,005	0,0001	0,0002	- 0,0048	-96
n C_5H_{12}	0,001	0,004	10^{-4}	0	- 0,004	-100
i C_6H_{14}	0,0006	0,002	n.w.	0	- 0,002	-100
n C_6H_{14}	0,0002	0,001	n.w.	0	- 0,001	-100
i N_2	32,5	130	56,2	115,21	-14,79	-11,38
O_2	0,31	1,24	0,2	0,41	- 0,83	-66,93
CO_2	n.w.	0	8,4	17,22	+17,22	+
H_2	24,2	96,8	0,05	0,102	-96,7	-99,9
He	0,12	0,48	n.w.	0	- 0,48	-
Ar	0,26	1,04	0,53	1,08	+ 0,04	- 3,85
CO	12,9	51,6	n.w.	0	-51,6	-100

50% loss of total volume

Complete loss of H_2

DEA

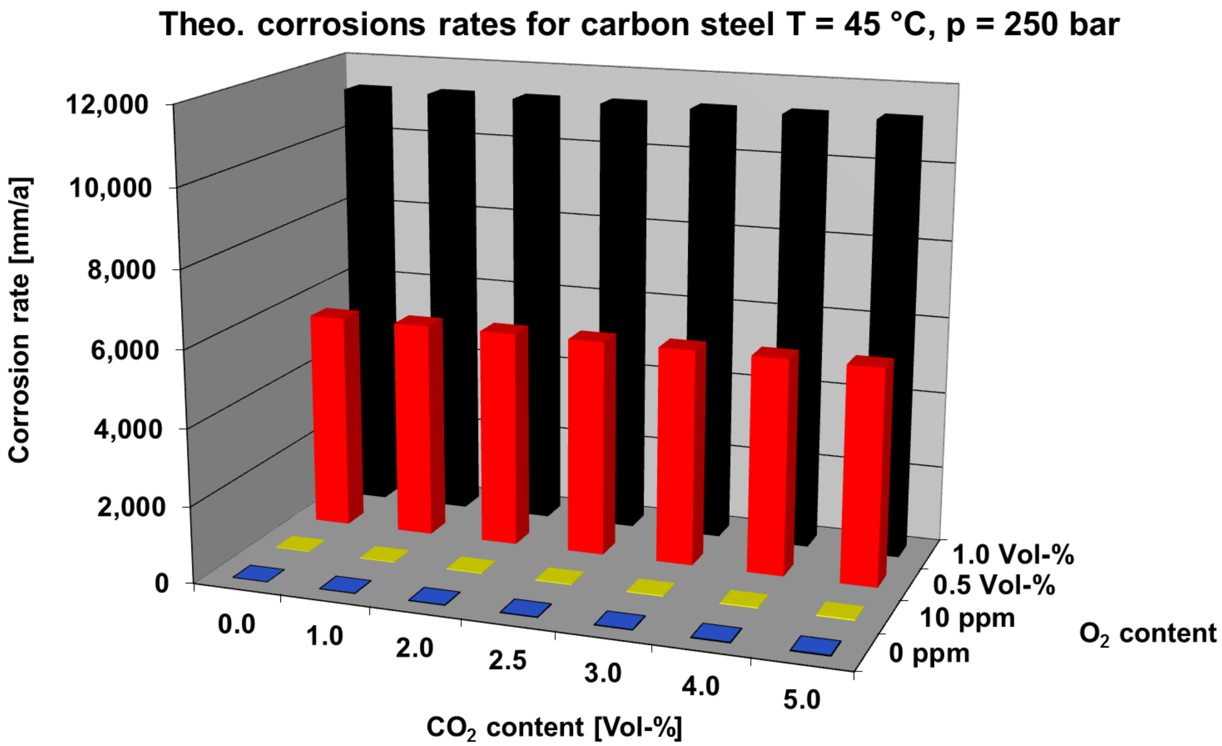
Carbon dioxide (CO_2) and Corrosion



DEA

➔ Keep existing EASEE-Gas limit for CO_2 of 2.5 mol%

Oxygen (O_2) and Corrosion



DEA

➔ Keep existing limit for O_2 of 10 ppm (0.001 mol%)