Dynamics of CO_2 stream composition in CCS clusters and its implications for CO_2 quality specifications

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CO_2 quality specifications

What are optimum proportions of CO_2 and impurities in captured CO_2 streams of different power plant types or industrial plants to

- ensure long-term, safe geological storage,
- control corrosion of equipment and pipelines and
- keep costs of CO_2 capture, transport and geological storage economically acceptable ?

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 flow rates.

⇒ 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.

CLUSTER – Scenario

Transportation

- pipeline transport and ship transport,
- transport distance:
  300 km onshore & 100 km offshore

Storage reservoir(s)

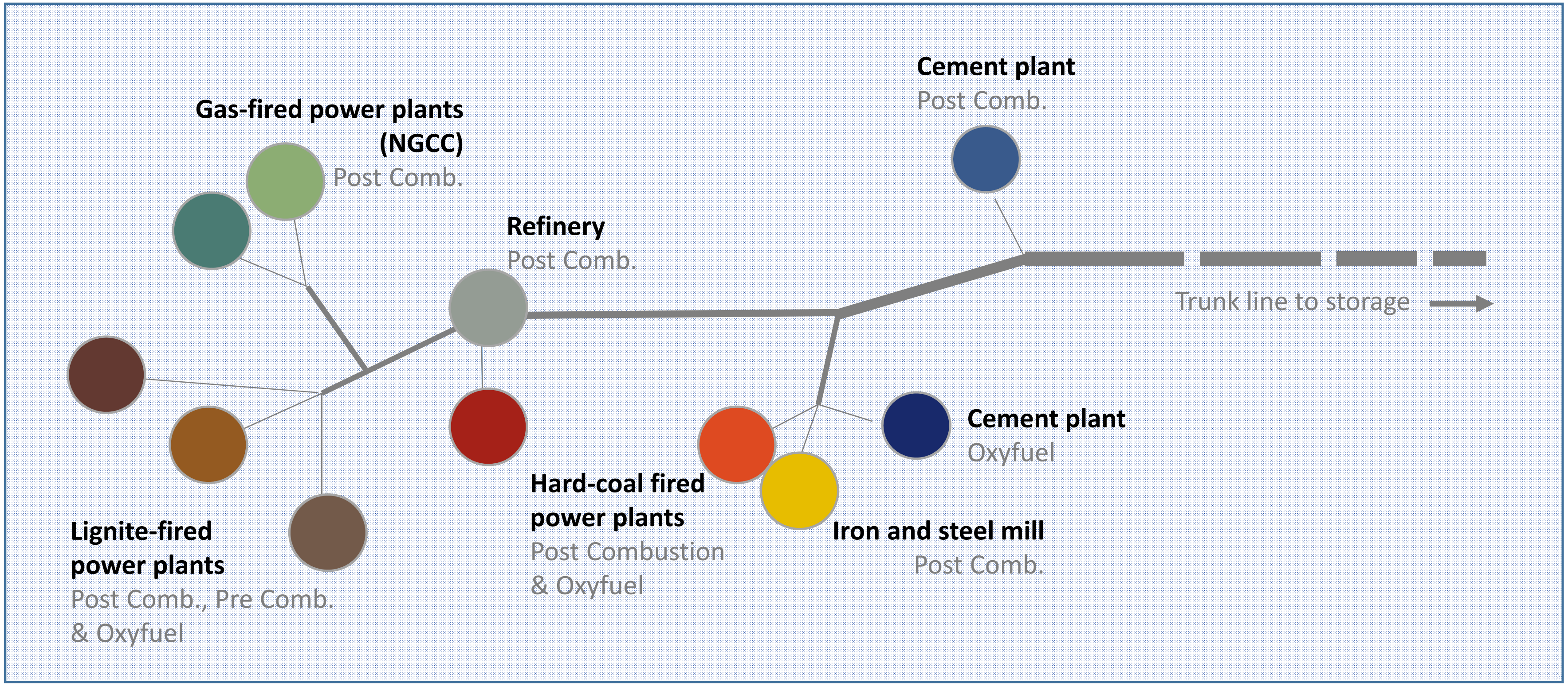
- saline aquifer (Buntsandstein),
- offshore,
- depth: 1600 m

CO_2 emitters

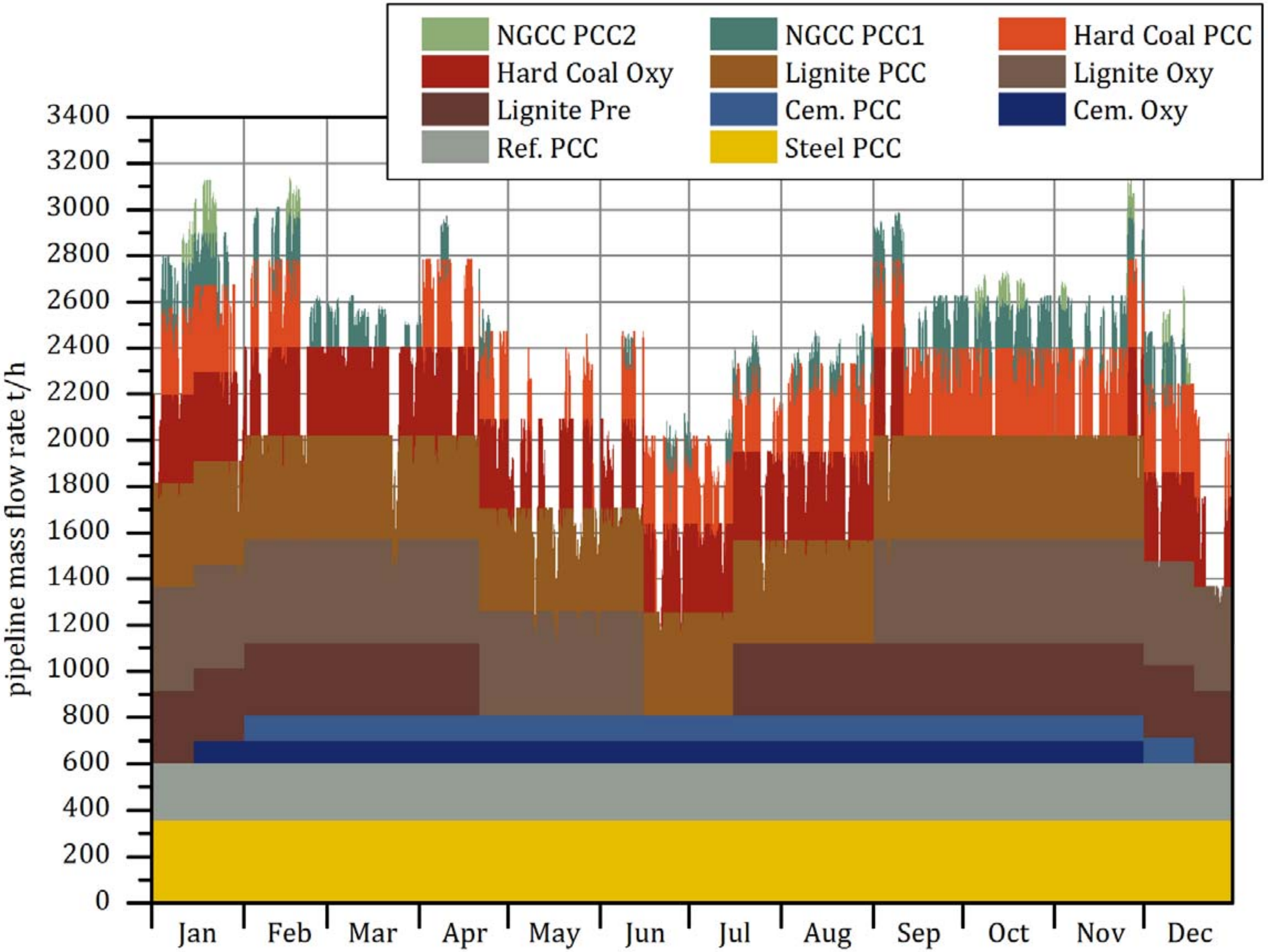
- power plants (coal, lignite or natural gas),
- cement plants,
- iron and steel mill,
- refinery

⇒ annual amount of captured CO_2 incl. impurities: 19.7 Mio t

Emitter cluster: power stations & industrial plants

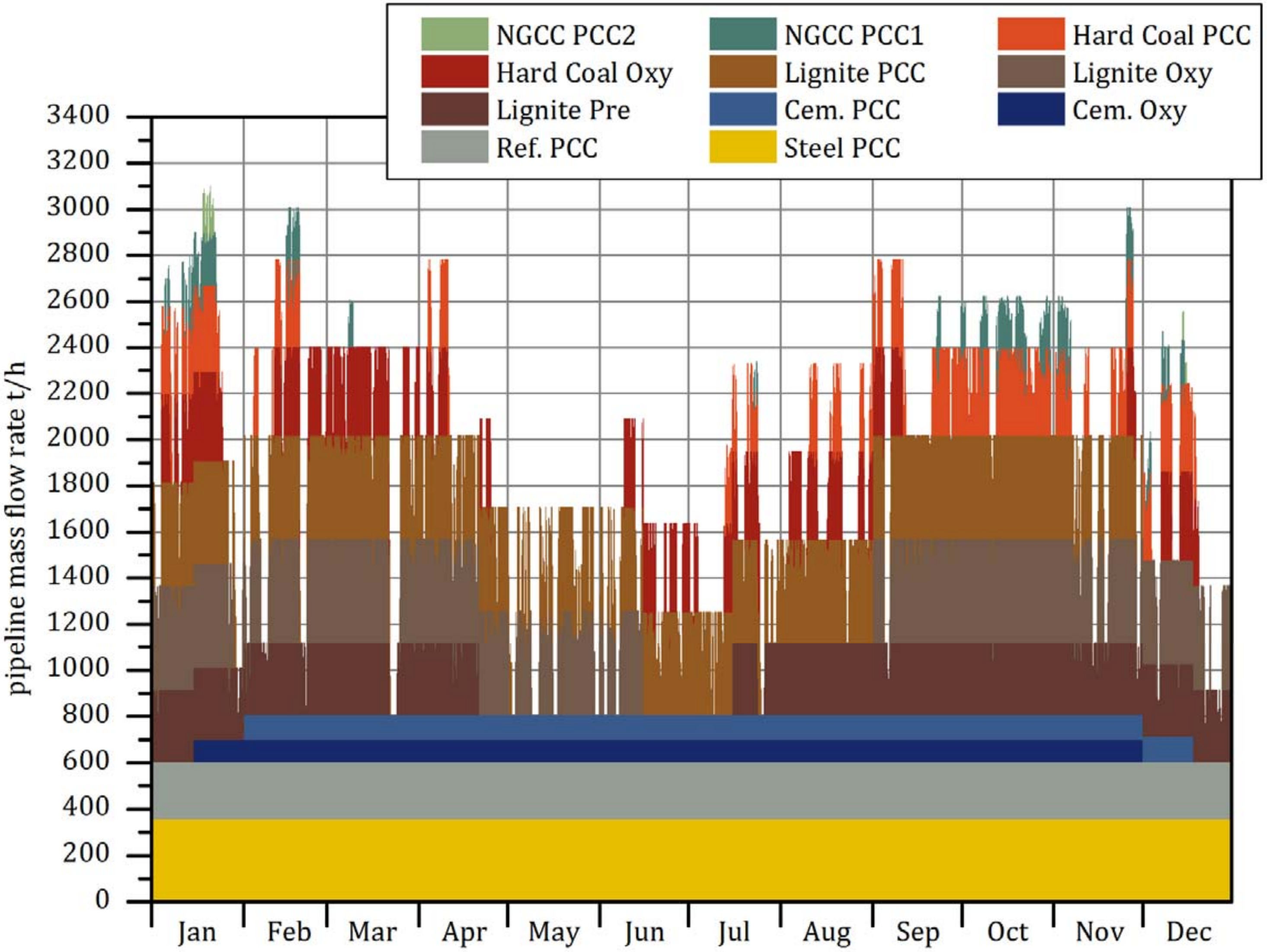


Scenario “27%RE”



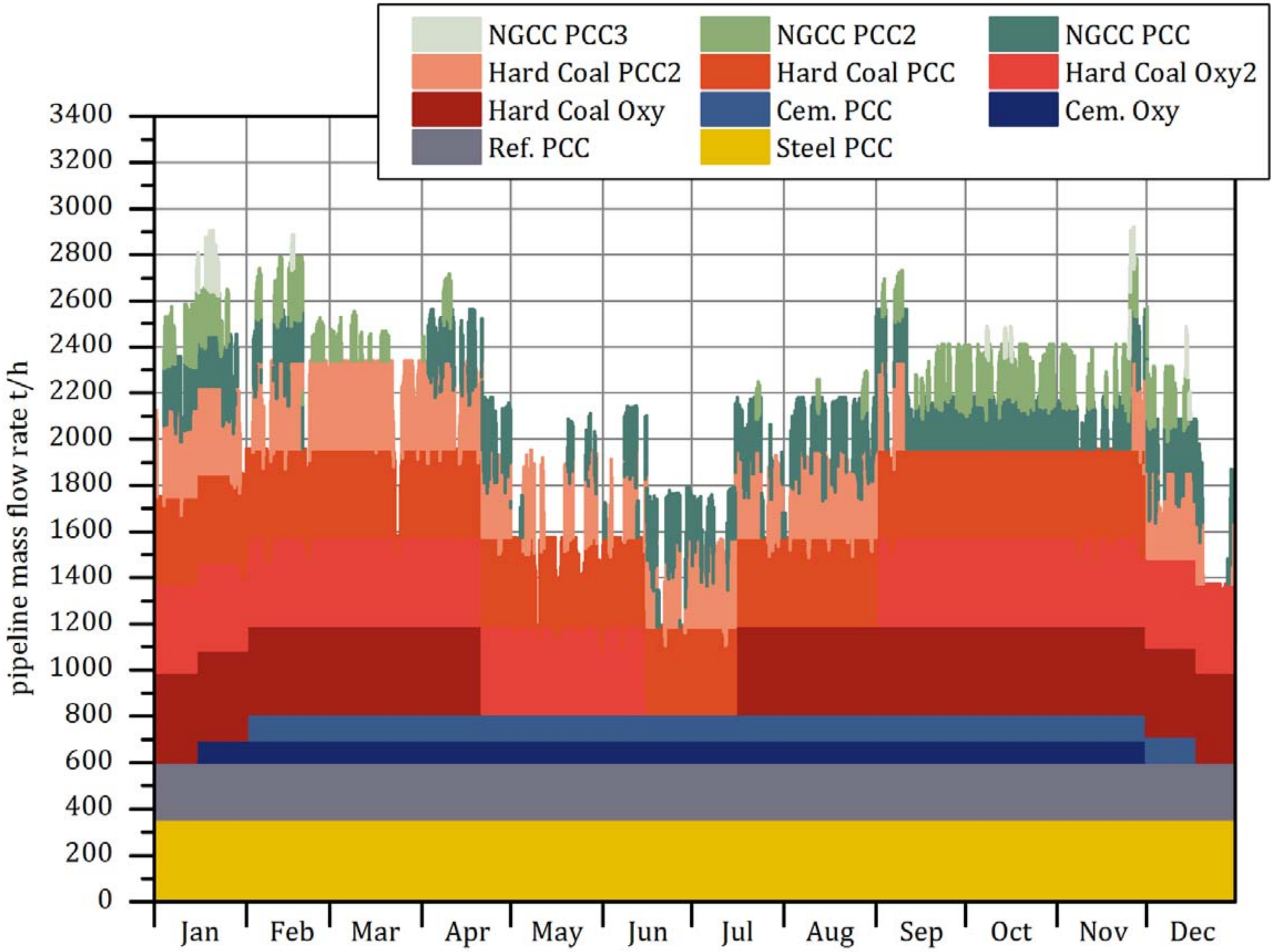
→ Based on real power production data in Germany in 2015.

Scenario "45%RE"



→ Same energy demand assumed as in Scenario 27%RE.

Scenario “NoLig”

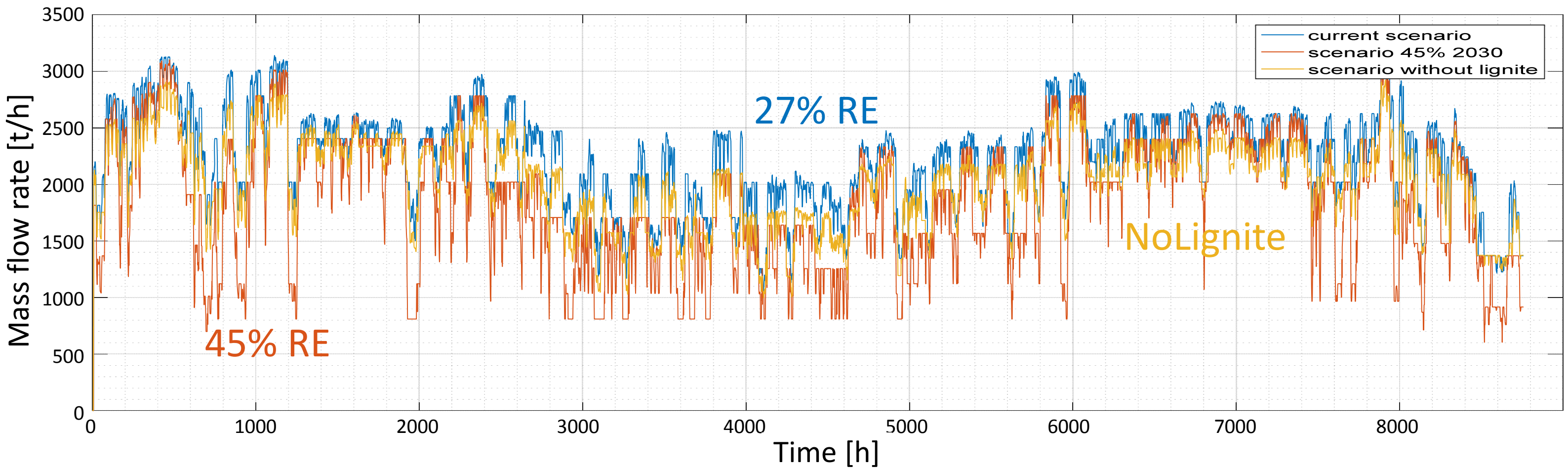


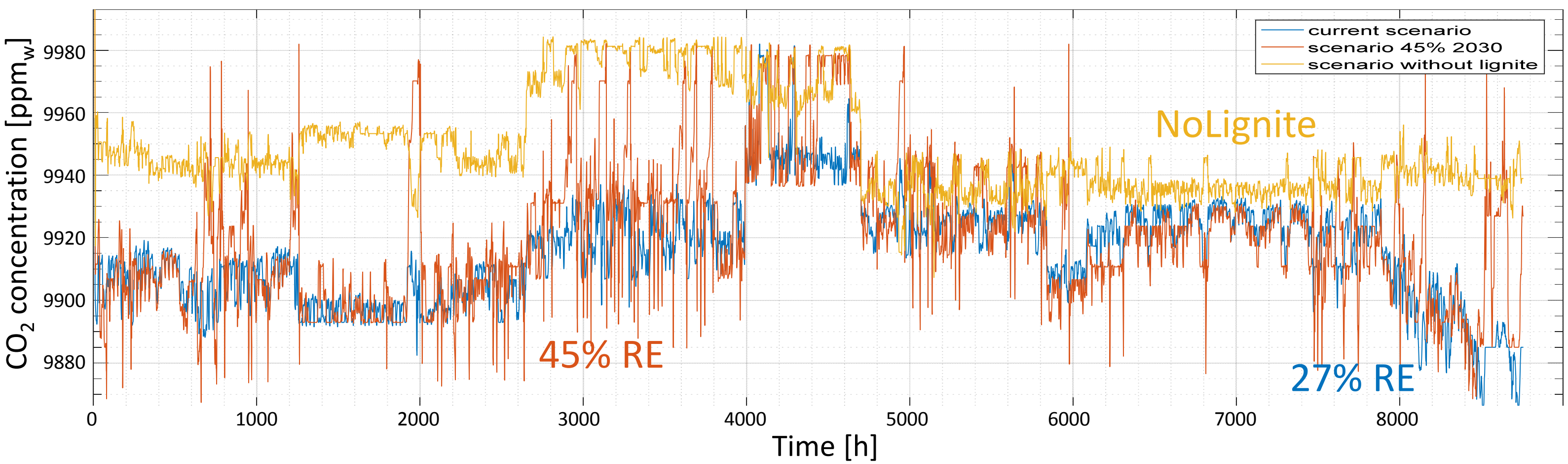
→ Same energy demand as in Scenario 27%RE; additional gas & coal-fired PP.

Captured CO_2 streams – total mass flow rate in trunk line (TL) and its variability

	Scenario 27%RE	Scenario 45%RE	Scenario NoLig
Annual total mass flow rate [Mt/a]	19.7	16.3	17.9
Max. mass flow rate [t/h]	3155 ↓ :3	3102 ↓ :5	2922 ↓ :3
Min. mass flow rate [t/h]	1033	604	997
Average mass flow rate [t/h]	2247	1863	2044
Inner diameter [m]	0.661	0.661	0.661

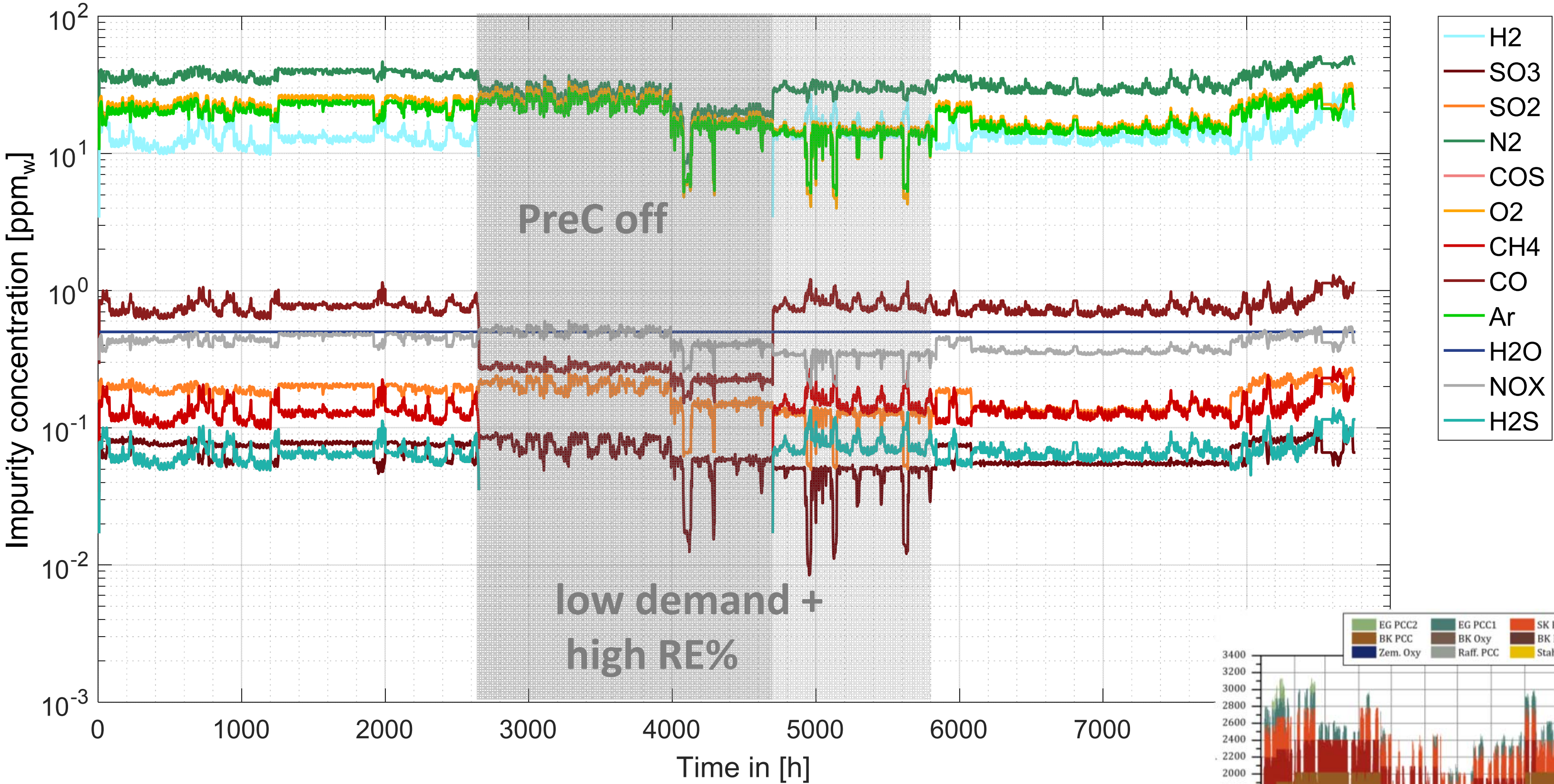
CO_2 stream properties (TL) – mass flow rate and CO_2 content

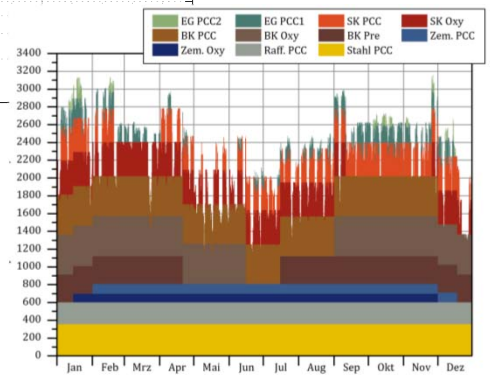




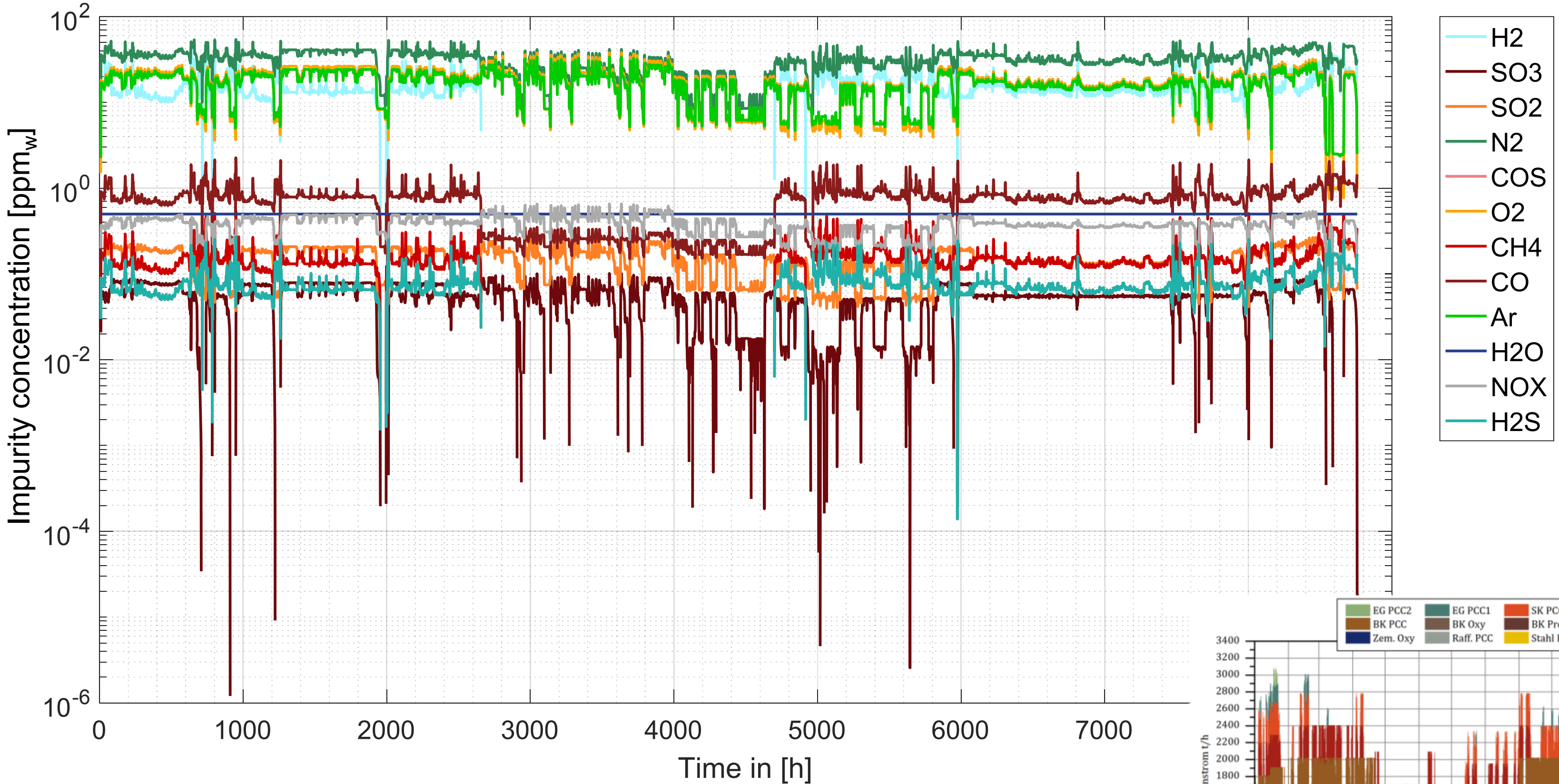
Onshore trunk line, 300 km, T = 288 K

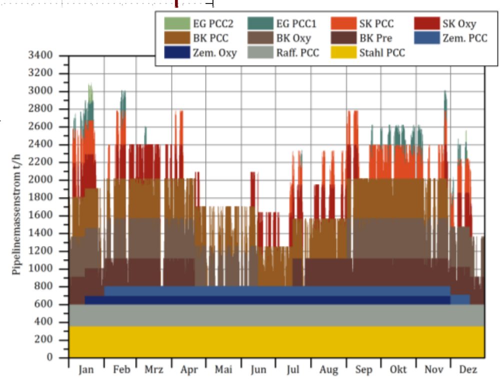
CO_2 stream composition (TL) – scenario “27%RE“



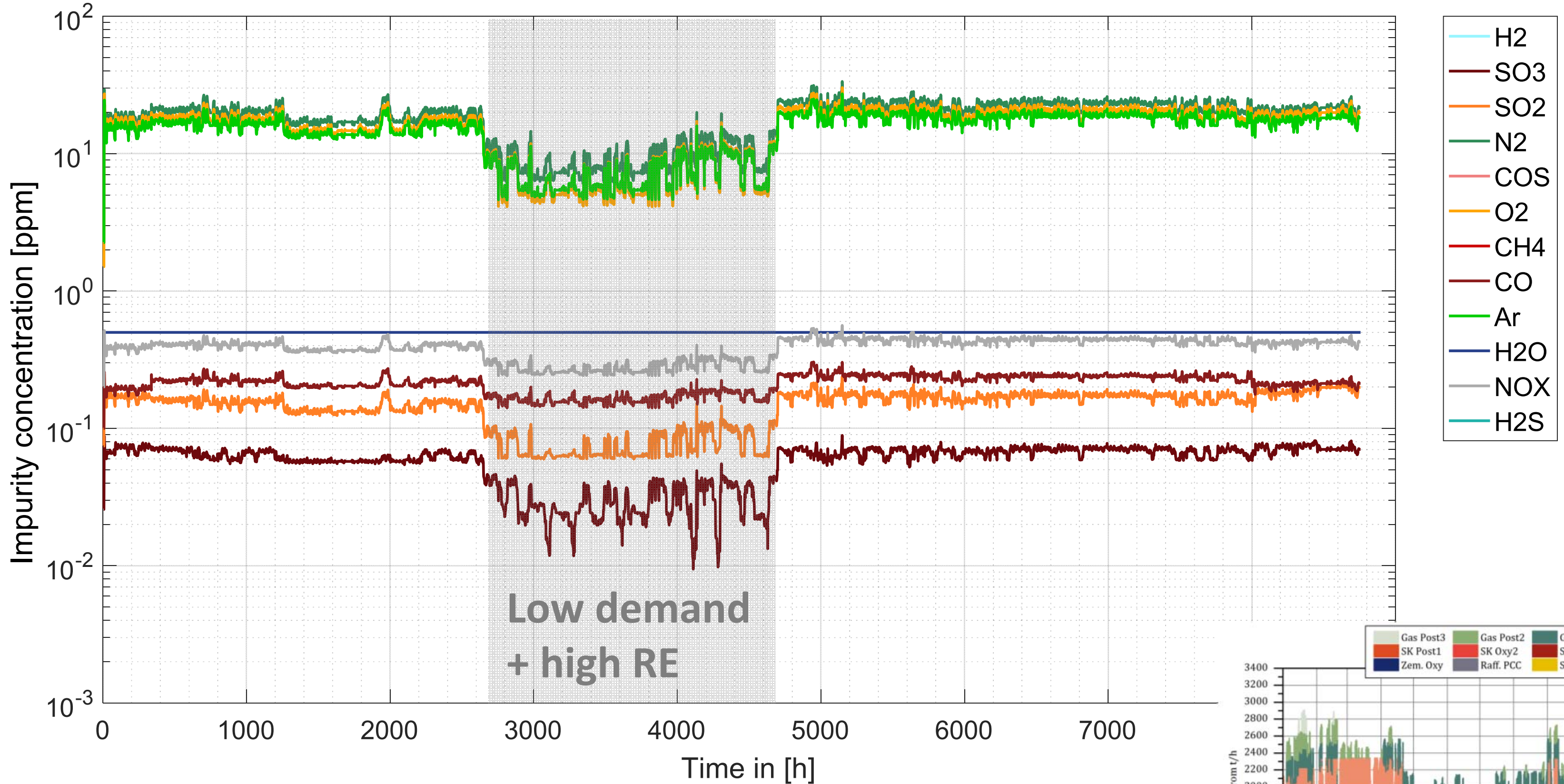


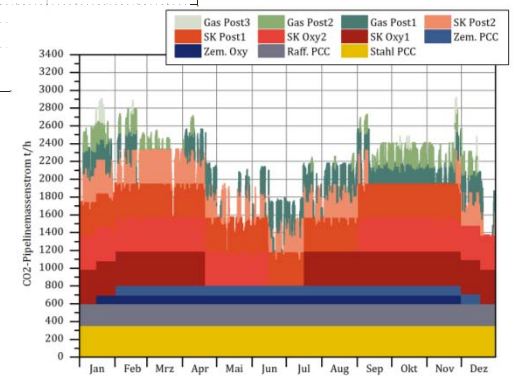
CO_2 stream composition (TL) – scenario “45%RE“



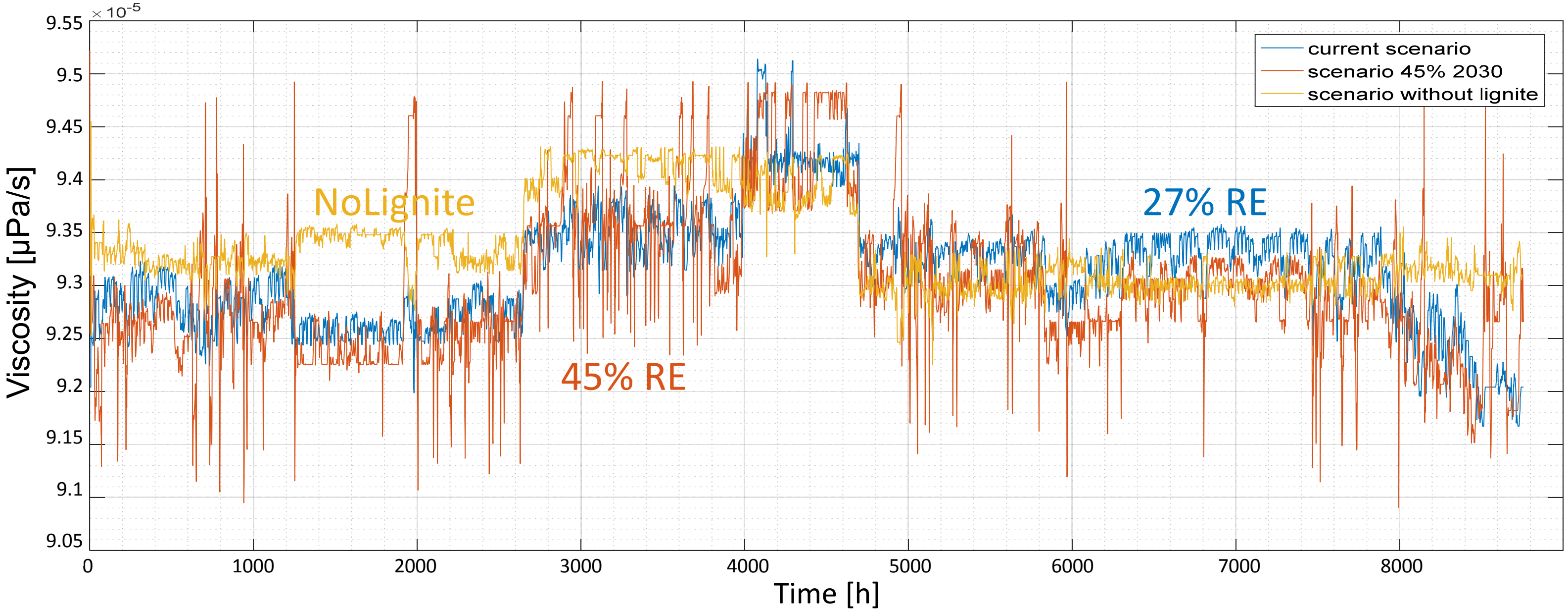


CO_2 stream composition (TL) – scenario “NoLignite“





CO_2 stream properties – example: dynamic viscosity (TL)



	27%RE	45%RE	NoLignite
Inlet pressure [MPa]	15.6	15.4	14.8

Onshore trunk line, 300 km, T = 288 K

Summary & Conclusions

Load variations of emitters

Clustering of CO_2 streams of different emitters

Variations in mass flow and CO_2 stream composition in pipeline network and trunk line

Design parameters of pipeline network & trunk line

FUTURE SCENARIOS ?

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Thank you for your attention !

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