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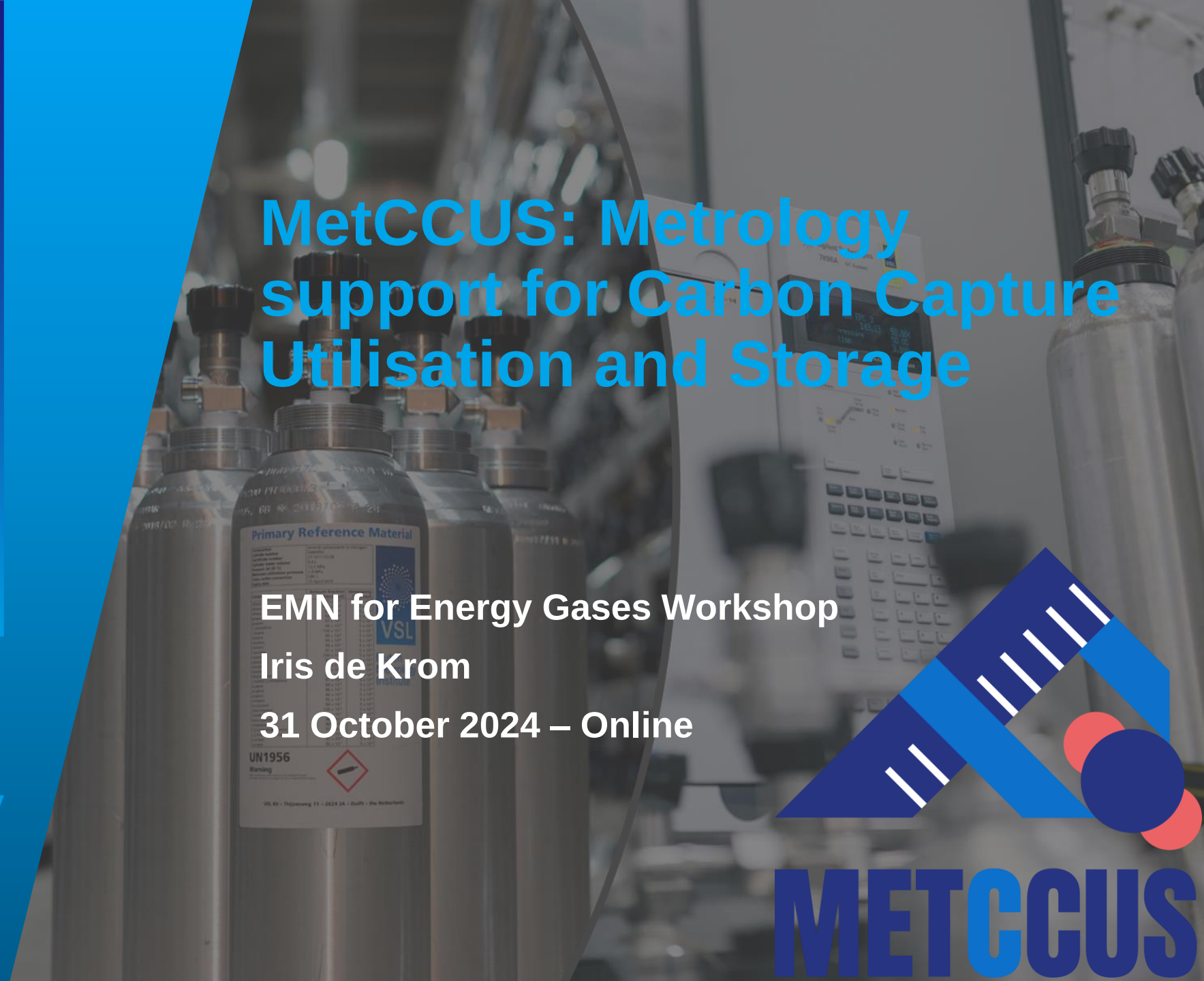
MetCCUS: Metrology support for Carbon Capture Utilisation and Storage



EMN for Energy Gases Workshop

Iris de Krom

31 October 2024 – Online

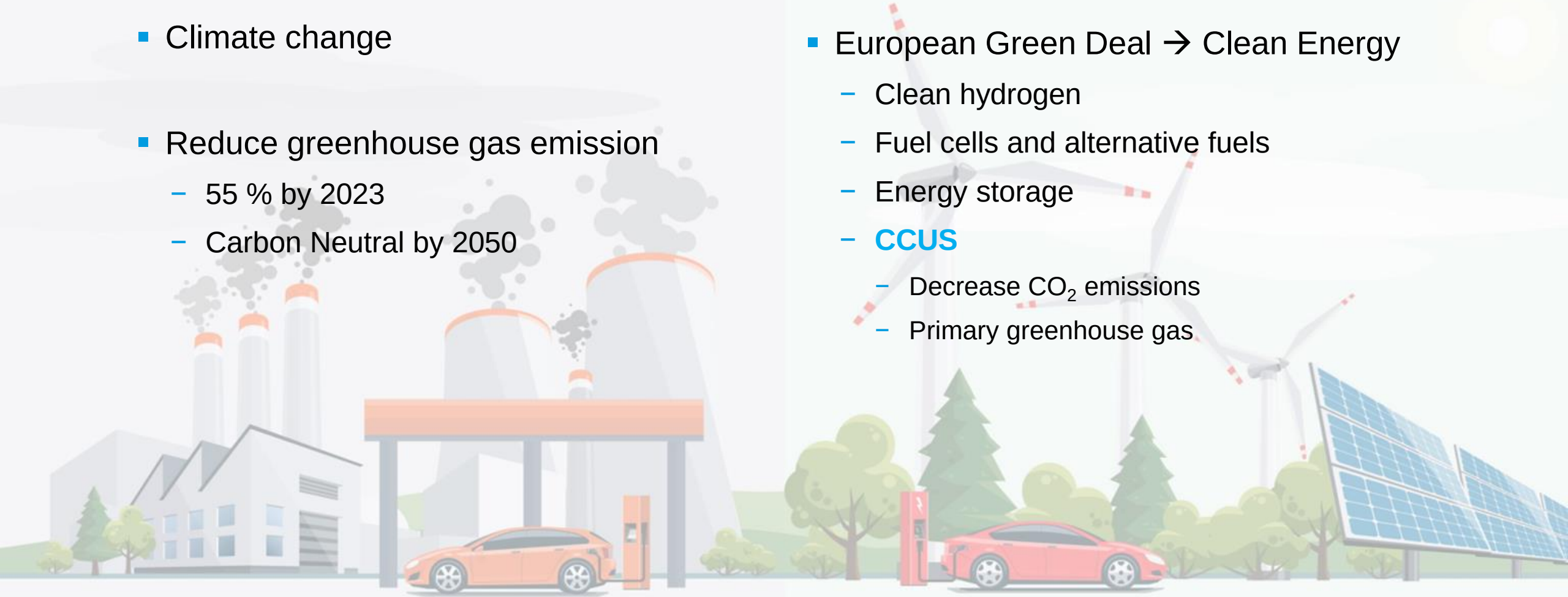
METCCUS

Carbon Capture Utilization and Storage (CCUS)

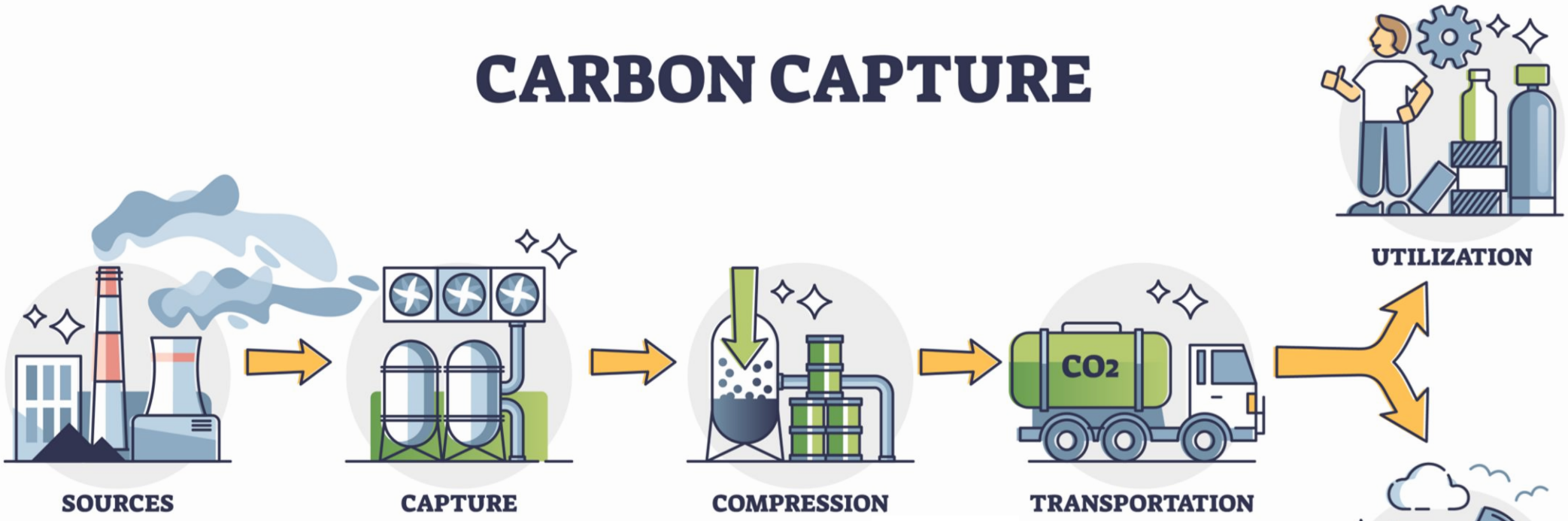
- Climate change

- Reduce greenhouse gas emission
  - 55 % by 2023
  - Carbon Neutral by 2050

- European Green Deal → Clean Energy
  - Clean hydrogen
  - Fuel cells and alternative fuels
  - Energy storage
  - **CCUS**
    - Decrease CO_2 emissions
    - Primary greenhouse gas



CCUS process



- European Emissions Trading System (EU-ETS)

- European directive 2009/31/EC

Metrology support for CCUS

- 1 October 2022 – 30 September 2025
- 21 participants

"The project has received funding from the European Partnership on Metrology, co-financed by European Union Horizon Europe Research and Innovation Programme and from the Participating States."

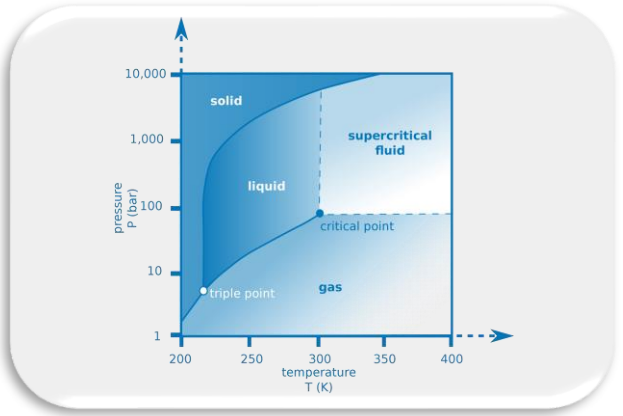
CCUS measurement challenges

Flow metering

Emission monitoring

Chemical metrology

Physical properties



Flow metering

Gas flow

- Metrology infrastructure for monitoring CO_2 flow
  - < 50 m^3/h and low pressure
  - Up to 400 m^3/h and higher pressure
- Primary and transfer standards
  - Intercomparison
  - Theoretical investigate the impact of impurities on transfer standards
  - Uncertainty 1.5 % - 2.5 %

Liquid flow

- Study to determine the current state of the art of traceable liquid CO_2 flow measurement and liquid CO_2 primary standard requirements → https://zenodo.org/records/11118645

CCS fiscal metering

- Good practice guide

Flow metering – primary calibration facilities

- Primary facilities for gaseous CO_2
  - < 50 m^3/h and atmospheric – 0.3 MPa
  - Up to 400 m^3/h and up to 20 MPa
- Validation and transferability between CO_2 and N_2 experiments are finalized
- Intercomparison of the different facilities started

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Emission monitoring

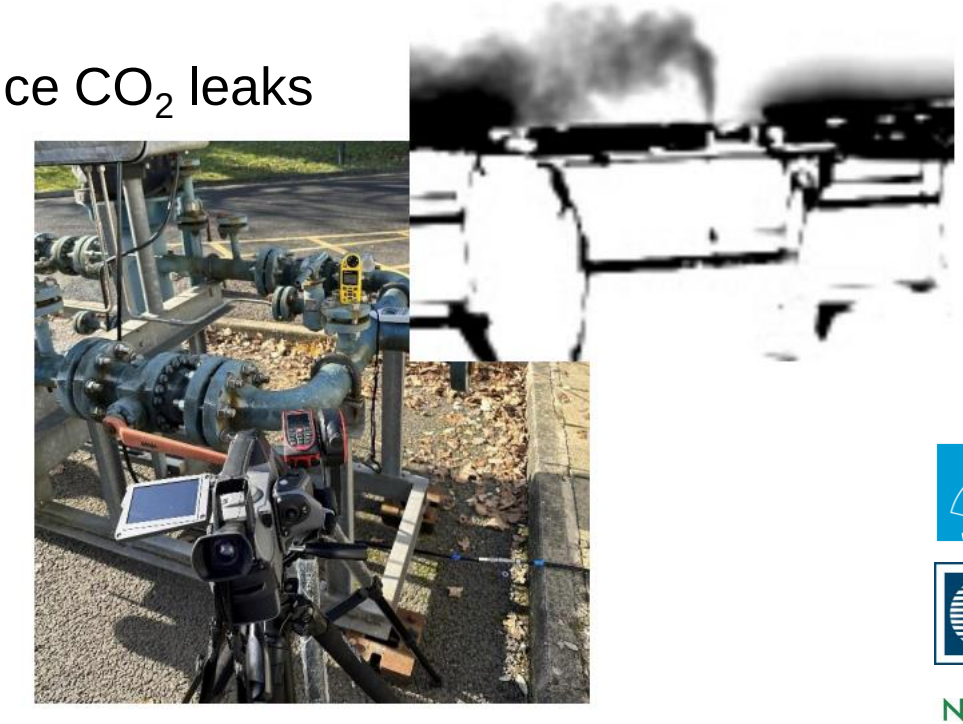
- Review requirements for monitoring **pollutants in CO_2** in the **emission from ducts and flues** from carbon capture processes
  - Focus on pollutants from **amine capture** → gas matrix and methods for monitoring nitrosamines/amines have been identified → facilities have been developed to generate test matrices to test monitoring methods
- Review **performance requirements** for the **detection of CO_2**, including leak monitoring techniques based on EN 1779.
- **Detection and quantification** of **CO_2 emissions** from **geological storage**
  - Isotopic measurements
  - Addition of tracers
  - Use of acoustic techniques

Emission monitoring - Nitrosamines

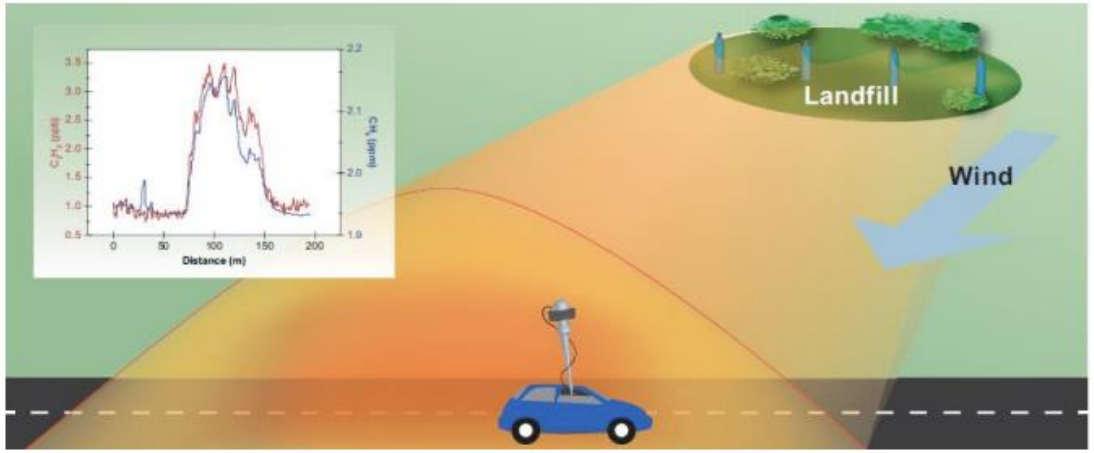
- Methods for monitoring nitrosamines
  - Sorbent trap method – dilution to dry sample
  - Wet chemistry based on EN1479 Thermo-sorb – sulfamic acid impinger solution

Leak detection

- Controlled Release Facility modified to produce CO_2 leaks
  - used to access CO_2 imaging camera



- Tracer correlation methods



- Subsea leakage → review of acoustic techniques → link

Chemical metrology

- **Primary reference materials** for impurities in CO_2 → https://zenodo.org/records/8421450
  - Key impurities e.g.; H_2O, NO_x, sulphur compounds, hydrocarbons, alcohols and amines
  - Permanent gases: O_2, Ar, N_2, CH_4, CO, H_2
- Material compatibility for **CO_2 sampling** → https://zenodo.org/records/8421721
- **Online CO_2 monitoring**
  - Development and validation of online methods
  - Round Robin Test for the measurement of impurities in CO_2
- **Offline analytical methods** for CO_2 quality
  - CO_2 capture, transport and storage
  - CO_2 conversion, utilisation and recycling

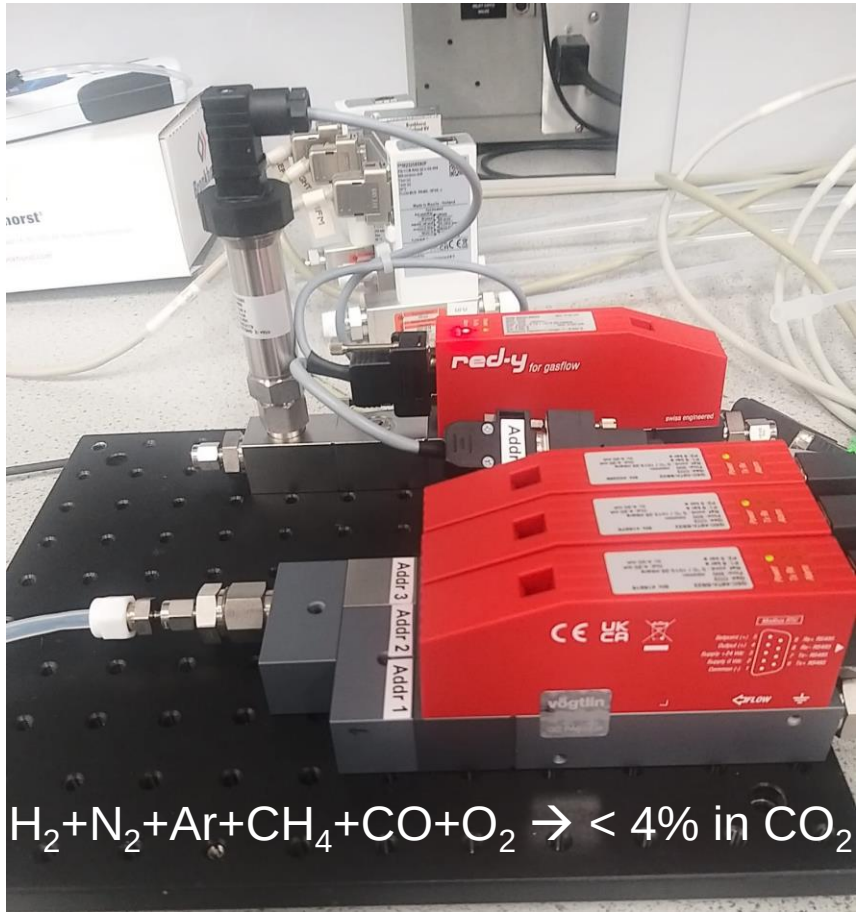
Chemical metrology – primary reference materials

Static gas mixtures (ISO 6142)

Binary: H_2O, NO_2, SO_2, ethanol, DSM, N_2O and H_2S in CO_2

Multi in CO_2: 1) H_2S, CO, O_2 and CH_4
2) N_2, H_2, CH_4, N_2O, SO_2, NO_2
3) CH_4, Ar, N_2, H_2, O_2, CO, NO SO_2

Dynamic gas mixtures (ISO 6145)



H_2+N_2+Ar+CH_4+CO+O_2 → < 4% in CO_2

Chemical metrology – CO_2 sampling

Component	Amount fraction (µmol/mol)	Restek Multifoil	Restek Altef	Calibrated Instruments Inc Cali5Bond	Airborne Labs True Blue 2LT
Methanol	4-8	Stable at least 30 days (loss < 20% after D50)	Concentration decreases quickly with time	25-35% loss D1, then stable	Concentration decreases with time
	10-15	Stable at least 30 days (loss < 20% after D50)	Concentration decreases quickly with time	25-35% loss D1, then stable	Concentration decreases with time
Acetaldehyde	0.5	Stable at least D30			More than 20% loss D30
	1	Stable at least D30			15% loss D30
	4-8	Stable at least D30			
	10-15	Stable at least D30			
Ethanol	4-8	20-25% loss D50. Analysis before D10	Concentration decreases quickly with time	35% loss D4, then stable	20-25% loss D50. Analysis before D10
	10-15	20-25% loss D50. Analysis before D10		35% loss D4, then stable	
Acetone	4-8	Max 15% loss D50	Concentration decreases quickly with time	Stable at least D7	Max 15% loss D50
	10-20	Max 15% loss D50		Stable at least D7	Max 15% loss D50
Benzene	0.3 – 2	Not compatible as benzene adsorbs on the walls	Stable at least D4		Stable at least D20 but recovery at D0 unknown
	7	Not compatible as benzene adsorbs on the walls			
Hydrogen sulphide	Ca 2			100% loss D30. Analysis before D5	
	Ca 10			50% loss D30. Analysis before D5	
	Ca 20			35% loss D30. Analysis before D5	
	Ca 40			20% loss D30	
	Ca 60			15% loss D30	
	Ca 100			Less than 10% loss D30	

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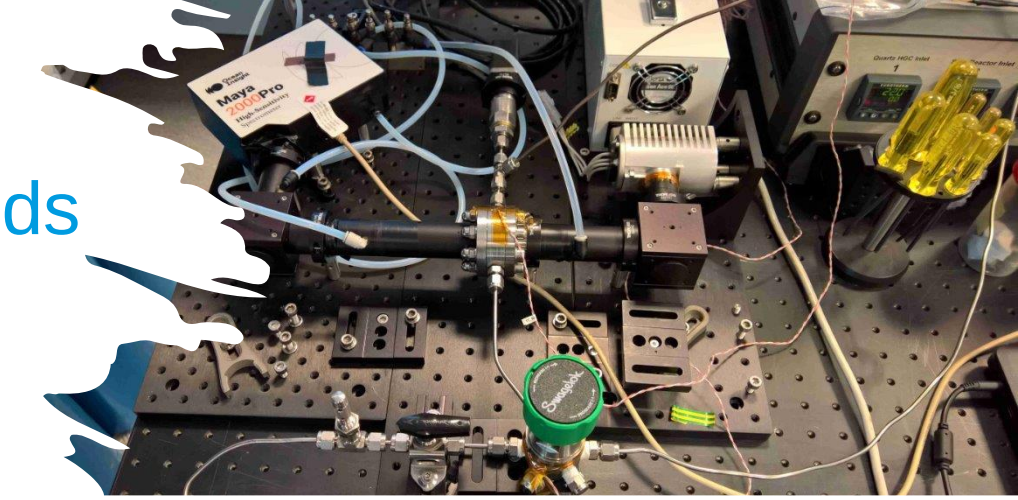
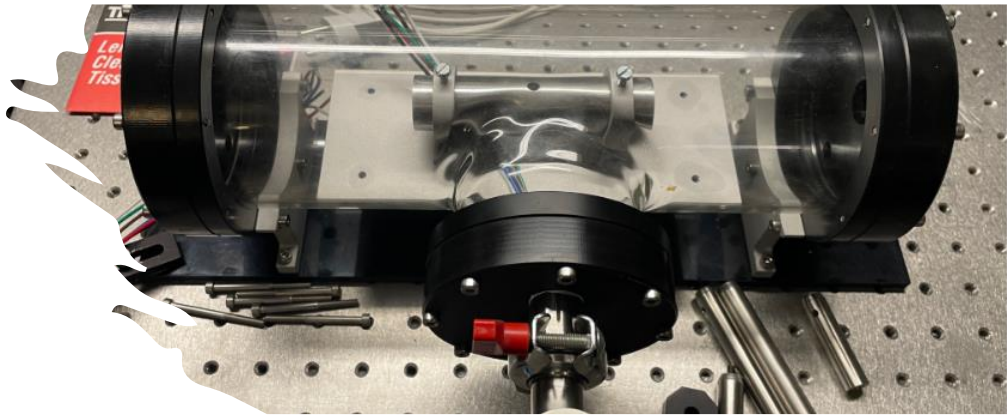
Report: Experiments to test the sampling of impurities, against material, for key impurities and materials → link

Chemical metrology – monitoring methods

- Photoacoustic spectroscopy for leak and purity monitoring
- Gas sampling and (far-UV)/FTIR-based analyser
- Demonstration at an industrial site
- Round robin for gas analysis capabilities of new and commercial monitoring methods against primary reference materials





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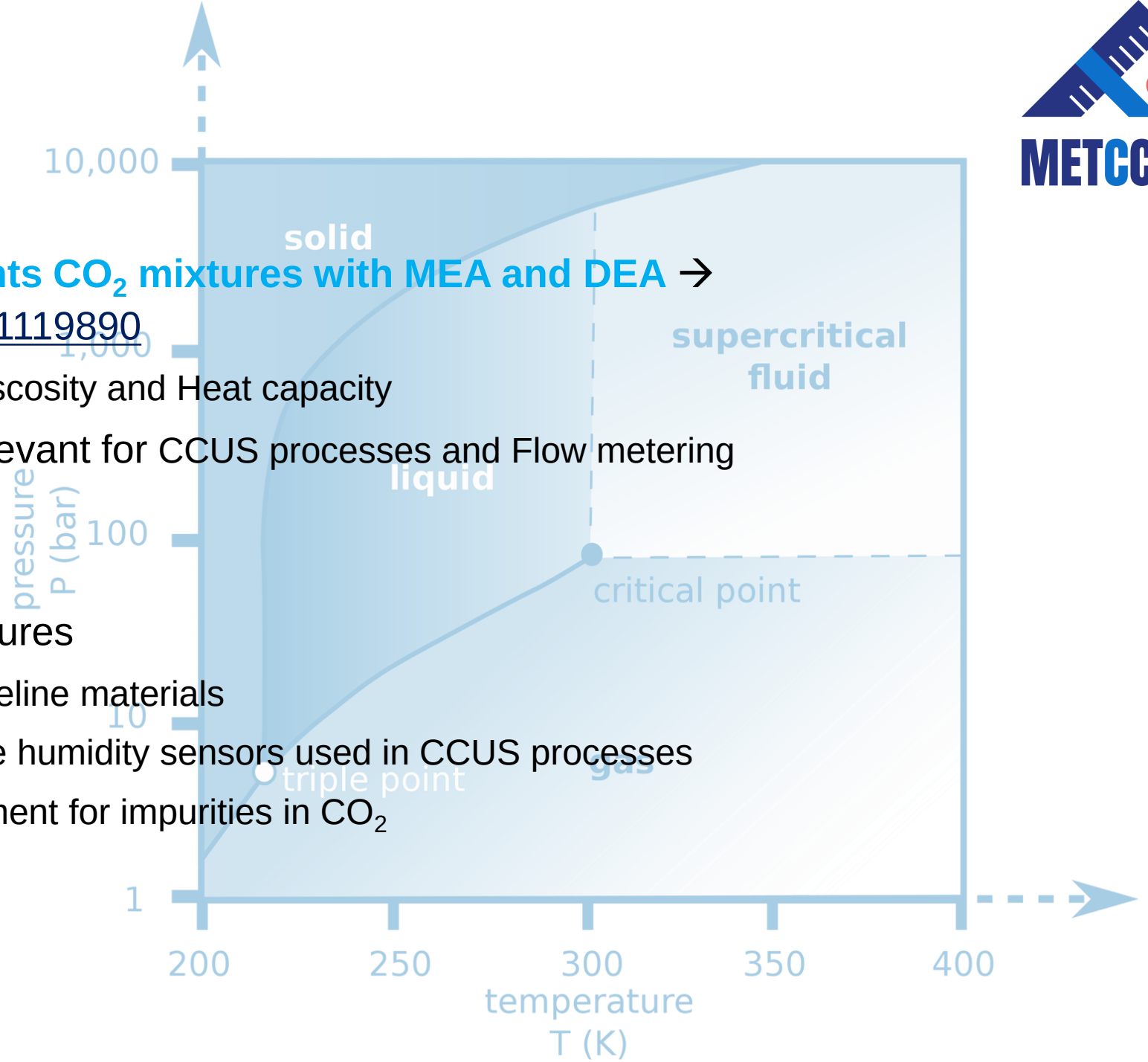
Physical properties

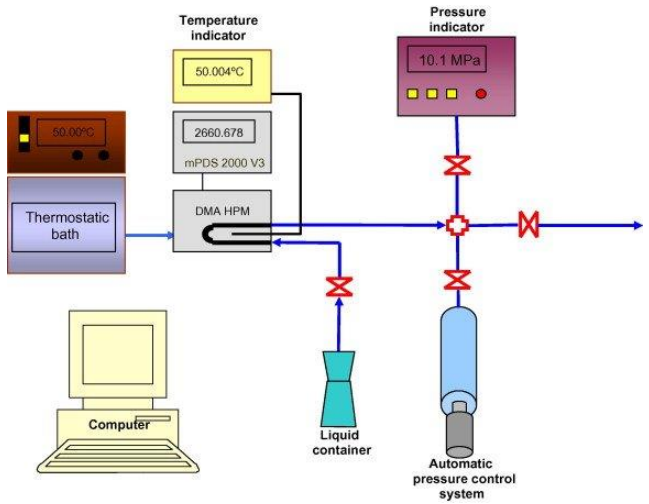
- **Experimental measurements CO_2 mixtures with MEA and DEA →** https://zenodo.org/records/11119890
  - Density, Speed of sound, Viscosity and Heat capacity
- Equation of state models relevant for CCUS processes and Flow metering
  - EoS-CG 2019
  - GERG-2008
- Monitoring CCUS infrastructures
  - Corrosion testing of CO_2 pipeline materials
  - Calibration method for online humidity sensors used in CCUS processes
  - Online measurement equipment for impurities in CO_2



Physical properties

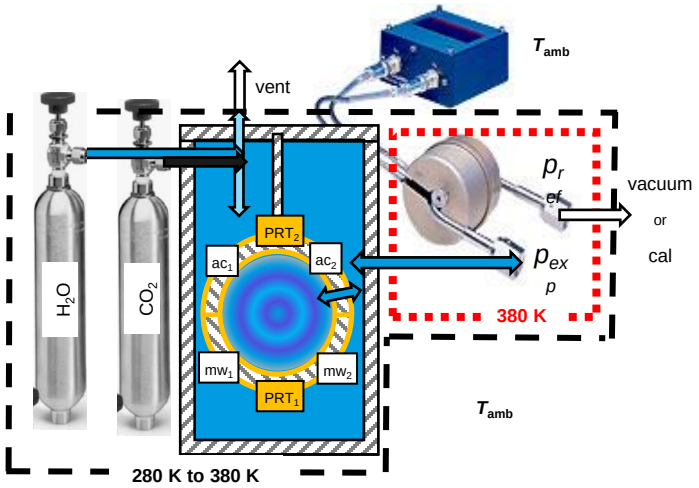
Vibrating tube densimeter

Density
(200 to 425) K
140 MPa



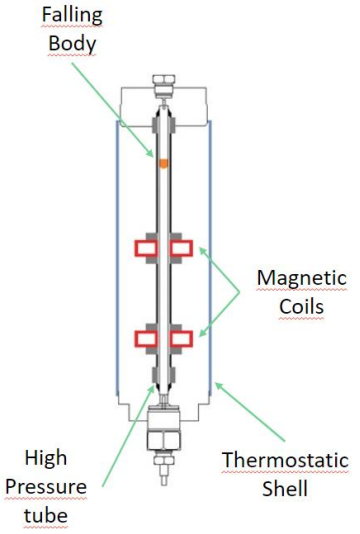
Acoustic/microwave resonator

Speed of sound (xCO_2 + (1-x)H_2O)
(280 to 380) K
5 MPa



Falling body viscometer

Viscosity
(200 to 425) K
140 MPa



Conclusion

- Developments in MetCCUS
  - Primary standards and reference materials
  - Calibration and measurement methods
  - Good practice guides
  - Literature reviews & peer reviewed articles

- Support
  - CCUS industry to comply with EU ETS and Directives
    - Track the amount of carbon
    - Safe operation of CCUS technologies
  - Development of key documentary standards, specifications and regulation
  - Effective implementation of CCUS technologies
  - CCUS industry to become carbon neutral and overcome climate change

Thank you for your attention

- Visit
  - www.metccus.eu
  - MetCCUS: Overview | LinkedIn

- Contact

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