



- catching our future

Atmospheric Dispersion Plume Modelling

Workshop on Measurement, Monitoring and Controlling Potential Environmental Impacts from the Installation of Point Source Capture

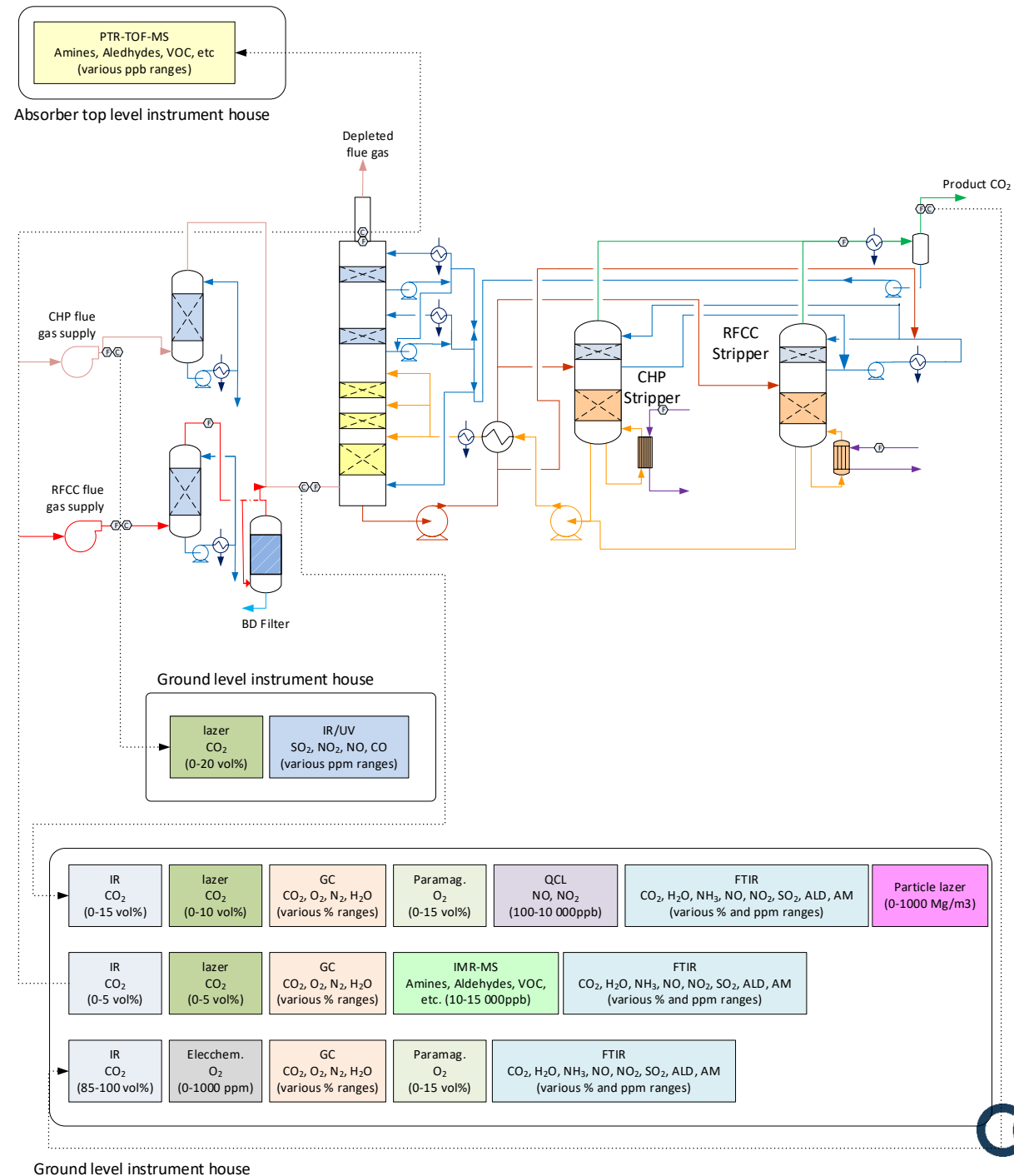
June 8th 2023

Rouzbeh Jafari



Amine plant at TCM

- Amines and degradation products
 - Released to the atmosphere with most sophisticated emission mitigation systems
- Atmospheric oxidation processes
 - Transform the emitted amines into nitrosamines and nitramines,
 - Substances with known carcinogenic properties.



TCM Emission Permit

- Emission permit is not enough for operation.

TCM Amine Plant Applicable Emission Permit

Emission Components	Emission Source	Emission Limits	
		Daily average limit	Yearly limit
Ammonia	Amine Plant	100 ppmv	6,000 (kg/year)
Total Amines	Amine Plant	6* ppmv	2,800 (kg/year)
Total Aldehydes	Amine Plant	1 g/s	

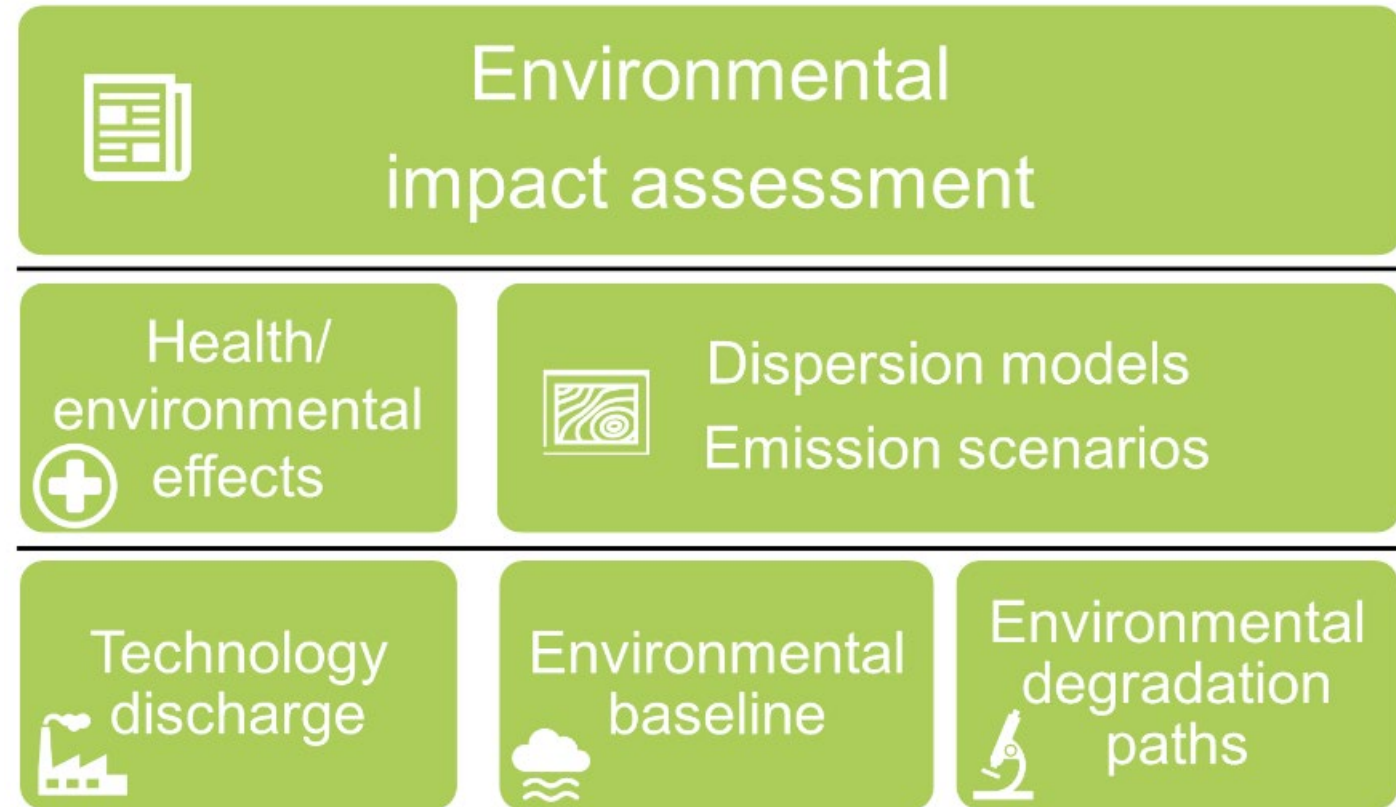
*: Maximum hourly average emission is 15 ppmv

- TCM needs to assess what is the Health and Environmental Effects of what is emitted.

Health and Environmental Effects

- Norway defined limits for these pollutants with respect to public health.
- The sum of nitramines and nitrosamines shall not exceed the recommended levels.

Exposure path	Recommended max level
Air	4 ng/L
Drinking water	0.3 ng/m ³



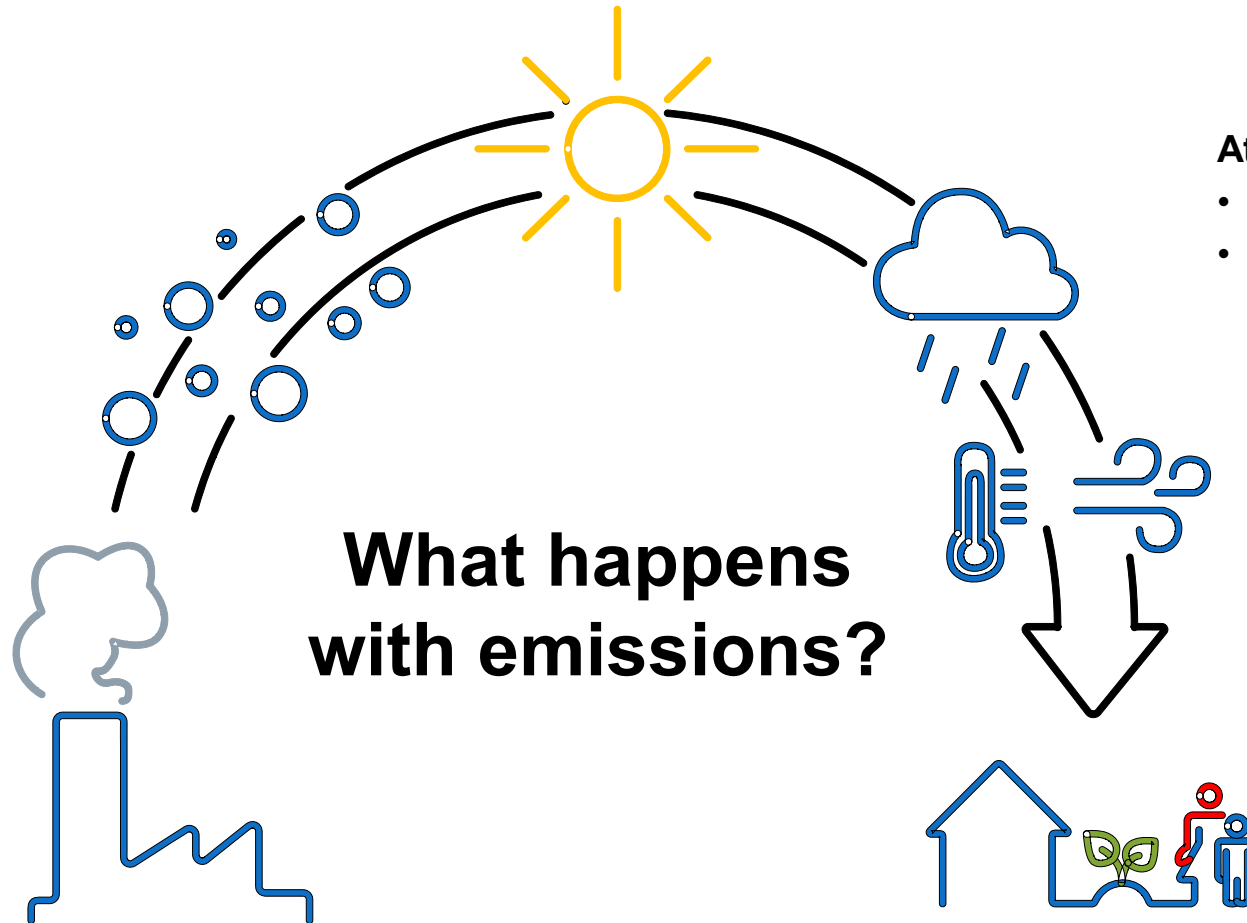
Atmospheric Chemistry and Dispersion Model - Overview

Dispersion modelling:

- Dispersion of amines
- Photochemical reactions
- Predicting air and water concentrations

Emission:

- Sampling system
- Online-monitoring
- Lab measurements



Atmospheric chemistry:

- Scientific research,
- Experimental and modelling approach

Dispersion effects and impact:

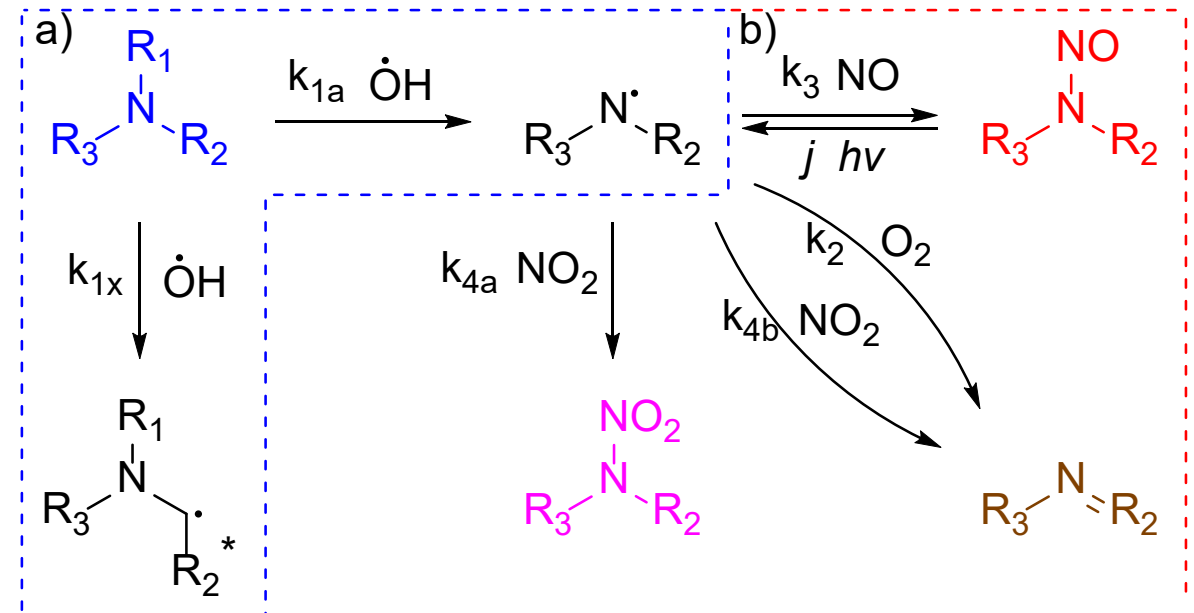
- Baseline study and environmental monitoring.

Environmental Baseline

- A thorough understanding of the current environmental conditions surrounding any new industrial activity.
 - Important for the site owner, as some pollutants might already be present in the local environment but not considered in previous.
- An example from the TCM application process is the limits to ammonia emissions.
 - The emissions limits placed on ammonia is stricter than what the dispersion models state as safe concentrations for human exposure.
 - This is because the region already has high load of ammonia in surface waters due to other industries and agriculture in the region.

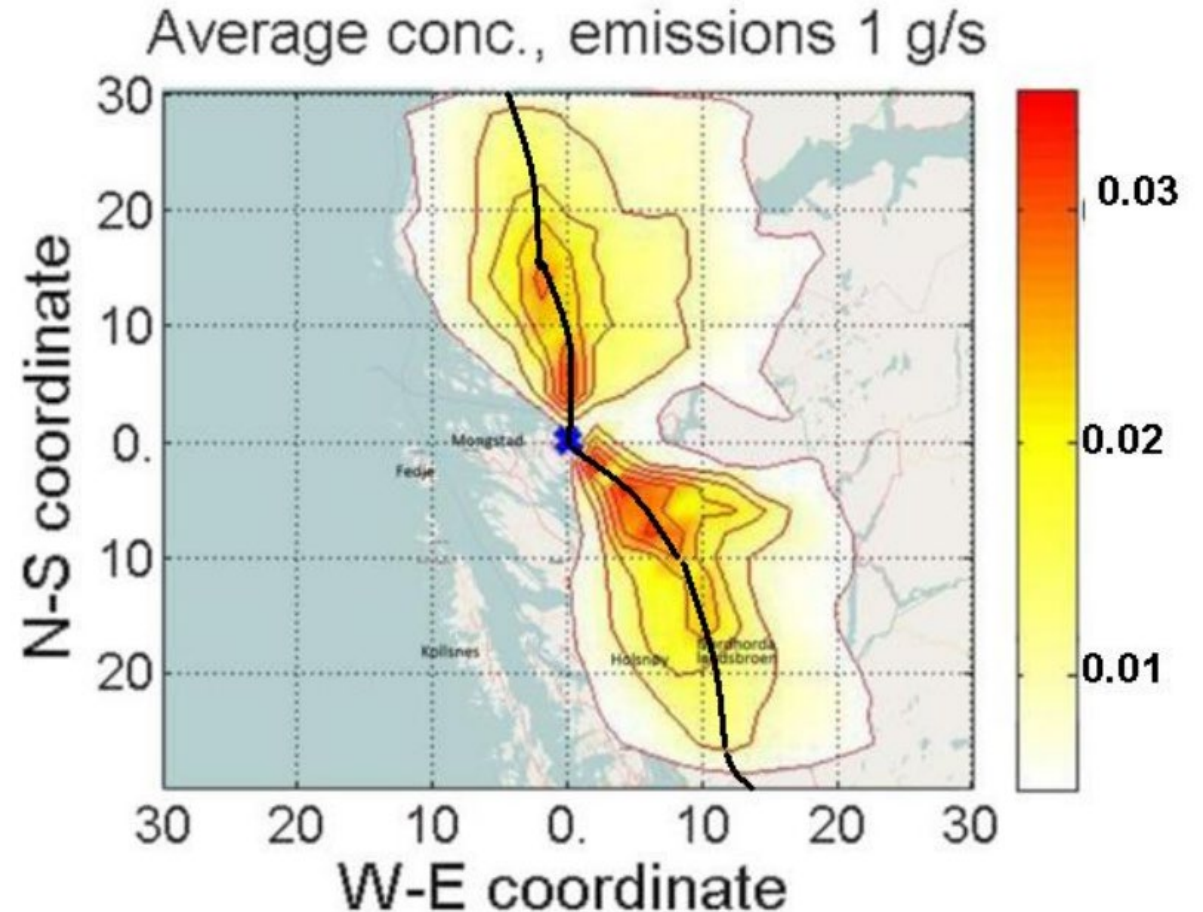
Environment Degradation Path - Atmospheric Chemistry

- Understanding the environmental pathways and life span of emitted pollutants is important.
- Amines degrade when exposed to radical species in the atmosphere.
 - Atmospheric chemistry defines degradation pathways and determine reaction kinetic parameters.
- Leading to the formation of Nitrosamines and Nitramines is the initial hydrogen abstraction by hydroxyl radicals (HO•)



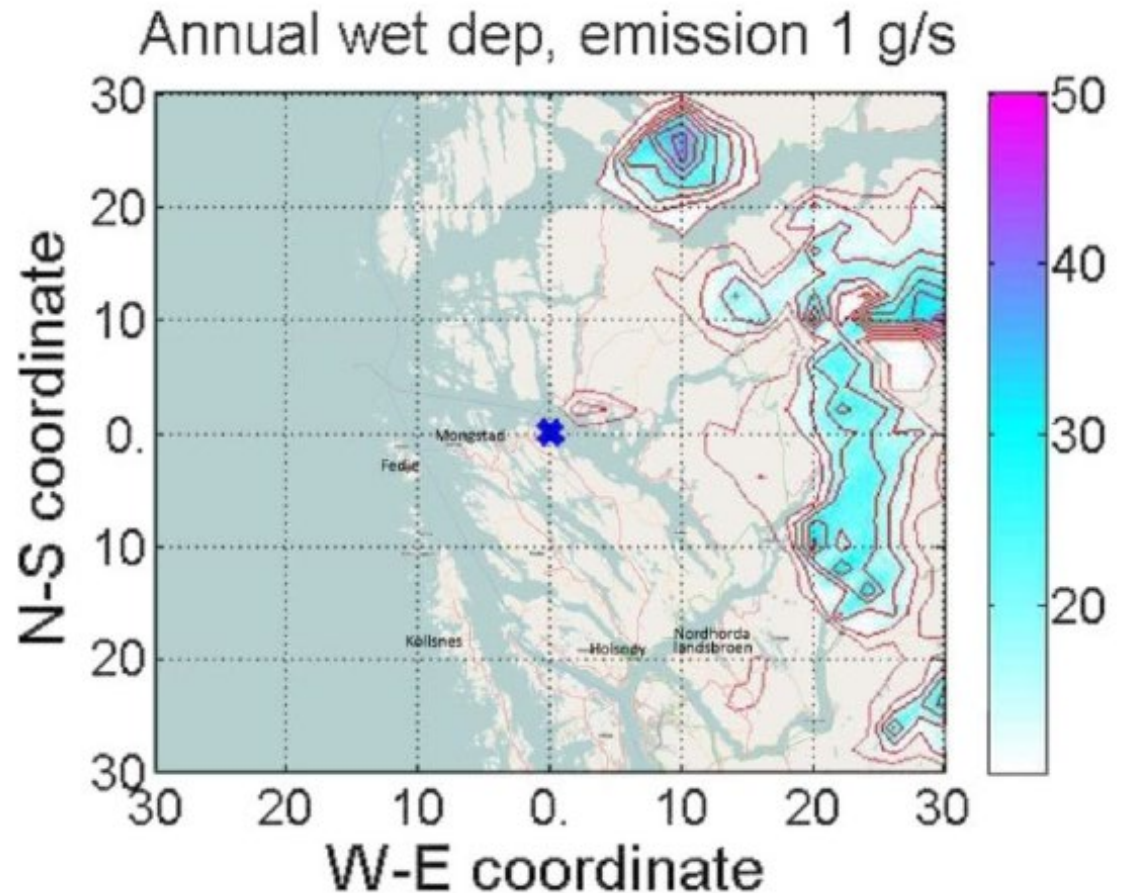
Case Study – Dispersion Model results

- Dispersion model results from NILU model.
- The model shows the average concentration ($\mu\text{g}/\text{m}^3$) if the TCM amine plant was operated with an emission rate of 1 g/s of amines.
- The west coast of Norway has strong prevailing winds in a north south direction.



Environment Degradation Path - Water – Deposition and catchment model

- Amines and their degradation products emitted and formed in the atmosphere are deposited and transported in the aqueous phase.
- Air dispersion models are often used to predict pollution deposition and as input to lake catchment models.
- These models are used to predict the prolonged effects of emissions on environmental parameters of the lake.



Acknowledgement

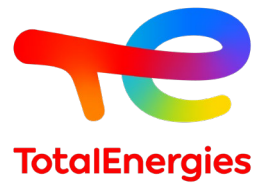


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Technology Centre Mongstad
(TCM)

The world's **largest** and most flexible **test center** for developing **CO₂ capture** technologies and a leading **competence center** for carbon capture.



Conducted TEST CAMPAIGNS

 **> 28.000 hrs**
Proprietary Campaigns

Solvent
Technologies
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2023
>

Start 2020
Emerging
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 **> 20.000 hrs**
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Scientific publications

2013

2023



TCM Advisory Services Offerings

Generic learnings

- Support on understanding requirements for Flue Gas Characterization-General.
- Advice on historical flue gas composition-Project specific.
- CO₂ capture Licensor Assessment: Tender questions, KPIs & Guarantees.
- TCM experience with generic amine-based technology for CO₂ capture.
- Summary calculation for CO₂ removal, CO₂ balance and SRD.
- **Gas sampling and analysis at absorber stack.**
- Overview of laboratory requirements for CO₂ capture projects.
- **Guidelines and recommendations for establishing an emission permit.**
- Guidelines on CO₂ product specifications

CO₂ Capture Plant design learnings

- General philosophy for CO₂ capture plant design.
- Guidelines and recommendations for absorber design.
- Guidelines and recommendations for regenerator design.
- Guidelines and recommendations for thermal reclaimer design.
- Guidelines and recommendations for water wash systems design.
- Guidelines and recommendations for heat exchangers design.

Operational Academy

- Key lessons from TCM on solvent and waste handling.
- Key lessons from TCM maintenance.
- Key lessons from TCM start-up and shut-down.
- Key lessons from TCM operation on thermal reclaimer.
- Summary of TCM learnings on foaming.
- Key lessons from TCM process control.

TCM support projects with its advisory services



Supporting Norwegian and EU decarbonization paths towards 2050

Advanced development of storage in North Sea driving TCM Advisory Services strategy

- Power
- Waste to energy
- ★ Cement
- ◆ Regulator
- ▲ Other

GREEN: Tailor-made

YELLOW: Simulations/Design

BLUE: Standard offerings (design, operational and generic learnings)