TCM: the first 5 years

Norway advancing full scale CCS on industrial flue gases

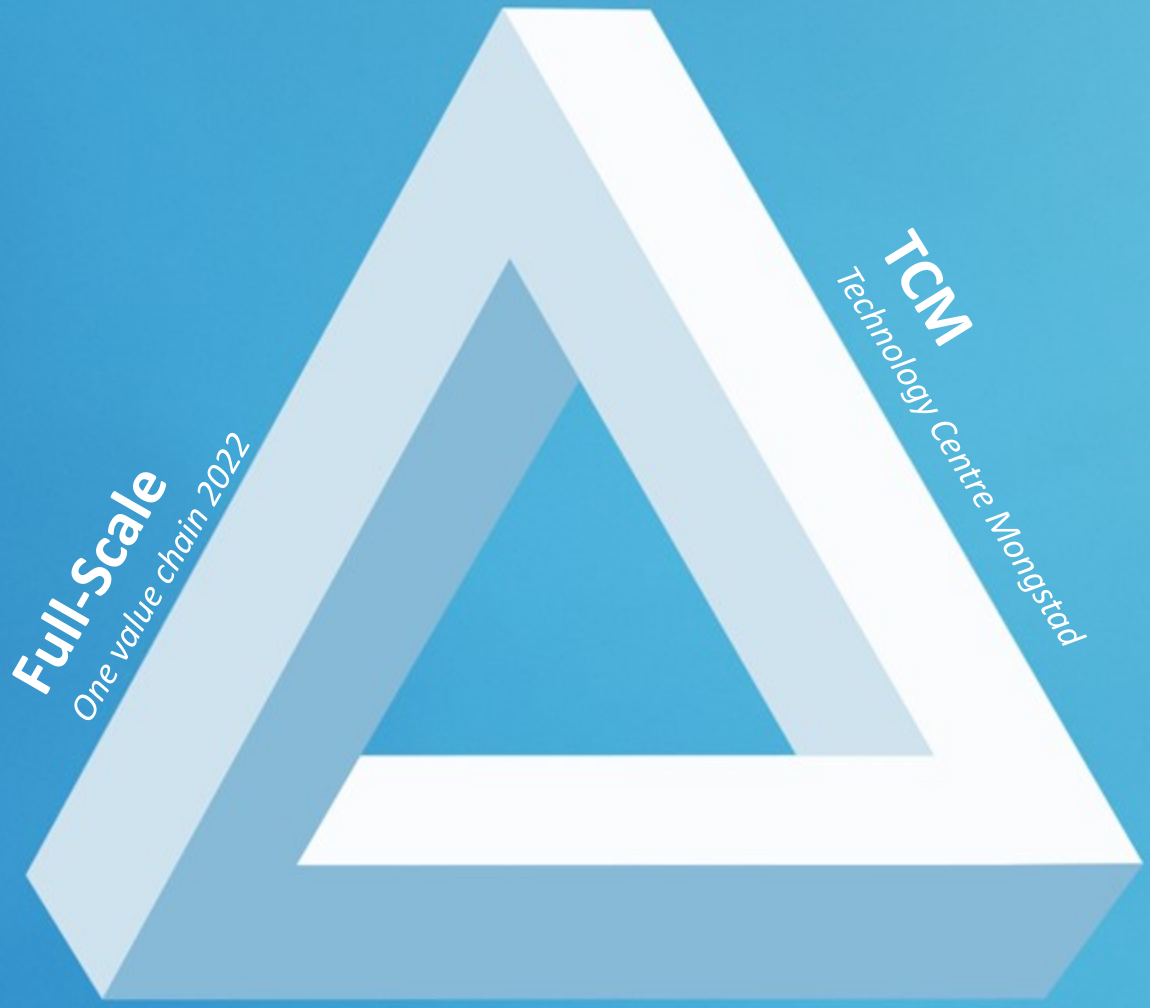
Bjørn-Erik Haugan

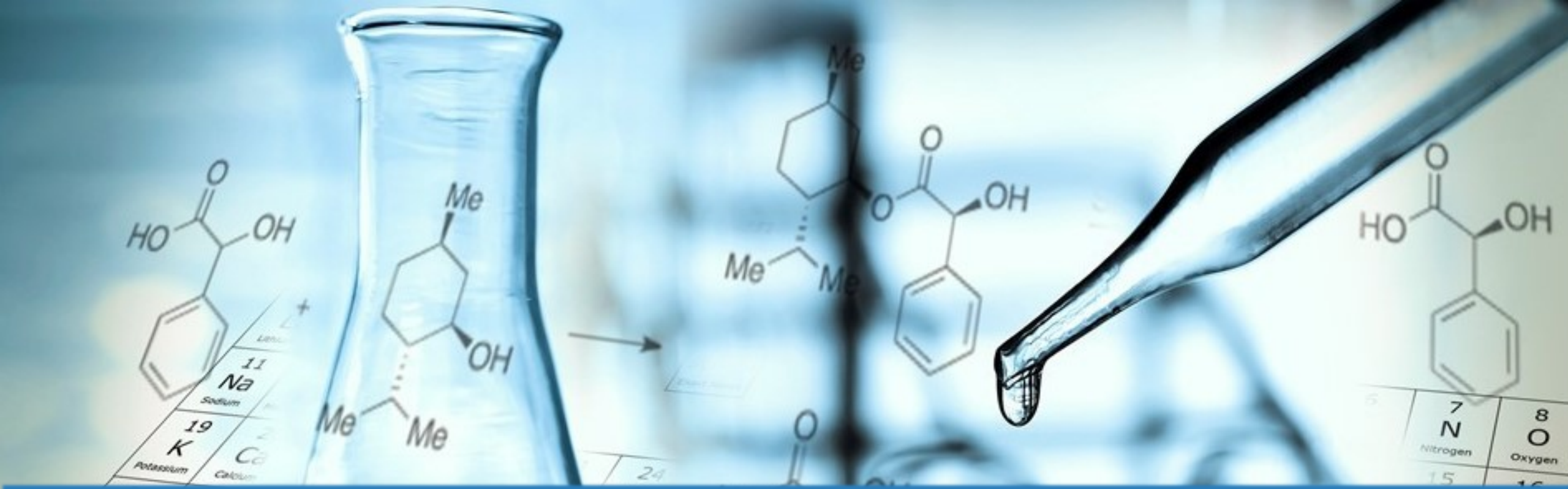
GASSNOVA

TECHNOLOGY CENTRE MONGSTAD

Norway's approach to CCS implementation

GASSNOVA





CLIMIT: RD&D funding:

More than 300 projects - Annual budget approx. 20 USD MUSD

- Three focus areas:
  - Early full-scale CCS value chain in Europe
  - Large-scale storage of CO_2 on the Norwegian shelf in the North Sea
  - Future cost effective solutions for CCS
- International co-operation

«Walk the talk !»

major CCS in Norway for 20 yrs

Sleipner

- Gas sweetening, saline aquifer
- Operator: Statoil
- CO_2: 1 MT/year
- Operational: **1996**

Snøhvit

- LNG: onshore to offshore storage
- Operator: Statoil
- CO_2: 700 kT/year
- Operational: **2008**

TCM

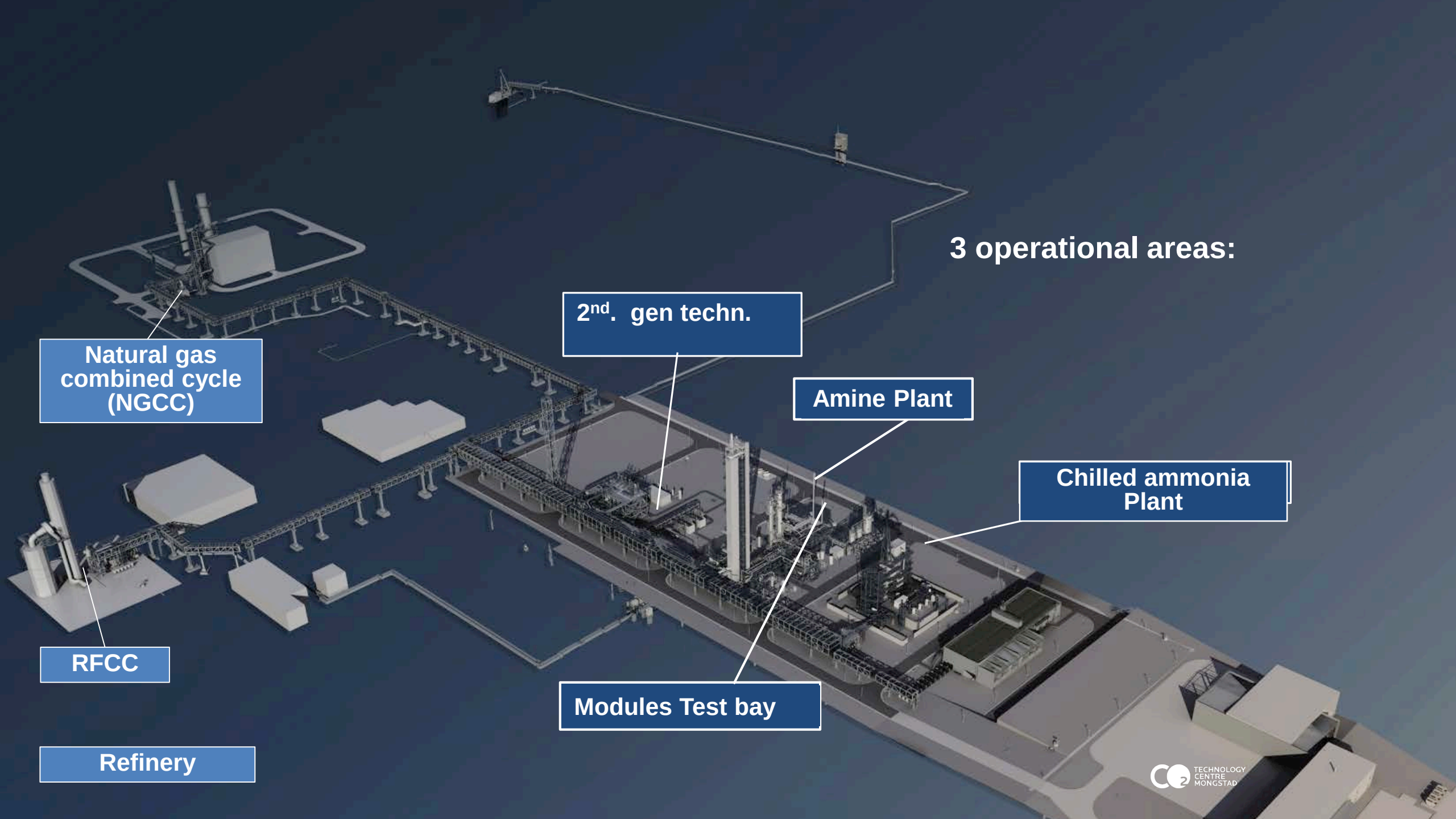
- Worlds largest CO_2 Test Center
- Operator: TCM DA
- CO_2: 100 kT/yr
- Operational: **2012**

5 Years of operations

TECHNOLOGY CENTRE MONGSTAD (TCM)

The world's largest and most flexible test facility for CO_2 capture

- Share expertise, knowledge and experience
- Close cooperation between the owners and technology suppliers
- Owners: Gassnova, Statoil, Shell and Total


3 operational areas:
Natural gas combined cycle (NGCC)
2nd. gen techn.
Amine Plant
Chilled ammonia Plant
RFCC
Modules Test bay
Refinery
TECHNOLOGY CENTRE MONGSTAD

TCM – partnership 2017

operational since 2012, new structure→ 2020

TOTAL

Statoil

GASSNOVA

The three main activities at TCM

Test campaigns with vendors and proprietary technology

A global competence center for CO_2 capture technologies, international networking

Scientific “Non-proprietary” test campaigns

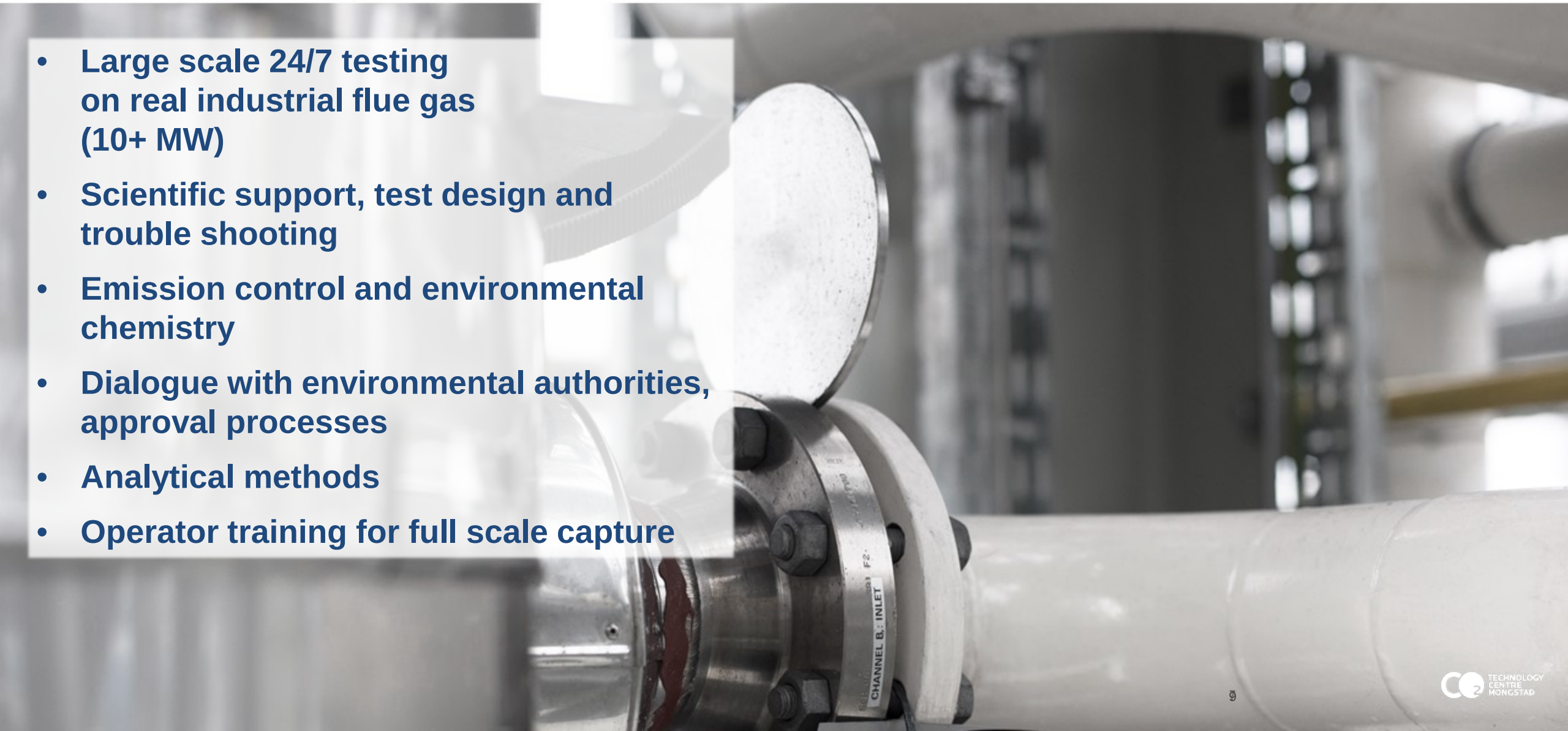
GASSNOVA

Statoil

TOTAL

Technology vendors: Proprietary campaigns

→technology to market faster, cheaper and with more confidence



- **Large scale 24/7 testing on real industrial flue gas (10+ MW)**
- **Scientific support, test design and trouble shooting**
- **Emission control and environmental chemistry**
- **Dialogue with environmental authorities, approval processes**
- **Analytical methods**
- **Operator training for full scale capture**

TECHNOLOGY CENTRE MONGSTAD

Test campaigns since 2012:

- Aker Solutions (Norway)
- Alstom/GE (US)
- Cansolv Technologies (Canada)
- Carbon Clean Solution (UK/India)

- **ION Engineering (USA)**
  -first funded by NETL

Non-proprietary Research

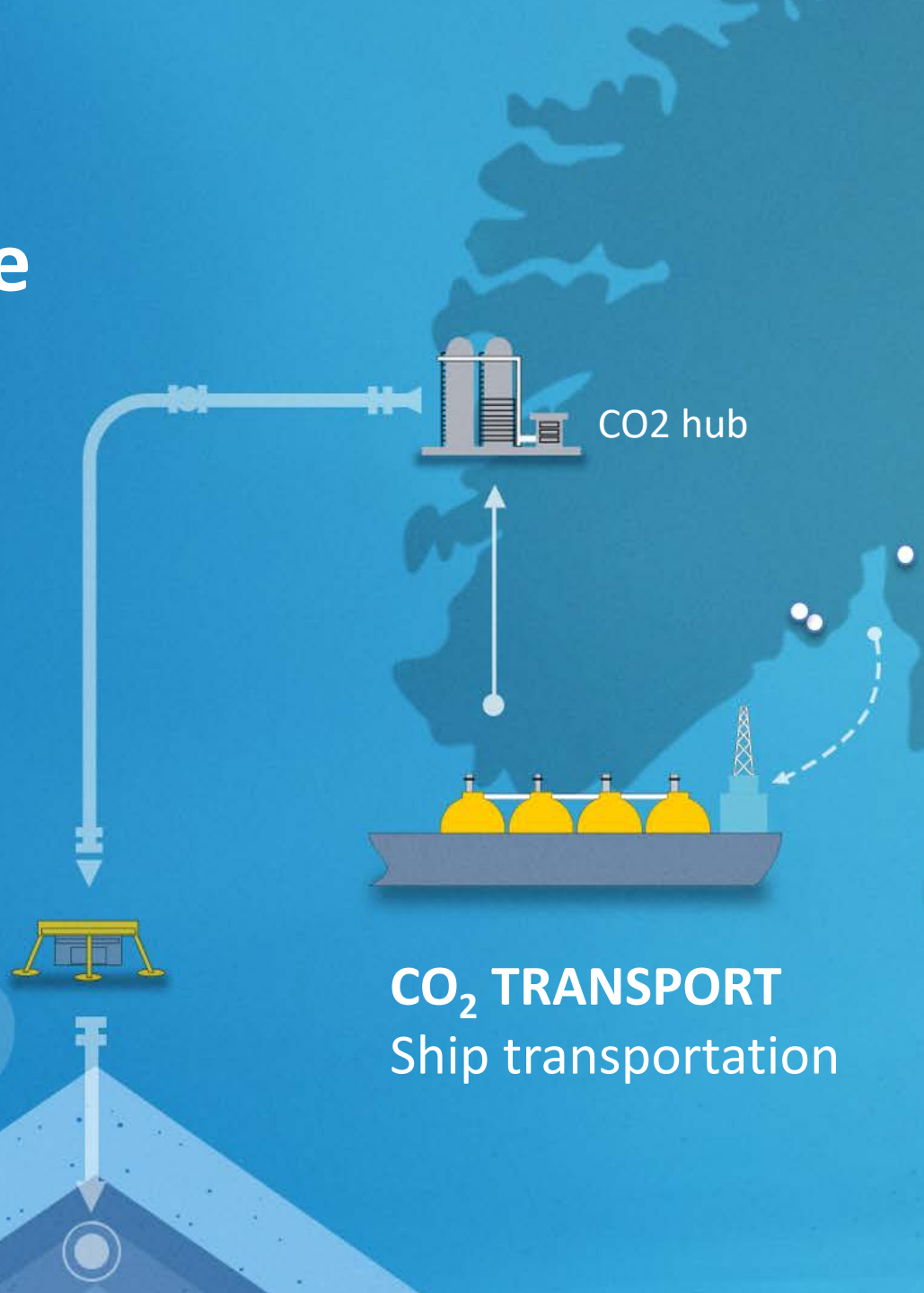
- Flue gas composition and impurities, pretreatment
- Plant control schemes
- Dynamic operations
- Workplace monitoring
- Emission monitoring and water wash operations
- Degradation mechanism
- Corrosion
- Absorber and stripper kinetics
- CO_2 product composition

TECHNOLOGY CENTRE MONGSTAD

Networking and competence sharing

- Bilateral international agreements and participation in the International test center network (ITCN)
- Collaboration agreements with academia and research institutions (eg. SINTEF/TCM)
- Support agreements with CCS projects globally
- Dedicated conference sessions (eg. GHGT-13)

NORWAY: Industrial scale CCS PROJECT



CO_2 CAPTURE

Norcem HeidelbergCement
Cement plant

Yara
Ammonia plant

Oslo City
Waste-to-energy plant

CO_2 STORAGE

- Statoil contract for concept and FEED studies

CO_2 TRANSPORT

Ship transportation

NORWAY: Industrial scale CCS PROJECT

Sleipner

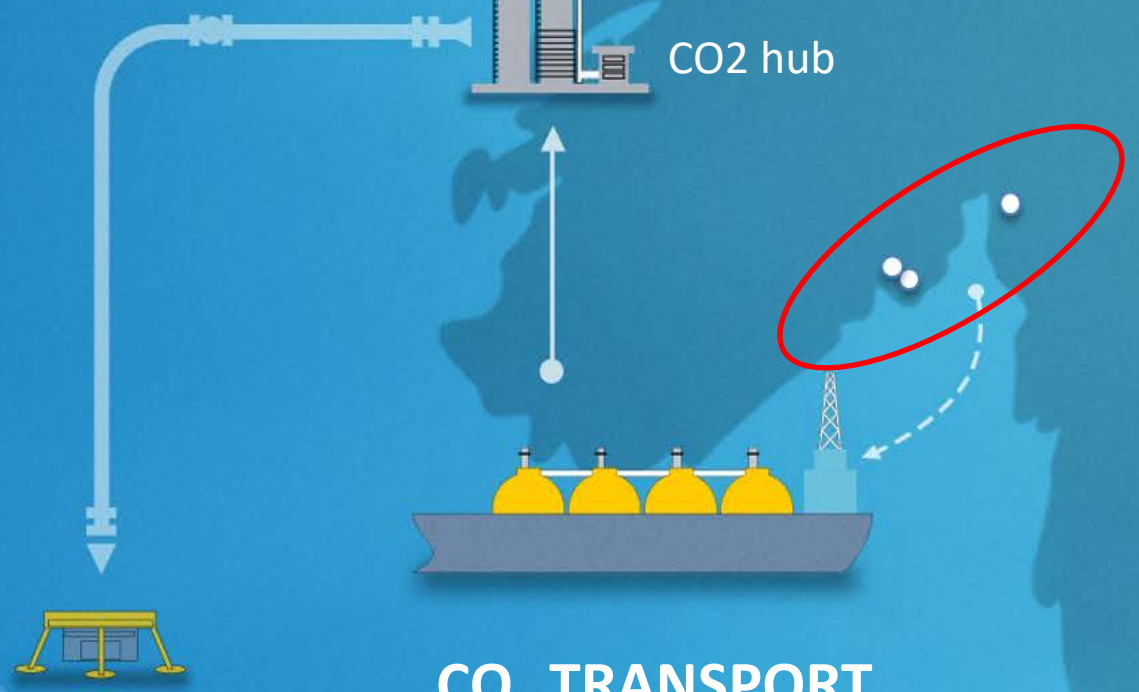
1 Mt/yr since 1996

Snøhvit

0,7 Mt/yr since 2008

TCM

CO2 hub



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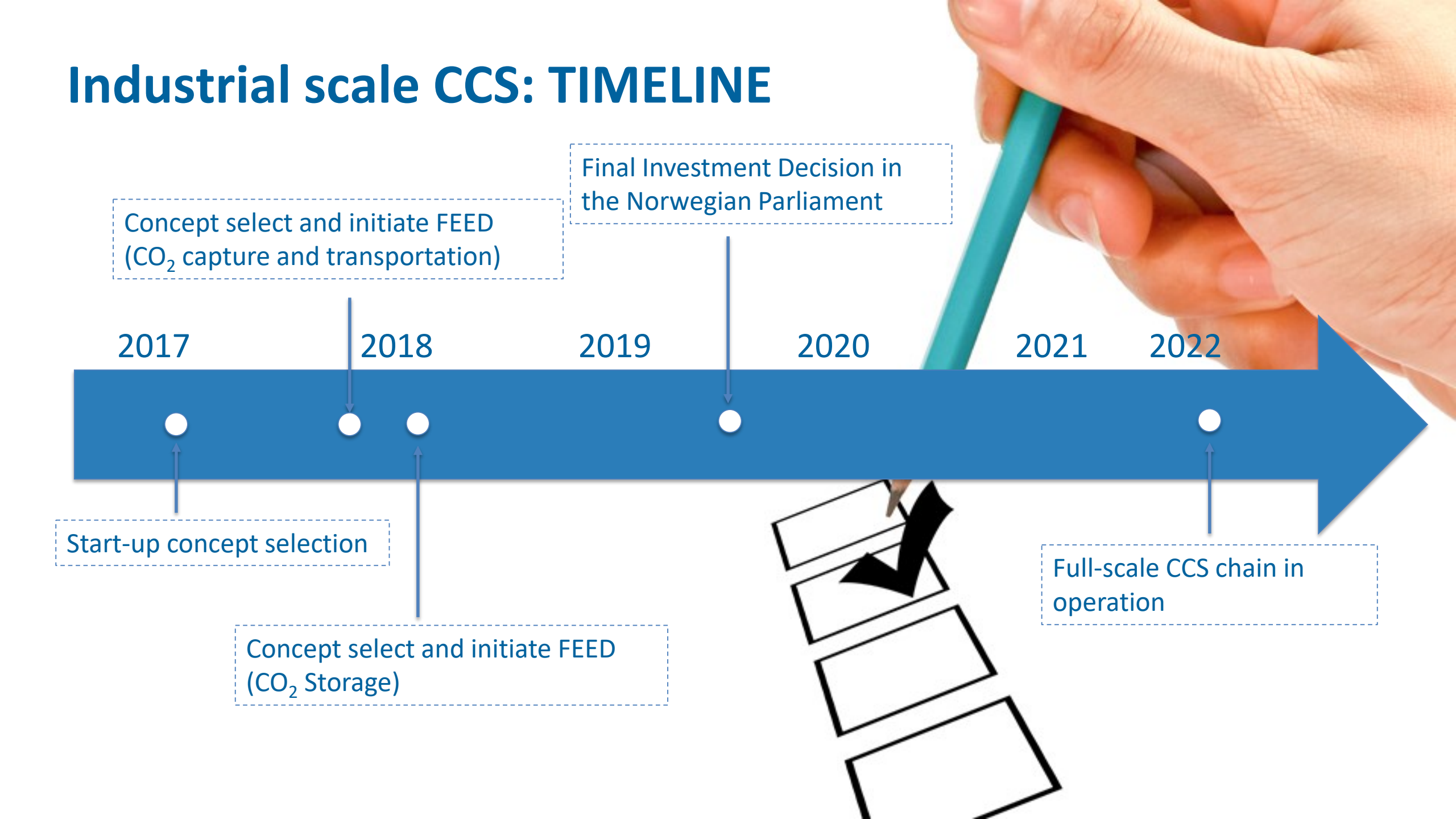
Industrial scale CCS: TIMELINE



NORCEM HEIDELBERGCEMENT PLANT IN BREVIK

- 400 000 tonnes of CO_2/year (50% of CO_2 emissions)
- Capture CO_2 utilising excess heat from cement production

YARA PORSGRUNN FERTILIZER PLANT

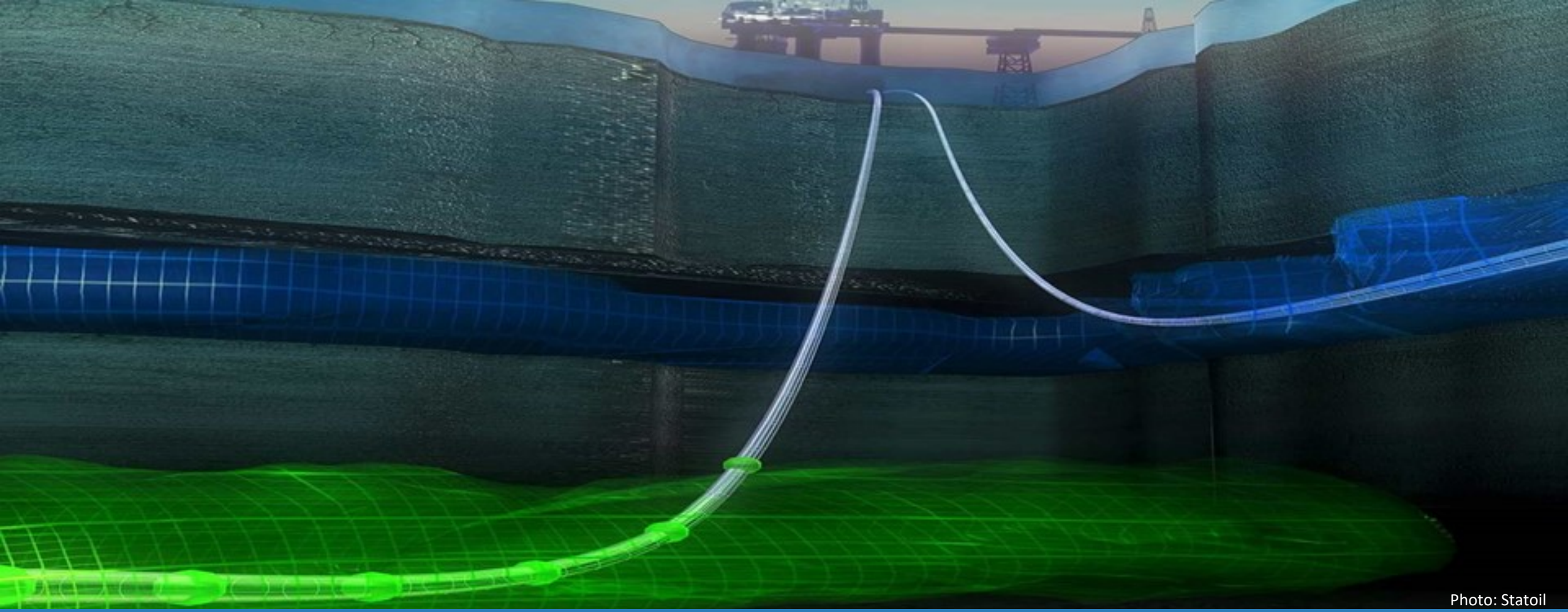
- 805 000 tonnes of CO_2/year
- Three sources of CO_2 from the ammonia plant
- Yara sells 200 000 tonnes of CO_2/year by liquefaction and ship transport to the market

City of OSLO
WASTE-TO-ENERGY PLANT

- 315 000 tonnes of CO_2/year
- 60% is bio-fuel: a CO_2 negative project !
- Heat integration to minimize energy loss

CO_2 TRANSPORTATION

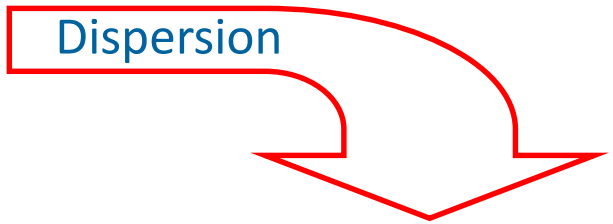
- CO_2 ship transport from multiple sources, a flexible CCS chain
- West coast CO_2 hub near injection
- Infrastructure suitable for organic growth, additional sources in Norway as well as from Europe

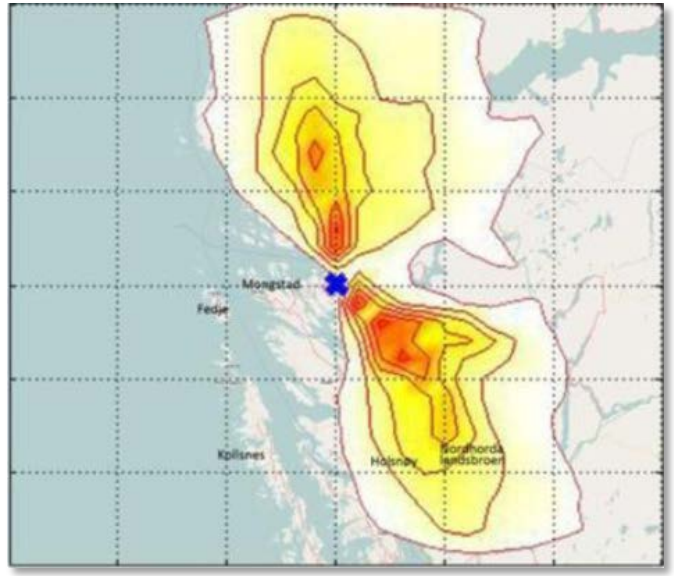


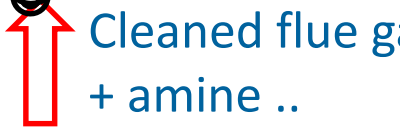
CO_2 STORAGE

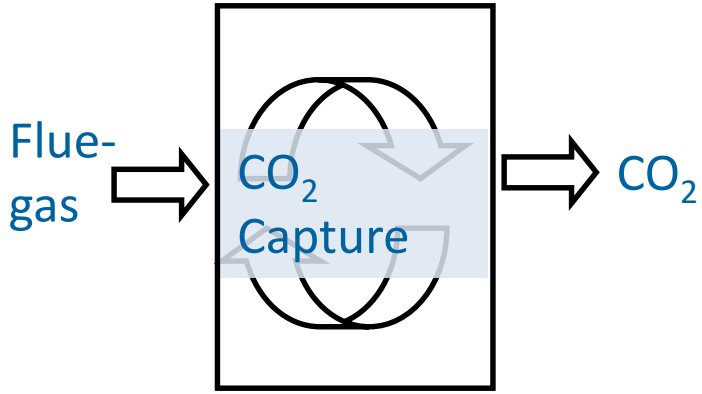
- An offshore storage site in a saline aquifer
- The "Smeaheia" storage located 50 km from the coast
- Large storage capacity (project will utilize < 1%)

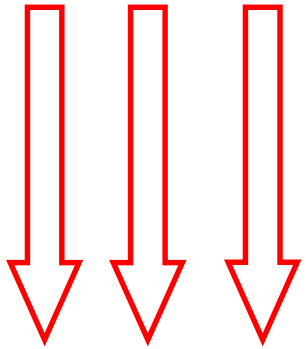
10 yrs sustained Amine Emission Initiatives





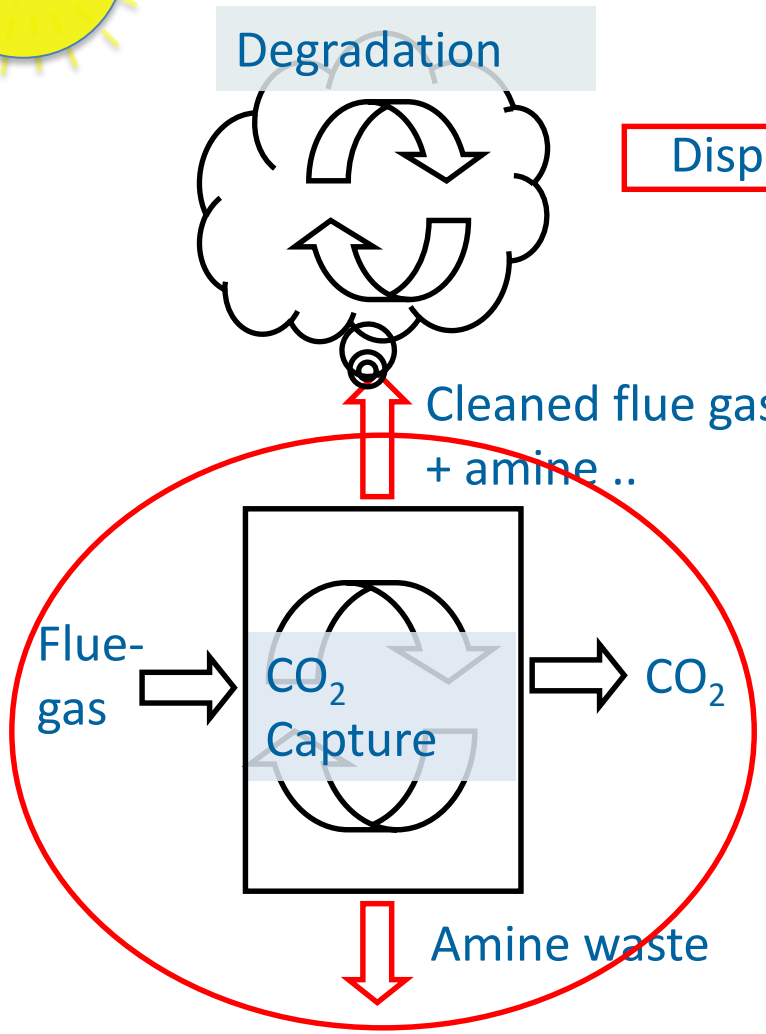


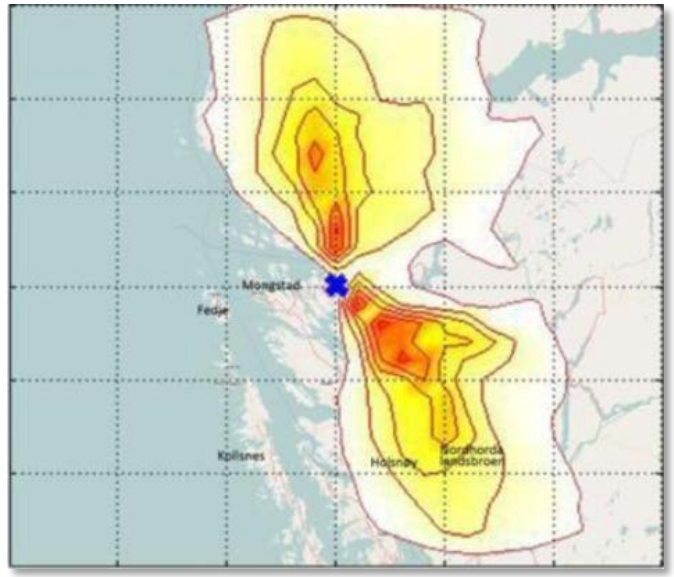


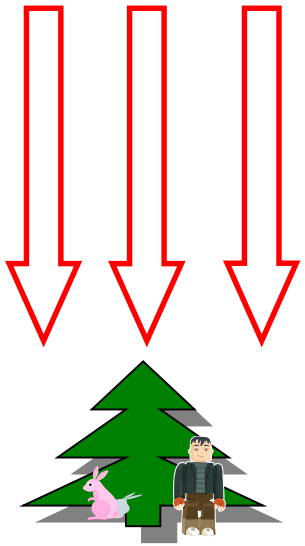


Environment

10 yrs sustained Amine Emission Initiatives







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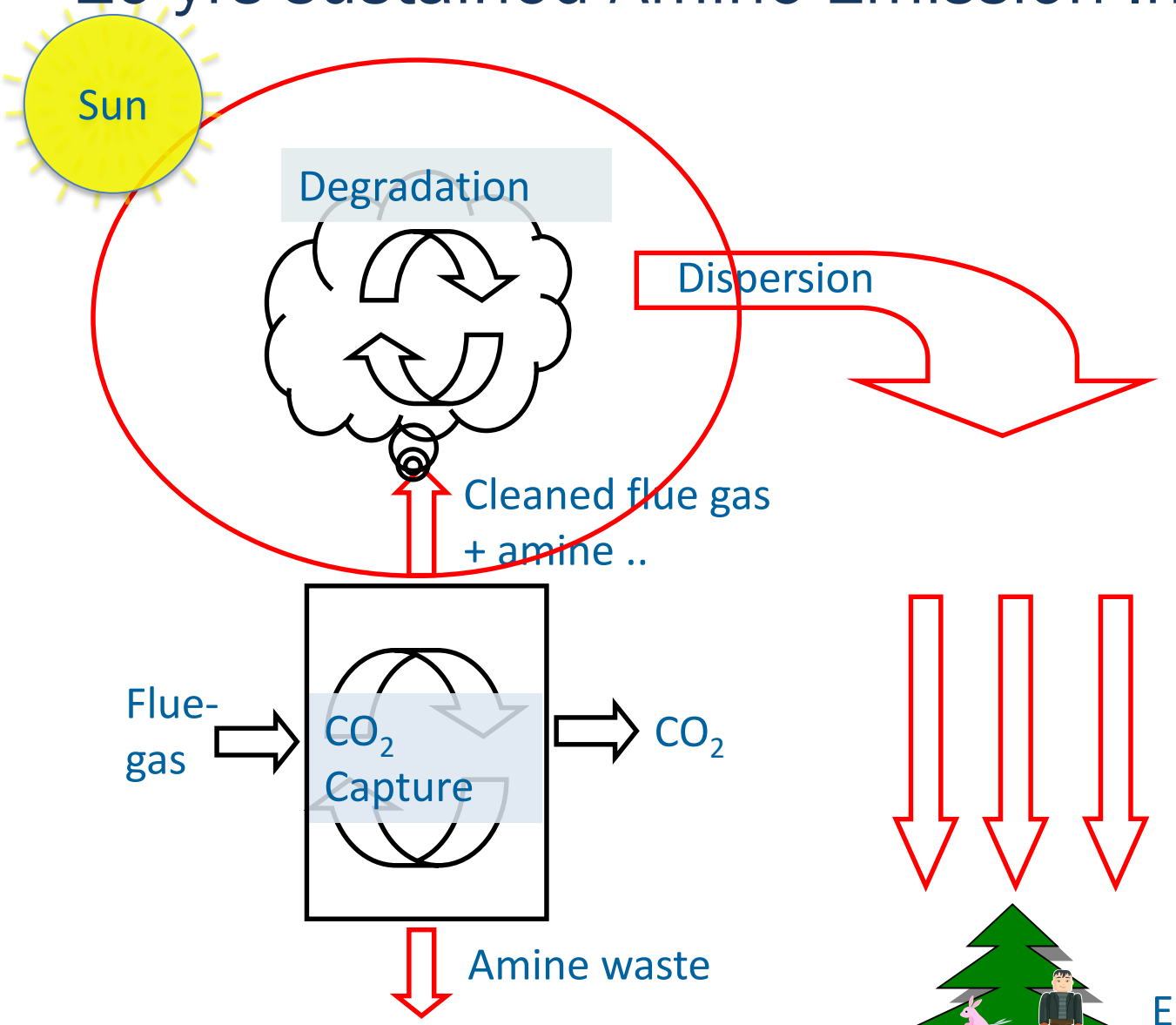

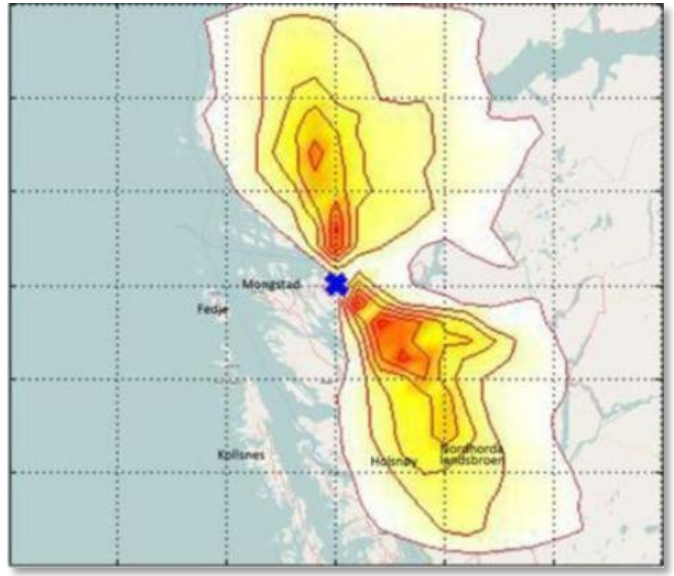

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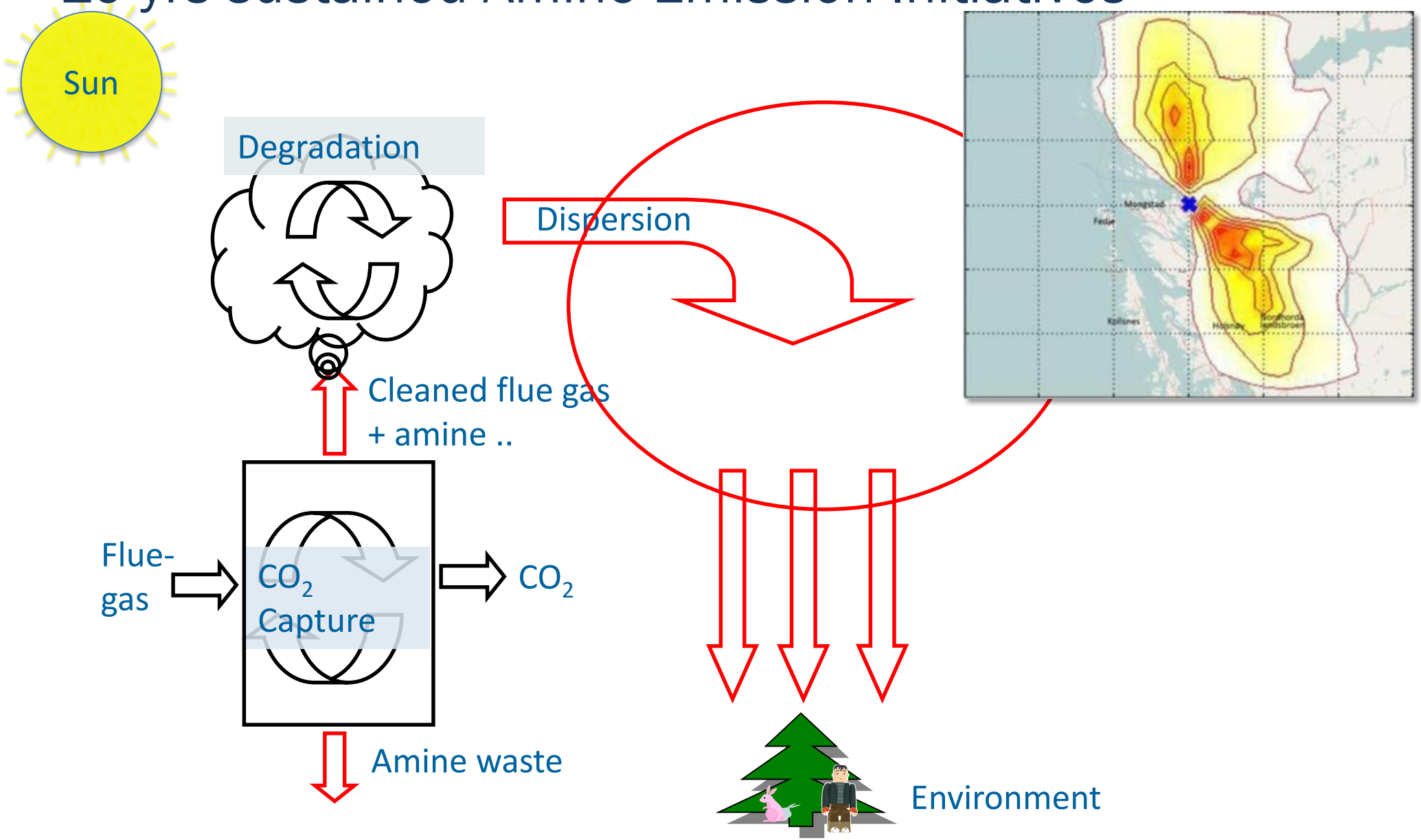

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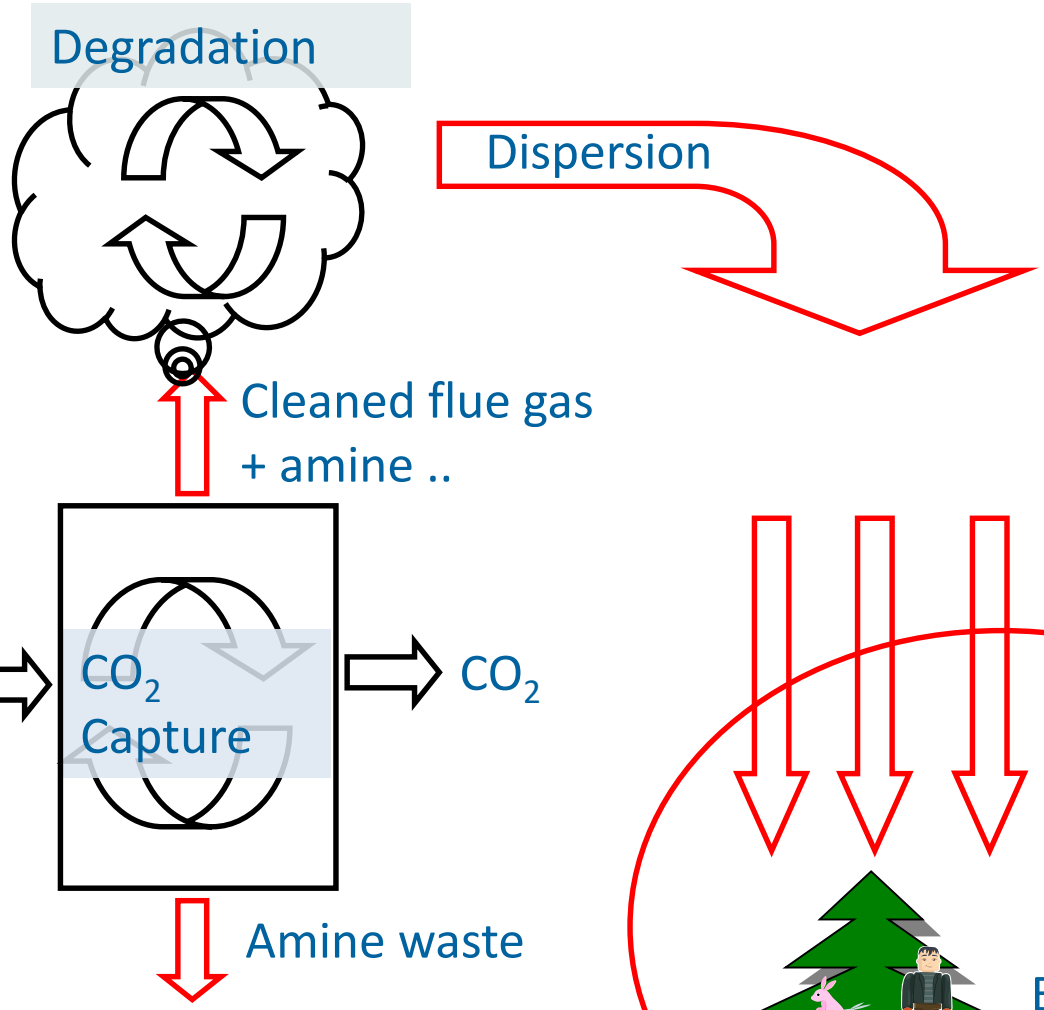
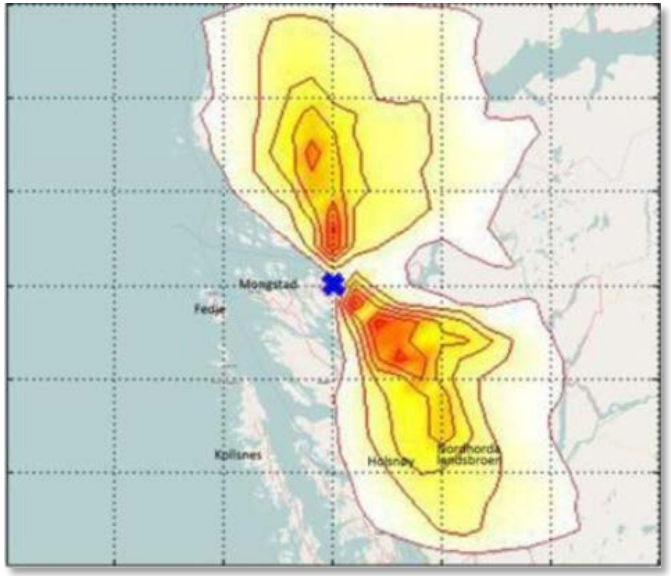




10 yrs sustained Amine Emission Effort

Degradation components - nitrosamines and nitramines

2006: Kårstø - capture from CCGT, 1 million ton CO_2 py: Emission of 1 – 4 ppm amines => 40 – 160 ton per year

2008: First literature assessment: Release of maximum 24 tonne amine py (1 mill ton CO_2 py)

2009: Hits the national press

2010: Delays of Mongstad project,

2010: National Research initiative > 20MUSD: procedures and methods for assessing amines and emissions

2011: Discharge permit TCM, Mongstad

- TCM discharge permit annual average sum of nitrosamines and nitramines.
- Yearly limits in air and drinking water by simulations

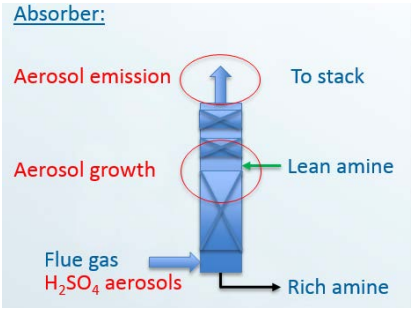
Elements of investigations:

- Solvent degradation rig for assessment of degradation and –products in plant
- Atmospheric degradation of amines: theoretical or combined with tests at EUPHORE, Valencia

Current focus:

- Amine mist: Aerosol based amine emission
- Impact: Health and environment & cost of amine lost

→ TCM installed BD filter for particle control



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THANK YOU!

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