

OUR OWN HISTORY



«Incredible things can happen if enthusiasm develops and is used as a driving force»

King Olav V of Norway

The background of the page is a high-angle, black and white photograph of an industrial facility, likely a power plant or refinery. It shows a complex network of metal walkways, railings, pipes, and structural beams. Yellow safety railings are prominent throughout the scene. The lighting is dramatic, with strong highlights and deep shadows, creating a sense of depth and scale.

TCM makes a difference in combatting climate change.

Technology Centre Mongstad (TCM) was initially established as the first step in the development of a full-scale process to capture CO₂ from the combined heat and power plant (CHP) at Mongstad. The purpose was to identify, develop, test and qualify possible capture technologies and technical solutions with the goal of reducing costs and technical and environmental risks associated with the construction and operation of a full-scale CO₂ capture plant.

In 2013, however, the overall risk of building a full-scale facility was considered too high. Although the technology was considered mature, high costs and uncertainty associated with the continued operation of the oil refinery led to the decision not to proceed with the full scale facility. This was a blow to the teams involved, who remained strongly committed to emissions reduction.

However, this disappointment did not prevail. The owners and staff were unified in their vision to make TCM the world's largest and most advanced centre for testing technologies for capturing CO₂ prior to full scale, and a global leader for competence in this field.

In retrospect, this restructuring of the business has been an unconditional success. We believe that the test programs performed at TCM were vital

to the development of Norway's flagship industrial CCUS project, "Longship". Testing at our facility has also been crucial for the development of the capture technology chosen for Fortum Varme's planned full-scale project at Klemetsrud in Oslo. We also believe that by sharing the knowledge generated at TCM with worldwide partners in research and industry, we have contributed to the accelerated deployment of CO₂ capture projects.

The Norwegian state, through Gassnova, and the company's industrial owners; Equinor, Shell and Total, contribute financially and via seconded personnel to the business. Our 60 skilled employees value the opportunity they have been given and look forward to future challenges and successes.



A PLANT WITH UNIQUE TEST FACILITIES

TCM's test facilities for CO₂ capture consist of an **amine plant** and an **ammonia plant**, as well as an area for **new capture technologies** (Site for emerging technologies). We have access to two industrial flue gas sources from Equinor's refinery and gas fired CHP plant at Mongstad with different CO₂ content. These different flue gas sources enable us to imitate emission gases similar to those from industries such as waste incineration, cement production and oil refining. TCM operates under an emission permit from Norwegian regulators, ensuring safe and verifiable results in every aspect of operation.

The amine plant is a unit with generic capabilities developed by Aker Clean Carbon, now part of Aker Carbon Capture. The unit has so far been utilized by five technology vendors in addition to scientific testing on the capture liquids MEA and CESAR 1. TCM also has a chilled ammonia unit, developed and licensed by Alstom, now Baker Hughes. Both these units capture CO₂ by the means of a chemical liquid mix called solvent, consisting of water and either amine- or ammonia-based solutions.

In addition, TCM has established a new area for testing new, ground-breaking capture technologies. From 2021, this plant will be used for testing technologies such as membranes and adsorbents (solid materials that bind CO₂). These emerging technologies are at a lower technology readiness level and the site creates new opportunities for technology development.

"We are a US\$1B+ fund that invests in technologies and projects that accelerate decarbonization in oil and gas, industry, and commercial transport. Access to TCM's test facilities and expertise is important for the development and progress of our CCUS initiatives." - Pratima Rangarajan, CEO, OGCI Climate Investments



WHAT WE HAVE TESTED AT TCM

With professional and technical assistance from TCM, commercial suppliers and research-based institutions from around the world have tested their technologies at our plant. Each test campaign normally lasts from three to six months.

2013 - 2014

AKER CLEAN CARBON (NORWAY)

Aker Clean Carbon, now Aker Carbon Capture, was the supplier of the amine plant at TCM, and performed testing of its capture technology. The implementation of this test resulted in valuable experience for later test campaigns at TCM. Aker Carbon Capture is the supplier of the technology chosen for capture in the planned full-scale project at Norcem's cement factory in Brevik.

2013 - 2014

ALSTOM (FRANCE)

With technical assistance from TCM, Alstom carried out the first and so far only test to date at the ammonia plant, with CO₂ capture based on the Chilled Ammonia Process (CAP) technology. Baker Hughes and TCM are considering reopening the ammonia unit and conducting tests in 2022 - 2023.

2014

THE OWNERS OF TCM AND AKER CLEAN CARBON

The first open access, research-based test campaign at TCM on the amine plant with the carbon capture liquid MEA (Mono Ethanol Amine), initiated and financed by the owner companies in collaboration with Aker Clean Carbon.

2014 - 2015
09 2016

CANSOLV TECHNOLOGIES INC (CANADA)

Cansolv conducted two separate campaigns a test of technology in the amine plant. The aim was to verify the technology for use in a CO₂ capture project in the UK. Cansolv, in collaboration with Shell, has further developed this technology. The capture technology was chosen for Fortum Varme's planned full-scale project at Klemetsrud in Oslo.

2015

THE OWNERS OF TCM

Based on results from the first open test with the carbon capture liquid MEA in 2014, a new test was carried out which gave significantly better results in terms of capture rate and energy consumption in the amine process.

2015 - 2016

CARBON CLEAN SOLUTIONS (UK / INDIA)

Carbon Clean Solutions carried out tests of its capture technology at the amine plant as part of the preparations for the company and partners to start full-scale capture and storage related to chemical processing in Chennai, India.

2016 - 2017

ION CLEAN ENERGY (US)

With support from The US Department of Energy (DoE), ION Energy conducted a test campaign at the amine plant of the company's proprietary carbon capture solvent. Based on the results, ION has further developed its technology.

2017

THE OWNERS OF TCM

The third research based MEA test was conducted. Among the research topics was reduction of contaminant levels in the treated gas leaving the process. In the tests with this carbon capture liquid at TCM, it has been possible to capture up to 98 % of CO₂ with aqueous MEA (a mixture of water and MEA).

2017

TCM, SINTEF, NTNU AND CYBERNETICA (NORWAY)

With support from the Norwegian state through CLIMIT, the partners jointly carried out experiments on the amine unit and in laboratories, with the aim to improve efficiency and operational stability of the process. This, and other open test campaigns at TCM, have given new insight into important advancements in generic capture technology.

2017 - 2018

THE OWNERS OF TCM AND SINTEF

With support from the Norwegian state through the CLIMIT-project Aerosolve, a test was carried out to identify aerosol-based mechanisms to reduce emissions when processing post combustion industrial flue gases e.g from refineries and cement plants in connection with CO₂ capture, and to take countermeasures to verify that the performance is within the environmental limits given in the emission permit. The knowledge of how to develop and operate

2019

FLUOR CORPORATION (US)

With support from The US Department of Energy (DoE), Fluor conducted a test campaign with their proprietary carbon capture technology.

2019 - 2020

ALIGN-CCUS

ALIGN-CCUS (Accelerating Low CarboN Industrial Growth through Carbon Capture Utilisation and Storage) was a project financed through the first ERA-NET Co-fund ACT program, funded by nine European countries and the European Union Horizon 2020 program. TCM was one of the test sites that demonstrated the use of the generic capture liquid CESAR1 on large scale with real industrial flue gas.

2020

THE OWNERS OF TCM

The owners of TCM jointly carried out a test with the research-based capture liquid CESAR 1 aiming at capturing CO₂ at the lowest possible cost. The test was initiated by the IEA, which through its «Greenhouse Gas R&D Program» has requested a comprehensive assessment of new technologies for capturing CO₂ in the energy sector. In the final phase, tests were performed for SSE Thermal (UK and Ireland) and Imperial College London.

2021

TDA RESEARCH (US)

As the first user of TCM's new site for emerging technologies, TDA Research will conduct experiments with a hybrid technology.

2021

**MITSUBISHI HEAVY INDUSTRIES
ENGINEERING (JAPAN)**

Mitsubishi Heavy Industries Engineering (MHIENG) will test its technology at the amine plant during the summer.

2021

**MEMBRANE TECHNOLOGY AND
RESEARCH (US)**

Membrane Technology and Research (MTR) will use the site for emerging technologies to conduct experiments with membranes.

2022

**INNOSEPRA LLC
(US)**

With support from The US Department of Energy (DoE), InnoSeptra is planning test on the site for emerging technologies starting in Q1 2022.

2022

RESEARCH FOUNDATION RTI (US)

TCM has entered into an agreement with RTI for an open test of a new solvent at the amine plant in the second half of 2022. The US Department of Energy (DoE) covers amine plant modification and test costs.



WE SHARE OUR KNOWLEDGE ON CARBON CAPTURE

TCM helps players in various industries to adopt technologies that will enable them to achieve their goals for reducing carbon emissions. After many years of scientific research and testing at the world's largest CO₂ test facility, we have gained unique knowledge and experience about carbon capture technology that we want to share with developers of projects for CO₂ capture.

Together with SINTEF and DNV, we offer joint global consulting services on capture, transport and storage of carbon dioxide. Our focus in this collaboration is on the CO₂ capture step of this process

TCM has provided consulting services for a number of projects for the development of carbon capture. In Norway, we have contributed our expertise to Fortum Varme's planned full-scale project at Klemetsrud in Oslo. We also aim to support the «Longship» project by contributing to the realization of CO₂ capture at Norcem's cement factory in Brevik.

TCM also provides advice to OGCI CI, the USD \$1 billion climate fund founded by the world's largest energy companies. Furthermore, TCM has shared our expertise on how to run a carbon-capture test plant with the first Asian open-access technology centre, the Haifeng CO₂ pilot plant in China. Within Europe, we have also advised SSE Thermal in the development of carbon capture at their facilities in the UK and Ireland.

In addition to commissioned consulting services, we also share knowledge and experience from our own research activities with the global CCUS community, through publication in reputable scientific journals and presentations at scientific conferences.

TCM paves the way to a low-carbon future.



CCS technology must be rolled out at significant scale and speed for the world to meet national and international climate targets. Since its inception, TCM has documented its advantages as the world's largest and most flexible plant for testing and improving technologies for CO₂ capture. Our partnership with TCM and SINTEF allows us to work closely together to accelerate the deployment of CCS as a critical technology to address climate change.

Liv A. Hovem, CEO in DNV



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