

# YOUR PARTNER IN CO<sub>2</sub> CAPTURE



*Technology Centre Mongstad (TCM) offers the world's largest and most advanced test center for developing CO<sub>2</sub> capture technologies and is a leading competence center for carbon capture. We help players in various industries to adopt technologies that will enable them to achieve their goals for reducing carbon emissions.*

# ABOUT TCM

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TCM is the world's largest and most advanced test center for developing CO<sub>2</sub> capture technologies and a leading competence center for carbon capture. TCM is an open access test center which tests, verifies and demonstrates different post-combustion technologies related to cost-efficient and industrial scale CO<sub>2</sub>-capture.

TCM is a technology neutral partner, working to facilitate the development and mass deployment of carbon capture technology worldwide. More than NOK 6 billion have been invested in construction and development of the plant. Since TCM began operations in 2012, technology developers, vendor companies and research communities from all over the world have come to TCM to test, verify and demonstrate industrial scale carbon capture technologies. Most of the mature carbon capture technologies have been tested here.

TCM's test facilities for CO<sub>2</sub> 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 CO<sub>2</sub> 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.

TCM is owned by the largest stakeholders in the Longship and Northern Lights projects, namely the Norwegian State (managed by Gassnova, 73,9 %), together with the industrial partners Equinor (8,7 %), Shell (8,7 %) and TotalEnergies (8,7 %). TCM's owners are dedicated to make a difference in combating climate change through CCS technology, and have entered into a new agreement for continued operations at TCM at least throughout 2023.

TCM has become a knowledge bank for technology developers and their customers, who are using carbon capture in large-scale operations. TCM has proven crucial in facilitating the development of carbon capture technologies that can be used on all kinds of post combustion applications worldwide.



# TCMS CORE STRENGTHS:

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**Well-earned reputation** built on public research, vendors proprietary testing and a highly qualified workforce with **unique competence**.

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Unique knowledge from operations since 2012

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Unique expertise in emission and its impacts on air and water

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**Large-scale testing** step before full-scale deployment, in real-world conditions

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Full priority on customers and 24/7 operations

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**Comprehensive non-proprietary datasets and industrial-scale baseline** for benchmarking purposes.

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Relentless focus on **health, safety and environment**

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**Strong partnerships** bringing together clients, vendors and other key stakeholders

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*“Development and operation of Technology Centre Mongstad (TCM) has given solid knowledge, and TCM has established itself as an international leading research community for demonstration of carbon capture technology”*

The Norwegian Ministry of Petroleum and Energy's St.meld 33 (2019-2020), page 25

# TCM'S OPERATIONAL EXPERIENCE WITH CARBON CAPTURE TECHNOLOGY

TCM has until 2021 conducted more than 20.000 hours of testing of several proprietary solvents and more than 20.000 hours of testing of non-proprietary solvents.

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Alstom, Shell Cansolv, Aker Solutions, CCS Limited, ION Engineering and Fluor Corporation have conducted thorough testing at TCM. In addition, TCM has tested measuring equipment and process components, and has conducted non-proprietary test campaigns in cooperation with Norwegian and foreign universities and research institutions. Projects with aid

from the American government, Department of Energy, have tested their technologies at TCM, and in 2018 the Department of Energy granted USD 33.7 million to four new projects for advanced carbon capture technology, all of which planned to test their technology at TCM.



# TEST CAMPAIGNS CONDUCTED IN 9 YEARS OF OPERATION

## Proprietary test campaigns

Vendors conduct proprietary testing with their own technology.



## Non-proprietary test campaigns

Several open scientific campaigns with non-proprietary solvent in collaboration with universities and research organisations, as well as several projects together with the EU.



<sup>1</sup> Project regarding aerosol-related emissions

<sup>2</sup> Demonstration of Optimal Control of Post-Combustion Capture Processes

<sup>3</sup> Carbon Capture Simulation for Industry Impact

<sup>4</sup> Accelerating Low carbon Industrial Growth through CCUS

<sup>5</sup> Long-term testing with monoethanolamine solvents and CESAR-1 (AMP+PZ) solvent



The results from non-proprietary campaigns and experiences are made public. Based on the many carbon capture campaigns conducted, TCM has accumulated world-leading know-how on critical success criteria for development and deployment of carbon capture technology, such as:

- KPIs for critical technology assessment
- Flue gas characterization and required conditioning
- Emissions to air (online + manual sampling measurements)
- Instrumentation and online monitoring
- Solvent reclaiming
- Mechanical issues to be considered (including lean/rich heat exchangers)
- Construction materials

The carbon capture campaigns conducted at TCM has also provided a broad operational experience:

- Manning of operations
- Frequency of regular and major maintenance
- Costs and manning of scheduled stoppages
- Units/systems requiring more maintenance (e.g. Lean Rich Heat Exchanger where CO<sub>2</sub> flashing might occur, hot spots etc.)
- Recommended spares
- Major operational costs and challenges (e.g. solvent consumption)
- Long term efficiency of the plant over time (corrosion, fouling etc. and how they will affect heat transfer efficiency)



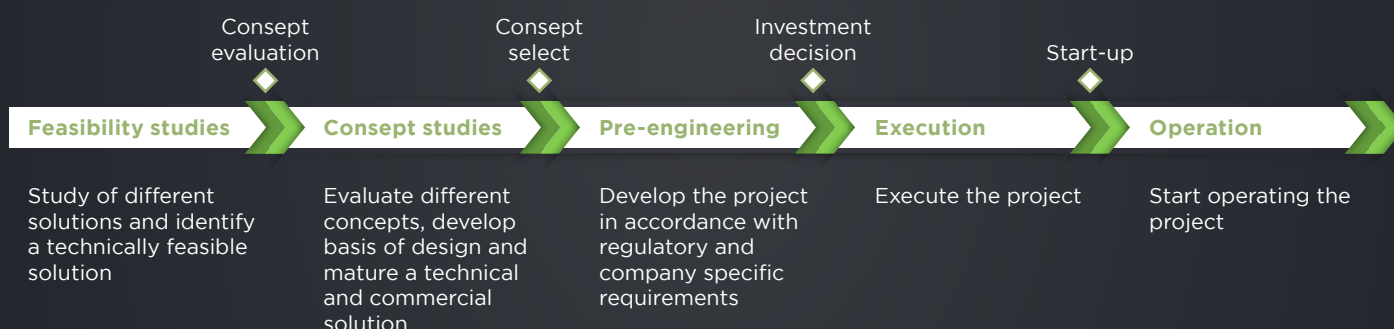
# TCMs testing facilities and advisory services – in different project phases

TCMs test facilities at Mongstad are unparalleled in scale and flexibility, with 4000 online measuring points, and with an advanced laboratory and access to world-class competence on carbon capture. TCM provides open-access datasets, industrial-scale baseline and close partnerships with the industry. At TCMs facilities, there are offices, utilities, control room, laboratory, workshop, warehouse space and meeting rooms to support the tests.

TCMs advisory services provide valuable contribution throughout the project. A large-scale carbon capture project is divided into different project phases, or milestones, and TCMs services can be adapted to one

or more project phases. Although TCM is not involved in all or some of the project phases, TCM may contribute in other phases of the project. TCM's typical deliverables in different project phases are:

## Project phases



### TCM Advisory services a few examples:

- Flue gas characterization
- Impact of flue gas on emission and solvent degradation, hygiene
- Key Performance indicators (KPIs) for technology
- Support in Environmental Impact analysis for technology assessment and selection
- Support project developers in small review of study reports
- Support in reviews of design basis
- Participate and support in HAZOP studies
- Support in piloting phase (Test plan, test results review, Lab procedures and analysis support, Q.A/Q.C etc.)
- Process modelling and simulation based in non-proprietary solvents for bench-marking purposes
- Basic engineering based on the above for bench-marking purpose
- Support project developers in smart review of study reports
- Support in technical & HSE related risk identification
- Support in specific questions on maintenance, turnarounds, spares, workshop etc.
- Operator training both on-site and potentially on OTS
- Support in start-up and shut down procedures
- Hands-on experience and risk mitigation
- Trouble-shooting (Emission, Thermal performance, Solvent degradation & Reclaiming, fouling, etc.)



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.

[Read more at tcmda.com](https://tcmda.com)

## Key clients on advisory services

TCM are providing Advisory Services to the following:

- Contributed with our expertise to Fortum Varme's planned Waste to Energy plant, a full-scale project at Klemetsrud in Oslo, Norway. We support the «longship» project by contributing to the realization of CO<sub>2</sub> capture to international as well as Norwegian projects.
- Provided advisory services to OGCI CI (Oil and Gas Climate Initiative), the USD \$1 billion climate fund founded by the world's largest energy companies.
- Performed a testing campaign, for Net Zero Teeside, with CESAR 1 solvent to evaluate dynamic and dispatchable performance of the CO<sub>2</sub> capture plant.
- Advised SSE Thermal in the development of carbon capture at their facilities in the UK and Ireland.
- Shared our expertise with UK-China (Guangdong) CCUS Centre, the Haifeng CO<sub>2</sub> pilot plant in China and the first Asian open-access technology centre, on how to run a carbon-capture test plant.
- Supporting Wartsila with development of CO<sub>2</sub> capture plants customized for marine vessels.
- Assisting Statkraft with engineering and development for a CO<sub>2</sub> capture plant on their existing waste to energy plant in Trondheim.
- Providing guidance and insights to Hoegh LNG in relation to quality of CO<sub>2</sub> product needed for transportation services.
- Supporting Vallourec with breakdown of materials of selection for typical post combustion CO<sub>2</sub> capture plants and estimation of typical amounts of steel needed for a commercial scale project.
- Provide methodology and guidance to Research Triangle Institute (RTI) for development and validation of their CO<sub>2</sub> capture technology model.
- Supporting Crodux Energetika during Feasibility Study phase for the Carbon Capture plant as a part of Hybrid Power Plant (250 MWe) for the purposes of project application on EU Innovation Fund.

*"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



TCM are in discussions to provide services to a number various CCS facilities in Norway and in other European countries within the following areas of competence:

- Support on CO<sub>2</sub> capture and requirements for onsite testing facilities
- Feasibility studies for various waste-to-energy projects
- Knowledge sharing on design of capture for CCGT power plants.
- Project for carbon capture at power station
- Support on emission-related know-know for several projects
- Data and knowledge sharing on solvent degradation and reclaiming
- Project for optimization of CCGT-CCS
- Various CCUS initiatives in the region
- Other feasibility studies



# POWERED BY PARTNERSHIP WITH SINTEF AND DNV

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TCM together with SINTEF and DNV is offering joint advisory services on capture, transportation and storage of carbon dioxide. Our focus in this collaboration is CO<sub>2</sub> capture.

SINTEF is one of Europe's largest independent research organizations and has a long history and broad portfolio within CSS R&D projects. SINTEF's activities range from molecular modelling to industrial pilot testing.

DNV has a global presence and is a highly acknowledged certification body with well-established and standardized technology qualification programs.

Together, we constitute a unique global force within consulting services on carbon capture and storage.

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*"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 CO<sub>2</sub> 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



[tcmda.com](http://tcmda.com)