DoE/NETL Project Review Meeting 2021

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TECHNOLOGY CENTRE MONGSTAD

– catching our future

The world’s largest open access test centre for carbon capture technologies

Technology Centre Mongstad (TCM) facilitates the advancement of carbon capture technology for mass deployment across industries.

We test, verify and demonstrate different post-combustion technologies related to cost-efficient and industrial scale CO_2-capture

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Joint venture established in 2009

TCM was established to support development and testing of carbon capture technologies at an early stage. Today, the company is a joint venture between the Norwegian state (managed by Gassnova) (73.9%), Equinor (8.7%), Shell (8.7 %) and TotalEnergies (8.7 %).

GASSNOVA

«We see an increasing interest for testing at TCM, and we are very pleased that we can continue our important work with testing and research necessary for the deployment of large-scale carbon capture.»

equinor

«TCM has contributed to maturing the carbon capture supplier market and will remain relevant with the increasing number of technology suppliers lining up for testing.»

«TCM plays a key role in further developing and reducing the cost of CCS – a crucial technology to help society and economies thrive through the energy transition.»

TotalEnergies

«TCM is a cornerstone in Total's strategy to tackle climate change by accelerating the development and adoption of innovative CO_2 capture technologies.»

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Testing

Proprietary &

Non-proprietary

Advisory Services

Provide risk intelligence

Applied R&D

Artificial Intelligence

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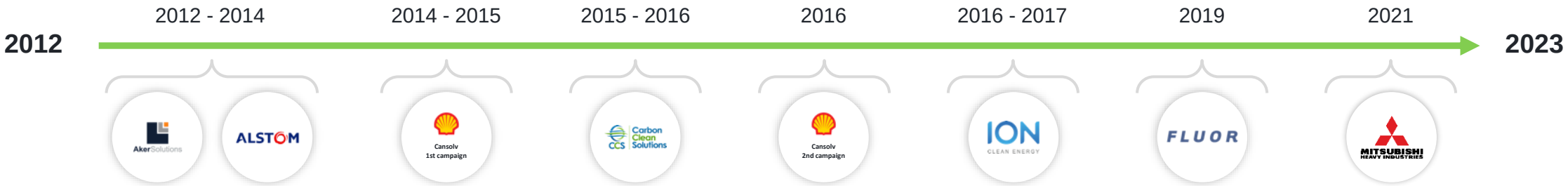
Test campaigns conducted in 9 years of operation

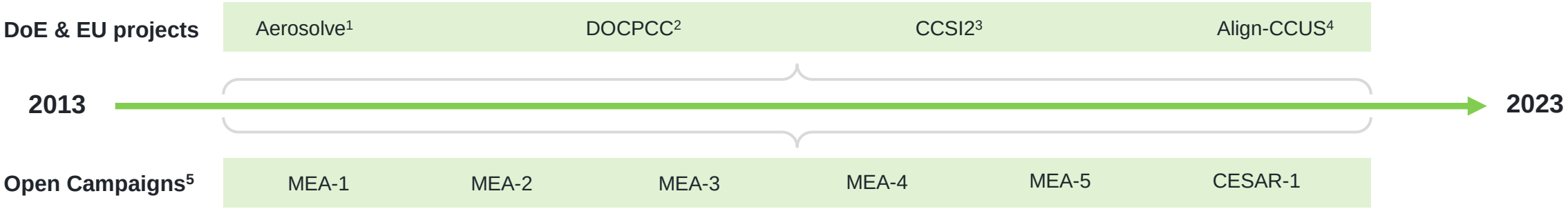
Proprietary test campaigns

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.



[1] Project regarding aerosol-related emissions
[2] Demonstration of Optimal Control of Post-Combustion Capture Processes
[3] Carbon Capture Simulation for Industry Impact
[4] Accelerating Low carbon Industrial Growth through CCUS
[5] Long-term testing with monoethanolamine solvents and CESAR-1 (AMP+PZ) solvent

Proprietary testing >20,000 hrs

Non-proprietary testing >20,000 hrs

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CESAR-1 Campaign 2019 – 2020

- CESAR-1 is a non proprietary solvent (blend of AMP and Piperazine)
- Aim to provide a new and improved benchmark for proprietary solvents
- Solvent has been tested for ~8k hrs at TCM with different flue gas compositions such as:
  - Combined cycle gas turbine (CCGT) flue gas (including exhaust gas recycle (EGR))
  - Steam methane reformer (SMR) flue gas
  - Residue fluidized catalytic cracker (RFCC) flue gas
- Extensive parametric tests including solvent reclaiming successfully conducted
- 3rd party verified (EPRI) baselines with CCGT flue gas and RFCC/coal are established
  - CCGT baseline presented at TCCS-11 in Jun'21
  - RFCC baseline planned to be presented at GHGT-16 in Oct'22
- CCGT baseline: 98% CO2 capture rate with improved energy consumption compared to MEA and potentially reduced CAPEX (reduced absorber packing height) have been demonstrated

First tests with MTR and TDA currently ongoing

Site for emerging technologies commissioned

- New site allows for testing lower TRL 3rd generation technologies such as membranes, adsorbents, MOFs etc.
- The site has CO_2 capture capacity up to 18,000 tonnes per year using up to 3 MWe modules
- Access to two different flue gas sources (RFCC and CCGT) either filtrated or unfiltrated with CO2 concentrations ranging from 1% to 15%.
- Utilities (process water, sea water, electricity, instrument air, fire water) available

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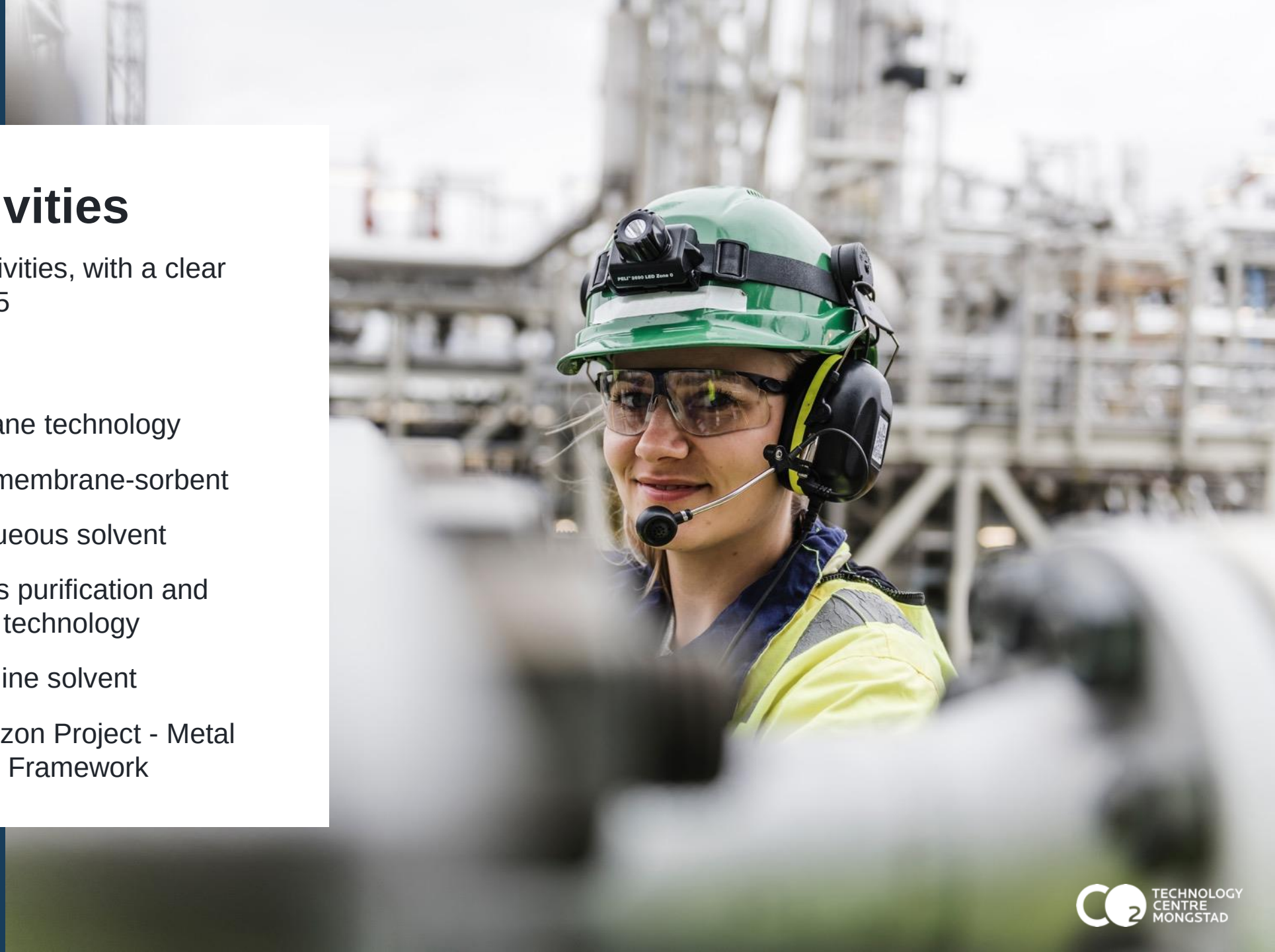
Testing activities

Strong pipeline of activities, with a clear strategy towards 2025

MTR	Membrane technology
TDA	Hybrid membrane-sorbent
RTI INTERNATIONAL	Non aqueous solvent
InnoSepra	Flue gas purification and sorbent technology
C-Capture	Non-amine solvent
MOF4AIR	EU Horizon Project - Metal Organic Framework



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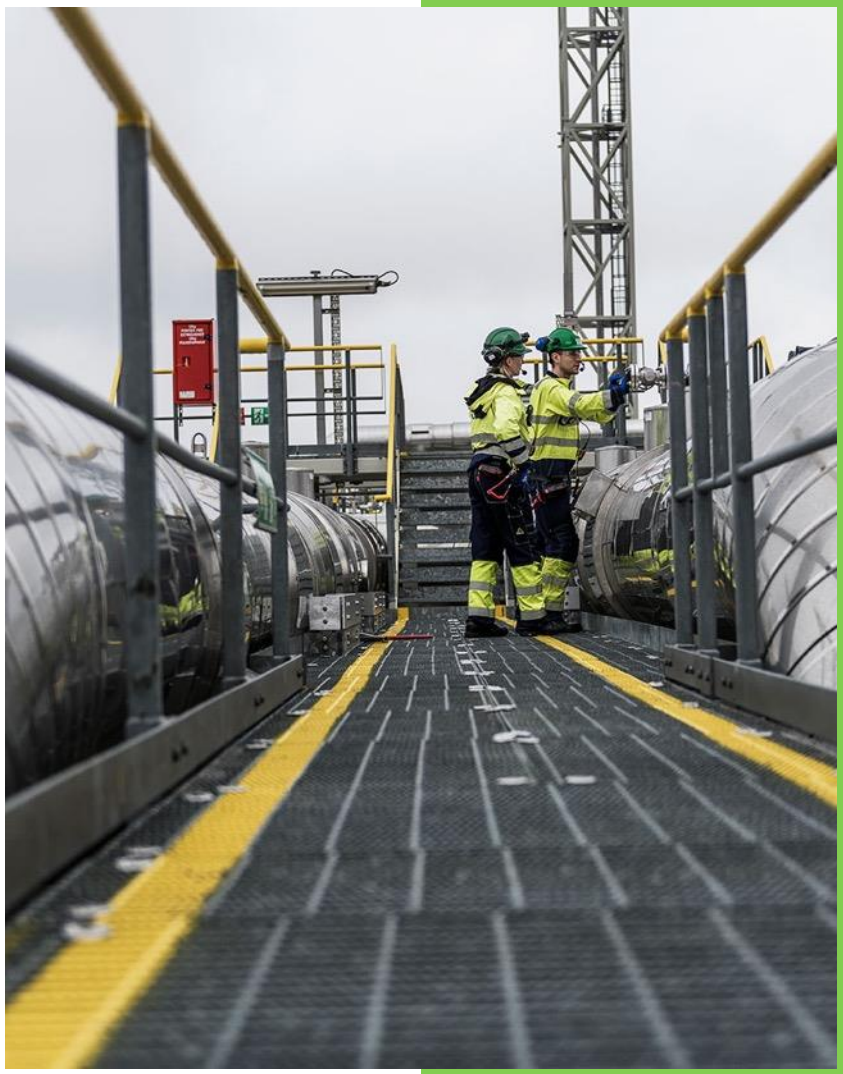
TCM’s operational experience

- Manning of operations
- Regularity of maintenance
- Frequency of major maintenance
- Costs and manning of scheduled stoppages
- Units/systems requiring more maintenance (e.g. Lean Rich Heat Exchanger where CO_2 flashing might occur, hot spots etc.)
- Recommended spares
- Major operational costs & challenges (e.g. solvent consumption)
- Potential of capture rate fluctuations (obligations to the user of CO_2)
- Efficiency of the plant over time (corrosion, fouling etc. & how they will affect heat transfer efficiency)



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Advisory Services

We provide risk intelligence

Our Advisory Services help you to reduce HSE, technical and financial risks of technology deployment at scale.

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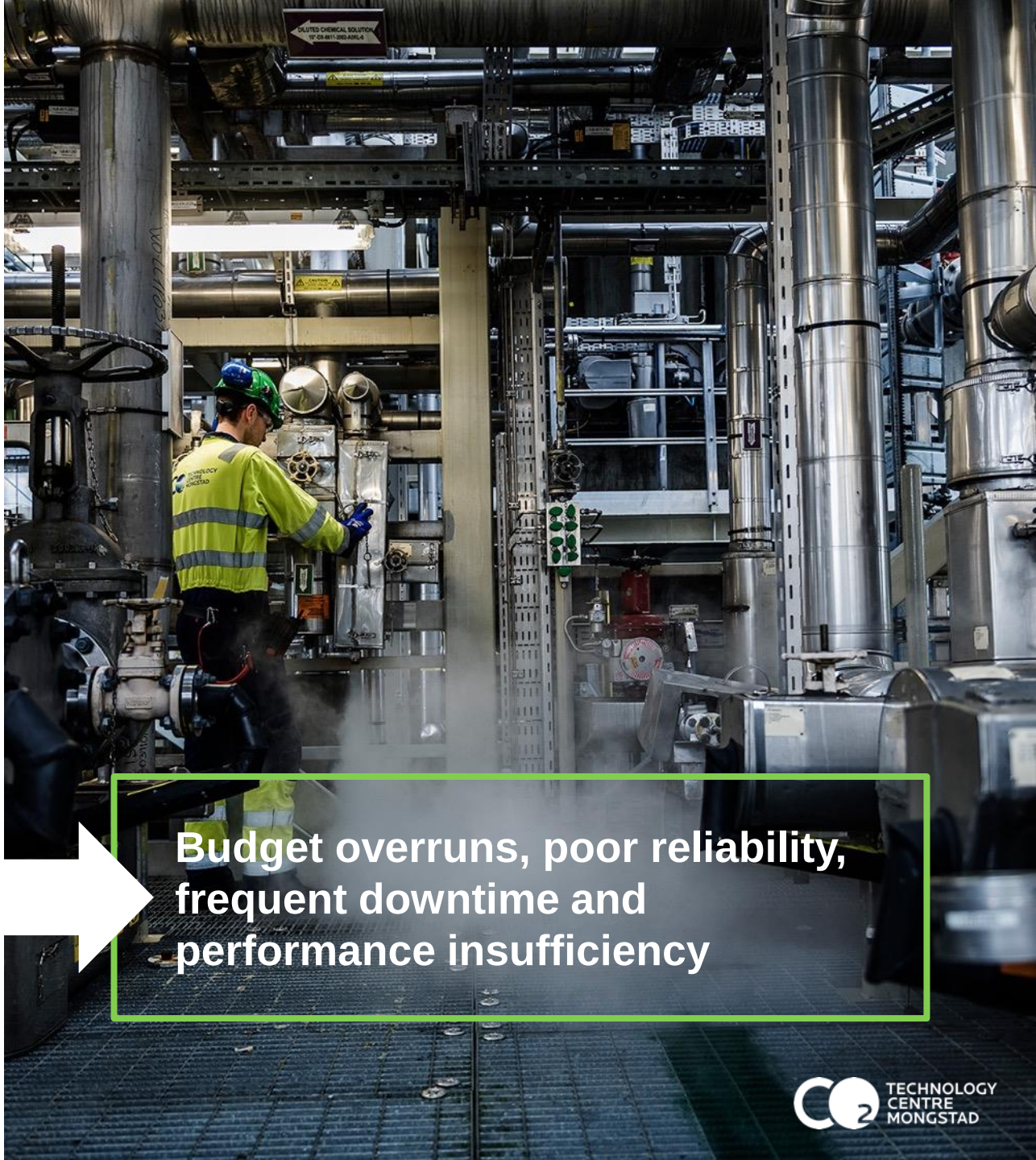
Typical pitfalls observed in CCUS projects

- Chosen technology does not match flue gas characterization.
- Risks and failure modes not systematically identified.
- Actual operating environment often not tested.
- Lack of validated simulation and analytical models and prediction tools.
- Probability and consequences of risks and failures not determined.
- Technical uncertainties leads to equipment over-design.



Where can TCM help

- Flue gas characterization
- Technology assessment methodology
- Emissions including measurements, permits and authority dialogue
- Technical design, planning and construction of a CO_2 capture unit
- CAPEX and OPEX assessment
- Process, control and operations
- Instrumentation and analysis
- HSE and risks including work environment and occupational hazards
- Solvent management

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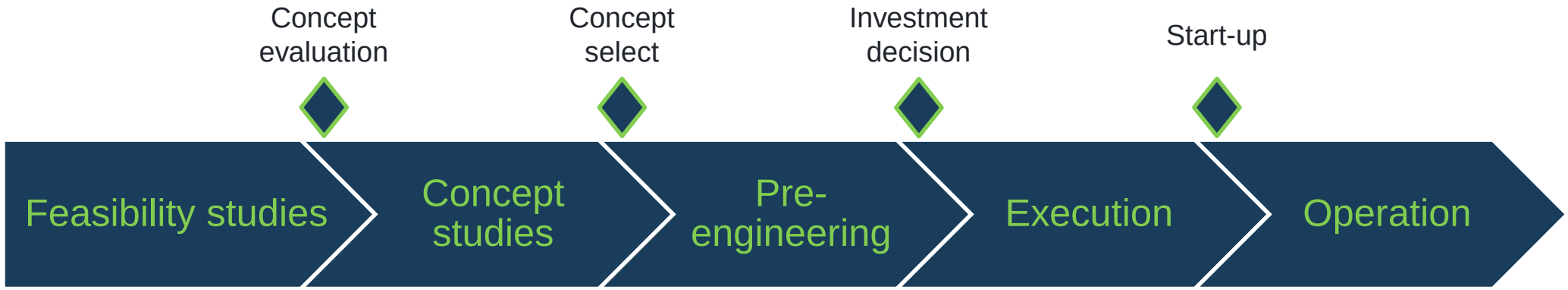
Our Advisory Services through your CO_2 capture project



Study of different solutions and identify a technically feasible solution.	Evaluate different concepts, develop basis of design and mature a technical and commercial solution.	Develop the project in accordance with regulatory and company specific requirements.	Execute the project.	Start operating the project.

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Our Advisory Services clients

OIL AND GAS CLIMATE INITIATIVE

sse

Statkraft

HEIDELBERG CEMENT

fortum Oslo Varme

TDA

中英（广东）CCUS 中心
UK–China (Guangdong) CCUS Centre

HÖEGH LNG

Net Zero Teesside

vallourec

RTI INTERNATIONAL

WÄRTSILÄ

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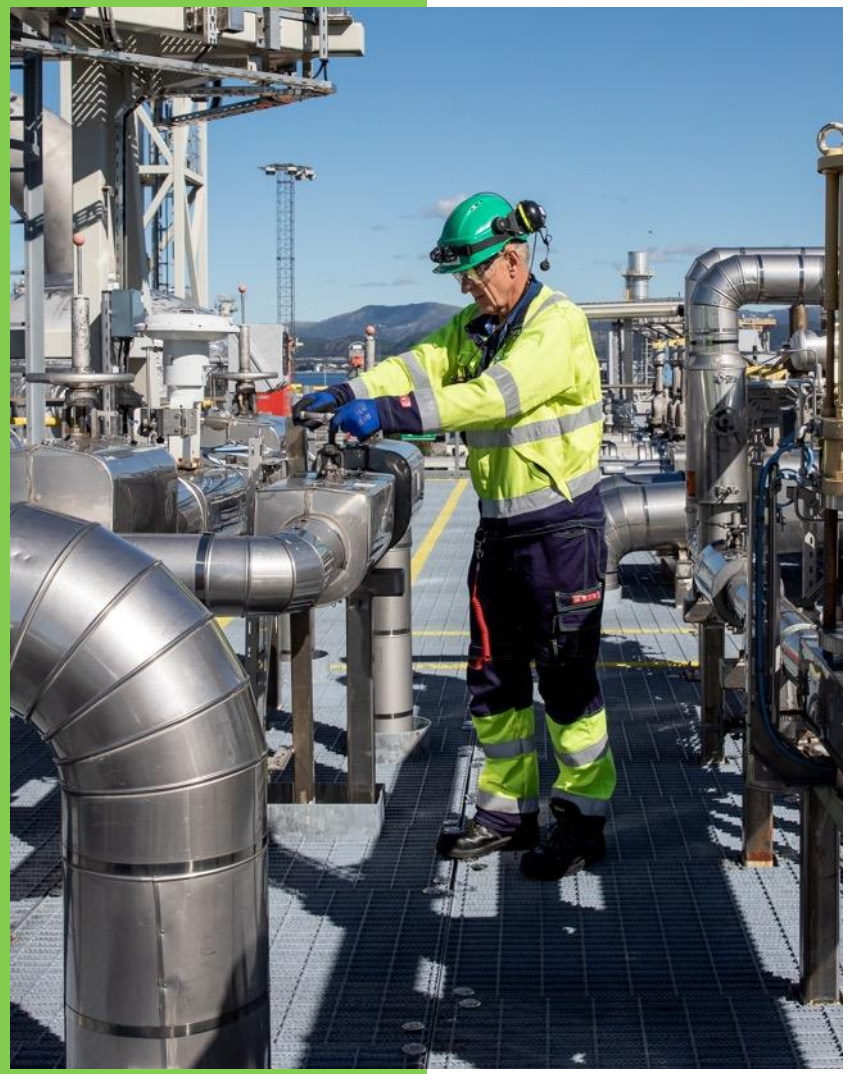

Our core strengths

- Well-earned reputation built on public research, vendors proprietary testing and a highly qualified workforce with unique competence.
- Unique knowledge from nine years of operations
- Simulating real-world conditions
- Large-scale testing step before full-scale deployment.
- Flexible facilities with thousands of measuring points.
- Full priority to customers and 24/7 operations.
- Comprehensive non-proprietary datasets and industrial-scale baseline for benchmarking purposes.
- Relentless focus on health, safety and environment.
- Strong partnerships bringing together clients, vendors and other key stakeholders.

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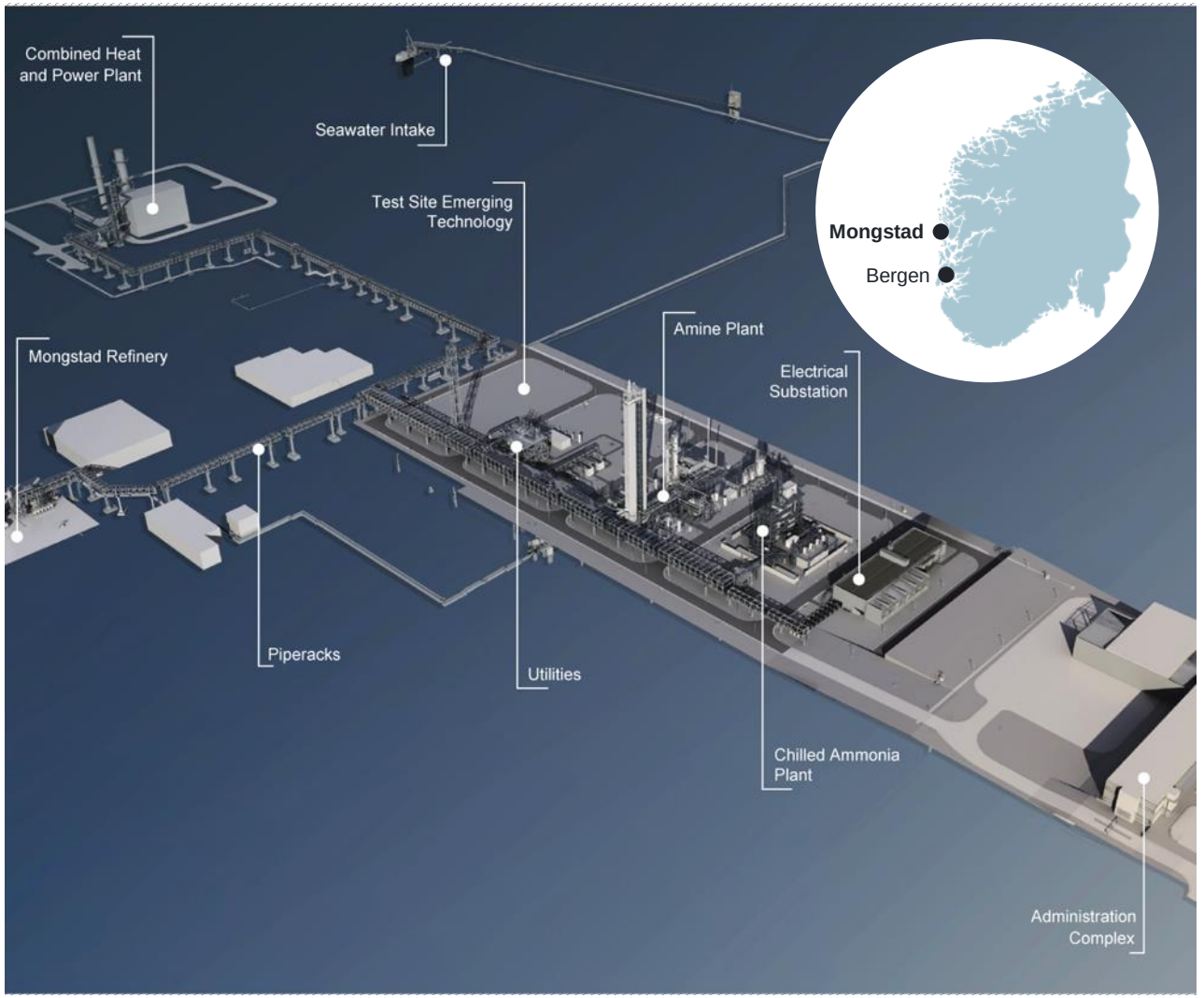
Key facts

Capture technologies: Post-combustion (amine plant, chilled ammonia plant and a test site for emerging technologies designed for modular based testing).

Source: Two flue gas sources that allow mimicking industrial sources with CO_2 concentrations ranging from 1% to 20% (up to 25% at the test site for emerging technologies).

Capacity: Amine and ammonia units each have approximately 12 MWe in size, capturing up to 75,000 tonnes CO_2 per year. Site for emerging technologies has CO_2 capture capacity up to 18,000 tonnes per year using up to 3 MWe modules.

Monitor and control: 4,000 online instruments and 100 manual sampling points, enabling TCM to monitor and collect valueable data for upscaling and commercial deployment.



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