



TECHNICAL REPORT

STATE OF THE ART: CCS TECHNOLOGIES 2025



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EDITOR'S NOTES

The Global CCS Institute ("The Institute") is an international think tank whose mission is to accelerate the deployment of carbon capture and storage (CCS), a suite of technologies to tackle climate change and deliver climate neutrality.

The Institute produces the "State of the Art: CCS Technologies" Technology Compendium annually to provide a platform for technology owners and providers to share their solutions, and allow developers, proponents, and interested parties to discover the field's state-of-the-art offerings. This is in accordance with our mission to accelerate the deployment of CCS globally.

The Technology Compendium is a free-to-enter publication, and technology providers collaborate with the Institute to provide their information to the Technology Compendium for review and publication. The technologies presented in the 2025 Technology Compendium represent a non-exhaustive picture of the overall landscape of CCS technologies. Where there has been no submission received for the 2025 Technology Compendium, there is no presence within the Compendium. The Institute is aware of other CCS technologies not mentioned in this Technology Compendium, established and emerging, and we are working to include these technologies in future issues.

If you wish to make a submission to the next edition of the Technology Compendium, please contact us via techcompendium@globalccsinstitute.com.

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Technology Readiness Level (TRL)

In this publication, the TRL of various technologies has been reported as a part of the submission. The guidance provided to submitters for TRL assessment is provided in Table 1. For inclusion in the 2025 Technology Compendium, a Technology must have a TRL of 5 or above.

Table 1: TRL Guidance Provided for 2025 Technology Compendium Submissions

CATEGORY	TRL	DESCRIPTION
Demonstration	9	Normal Commercial Service
	8	Commercial demonstration, full-scale deployment in final form
	7	Sub-scale demonstration, fully functional prototype
Development	6	Fully integrated pilot tested in a relevant environment
	5	Sub-system validation in a relevant environment
	4	System validation in a laboratory environment
Research	3	Proof-of-concept tests, component level
	2	Formulation of the application
	1	Basic principles, observed, initial concept

Key Data Table

The Key Data Table is a section of the Technology Submission Template used to outline the capabilities of individual technologies presented on parameters of interest. For Capture Technologies, the parameters are fixed, however for Capture Adjacent, Transport, and Storage Technologies the parameters can be adjusted to better reflect the parameters of interest for each technology. The only required parameter across all submissions is the TRL, assessed against the guidance in Table 1.

Definitions of Note for the Key Data Table:

Capture Percentage (%): This is the percentage of CO₂ captured from the inlet stream to a capture technology. A facility may have more than one source of CO₂ emissions – when considering capture percentages only the specific source directed to a capture plant is considered.

Source CO₂ Purity Range: This is the range of CO₂ concentrations that a technology is suitable for deployment on. This is generally in mol%.

Energy Consumption (GJ or kWh(e)/tCO₂): This is the energy involved in the operation of a technology across the entire system of capture. This can be electric power. This value may include the net effect of waste heat recovery systems or other energy integration. Where these systems may have an impact, but the impact depends on the host site, this is noted.

Specific Regen. Energy (GJ or kWh(e)/tCO₂): This is the "specific regeneration energy". This data point is the amount of energy to capture CO₂ and regenerate a technology for continuous operation. No waste heat recovery or other energy recovery is included in this data point. No pretreatment upstream or post treatment downstream of a capture unit is included in this data point.

Front Cover Image: The Just Catch™ carbon capture plant at Twence in Hengelo, the Netherlands. Image courtesy of SLB Capturi.

Foreword Image: The Petra Nova Carbon Capture Project in Texas, the United States. Image courtesy of Mitsubishi Heavy Industries.



Site photo of Tomakomai CCS Demonstration Project, Japan with BASF's OASE® CO₂ capture process, shown as three columns. Photo courtesy of Japan CCS Co., Ltd. (JCCS).

SUMMARY

At BASF, we create chemistry for a sustainable future. With more than 50 years of experience, BASF offers its customers amine-based gas treating solutions under the OASE® brand name for a variety of applications, such as synthesis gas (OASE® white), natural gas (OASE® purple), flue gas (OASE® blue), biogas (OASE® green) and Sulphur selective treatment (OASE® yellow). With recent developments in the OASE® white and OASE® blue technologies, BASF continues to enhance CAPEX and OPEX optimised designs tailored to site specific boundary conditions.

About 70% of the global ammonia production is based on the reforming of natural gas feedstock. A majority of these ammonia plants utilise OASE® white technology for energy efficient two-stage CO₂ removal process. BASF's latest innovation with advanced low-low pressure flash configuration further reduces the specific energy consumption.

OASE® white technology can also be applied to hydrogen production via gasification, reforming, partial oxidation and direct reduction iron processes. In combination with OASE® blue post-combustion CO₂ capture technology, BASF offers deep decarbonisation solutions for ammonia and hydrogen production.

BENEFITS

OASE® provides to business partners:

- Know-how derived from over 500 references and BASF's expertise in chemistry
- Long track record and expertise in design and operation of large scale CO₂ capture units
- Non-exclusive access to OASE® technology for customers and engineering companies
- Unique licensing model integrated with OASE® solvents sales produced and supplied by BASF
- Process performance warranties
- Customised design, operating and analytical manuals
- OASE® connect digital platform
- OASE® digilab with the capability to analyse the composition of OASE® solvents in near real time

KEY PROJECTS

- **Tomakomai CCS Demonstration Project, Japan:** In this project, an energy-efficient OASE® process configuration was implemented to capture CO₂ containing tail gas stream from Pressure Swing Adsorption (PSA) of a Hydrogen Production Unit. The captured CO₂ was transported for offshore sequestration.
- **HyNet Low Carbon Hydrogen Production Plant (HPP1), UK:** Syngas stream with CO₂ generated by autothermal reforming process. Highlighted in the Phase 2 Hydrogen Supply Competition Report for UK BEIS, BASF's OASE® technology fulfills all technical requirements while offering the lowest risk technology and the highest CO₂ removal efficiency.
- **Steel Plant in Abu Dhabi, UAE:** A world-scale operational direct reduction iron plant with an integrated OASE® CO₂ capture unit, constructed by Linde Engineering.

KEY DATA

TRL	9	Capture Rate Range (tpd)	10 - 10,000+	Capture Efficiency (%)	>99%
Source CO ₂ Purity Range	<0.1 - 70%	System Energy (GJ/tCO ₂)	~	Specific Regen. Energy (GJ/tCO ₂)	0.6 - 6.0
Number of Commercial Plants	>500	Number of Pilot Plants	6	Modular (Y/N)	Yes
Target Industries	Ammonia, Hydrogen, LNG, Floating/OCCS, Refineries, Steel, Cement/Lime, Waste-to-Energy, Power Plants				

TECHNOLOGY DESCRIPTION

OASE® WHITE TECHNOLOGY FOR CO₂ REMOVAL IN AMMONIA AND HYDROGEN APPLICATIONS

BASF's OASE® two-stage absorption process know-how

Proven and operating reliably in world scale ammonia production facilities (3300 MTPD capacity) around the world.

Applying BASF's OASE® know-how in hydrogen application

For Tomakomai CCS Demonstration Project, a two-stage OASE® absorption process, which includes a low-pressure (LP) flash tower, had achieved specific thermal energy consumption comparable to 30-50% of a conventional single-stage absorption process.

Advanced low-low pressure (LLP) flash configuration

The additional flashing stage results in lower CO₂ loading of semi-lean solvent, therefore less reboiler heat duty is required for full solvent regeneration. With that, a further reduction in specific thermal energy consumption up to 25% can be achieved in comparison to already energy efficient two-stage absorption process. A revamp opportunity with LLP flash can also be considered by existing plants to achieve capacity debottlenecking or OPEX optimisation.

OASE® BLUE TECHNOLOGY FOR POST-COMBUSTION CO₂ CAPTURE FROM FLUE GAS OF STEAM METHANE REFORMING (SMR) FACILITY

Key features of OASE® blue technology

- Advanced amine solvent with 10-year continuous testing and 7-year commercial operation in various industries
- High oxidative resistance / Low degradation / Low makeup of amine solvent
- Low regeneration energy and maximize heat integration
- OASE® aerozone patented emission reduction technology

Post-Combustion CO₂ Capture Study for Linde's SMR Hydrogen Plant

- Funded project by US Department of Energy under Award Number DE-FE0031943
- Plant design by Linde Engineering, leveraging the key features of OASE® blue technology
- Designed for 95% CO₂ capture rate and 1.4 mtpa (~4200 tpd) CO₂ capture capacity
- Solvent regeneration with an integrated interstage heater enables more efficient semi-lean solution regeneration, resulting in reduced overall thermal energy consumption

INTEGRATION OF OASE® WHITE AND OASE® BLUE TECHNOLOGIES IN A SMR FACILITY

For a natural gas hydrogen SMR plant, about 60% of the total CO₂ quantity is contained in the process gas (syngas) or PSA tail gas stream. OASE® white technology offers the capability to perform deep CO₂ removal from such streams down to ppm level using an energy efficient process configuration. The remaining 40% of the total CO₂ emission comes from the SMR flue gas. CO₂ from these low pressure streams can be captured with OASE® blue advanced amine solvent, resulting in an energy optimised design for large scale plants.

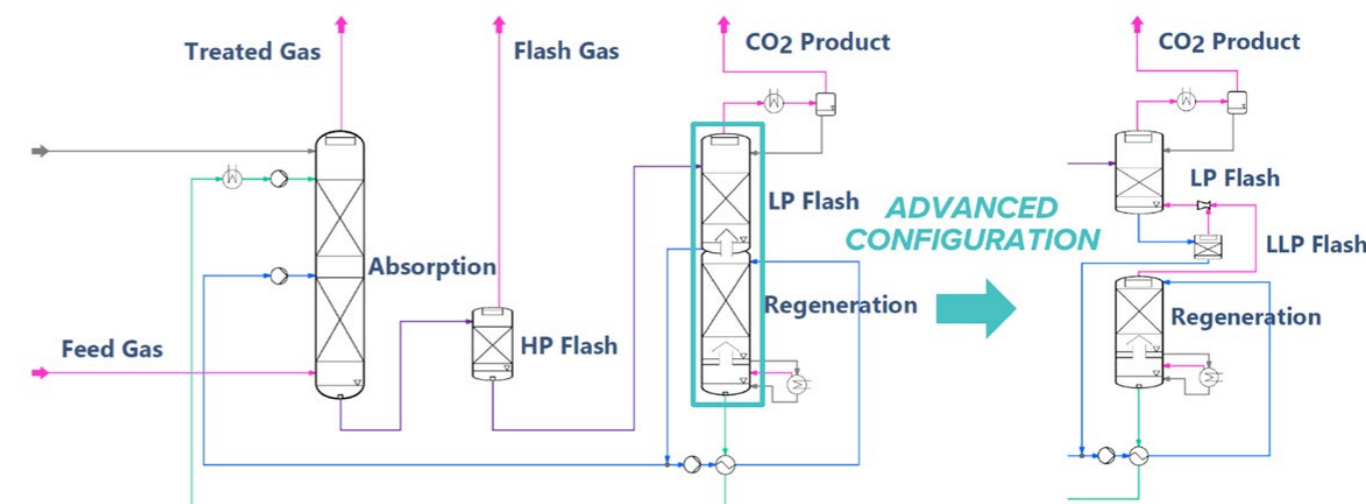


Figure: OASE® technology with two-stage absorption process and advanced LLP flash configuration

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