GLOBAL CCS INSTITUTE

EDITOR’S INSIGHTS

STATE OF THE ART: CCS TECHNOLOGIES 2025

AUGUST 2025

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1.0 INTRODUCTION

The "State of the Art: CCS Technologies 2025" Technology Compendium is the latest edition of the annual publication produced by the Global CCS Institute. The Technology Compendium is released publicly to provide a platform for technology owners and providers to share their offerings, and to allow developers, proponents, and the wider CCS community an opportunity to dive deeper into the field's latest offerings.

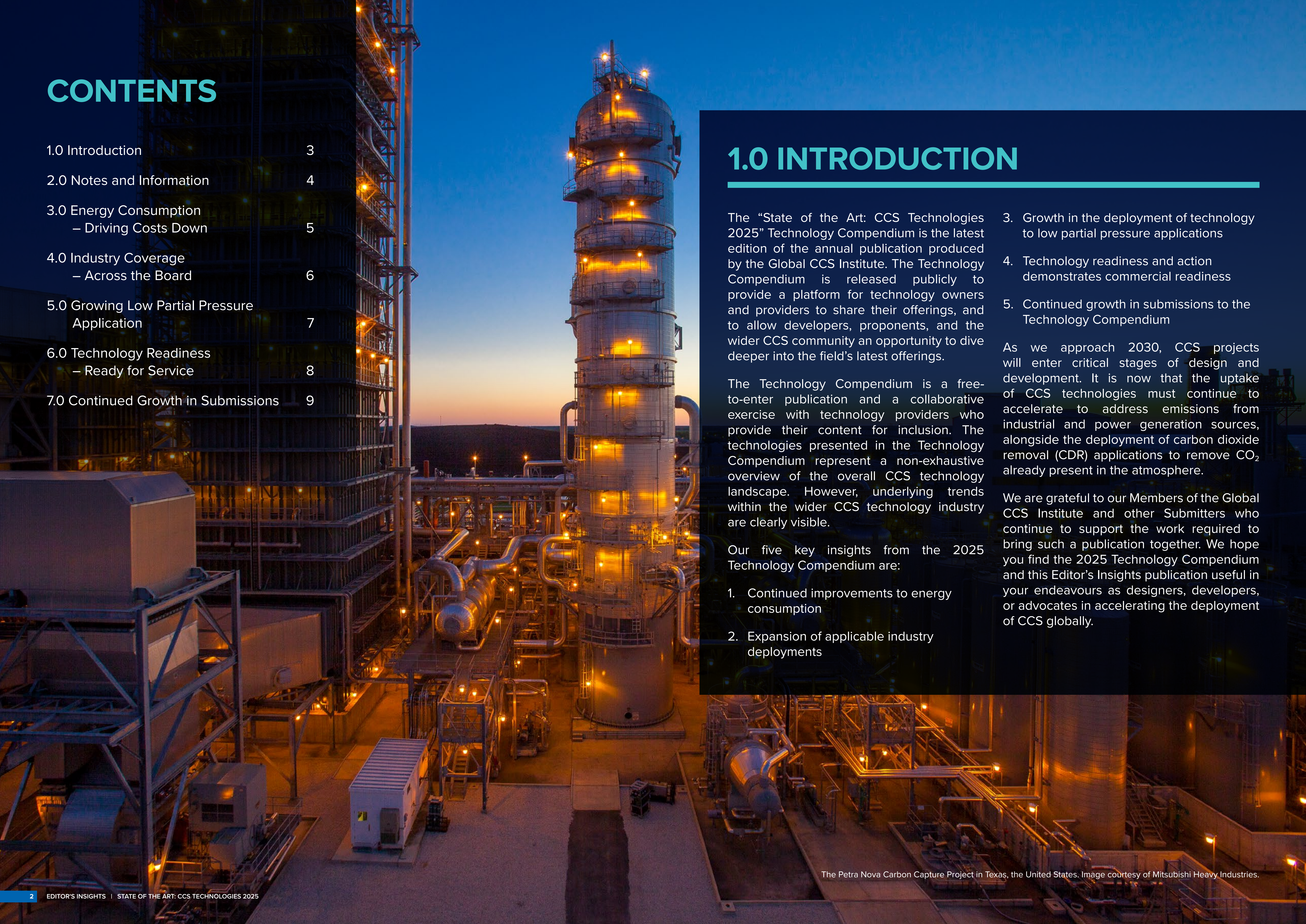
The Technology Compendium is a free-to-enter publication and a collaborative exercise with technology providers who provide their content for inclusion. The technologies presented in the Technology Compendium represent a non-exhaustive overview of the overall CCS technology landscape. However, underlying trends within the wider CCS technology industry are clearly visible.

Our five key insights from the 2025 Technology Compendium are:

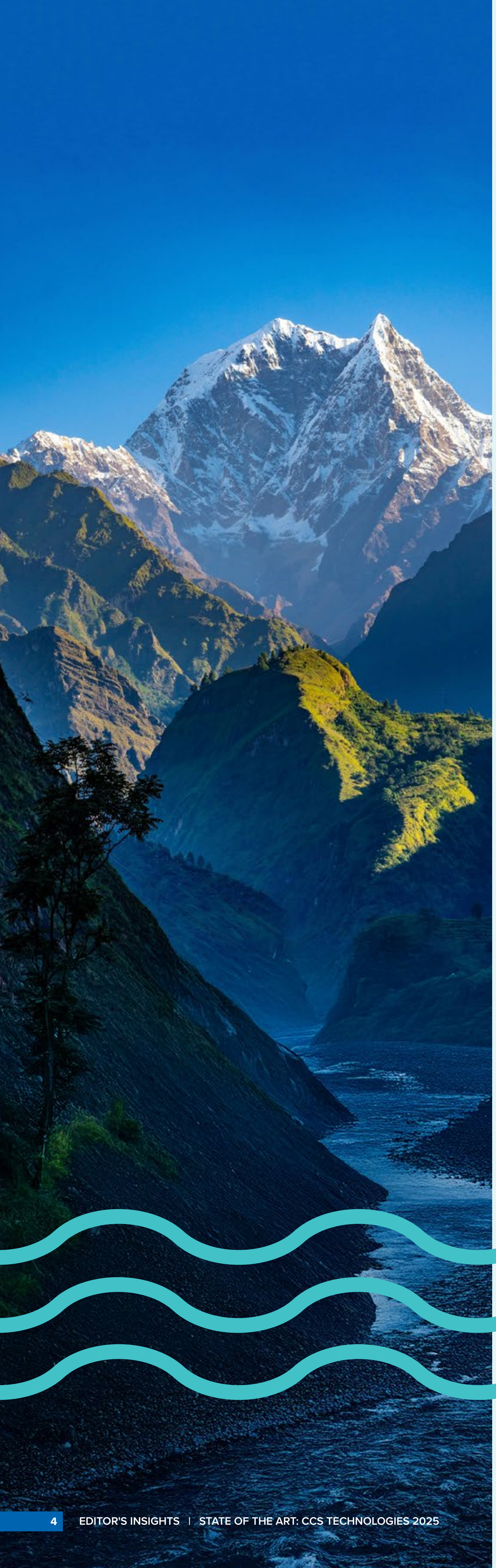
1. Continued improvements to energy consumption
2. Expansion of applicable industry deployments
3. Growth in the deployment of technology to low partial pressure applications
4. Technology readiness and action demonstrates commercial readiness
5. Continued growth in submissions to the Technology Compendium

As we approach 2030, CCS projects will enter critical stages of design and development. It is now that the uptake of CCS technologies must continue to accelerate to address emissions from industrial and power generation sources, alongside the deployment of carbon dioxide removal (CDR) applications to remove CO_2 already present in the atmosphere.

We are grateful to our Members of the Global CCS Institute and other Submitters who continue to support the work required to bring such a publication together. We hope you find the 2025 Technology Compendium and this Editor's Insights publication useful in your endeavours as designers, developers, or advocates in accelerating the deployment of CCS globally.



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



2.0 NOTES AND INFORMATION

The Global CCS Institute has relied on the contributions of over 80 CCS technology providers to compile the Technology Compendium. Any claims regarding technology performance are the responsibility of the company concerned and are not endorsed by the Global CCS Institute. The data reported in this Editor's Insight publication are solely a set of observations regarding the information that has been put forward by the group of technology providers in the Technology Compendium. Readers should confirm any technology-specific details contained in the Technology Compendium with the technology holder concerned.

The Global CCS Institute has endeavoured to ensure the information in the Technology Compendium is as accurate as possible. However, it does not guarantee that the information in the Technology Compendium is totally reliable, accurate, or complete. Therefore, the information in the Technology Compendium should not be relied upon when making an investment or commercial decision or provided to any third party without the written permission of the Global CCS Institute.

To the maximum extent permitted, the Global CCS Institute, its employees, and advisers accept no liability (including for negligence) for any use or reliance on the information in the Technology Compendium, including any commercial or investment decisions made on the basis of information provided in the Technology Compendium.

3.0 ENERGY CONSUMPTION – DRIVING COSTS DOWN

The reported Energy Consumption of capture technologies sits well below the reference of MEA and continues to drive costs downwards.

One of the most significant contributors to the cost of CCS is the cost of energy used within the capture facilities. According to a recent Global CCS Institute analysis, the cost of the reboiler for regeneration in a typical amine CO_2 capture facility can be nearly 70% of the overall cost of capture. Therefore, technology providers have devoted significant effort to improving the performance of their technologies beyond that of a typical amine solvent capture facility using monoethanolamine (MEA) solvent.

In the 2025 Technology Compendium, capture technology providers had the option of providing two parameters of the key data tables: Energy Consumption and Specific Regeneration Energy.

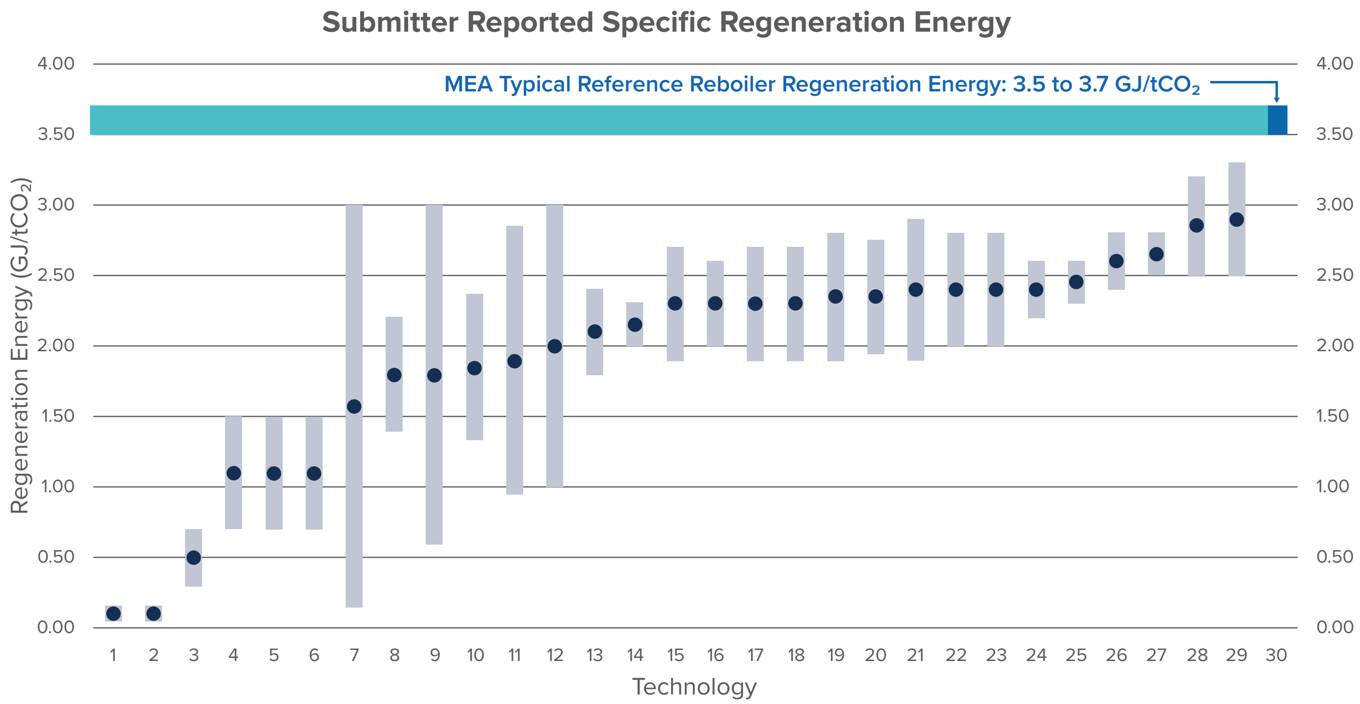
Specific Regeneration Energy in the Technology Compendium is defined as the amount of energy (thermal/electrical) to capture CO_2 and regenerate a technology for continuous operation, excluding the impact of waste heat integration or other energy integration systems.

Energy Consumption in the Technology Compendium is defined as the energy (thermal/electrical) involved in the operation of a technology across the entire system of capture, including the impact of waste heat integration systems or other energy integration systems.

The values for Specific Regeneration Energy are shown in Figure 1. This must be considered separately from the Energy Consumption parameter due to the exclusion of energy integration systems.

The data on specific regeneration energy shows a clear conclusion – while MEA has generally been considered as the reference solvent for carbon capture applications, it is completely outclassed by the other technologies in the Technology Compendium – chemical solvent, membrane, cryogenic, solid adsorbent, and hybrid systems. These systems are generally reported to have a specific regeneration energy between 1.7 and 2.5 GJ/tCO_2. MEA has served as an excellent 1st generation reference solvent, but the time is rapidly approaching to begin benchmarking against a new reference that better reflects the capabilities of today's commercial technologies, which continue to drive costs down.

Figure 1: Reported Specific Regeneration Energy in the 2025 Technology Compendium.



NB: Technologies 1 and 2 are physical solvents that operate in high-pressure environments and so are expected to have relatively lower regeneration energies.

4.0 INDUSTRY COVERAGE – ACROSS THE BOARD

CCS is deployable in many of the critical industries that require deep decarbonisation to meet net zero targets.

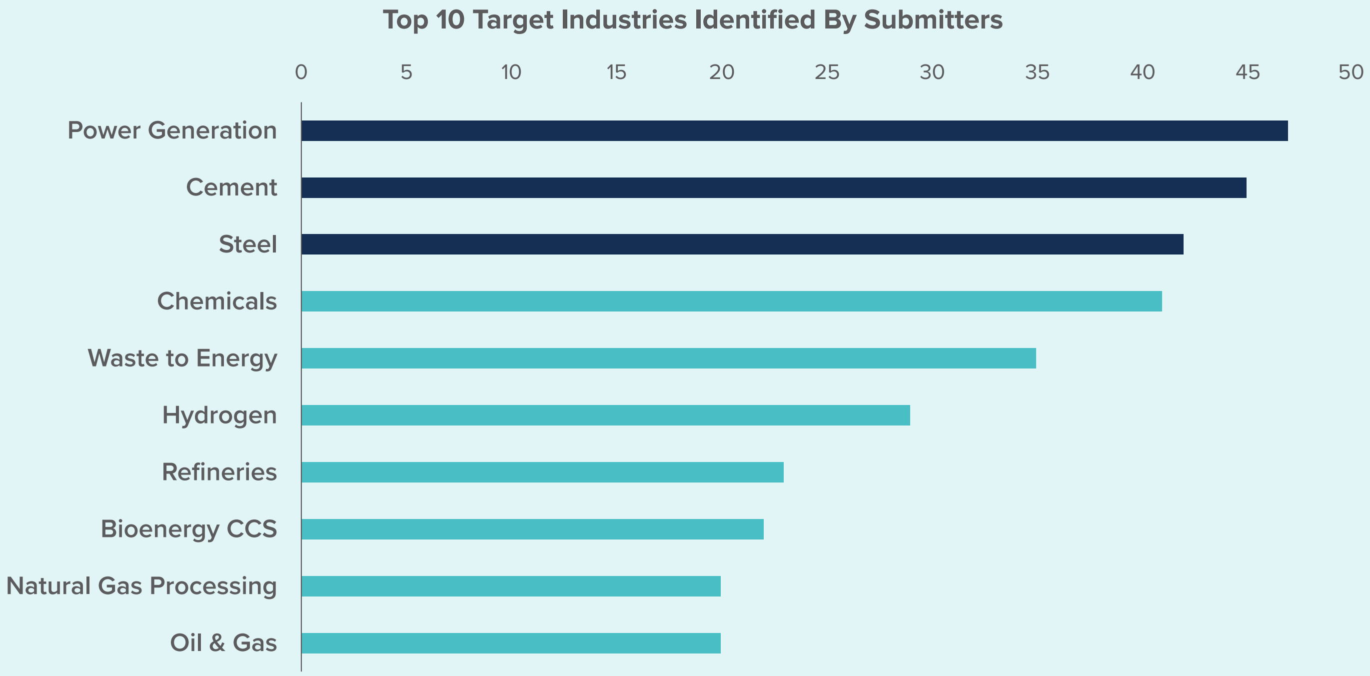
CCS is a decarbonisation lever available to many different industrial sectors, and a critical one to several, such as cement. The widespread applicability of CCS is reflected in the targeted industries identified by technology providers that made submissions to the Technology Compendium.

The most common target industries mentioned in the Technology Compendium are power generation, cement, and steel. This data mirrors the emissions intensity, emissions volume, and in some cases, the difficulty in decarbonising certain industries.

Several technology providers did not indicate a preference for targeting any industry in particular, with 11 providers stating some variant of "all point sources". This highlights the growing confidence in the sector to handle point source streams from industry with lower CO_2 partial pressure (more in Section 5), higher impurity loads, and space or utility constraints.

It is well within the technological capabilities today to separate CO_2 from a gas stream with low partial pressures, as is seen with existing capture systems and other plants such as air separation units. The challenge now is building the legal and business framework such that emissions sources and industries are incentivised to do so.

Figure 2: Top 10 target industries identified by technology providers in the 2025 Technology Compendium.



5.0 GROWING LOW PARTIAL PRESSURE APPLICATION

Technology providers are taking on the challenge of natural gas combined cycle CCS and continue to push limits, with growing success and momentum.

A noticeable trend reflected in the Technology Compendium is the growth in interest and deployment of carbon capture technologies to low partial pressure applications. This refers to point sources of CO_2 usually at atmospheric pressure and with a relatively low concentration of CO_2. Typically, this is in reference to natural gas combined cycle power generation, where CO_2 concentration in the flue gas ranges between 3 and 5%. This is significantly lower than that of other point emission sources such as coal power generation or cement facilities. Natural gas power plants have generally been considered challenging to capture from due to this low partial pressure of CO_2.

However, in the latest Technology Compendium, the trend of growth is reflected in both the reported source concentration that technologies can address, as well as the reported key projects. Table 1 outlines a selection of the projects tracked by the Institute's CO_2RE CCS Project Database that have been or are to be deployed in the natural gas power generation sector, and the technology deployed by each project. Additional technology providers and project developers are announcing new pilots, demonstration projects, and commercial ventures that will further validate and demonstrate capabilities in this more challenging application.

The growth in low partial pressure applications is an encouraging sign for the advancement of CCS technologies applied to more challenging sources of CO_2. The deployment also represents an opportunity to decarbonise natural gas power systems in potential deployments for applications such as data centres with increasing consistent energy demands.

Table 1: Overview of select CCS natural gas power generation facilities.

PROJECT NAME	START YEAR	CAPACITY (KTPA)	TECHNOLOGY DEPLOYED	PRESENT IN THE TECHNOLOGY COMPENDIUM?
Northeast Energy Associates, Bellingham (CCU)	1991 to 2005	120	Fluor Econoamine FG Plus	✓
Tata Chemicals Northwich (CCU)	2022	40	Pentair Advanced Amine	✓
Glacier Gas Plant (Phase 1 & 2)	2022 (Phase 1) 2026 (Phase 2)	160 (total)	Entropy iCCS	✓
Ravenna Phase 1	2024	25	Mitsubishi Heavy Industries KMCDR Process	✓
Net Zero Teesside Power	2028 (FID Approved)	2,000	Shell CANSOLV	✓

6.0 TECHNOLOGY READINESS – READY FOR SERVICE

CO_2 capture technology is well established. The first recorded patent for CO_2 capture from a gas stream to "sweeten" the gas for further sale and use was lodged nearly 100 years ago, in the 1920s[1]. The first capture from a post-combustion flue gas stream was in 1978 at Searles Valley Minerals in Trona, California[2]. In many other industries today, such as ammonia and hydrogen production, and petrochemicals, the capture and removal of CO_2 is an established practice with technology in regular commercial service.

In the 2025 Technology Compendium, technology providers report their current technology capability using the qualitative Technology Readiness Level (TRL) system, outlined in Table 2. The TRL of a technology is checked where necessary. Any claims regarding technology performance are the responsibility of the company concerned and are not endorsed by the Global CCS Institute. Readers should confirm any details with the technology holder concerned.

Table 2: 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

To be included in the 2025 Technology Compendium, a technology submission needed to have a TRL of 5 or more. This would be "sub-system validation in a relevant environment", which includes deployment at testing centres such as Technology Centre Mongstad in Norway and the National Carbon Capture Centre in the US. Figure 3 outlines the distribution of TRLs across the Technology Compendium, indicating a significantly high level of commercial readiness among CCS technologies, with nearly 100 at the highest level.

Figure 3: Reported Technology Readiness Levels of submissions to the 2025 Technology Compendium. Where a range has been given, the average of the range has been taken and rounded down.

[1] Sperr, J. F. W., Hall, R. E., & Inc, K. C. (1921, December 8). US1533773A - Gas-purification process, https://patents.google.com/patent/US4080424A/en

[2] Herzog, H. J. (2018). Carbon capture. In The MIT Press eBooks. https://doi.org/10.7551/mitpress/11423.001.0001

7.0 CONTINUED GROWTH IN SUBMISSIONS

An expanded Technology Compendium enables designers, developers, and advocates to access a more inclusive reference tool on technology providers and their offerings.

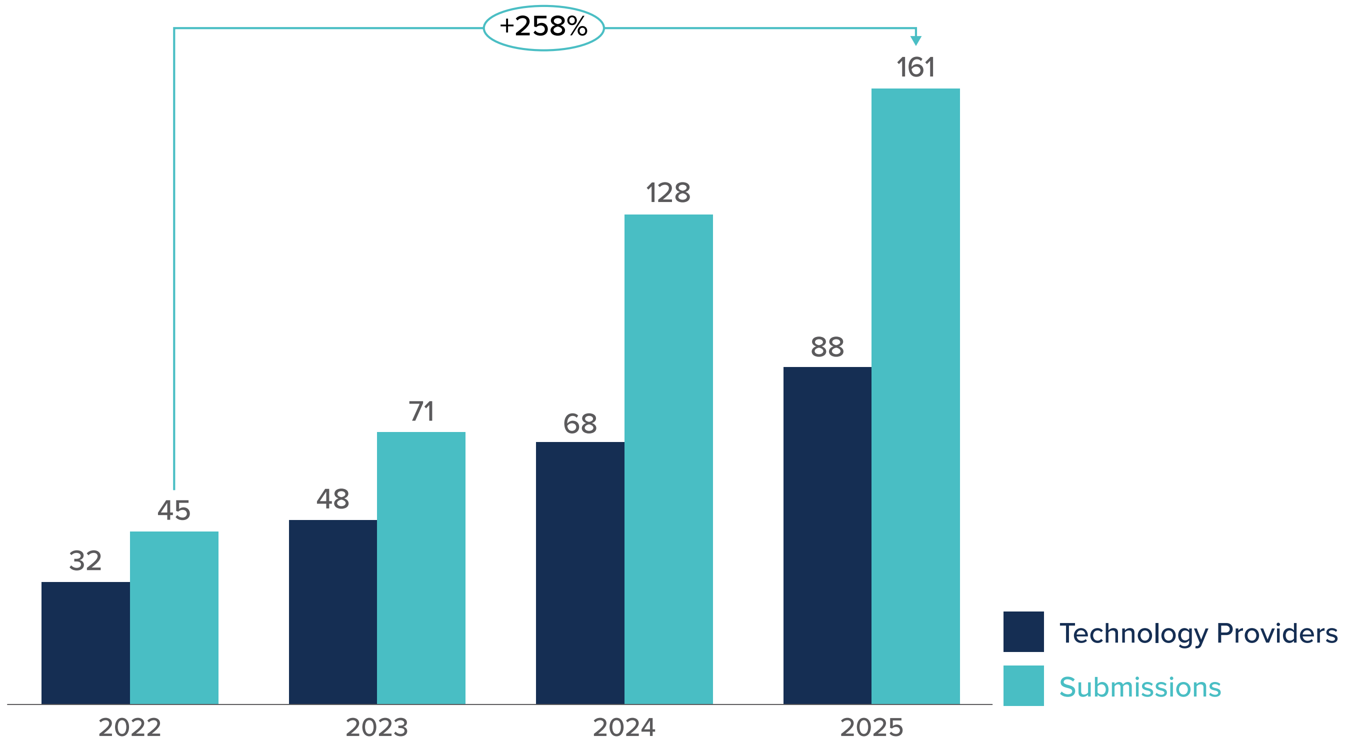
The Technology Compendium is a voluntary, collaborative exercise between the Institute and technology providers in industry. The result is a non-exhaustive list of available technologies on the market, both available for implementation today and upcoming novel technologies. The Institute is grateful to our Members and Technology Compendium Submitters for their ongoing support and efforts to help bring this content to the CCS community and the wider public.

Since launching in 2022 with 45 submissions, the Technology Compendium has grown to 161 submissions in 2025. The number of technology providers represented has also grown over the same period, from 32 to 88. This growth includes both new entrants to the CCS space and the inclusion of established technology providers able to contribute for the first time. The growth over the past four editions is shown in Figure 4.

This growth in both companies and submissions is derived from a combination of existing providers sharing more about their technology, and newcomers to the CCS industry starting to offer innovative solutions to the market. With more companies and submissions represented, the Technology Compendium better serves its purpose as a key reference publication for CCS developers, proponents, and advocates to better understand and engage with CCS technology providers.

The Institute is aware of additional CCS technologies not mentioned in this or past Technology Compendiums, established and emerging, and we are working on future editions to include these technologies.

Figure 4: Number of technology providers and submissions included in the Technology Compendium.



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

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