

CCUS

AND THE PATH TO NET ZERO



BUREAU
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CCUS TURNS 100 AND HITS ITS STRIDE

When engineers began to use capture technology to separate out the carbon dioxide (CO₂) found in natural gas reservoirs in the 1920s, they could not have imagined the role their breakthrough would play in the energy transition a whole century later. As 2030 targets for net zero draw closer, the number of projects involving carbon capture, utilization and storage (CCUS) is growing rapidly. 71 new CCS projects launched from January to September 2021, more than doubling the number of commercial facilities in the pipeline¹.

According to the International Energy Agency's Net Zero by 2050 plan, CCUS will be the most impactful technology for emissions reductions, and will be responsible for 55% of reductions by 2050. While coal is estimated to still account for 22% of energy use in 2050, 90% of coal energy will likely be deployed alongside CCUS².

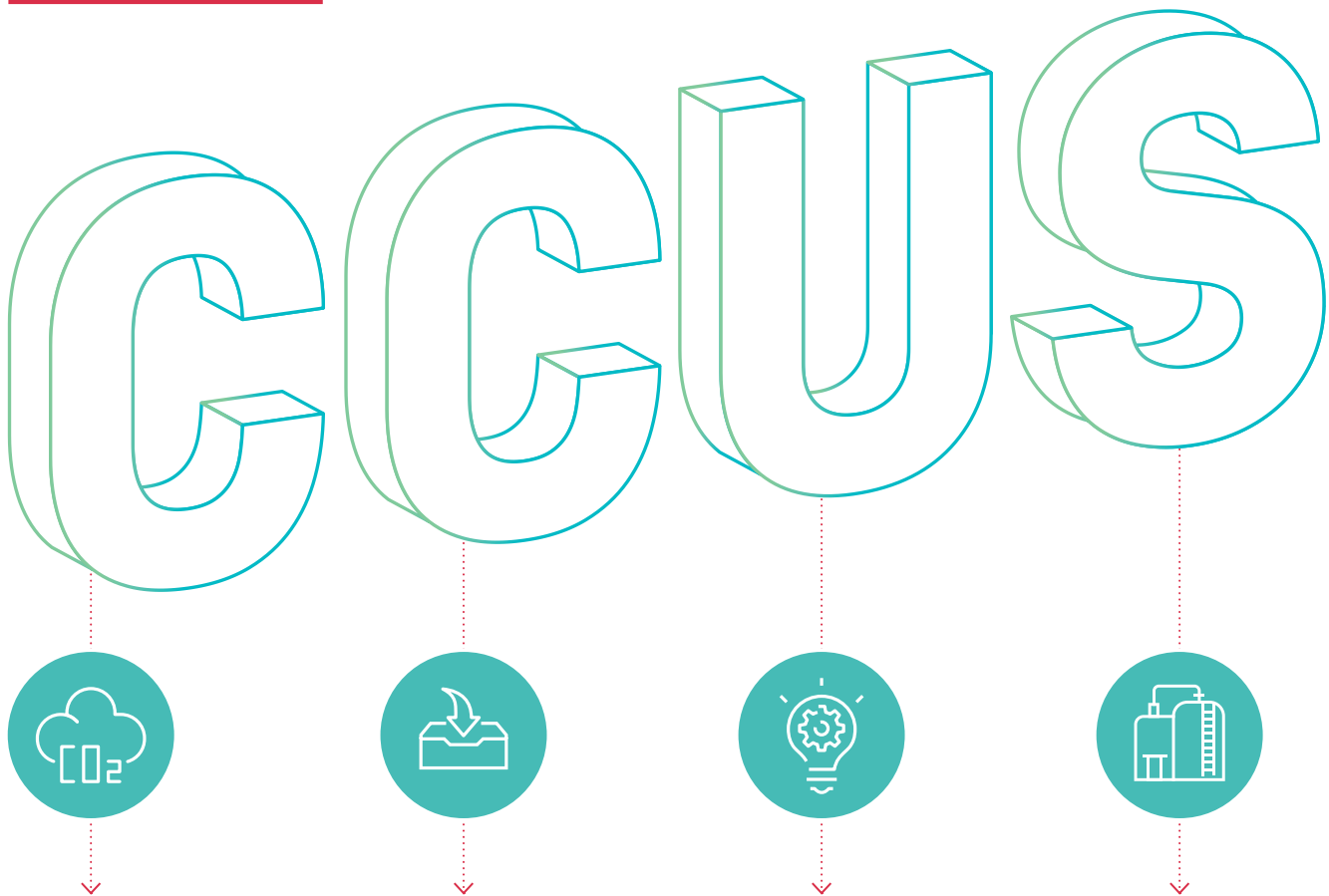
However, while it has great potential, CCUS is not without its challenges, specifically in terms of safety and impact on the environment. As a result, it requires that operators and energy-intensive industries make a number of important decisions. CCUS is a particularly attractive option for industries that have difficulty cutting their emissions, and companies in these sectors are quickly waking up to the possibilities it offers. But if CCUS is to live up to its potential and help the world reach emissions reductions targets set for 2030 and 2050, rollout has to accelerate rapidly. Specifically, the 40 million metric tons captured in 2020 will need to be increased to 1 metric gigaton (Gt) by 2030 and 7 Gt by 2050.

1. <https://www.globalccsinstitute.com/wp-content/uploads/2021/10/The-Global-Status-of-CCS-2021-Global-CCS-Institute.pdf>
2. https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroBy2050-ARoadmapfortheGlobalEnergySector_CORR.pdf

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CCUS: WHAT'S IN A NAME?



CARBON

The first C in CCUS is for CARBON DIOXIDE. Carbon is the fourth most abundant element in the universe, and essential to 10 million known compounds, including carbon dioxide (CO₂). CO₂ is a greenhouse gas (GHG) that contributes to climate change and global warming. It is a natural byproduct of many chemical reactions and cannot be fully eliminated from all industrial processes.

CAPTURE

Next comes CAPTURE. This refers to the process of filtering gases and separating out CO₂ that is generated by industrial processes and cannot be eliminated. It also includes burgeoning technologies in development to vacuum CO₂ directly from the atmosphere; the captured carbon will be processed and stored or used.

UTILIZATION

The next step is the UTILIZATION of captured carbon. At this stage of development, only a very small amount of carbon is predicted to be utilized, but future applications may include the production of synthetic fuels. For the time being, as utilization projects are in development, the next step in CCUS is absolutely critical for the energy transition.

STORAGE

Lastly, S stands for STORAGE. It is crucial that captured carbon is **transported** safely to leak-proof reservoirs in which it can be stored for the long term and utilized as more and more options for its use are found and developed.

CCUS IN NUMBERS

KEY FIGURES



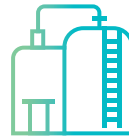
40 MILLION
METRIC TONS OF CO₂
captured and stored
globally in 2020



7 GT OF CO₂
need to be captured each year by
2050 to meet net zero targets



550 BILLION
METRIC TONS
of CO₂ storage resources have
been classified as Discovered
Resources globally⁴



800 METERS
minimum depth required for
a secure CO₂ reservoir⁵



1970s
WHEN CO₂ WAS
FIRST USED
for Enhanced Oil Recovery⁶



33 BILLION
METRIC TONS OF CO₂
emissions in 2019³



\$9.7 TRILLION
of investment required to follow the
Clean Technology Scenario (CTS)⁷

3. <https://www.iea.org/articles/global-co2-emissions-in-2019>

4. <https://www.globalccsinstitute.com/wp-content/uploads/2021/10/The-Global-Status-of-CCS-2021-Global-CCS-Institute.pdf>

5. <https://www.globalccsinstitute.com/archive/hub/publications/190903/brazilian-atlas-co2-capture-geological-storage.pdf>

6. https://ieaghg.org/docs/General_Docs/Publications/Information_Sheets_for_CCS_2.pdf

7. https://iea.blob.core.windows.net/assets/fc698d6d-1f9d-4c46-9293-e67a600d01c6/Exploring_Clean_Energy_Pathways.pdf

LAYING THE GROUNDWORK FOR NET ZERO

CCCUS is an essential part of the world's efforts to reduce emissions and reach net zero. It offers a way to offset carbon emissions that are difficult to abate. The cement, iron and steel, and chemical sectors are traditionally among the hardest to decarbonize due to the nature of their processes and heat requirements. CO₂ is a natural byproduct of many of their production processes. This will make these industries key adopters of CCUS techniques.

CCUS has huge potential, and is a promising option among a growing number of viable solutions to reach emissions targets. However, for CCUS to make a difference, its growth must accelerate and the number of projects worldwide must increase dramatically.

In addition, for offset through CCUS to be effective, operators need to be sure that the amount of CO₂ captured is consistent with the amount transported and stored, and that no gas is allowed to escape. This is likely to pose a particular challenge, as captured CO₂ will almost certainly be handled by a series of different intermediaries before being injected. Suppliers and operators therefore require a comprehensive CCUS solution that considers and streamlines operations along every step of the value chain and ensures end-to-end traceability.

Finally, operators must demonstrate that they are using CCUS exclusively for CO₂ emissions that cannot be abated. They must ensure that industrial processes are efficient and carbon emissions have been reduced as much as possible before using CCUS to process the remaining CO₂.



ENSURING THE SAFETY OF OUR PLANET AND ITS PEOPLE

RESPECTING THE ENVIRONMENT

It is now universally acknowledged that CO₂ is a major contributing factor to global warming. Despite this, massive amounts of the gas are still emitted around the world. While efforts are being made to reduce emissions, CCUS has a pivotal role to play in meeting net zero targets. CCUS will contribute to these efforts by capturing hard-to-eliminate emissions, keeping them out of the atmosphere and safely sequestered for the long term, or possibly for future use.

However, this state-of-art solution comes with challenges inherent to the specific technical nature of its operations and the long timespan that CO₂ must be stored in reservoirs. Environmental protections must be put in place that will last indefinitely, from the moment of injection into a well. Capturing and sequestering CO₂ safely requires

scalable technology that adapts to the needs of operators in all industries conducting CCUS.

For example, when CO₂ is stored and used for injection it must be kept at the supercritical stage. It resembles a liquid in terms of density but expands to fill space like a gas. Reservoirs used to store CO₂ in a supercritical state need to be at a minimum depth of around 800 meters.⁸ These are the kinds of unique conditions operators must comply with if they want to use CCUS methods and ensure continuously reliable service in the long term.



8. <https://www.ctc-n.org/technologies/co2-storage-technologies>



KEEPING US ALL SAFE

Working with gases like carbon dioxide creates challenges in terms of ensuring both the safety of teams involved and the surrounding areas. While studies have shown the risk of CO₂ is generally low and declines over time, operators have a duty of care to ensure that the entire value chain is secure. Careful selection of storage sites and thorough assessment is critical to mitigate risk.

It is also vital to test and certify all equipment to be used in CCUS applications before projects begin to ensure CO₂ remains in its less dangerous, easier-to-handle, supercritical state. Equipment failure can result in sudden and extreme pressure drops, causing significant potential hazards as the CO₂'s supercritical state becomes liable to change. Ensuring equipment is fit for the job is therefore key to mitigating the risks of CCUS and making it a viable and safe option.

STARTING A PROJECT: IDENTIFY YOUR CHALLENGES

ENSURING CARBON INTENSITY FROM CRADLE TO GRAVE

Since sequestered carbon dioxide is liable to pass through many hands before it is utilized or stored, there is a risk of gas leakage at each transfer. Operators at both ends of the chain of custody have a responsibility to prevent leakage throughout the entire value chain and ensure the reliability of the different downstream players. They need to be able to attest that the same amount of CO₂ captured is also transported and stored, even if they do not oversee the CO₂ from the beginning to the end of the project.

The involvement of an impartial third party in this sometimes long value chain can prove a valuable source of assurance for all stakeholders. By providing an objective quantification methodology that is applied throughout an entire project, an independent body can offer operators visibility over their value chain. They can also give operators the data they need to prove that their work is being conducted safely. This helps them remain part of the solution to climate change rather than an unwitting contributor to the problem.





SECURING ESG INVESTMENT THROUGH TRANSPARENCY AND TRUST

It is only natural that potential environmental, social and governance (ESG) investors in a CCUS project should want some assurance of operators' expertise and experience. They need to be confident that the projects and companies they are backing know what they are doing in order to protect both their investment and reputation.

Emissions fall into two categories: those that can be lessened by improving industrial performances, and those that are unavoidable and difficult to abate. The former fall under the responsibility of operators while the latter are the concern of wider society. Investors want to see that everything is being done to identify and appropriately process both types of emissions.

Increasing numbers of industries are turning to CCUS as a viable option for offsetting hard-to-eliminate emissions. As momentum for projects grows, there will be more and more investor dollars, euros and yen up for grabs. The result: operators will face more and tougher competition to win investor trust and to secure financing.

To get ahead of the pack, operators will need to demonstrate both their credentials and the feasibility of their projects. The most obvious way to do this will be through the certification of their organizations and processes by an independent third party. This enables them to prove compliance with the latest industry regulations and standards.

STANDARDS RAISE THE BAR

As the use of CCUS techniques becomes more widespread, the industry is responding with the creation of more—and more stringent—regulatory standards. The ISO/Technical Committee 279xx series of standards from ISO/Technical Committee 265 relates to carbon dioxide capture, transportation, and geological storage. The 11 standards that have been published so far under ISO/TC 265 are intended to cover a range of CCUS-related activities. These include design, construction, operations, environmental planning and management, all the way through to risk management, quantification, monitoring and verification. Four more ISO/TC 265 standards are currently in development.

As projects proliferate, certification to these standards will effectively become a license to operate in this growing market. Operators seeking to reap the benefits of CCUS techniques will need a third-party certification body. This external entity can verify that an operator's employees have the necessary expertise, and that its processes are safe, reliable and subject to continuous monitoring and improvement.



SERVING THE VALUE CHAIN, FROM END TO END

UPSTREAM SOLUTIONS

The first step for operators considering a carbon capture project is to undergo a careful, accurate appraisal of a plant's CO₂ emissions. The project's proposed methodology for capture requires a thorough review to ensure efficiency, safety and accuracy. It is also crucial that companies evaluate and understand the legislative, regulatory and environmental context in which capture will take place.

Qualified and experienced experts from an impartial third-party organization like Bureau Veritas can provide invaluable support in any CCUS venture to ensure projects run smoothly and optimally. They can help ensure successful capture and prepare the operator for transport and storage through the quantification of captured emissions.

In order to complement CCUS, there are a number of other upstream options available to companies looking to reduce their emissions before capturing what remains. BV Green Line includes, for example, solutions for carbon footprinting and certification. Carbon footprinting is a recognized best practice for companies seeking to track their carbon output in an effort to reduce it. Accurate monitoring and reporting shows companies where changes can be made and impact minimized, helping them achieve net zero targets. Carbon footprint verification through Life Cycle Analysis helps companies prove they measure and report on their carbon footprint rigorously and transparently.





MIDSTREAM SOLUTIONS

Before entering long-term storage, captured CO₂ is placed into intermediate storage, for which it can require compression. As a result, captured CO₂ undergoes multiple stages of transportation—first to a holding area, then eventually to its final long-term reservoir.

Bureau Veritas' Certification of Conformity of CO₂ Injection and Storage (CIS) takes a modular approach to ensuring compliance with applicable legislation and particular project requirements, especially when selecting sites for injection. Bureau Veritas acts as a third party for this certification service and can issue a certificate of compliance to the legislations or modules selected.

Our Approval in Principle (AiP) service involves verifying that a project plan is feasible and suitable for all phases of the project, including site selection, design, and risk analysis. Bureau Veritas Marine & Offshore, working as a Classification Society, provided AiP to a liquefied CO₂ carrier in September 2021, ensuring that it meets the International Maritime Organization's standards.

Furthermore, all operators involved in the transportation and interim storage of CO₂ can find support in BV Green Line to ensure that their operations are sustainable.

DOWNSTREAM SOLUTIONS

Once it has been injected, CO₂ needs to be stored long-term, and it must be subject to careful monitoring. At this stage, carbon sequestration intensity needs to be guaranteed through a comparison between the quantity of CO₂ captured and the final amount stored. A quantification plan by an independent assessment body is essential to demonstrate the safety and efficacy of CO₂ storage, proving CCUS to be a viable and reliable solution.

It is also vital that operators receive support in locating and certifying a reservoir as fit for long-term storage. For this, Bureau Veritas offers Concept Approval, a technology-related certification consisting of design appraisal, witnessing of testing on a prototype model, and qualification testing (safety and functional testing). Bureau Veritas is also qualified to issue projects with a certificate of conformity. These can cover a series of selected certification program modules, such as material and equipment certification, manufacture monitoring, acceptance tests, and inspections. Bureau Veritas can issue a certificate of conformity for CO₂ injection and storage; CO₂ injection, storage and closure; or CO₂ injection, storage monitoring and post-closure.



YOUR OPTIONS FOR CERTIFICATION

Bureau Veritas' various certifications help your projects comply with worldwide CCS legislation. There are a number of options to suit your needs. Our verification solutions follow the ISO/Technical Report 27918:2018 standard for lifecycle risk management for integrated CCS projects.



Bureau Veritas certifications for CCUS

- Project support, including Approval in Principle, Concept Approval, Certificate of Conformity, Independent Module Certification, Sensitivity Characterization, Risk Assessment, and Site Selection
- Equipment certification and supply chain resilience assessment
- BV experts can provide guidance based on a CCS technical and economic feasibility study that Bureau Veritas conducted, which included H₂ injection scenarios
- Bureau Veritas can also support the technical qualification of the equipment used in CCUS projects
- For offshore projects, Bureau Veritas brings expertise gained through involvement in a project to retrofit a liquefied natural gas carrier with CCS equipment



Bureau Veritas certifications for CO₂ injection and long-term storage

- Bureau Veritas' Certification of Conformity of CO₂ Injection, Storage, Monitoring and Post-Closure (CISM) covers well design and project support through to appraisal and witness of testing
- It includes Approval in Principle, and takes CIS and CISC a step further with the addition of monitoring and post-closure certification



Bureau Veritas certifications for CO₂ transport, intermediate storage and injection

- Bureau Veritas Certification of Conformity of CO₂ Injection and Storage (CIS) covers everything from project description, environmental impact assessment and risk analysis through to certification of wells, CO₂ composition and storage
- Certification of Conformity of CO₂ Injection, Storage and Closure (CISC) covers the same aspects as CIS certification with the addition of site closure and inspections



Bureau Veritas certifications for carbon offset intensity level

- Bureau Veritas can conduct life cycle assessment of CCUS projects from cradle to gate or cradle to grave
- At the project level, carbon offset verification and quantification evaluates the technology used for sequestration as well as the energy consumed in further processing the captured CO₂ (i.e., compression, cooling, etc.)

POWER FOR TODAY AND TOMORROW

Throughout its existence, Bureau Veritas has operated at the cutting edge to help drive our industries and our clients forward. In the late 1800s, Bureau Veritas classed the first-ever steam-driven oil tanker and helped open up a new form of energy to consumers all over the world. Bureau Veritas has continuously leveraged our knowledge to create new offers and become an active player across all types of power-generation and energy markets.

Now, Bureau Veritas is applying our inspection and certifications expertise to support the energy transition. With our extensive history in oil &

gas, as well as our global network of industry leaders and global resources, Bureau Veritas is uniquely positioned to bridge the gap between old and new sources of energy.

Our solutions for CCUS form part of a wider offer to help conventional energy companies transition to greener energy sources and methods. From inspecting carbon sequestration equipment to classing liquified CO₂ carriers for marine transport, Bureau Veritas provides comprehensive support for operators working in this rapidly evolving application. As CCUS gathers momentum and garners more support from investors and operators, Bureau Veritas stand ready to certify, inspect and advise clients, with an eye to durability, efficiency and safety.



BV GREEN LINE: THE PERFECT ADDITION TO CCUS SOLUTIONS



At Bureau Veritas, sustainability is embedded in our strategy, our organization, and across all our businesses. Through our BV Green Line of services and solutions, our experts empower organizations—both private and public—to implement, measure and achieve their sustainability objectives. This comprehensive suite of services includes specific solutions to help companies reduce their emissions and identify new areas for emissions reduction. When employed together with CCUS, these services enable more effective emissions abatement.



For example, certification to ISO 14064-1, the number one international standard for quantifying and reporting greenhouse gas (GHG) emissions, offers a wide range of benefits for companies of all types and sizes. These include compliance with legal requirements, and support for improving emissions in line with 2030 and 2050 targets.

ISO 14067 offers companies guidelines for the quantification and communication of their carbon footprint. Certification to this internationally recognized standard enables organizations to quantify the carbon footprint of a service or product and gives credibility to carbon labeling. For emissions that cannot be eliminated or captured, Bureau Veritas provides carbon offsets and GHG removal services that enable businesses to “cancel out” residual emissions and make real inroads toward carbon neutral targets.

Whatever your company’s size, type or needs, Bureau Veritas has a solution to help you reach your targets, stay compliant, and prove transparency to foster stakeholder trust and safeguard your reputation.



SHAPING A WORLD OF TRUST

Bureau Veritas is a Business to Business to Society company, contributing to transforming the world we live in. A world leader in testing, inspection and certification, we help clients across all industries address challenges in quality, health & safety, environmental protection and social responsibility.

For more information,
contact Bureau Veritas:
net-zero@bureauveritas.com

Le Triangle de l'Arche
8 cours du Triangle
CS 90096
92937 Paris La Défense Cedex
FRANCE

[bureauveritas.com](https://www.bureauveritas.com)



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