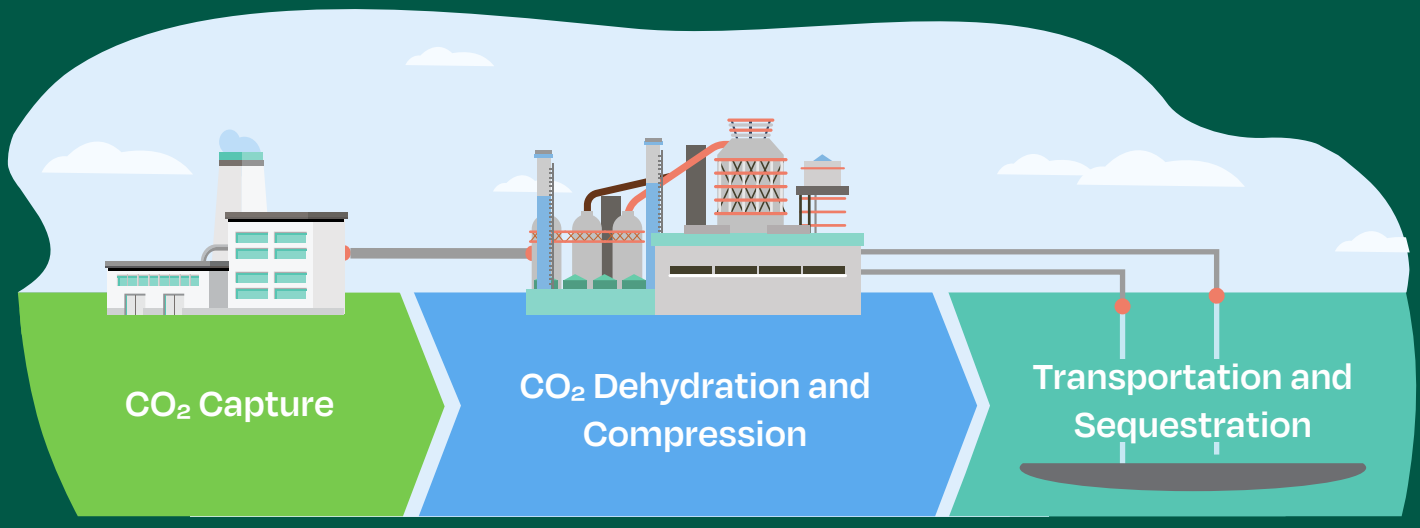
Carbon Capture & Sequestration: The Safe, Proven Pathway to Rapid Reduction of CO_2 Emissions

CF Industries is the global leader in safe, industrial scale ammonia and nitrogen fertilizer production, having reliably and safely manufactured and distributed the products farmers need to feed the world for more than 75 years. As part of our continuing commitment to sustainability, we are decarbonizing our ammonia production network. A crucial step in this process is the buildout of carbon capture and sequestration (CCS) technology, which will enable CF Industries to move quickly to significantly reduce emissions while producing the essential products that are vital for food production today.

About CCS

- The U.S. has substantial geological formations suitable for 2,400 to 3,700 metric gigatons (a gigaton is equivalent to one billion tons) of potential permanent CO_2 storage[1], which is approximately 100 times the annual global energy-related CO_2 emissions[2]. Using the International Energy Agency's Sustainable Development Scenario[3] of 220 gigatons stored globally from 2020-2070, domestic storage capacity far exceeds what will be required.
- Permanent geologic sequestration involves storing CO_2 in underground rock formations, typically about a mile deep. The CO_2 that is transported and injected into these formations has been compressed into a dense fluid, which, together with the impermeable rock in these underground reservoirs, ensures secure storage.
- Surface and subsurface monitoring are performed before, during, and after CO_2 is injected to ensure the CO_2 is contained and is not impacting groundwater.
- For more information on different CCS technologies, please visit the websites of the International Energy Agency[4] and the U.S. Geological Survey[5].

CCS requires three steps:



Carbon capture and sequestration, or CCS, is the process of capturing carbon dioxide (CO_2) before it is emitted to safely and permanently sequester it in proven and secure storage areas deep underground.

CCS is a mature and proven technology.

- **Safe and Proven Technology:** Industry has decades of commercial experience safely storing CO_2 geologically at large scale. In 2021, power and industrial facilities around the world captured 40 million metric tons of CO_2, and there are nearly 200 commercial CCS facilities in development globally, according to the International Energy Agency.
- **Heavily Regulated:** CCS projects, including CO_2 storage, are also heavily regulated and require both state and federal permitting after extensive review and analysis. As part of the permitting process, storage providers must demonstrate they have a plan to monitor and report on the CO_2 storage throughout operation and beyond completion of injections into the facility.
- **Efficient:** Existing infrastructure can be retrofitted with carbon capture equipment, resulting in a shorter ramp-up period than building an entirely new zero-emissions system.
- **Less Air Pollution:** CCS technology works to eliminate other harmful pollutants in addition to CO_2.
- **Job Creation and Positive Economic Impact:** CCS creates jobs and provides beneficial economic impacts for the surrounding communities. CCS projects require significant capital and operating investments, leading to good-paying construction and permanent jobs. For that reason, The Inflation Reduction Act (IRA) and the Bipartisan Infrastructure Investments and Jobs Act both provided strong support for carbon capture projects, which are expected to incentivize hard-to-abate industries to start immediately investing in CCS.

KEY TAKEAWAY

CCS is a proven technology with broad public and government support that has long-term viability due to the expansive carbon dioxide storage reservoir in the U.S.

The Need for CCS

The scientific community views CCS as essential to reaching the world's 2050 climate goals for net-zero emissions.

- The International Energy Agency[7] has concluded that "reaching net zero will be virtually impossible" without CCS. The U.N. Intergovernmental Panel on Climate Change (IPCC) has also observed that the cost of reaching net zero will be considerably higher without CCS. Excluding CCS from our climate toolkit will not only result in significant increases in the cost of achieving overall emissions reductions, but it will also pose an unacceptable risk of failure to meet climate goals.
- The energy transition requires an all-solutions approach. For many sectors of the economy, there are no short-term economic alternatives to fossil fuels, including agriculture, cement, steel, and chemicals. CCS offers a pathway for these and other critical industries to continue to grow while also reducing emissions of CO_2 now.
- Experts estimate that U.S. industry could reach 200 million tons of CO_2 captured per year by 2030, equivalent to avoiding the emissions of 39 million passenger vehicles each year.[8]
- CO_2 emitted today remains in the atmosphere for 100 years, thus reductions made sooner will be in place longer and therefore have a large cumulative impact to the level of CO_2 in the atmosphere by mid-century.
- The Mission Possible Partnership explained in September 2022 that "blue ammonia offers a transitional abatement option for existing and new assets until green ammonia costs come down".

CCS that enables the production of blue ammonia is expected to accelerate the decarbonization of hard-to-abate industries, such as marine shipping and power generation, and will make possible the production of low-carbon fertilizers.

- Because ammonia does not emit carbon when combusted, switching to ammonia as a fuel source could dramatically reduce the emissions across a range of industries.
- There is increasing end-market interest in coal co-combustion with ammonia for power, primarily in Japan and South Korea; Japan's largest utility, JERA, has issued an RFP for supply of low-carbon ammonia and accelerated its testing of co-firing coal and ammonia to 2023.
- Ammonia as a low-carbon maritime fuel continues to be the leading alternative fuel candidate to carbon-intensive heavy fuel oil, with blue ammonia expected to play a large role in supporting the transition to alternative fuels.
- Low-carbon fertilizers provide the most direct and certifiable way to support decarbonization of agricultural inputs.
- Scaling blue ammonia supply and investing in the near-term is important to meet market demand expected for blue ammonia in the second half of this decade.
- Ammonia is the most efficient transport mechanism for clean hydrogen, having an energy density 1.5 times higher than liquid hydrogen and capable of being stored and transported under more moderate conditions enabling trade in the hydrogen economy.

KEY TAKEAWAY

CCS is a necessity to mitigate climate change in the short-term and can create new, sustainable solutions in other industries over the long-term.

CCS at CF Industries

CF Industries is pursuing CCS projects that will accelerate progress towards our decarbonization goals.

- CF Industries has committed to reduce the carbon intensity of our manufacturing network by 25% by 2030 (compared to a 2015 baseline) and achieve net-zero carbon emissions by 2050.
- Action is needed now – in this decade – to drive emissions reductions across all sectors, and CCS is a critical part of CF Industries' plan to reach net-zero emissions by 2050.
- Today, CF Industries' ammonia production process generates approximately 1.8 tons of CO_2 per ton of ammonia produced, of which 1.2 tons are process CO_2 that is captured through amine CO_2 recovery and can then be used in the urea manufacturing process, captured for sale, or captured via CCS.
- We estimate that CCS technology could reduce more than 60% of our CO_2 emissions from the traditional manufacturing process.

CCS will enable CF Industries to produce a significant volume of blue ammonia each year.

- A chemical process is considered "blue" when a substantial portion of the CO_2 emissions are captured and permanently sequestered before their release into the air.
- Blue ammonia refers to ammonia produced conventionally using hydrocarbons as a feedstock, with the corresponding CO_2 byproduct being captured and sequestered.
- At our Donaldsonville Complex, CF Industries is investing $200 million to install CO_2 dehydration and compression equipment at the facility to enable the production of blue ammonia.
    - The Company has signed a definitive agreement with ExxonMobil for the offtake and sequestration of up to 2 million tons of process CO_2 from Donaldsonville annually in a Class VI well. The CO_2 will not be used for enhanced oil recovery.
    - Once sequestration is initiated, which is expected in 2025, the Company will be able to produce up to 1.7 million tons of blue ammonia per year.
- Additionally, in May, CF Industries and Mitsui & Co. announced[9] an agreement to jointly develop a greenfield ammonia production facility in the U.S. that would produce blue ammonia. CF Industries is currently evaluating a site in Louisiana for this plant.
- Blue ammonia is expected to accelerate the decarbonization of hard-to-abate industries, such as marine shipping and power generation, and will make possible the production of low-carbon fertilizers.

KEY TAKEAWAY

CCS not only aligns with CF Industries' commitment to decrease emissions, but also our goal to generate low-carbon solutions that help our customers and other industries lower their own emissions.

ENDNOTES

1. U.S. Geological Survey
2. International Energy Agency
3. International Energy Agency
4. International Energy Agency
5. U.S. Geological Survey
6. International Energy Agency
7. The International Energy Agency
8. Princeton Net-Zero America Report
9. CF Industries – Mitsui & Co. Announcement