The 2023 US merchant CO_2 report

Act now to secure future supply

By **Maura D. Garvey**

The sourcing issues that continually affect the merchant carbon dioxide (CO_2) business, and especially in the context of the federal government's push toward carbon capture and sequestration (CCS) using tax credits, needs to be well-managed by end-users and suppliers of carbon dioxide (CO_2) in the years ahead. The time to take action to mitigate potential future disruptions is now, rather than when operations and supply chains are suddenly interrupted due to unplanned events.

With demand growth anticipated at 2% to 3% and not enough new sources coming online to support that growth, purposefully conserving CO_2 use, finding or fixing leaking systems, or switching cryogen products should be looked at now. Maintaining and improving current processing-system efficiency, investment in recycle systems, or investment in alternative processing equipment should all be investigated.

2022 was a year marked by the worst shortage experienced by the US CO_2 industry. It took the market by surprise but should not have.

The normal plant turnarounds in the fertilizer industry are expected every year, but the unexpected contamination from the Jackson Dome CO_2 crude came at the same time. The CO_2 sourced from this accounts for almost 15% of merchant CO_2 capacity. In addition, the industry was hampered by unprecedented delays in railroad shipping, with a reported labor shortage for rail companies. There was also a lack of licensed commercial drivers as many had either retired during the pandemic or left the industry – a phenomenon being experienced by many industries, not just industrial gases. The start of 2023, meanwhile, has been marked by high inflation and recession concerns; how that impacts the CO_2 business remains to be seen.

The government's system of green credits, 45Q and 45Z, and the Inflation Reduction Act (IRA) that lowered the volume requirements to qualify and increased the 45Q tax credit to $85/ton of CO_2 sequestered has made it more lucrative for clean CO_2 producers of ethanol and fertilizer to sequester their CO_2 by-product in the ground.

It is an unusual situation in that this is counter to securing the US food supply chain, which needs new CO_2 feedstock sources for food processing to counter feedstock sources that plan to take advantage of the federal tax credit.

Today, investors, project developers, and emitters can put significant value on their financial bottom lines by permanently storing manmade CO_2 underground.

There is a likely tension here, of course, in that diverting CO_2 away from important industries like food and beverage will put a further squeeze on CO_2 supply and will send prices up.

This is a scenario that looks poised to happen. Companies including Navigator CO_2 and Summit Carbon Solutions have proposed building expensive pipelines across Iowa, Nebraska, Minnesota, and South and North Dakota to move CO_2 to locations in North Dakota or Illinois so it can be sequestered underground.

Wolf Carbon Solutions, at the same time, has plans to put pipelines in Iowa and eventually expand into Indiana and Ohio to capture CO_2 from refineries, cement, steel, and petrochemical companies. Another company, Cardinal Ethanol, with its joint venture partner, Vault 44.0, plans to sequester on site in Indiana.

However, it is not all plain sailing with these projects. There is a lot of concern about the safety of pipelines from citizens in the affected states – and the pipeline companies are a long way off achieving final approvals. How many of the Midwest CCS pipelines will ultimately be built remains to be seen. In the meantime, end-users are concerned that eight crude feedstock plants that

are selling at the moment to merchant CO_2 producers have signed on with the pipelines and if that supply gets diverted it would leave supplies even shorter.

2023 will have new CO_2 sourcing coming online from POET and Reliant, with plans for additional sources in 2024 and 2025. The regional shortfalls that affect the West Coast and East Coast remain, as more than three-quarters of CO_2 sources are located in the Midwest and South. New England and the West are burdened with very few sources and therefore higher transport costs for supply. In the US, rail transport is critical to bring product from surplus locations to deficit locations and to back up sources when supply is variable.

Diversity of sourcing to protect the infrastructure has caused some suppliers to consider branching out into other alternative-fuel feedstock for CO_2 production plants. Biogas is in the frame but unfortunately very capital-intensive relative to product volume. Yet with the price of merchant CO_2 increasing, the investment may eventually be justified. Companies like Spectrum Carbonic in Canton, MA and Biocarbonics Ltd of Amsterdam are working to get CO_2 sourced from biogas off the ground.

Next to this, there is also progress on the capture of CO_2 from giant boiler systems in large apartment complexes. CarbonQuest, headquartered in Washington state, installed its CO_2 capture, liquefaction and storage system in a tower on Manhattan's Upper West Side. The CO_2 is trucked to a concrete factory nearby, where it is mixed with the cement and permanently sealed into concrete blocks using technology from Canada's CO_2-into-the-built-environment business CarbonCure.

By the end of 2023, US nameplate (NP) CO_2 capacity is estimated at 36.7 thousand tons per day (ktpd), which is flat over last year as some plants closed or suffered reduced feedstock. This capacity is not, as widely noted, keeping up with CO_2 demand, which is growing closer to 2% or 3% per year – pushing plant capacity utilization.

Future demand growth is projected to continue at this pace of growth each year. This will, of course, result in continued tight supply during times of planned and unplanned plant outages and seasonal demand spikes and price increases. The new sources coming through will keep sourcing flat over 2022, since a number of production plants were idled, shut down, or had reduced feedstock eliminating gains made elsewhere.

In this report we do not cover the large volumes of CO_2 that are piped for enhanced oil recovery (EOR). This is estimated at over 80 million tons per year in the US – a very small part of which uses merchant CO_2.

Intelligas Consulting, on behalf of **gas**world (US Edition), spoke with the independent CO_2 suppliers, equipment manufacturers and CCS pipeline companies to get the insider's view of this critical market and the changes underway within it. In addition, discussions with managers at major industrial gas companies and distributorships occurred throughout the year. Those views and opinions are shared now as we explore the US merchant CO_2 market for 2023 and beyond.

CO_2 markets

CO_2 is integral to how food is processed and packaged. In terms of the US markets for all modes of CO_2 supply, food and beverage comprises 70% of the higher purity merchant CO_2 supply as shown in Figure 1. Dry ice, the fastest growing part to this segment, includes blocks, pellets, snow, and transport ice. Many consumers changed their food buying patterns during the pandemic and still continue to buy weekly groceries through delivery services or specialized food service providers, many of which require dry ice to keep food cold or frozen. However, with high inflation, this use is slowing as consumers rework their discretionary spending.

Recycle systems for dry ice manufacturing is a significant way to reduce overall CO_2 consumption. On average, it takes about 2.4lb of liquid CO_2 (LCO_2) to produce 1lb of dry ice. With a recycle system, it only takes 1.2 to 1.3lb of LCO_2 to produce 1lb of dry ice. The return on investment, depending on scale, can be significant. With over 100 dry ice manufacturing locations in the US, the reduction in CO_2 consumption from locations without recycle systems would be significant.

Beverage use has been in decline over the past decade as consumers have moved away from high-sugar carbonated soda toward lighter, flavored non-carbonated beverages. However, CO_2 use in carbonation for seltzers and microbreweries has brought this segment back and it is steadily growing.

The industrial sector makes up 30% of the US CO_2 market, for welding, wastewater treatment, blast cleaning, production of legalized cannabis, fire systems, and oil field services like well workovers. CO_2 use is fastest growing in the cannabis supply chain for cultivation and for extraction in hemp and marijuana. Cannabis is currently fully legal in 18 states and the District of Columbia for medical and recreational use. And so CO_2 use for cannabis greenhouses has been increasing as more states legalize the use. This is a fast-growing emerging market and provides the industrial gases industry with a great growth opportunity.

Another growing application already mentioned in passing is the injection of CO_2 into cement as a means of improving the strength of the concrete and permanently embedding, and therefore storing, CO_2 in concrete. The CarbonCure technology ensures that the CO_2 will never re-enter the atmosphere even when the concrete ▸

US CO_2 demand by application – 2023

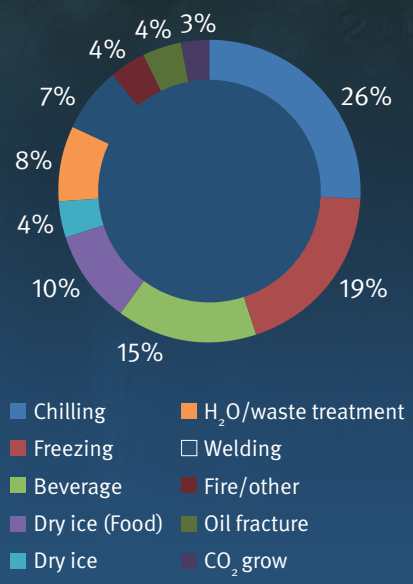

Figure 1. Source: Intelligas Consulting

is demolished. There are hundreds of construction projects in the US that are now using this technology, and it is growing for lots of good reasons.

The merchant CO_2 market is serviced by a complex supply chain where some companies are fully integrated in the CO_2 supply chain as they produce the crude, purify it to liquid, and distribute to distributors and end-users. At the other end of the spectrum, there are some companies that are strictly CO_2 and/or dry ice distributors.

As a product, CO_2 is delivered in several forms, including as crude, gaseous, compressed liquid, and solid (dry ice). It is transferred via pipeline, bulk and micro-bulk trucks, cylinders, and as dry ice. There are many different sources of CO_2, but in the US it is primarily sourced from ethanol (fermentation), natural CO_2 wells, ammonia, and hydrogen/refining. It can also be captured from the gas streams emitted by power plants. There are several potential CO_2 sources in the Midwest (ethanol), South (ammonia) and alternative fuels plants that remain untapped due to the high cost of new plant capital and the cost to distribute from those locations to regions with short supply.

Sourcing merchant CO_2

Merchant CO_2 is recycled and purified from existing CO_2 emissions from other processes that would otherwise have been vented to the atmosphere. CO_2 is a byproduct of a main supplier's operations, so understanding the dynamics of the industries supplying the feedstock is critical to understanding CO_2 supply. The majority of US merchant CO_2 is sourced from hydrocarbon conversion facilities where the primary product is ethanol, ammonia, hydrogen, and wells/EOR. There are a few plants sourced from ethylene oxide. Because CO_2 is essentially a by-product of another process, this makes sourcing risky due to supplier planned and unplanned maintenance, supplier market conditions, and even the weather.

Carbon dioxide sources are also highly sensitive to location, as shown in figure 2. Due to a lack of strategically located alternatives, the current ethanol plant fleet cannot be economically replaced. For example, there are not enough ammonia plants, the second-largest CO_2 source, available to replace ethanol sources. The recent contamination of crude feedstock at the Jackson Dome illustrated the major scramble required to meet the potential disruption of CO_2 supply during the peak summer-to-fall period.

Conserving CO_2 use, fixing leaking systems, or switching cryogen products should be considered to maintain and improve processing system efficiency. Investment in recycle systems or investment in alternative processing equipment should all be investigated. As CO_2 supply tightens, these options need to be strategically considered now to avert costly plant shutdowns.

As shown in figure 3, 36% of crude CO_2 capacity is sourced from ethanol, 25% from wells/EOR, 23% from ammonia, 12% from H_2/refining, and 4% from other alternative fuel sources of CO_2 such as cogeneration/ethylene oxide.

New merchant CO_2 sources

POET, the only vertically integrated CO_2 supplier, brought online three new CO_2 plants in 2021 and the addition of Crystal Lake later this year will bring its total number of merchant CO_2 production facilities to fifteen. This year it will also be expanding production in Laddonia, MN and adding dry ice manufacturing.

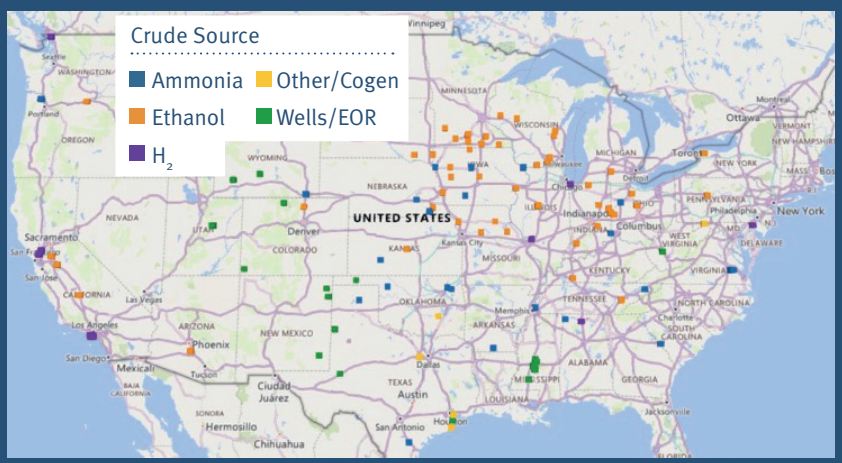

Figure 2. Source: Intelligas Consulting

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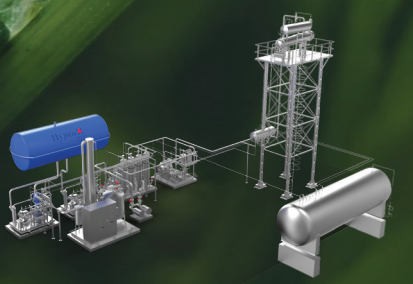

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It previously added dry ice production at its Macon, MO facility.

Independent CO_2 supplier Reliant Gases also has plans to add new sources: another plant is planned this year and possibly two more in the next few years. Part of its strategy is to diversify feedstock sources to increase the stability of its business.

Merchant CO_2 capacity

US NP CO_2 capacity is estimated at 36.7 ktpd in 2023, based on known capacity additions and plants that have gone offline: this is a growth of less than 0.5% a year over the past five years. As mentioned earlier, CO_2 demand growth has been higher than this at around 2% or 3% a year. The capacity utilization rate, which affects the CO_2 available to the market, has been increasing to keep up with demand. We estimated that capacity utilization was about 85% five years ago, but is over 90% today, including the losses due to dry ice production. Other issues like crude feed source reliability, weather, and source plant maintenance will continue to cause periodic tight supply in different regions across the US.

Crude CO_2 sources for the US merchant market – 2023

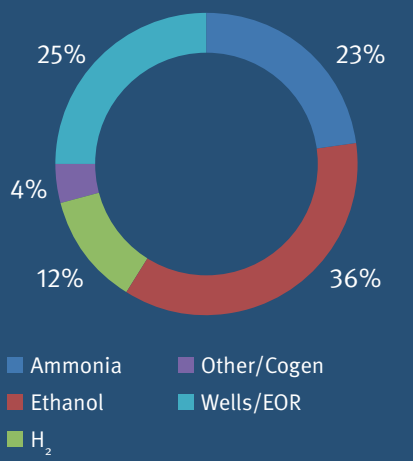


Figure 3. Source: Intelligas Consulting

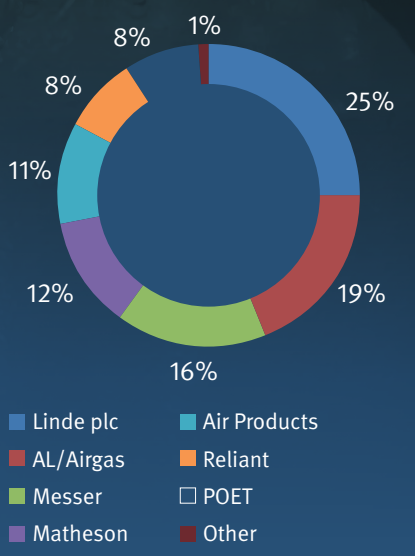
As shown in figure 4, Linde plc is the number-one merchant CO_2 supplier while AL/Airgas is number two. Combined, these two own 44% of supply. Messer LLC is a very close number three and Matheson comes in at number four. The industrial gas companies represent 83% of CO_2 supply, which is declining as POET and Reliant have been opening more new plants, increasing their market shares over the past decade. By the end of 2023, POET will operate 15 plants along with a comprehensive fleet of truck and rail transports Reliant will have 12 CO_2 plants operating by the end of the year, sourced from ethanol, wells/EOR, and ammonia. Reliant has a large fleet of portable storage units and a fleet of railcars for CO_2 delivery.

Merchant CO_2 production is about 10.3 million tons per year. Non-industry independents have increased their share of the merchant CO_2 business over the past five years from a 9% share to a 17% share. Significant players remaining from outside of the traditional industrial gas company circle include Reliant and POET, each with an 8% share of the market with their recent plant additions. Other small companies account for another 1% share. We expect to see growth in the non-industry independents going forward in this very important and profitable CO_2 market. For example, CeeKay Supply, headquartered in St Louis, MO, owns a merchant CO_2 plant in Malta Bend, MO that was purchased from Air Products several years ago. We may see more independent distributors follow this path.

Market opportunities

Merchant CO_2 suppliers need to strategically think about how to secure their infrastructure in this environment of CCS tax credits. This includes actively pursuing new sources of crude CO_2 feedstock as well as considering diversifying their own sourcing. Merchant CO_2 end-users need to act to purposefully conserve CO_2 use by finding or fixing leaking systems, switching cryogen products, or investing in recycle systems.

Player share of US merchant CO_2 capacity – 2023



2023 US CO_2 Capacity = 36.7 KTPD

Figure 4. Source: Intelligas Consulting

Annual CO_2 demand growth is estimated at 2% to 3% per year. This cannot be supported by the potential decline in CO_2 sources from CCS tax credits and with slow progress in the addition of merchant CO_2 sources. However you look at it, new sources are needed. The industry needs capacity growth and new sources such as biogas should be considered. gw

ABOUT THE AUTHOR

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