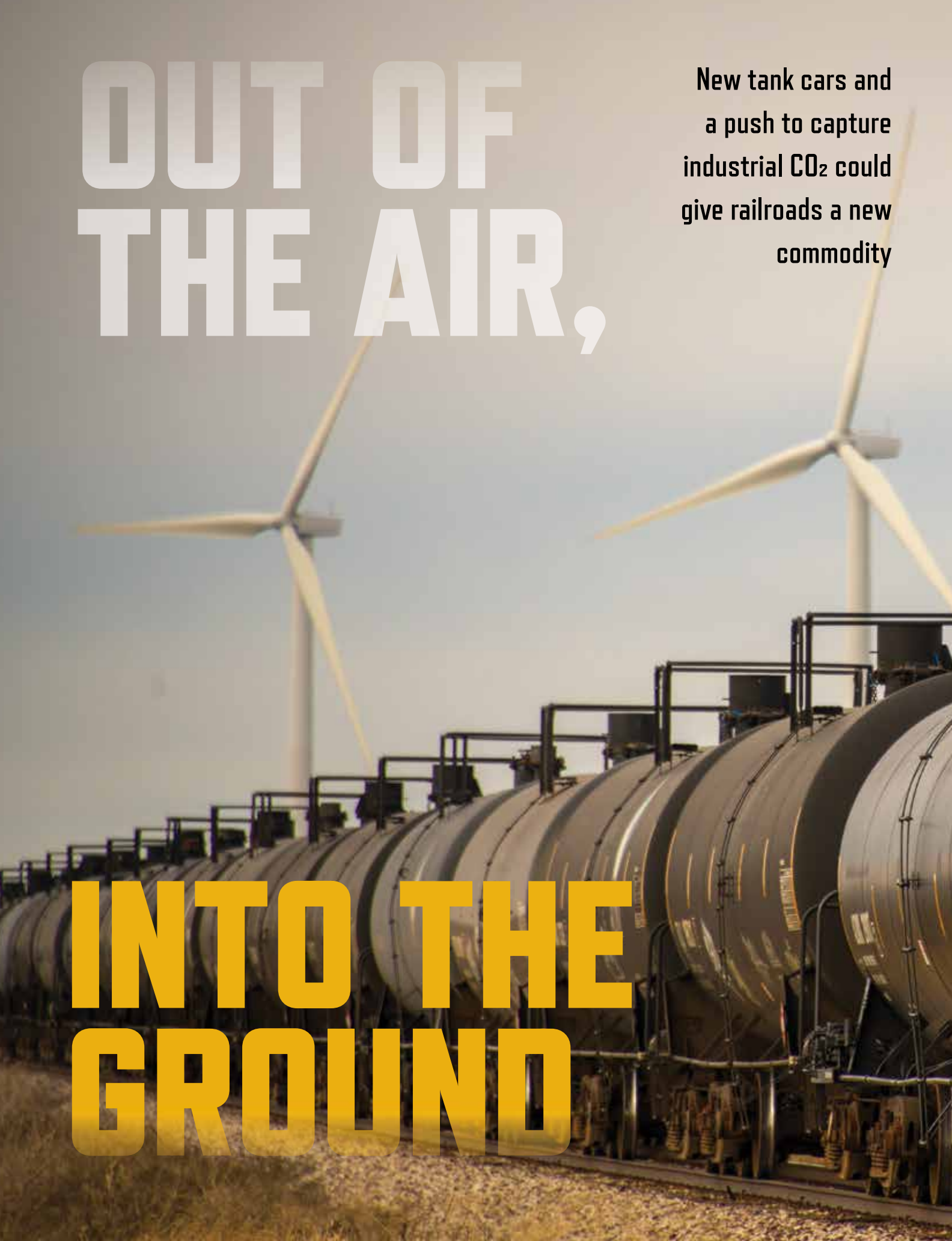
OUT OF THE AIR, INTO THE GROUND

New tank cars and a push to capture industrial CO_2 could give railroads a new commodity



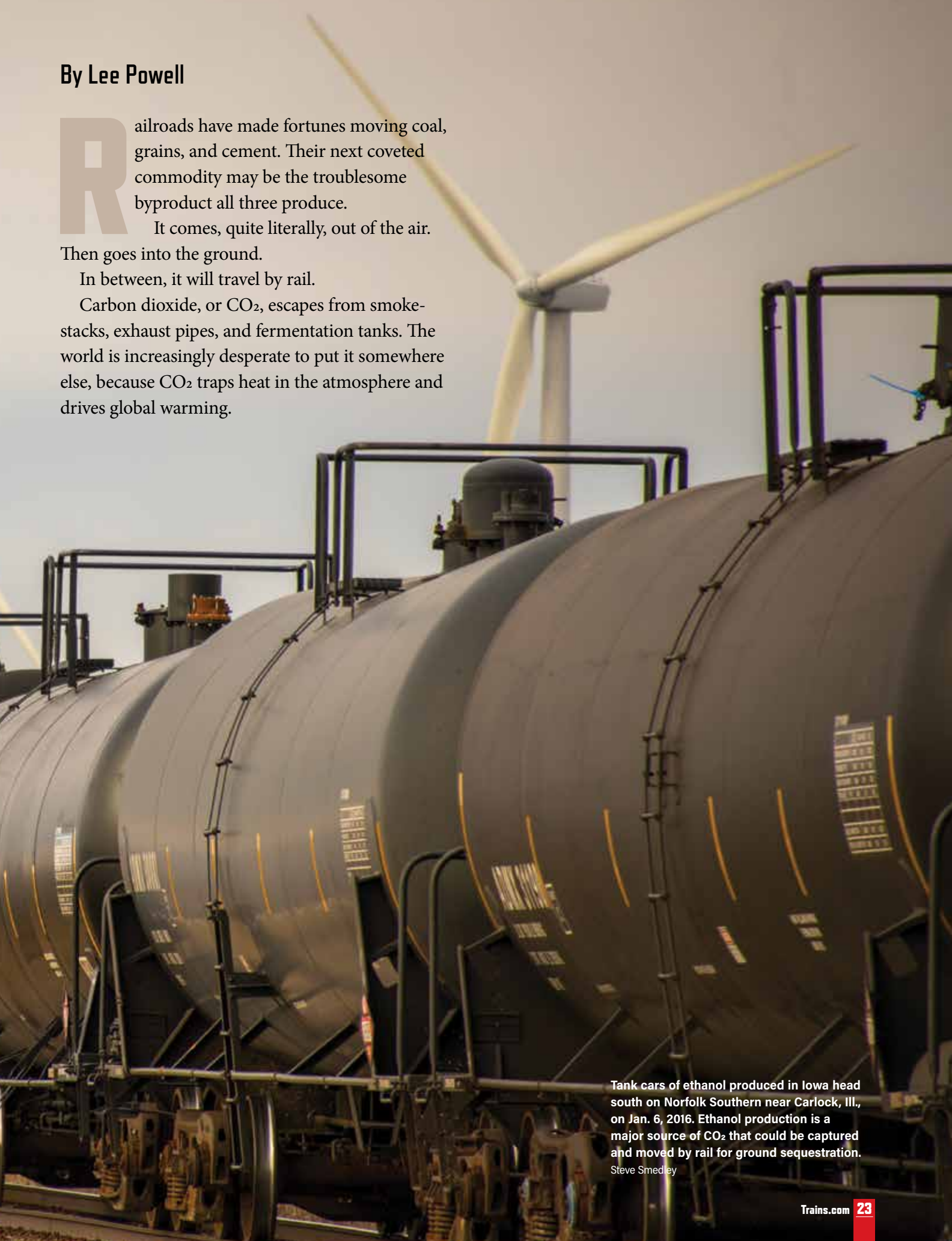
By Lee Powell

Railroads have made fortunes moving coal, grains, and cement. Their next coveted commodity may be the troublesome byproduct all three produce.

It comes, quite literally, out of the air. Then goes into the ground.

In between, it will travel by rail.

Carbon dioxide, or CO_2, escapes from smokestacks, exhaust pipes, and fermentation tanks. The world is increasingly desperate to put it somewhere else, because CO_2 traps heat in the atmosphere and drives global warming.



Tank cars of ethanol produced in Iowa head south on Norfolk Southern near Carlock, Ill., on Jan. 6, 2016. Ethanol production is a major source of CO_2 that could be captured and moved by rail for ground sequestration.
Steve Smedley

From soda to sandstone

Railroads have long hauled CO_2 for industrial uses. The gas is liquefied for transport in tank cars. It puts the fizz in your soda, keeps refrigerated warehouses cold, and makes dry ice. CO_2 is also used to coax oil out of mature reservoirs. Still, annual CO_2 carloads for railroads are small, with most CO_2 moving by truck or pipeline.

But industry produces far more CO_2 than it can use. The surplus enters the atmosphere from everywhere: oil and natural gas operations, steel and iron mills, cement plants and ethanol refineries.

U.S. industries account for about 23% of domestic greenhouse gas emissions, according to the Environmental Protection Agency. That's 1.4 billion metric tons per year.

Reducing these greenhouse gas emissions requires industries to become more efficient or capture CO_2 before it escapes. Government tax credits are making that economically viable by offsetting added costs of capturing and storing it.

Yet not all CO_2 can be captured as cleanly or efficiently. Emissions from burning fossil fuels, for instance, are far harder and more expensive to isolate. But biogenic CO_2 produced during the fermentation stage of ethanol is different. At 99% purity, it is nearly ready for industrial use. Or for capture and storage.



CO_2 already exists as rail traffic, but on a small scale. A Gio Rail GP9u departs St. Thomas, Ontario, with a single CO_2 tank car bound for an ethanol plant in Aylmer, Ontario, on Feb. 14, 2022. Kyle Stefanovic

The question: where to put it?

This is where our railroad story picks up. Ethanol production in the United States is centered in the Midwest, where corn, its main source, and other grains are abundant. Sequestering CO_2 means injecting it underground into geologic formations engineered by nature to hold it.

"You want a layered sequence of rocks, where you have some sandstones which have a high porosity and permeability, which means there's pore space for the CO_2 to go into," says Sarah Saltzer, managing director of the Stanford Center for Carbon Storage at Stanford University. "But you want layers of shales, which are impermeable. What they end up doing is trapping CO_2 down there."

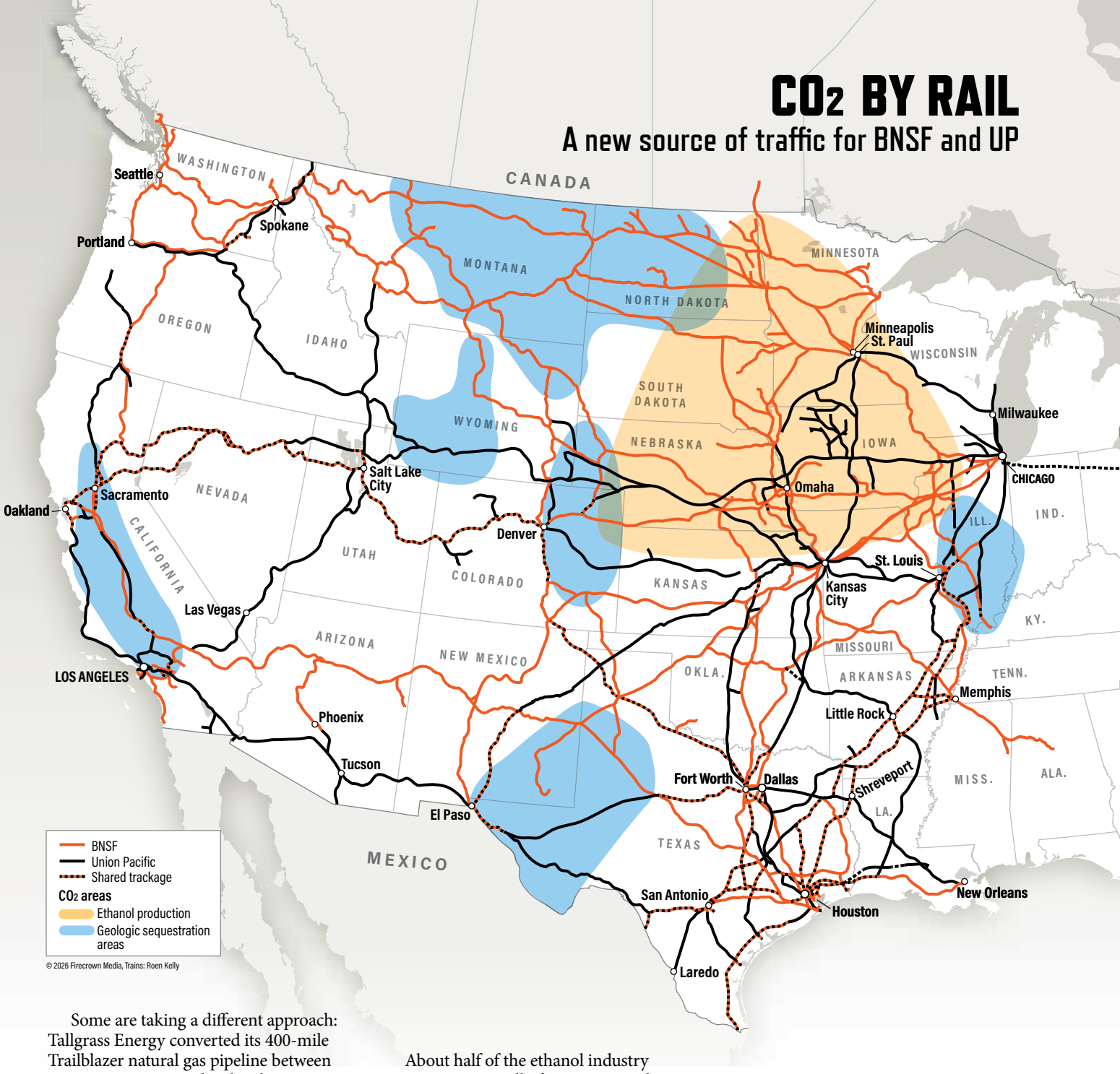
That rock is largely in oil and gas basins hundreds of miles to the west in Wyoming, Montana, or even farther to California. A CO_2 pipeline would get it there cheapest, but an extensive network does not exist. Building one faces long odds, from cost to community opposition along the route.



A Port Harbor Railroad industry job works the Green Plains biorefinery ethanol plant in Granite City, Ill., on July 24, 2025. Steve Smedley

CO_2 BY RAIL

A new source of traffic for BNSF and UP



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Some are taking a different approach: Tallgrass Energy converted its 400-mile Trailblazer natural gas pipeline between eastern Wyoming and Nebraska to carry CO_2, tying in ethanol plants along the way. CO_2 started flowing to Wyoming for underground sequestration in 2025.

In Decatur, Ill., ag giant Archer-Daniels-Midland has been capturing CO_2 from its ethanol operations and sequestering it in a sandstone formation since 2011.

There are more than 40 carbon capture and storage operations in the U.S., according to Global CCS Institute data from 2025. A half dozen are under construction, but some 290 are at various stages of development.

While some ethanol operators may lack pipeline access, more have rail access. Corn often gets delivered by rail, and ethanol and coproducts leave in tank cars or hoppers.

About half of the ethanol industry captures some or all of its CO_2, says the Renewable Fuels Association, the industry's trade group.

"They are willing to sell it and transport it somewhere," says Tad Hepner, vice president of strategy and innovation at the association. "We've just got to figure out how to do that and do it at scale."

Ethanol producers typically rely on trucks to take away CO_2 when it's sold for industrial use, Hepner says. Putting CO_2 into the ground introduces new logistical challenges of distance, volume, and weight that outpace what trucks can handle.

Enter the virtual pipeline, built of tank cars and steel rail. Liquefy CO_2, load it onto insulated tank cars, and move it west. Then offload it at an injection site, where it's sequestered in porous rock for the ages.

"There's going to be a basket of opportunities here" for ethanol plants that lack pipeline access and can't sequester on site, says William Graham, a consultant at PLG.

Carbon by rail

Plot the core Midwest ethanol production on a map. Add in regions where geology is favorable for CO_2 sequestration. Then overlay the networks of the Union Pacific Railroad and BNSF Railway. You can almost see railroad executives' eyes brighten.

"As you produce ethanol, every carload of ethanol produces about another carload



A Tazewell & Peoria Railroad crew works on Oct. 24, 2012, surrounded by tank cars, most carrying ethanol from Archer-Daniels-Midland. ADM, which operates one of three ethanol plants in the Peoria area, captures and sequesters CO_2 at a plant in Decatur, Ill. Two photos, Steve Smedley

of CO_2," said Beth Whited, then Union Pacific president, during an investor day presentation in 2024. "By the God's grace of the Union Pacific franchise, in blue, those areas are prime sequestration points."

Union Pacific lines run through the blue areas on the presentation's map: from the Permian Basin in Texas, through formations in Illinois, to the Powder River Basin and southwest corner of Wyoming.

BNSF says its marketing side has a team focused on carbon transport, with inquiries increasing from producers and offtake partners who could receive CO_2.

"We see significant growth opportunities over the next several years," a BNSF representative tells *Trains*.

Given the reach of their networks, CPKC and Canadian National also enter the carbon-by-rail picture.

But to haul CO_2 you need a tank car — one that keeps CO_2 loss through venting to a minimum, if required at all.

About three years ago, The Greenbrier Companies, which makes railcars, says shippers and railroads started asking about a CO_2 tank car. This followed legislation from Congress incentivizing underground storage of CO_2.

"Whatever they're making, if they're also producing CO_2, it becomes another product for them," says Kari Wagner, vice president of commercial strategy at Greenbrier. "We saw that as a growth space."

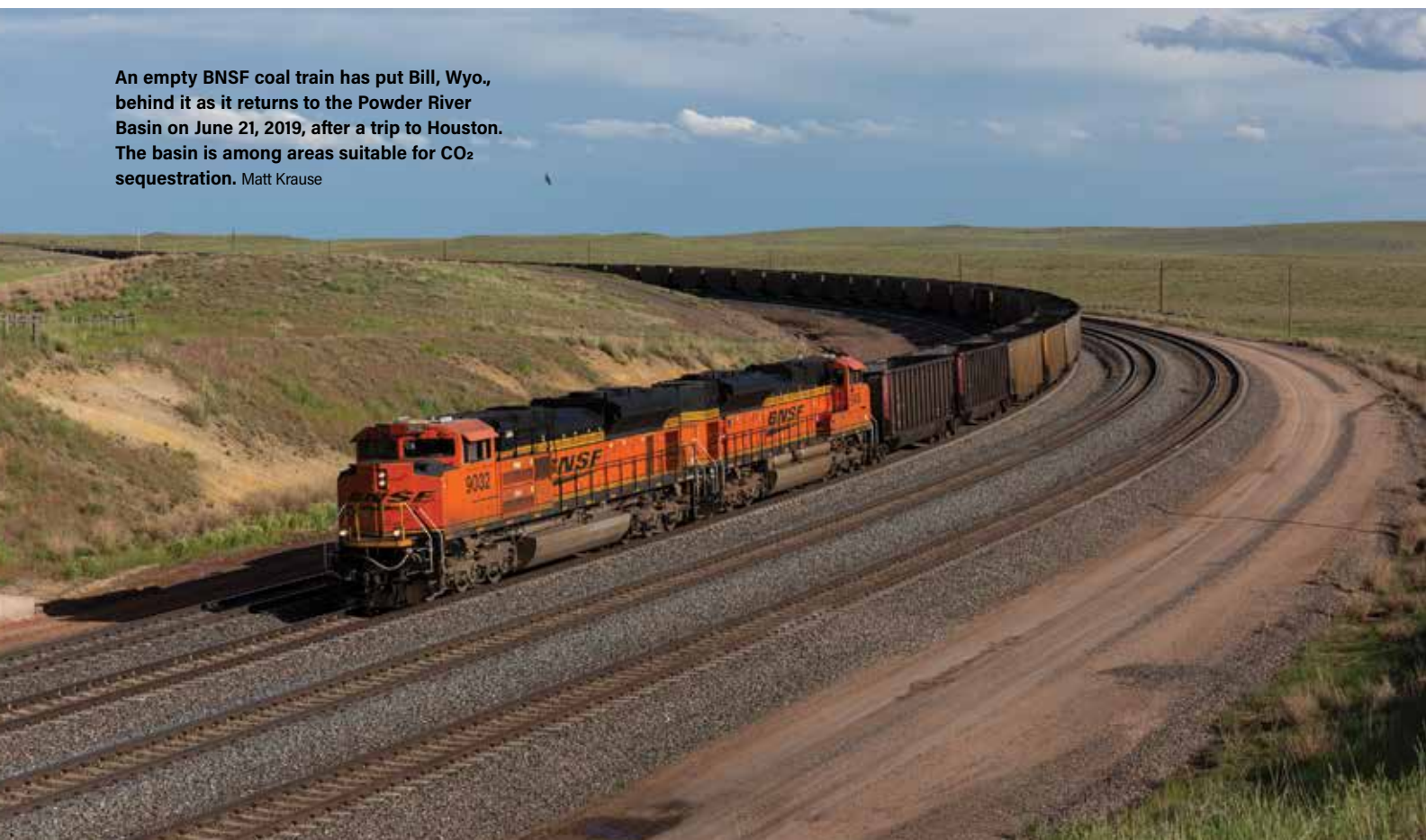
For the next two years, the Oregon-based company studied the market, developed two prototype cars, and ran tests with customers. Wagner says Greenbrier leaned on its experience building other kinds of tank cars, along with refrigerated boxcars.

This spring, with several orders in hand, full production began on what Greenbrier says is a next-generation CO_2 car. Greenbrier isn't saying how many CO_2 tank cars it's making or who the customers are.

The 22,000-gallon, 55-foot car uses a DOT-105J500W specification, a pressure tank car design approved by regulators and in service. The key was insulation and ensuring minimal CO_2 loss. In a company presentation, imaging from a FLIR thermal camera confirms the insulation is evenly applied across the tank.

Time in transit is both a technical concern and a logistical one.

Depending on the load temperature and



An empty BNSF coal train has put Bill, Wyo., behind it as it returns to the Powder River Basin on June 21, 2019, after a trip to Houston. The basin is among areas suitable for CO_2 sequestration. Matt Krause

ambient conditions outside the car, Greenbrier says CO_2 could go 25-plus days before a first vent.

The chief concern for railroads and shippers: "How long can this car go on the rail and get to the destination with zero or very little venting happening?" Wagner says.

"These are expensive cars. You can't have them sit. You've got to have velocity," says Graham, the consultant at PLG. "Otherwise, you have this huge fleet, which would be like a boat anchor around your neck."

TrinityRail, part of Dallas-based Trinity Industries, has been making CO_2 tank cars for industrial users — fizz in soda, dry ice, refrigeration — since the 1980s. It says it has built the most CO_2 cars and is the largest owner. But it, too, is seeing growing interest and orders from the emerging CO_2 capture and sequestration market. Trinity says it's drawing on decades of experience building these tank cars, using data around features like insulation thickness, vent loss, and transit times to adapt its designs.

"This is a rail car operating in a rail environment, but it's constructed very, very differently than most tank cars," says A.D. McKisic, vice president and chief engineer.

Says Cody Aldredge, Trinity's product line engineering manager: "We have quite a few different features that we can turn on and off with the standard base car to get better thermal performance if it's needed."

The cars have long transported CO_2 to industrial users. But some customers also rely on them for on-rail storage before offloading. If time passes and some CO_2 must be vented, it hasn't been a pressing concern. Trinity says that changes with carbon capture, given a federal tax credit of up to $85 per metric ton for qualifying CO_2 that is captured and sequestered underground.

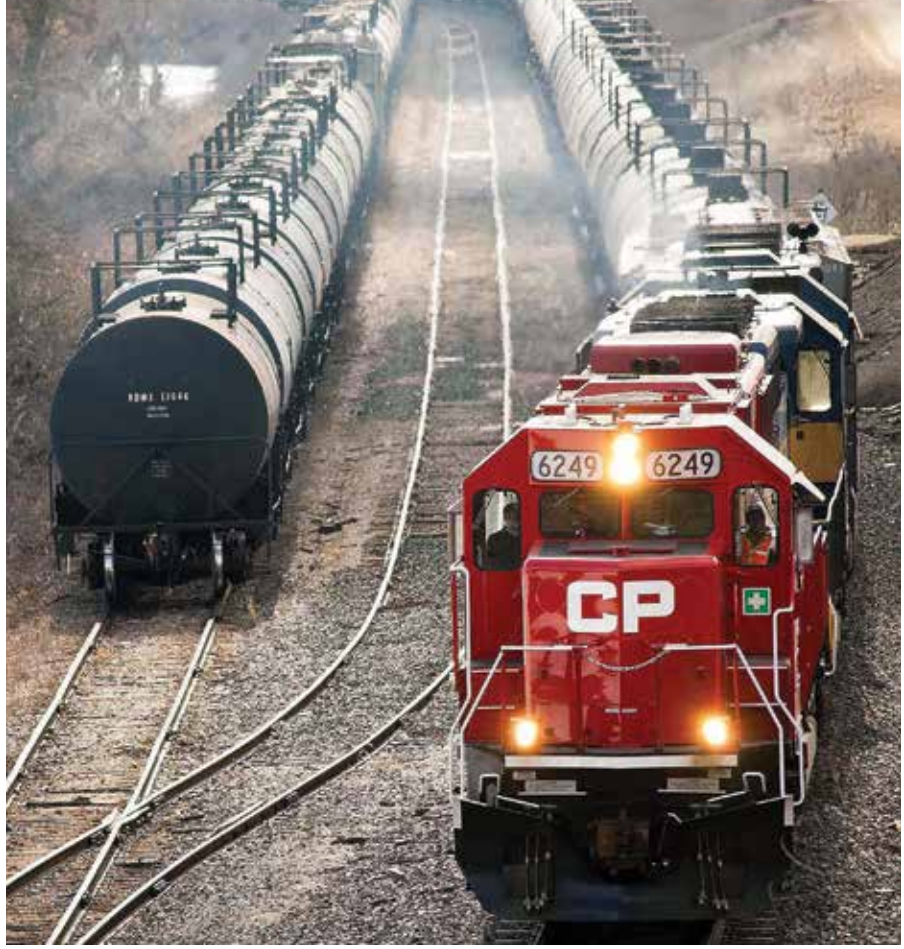
"Every time this thing vents, you know, my $85 a ton is potentially going out the top of the rail car," says Neal Danner, director of sales for Trinity's agriculture team. "And if I'm pretty thin on my economic footprint anyway, I want to try to minimize that."

CO_2 is also a trickier commodity to handle. As McKisic explains, you can quickly splash-load an ethanol or crude oil car, then open the bottom outlet valve at its destination and let everything flow out. CO_2 requires a more controlled process, taking time to unload while maintaining the same pressure in the railcar and storage tank.

If not, "when you unload it, you're going to turn the thing into a block of dry ice instantly," McKisic says. A sudden drop in pressure can cause liquid CO_2 to rapidly expand and freeze into solid CO_2, or dry ice.

CO_2 is an asphyxiant and in high concentrations, it displaces oxygen, which can affect breathing and brain function. Humans breathe in about 0.04% CO_2, but the body exhales 4% to 5%, or roughly 2.2 pounds of CO_2 per day.

Of course, nature produces its own CO_2 — think forests, oceans, volcanoes, and wildfires. But the added volume from combustion of fossil fuels, a hallmark of the industrial age, has outpaced what nature can absorb. And experts say even reducing pollution levels won't be enough, prompting the push toward CO_2 removal.



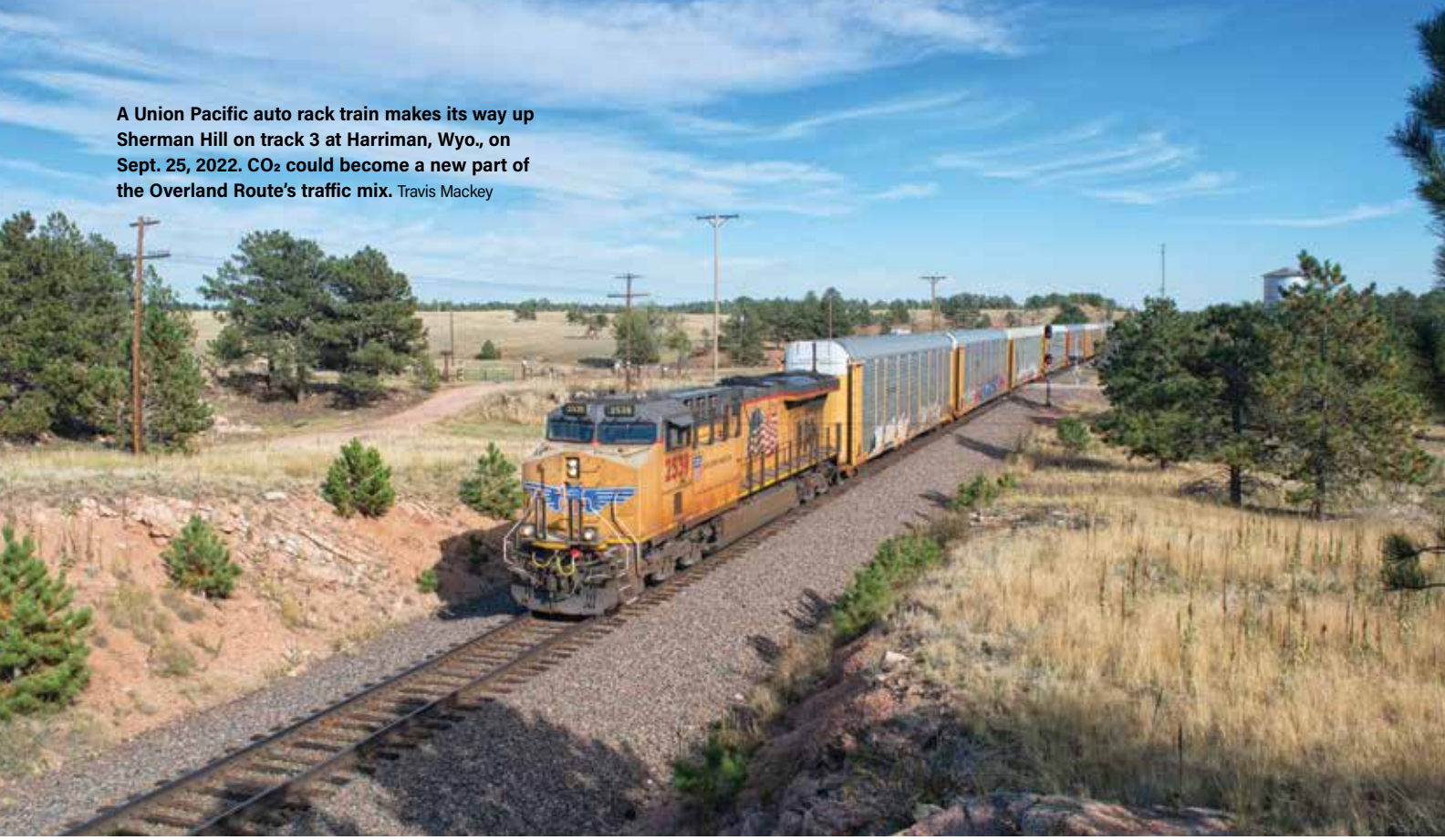
While BNSF and UP are likely to be the biggest players in CO_2 movement, CPKC and CN also reach ethanol producers and areas fit for carbon sequestration. Rebuilt SD60 No. 6249 leads an empty ethanol unit train through the Samoa neighborhood in Sabula, Iowa, on Feb. 16, 2013.

The sequestration terminal

The Union Pacific has stretched across southern Wyoming since, well, forever. It's



After two years of studying the market, Greenbrier is currently building CO_2 tank cars to fulfill orders. The cars meet existing DOT-105J500W specifications. Greenbrier



A Union Pacific auto rack train makes its way up Sherman Hill on track 3 at Harriman, Wyo., on Sept. 25, 2022. CO_2 could become a new part of the Overland Route's traffic mix. Travis Mackey



Frontier Infrastructure Holdings has developed a terminal for CO_2 sequestration traffic near Granger, Wyo. Frontier Infrastructure Holdings

the transcontinental railroad, the stuff of Sherman Hill and Big Boys. Today, the line sees a parade of intermodal and mixed freight. Soon, blocks of CO_2 tank cars could become part of the mix, through Laramie and Rawlins and into the Great Divide Basin. This is sagebrush country, with wicked winds and wide-open vistas where Interstate 80 drapes across the landscape as it parallels the UP.

Southwest Wyoming is also CO_2 country. Some 90% of the world's mineable trona is found here, which is refined into soda ash, used in glassmaking and as baking soda. Another part of the area produces half of North America's helium. Both operations emit CO_2. Add in natural gas production, and that means nearly 10 million tons of CO_2 emissions in a year within a 25-mile radius.

Below all of it, the geology is waiting.

"We know they have the right geology," says Stanford's Saltzer about basins like this one, "because the same geology that resulted in oil and gas being there is the same geology that's really good to trap it all."

And now, to trap CO_2.

Frontier Infrastructure Holdings sees opportunity in the air, underfoot, and on the rails. The Dallas-based energy infrastructure developer has private equity backing and has developed a carbon storage hub north of Granger, Wyo., population 97. This is where the Union Pacific splits, and its onetime subsidiary Oregon Short Line begins the trek across Idaho and into Oregon.

It's the kind of rail connectivity Frontier says is ideal for its Sweetwater Carbon Storage Hub. A spur will lead into the terminal, with a series of low-slung tanks, not dissimilar to other industrial gas offloading sites.

"It's effectively a gas station," says Robby Rockey, founding partner and co-CEO of Frontier. The terminal can unload 48 tank cars per day and process up to 750,000 tons of CO_2 per year, with expansion capabilities of more than a million tons.

Frontier is looking to be operational by the fourth quarter of 2027.

From here, CO_2 will travel by pipeline to an injection well 4 miles away. It's more than 18,000 feet deep, below hydrocarbon production zones, typically around 12,000 feet, and well below drinking water aquifers. Frontier's Class VI wells are the deepest of their kind in the U.S. for carbon storage, some 3.5 miles down. All of this is regulated by the Environmental Protection Agency, says Stanford's Saltzer, especially concerning groundwater.

"Sites that are considered for permanent CO_2 injection go through a very rigorous evaluation," she says. "The EPA reviews it; it takes quite a few years, upwards of three or

four years per permit."

When injected into underground reservoirs, CO_2 is more fluid than gas.

"Over time, it will bind with the mineral content in the rock and become part of the matrix," Rockey says.

Eventually, pipelines will also bring captured CO_2 emissions from trona and helium sites to Frontier's injection wells.

Frontier has put together a contiguous leasehold that's just shy of 100,000 acres. Its parent, Tailwater Capital, has raised more than $6 billion for energy and infrastructure since its founding in 2013.

"We fully expect to sell out our first well and move into drilling a second well," Rockey says, adding that Frontier plans to expand as demand grows. "We have huge, huge demand for it, just because there are so few places you can actually put CO_2 into the ground."

Who knew a corner of the least populated U.S. state could become a CO_2 kingmaker? Certainly not the builders of the transcontinental railroad when passing through here in 1868. They were building a virtual pipeline by rail.

The right-of-way for the Union Pacific? Courtesy of President Lincoln, as Frontier Co-CEO Steven Lowenthal likes to say.

The business of carbon

A transcontinental railroad built for commerce is now being asked to serve a larger purpose. The ambition is a greener future that puts less carbon into the sky. Driving it is money: an ecosystem of tax incentives and tradable emissions credits designed to create a payment chain, a sort of economic flywheel where costs are covered and profit flows to everyone in the chain.

The carbon capture industry revolves around several tax credits. One rewards lower carbon intensity fuels like biofuels for clean transportation. The other incentivizes geologic carbon sequestration and injection at $85 for every metric ton captured from industrial and power production. It's this credit that aligns most closely with CO_2 by rail efforts and the search for suitable underground storage sites.

Ethanol sits at the center of both. Federal standards requiring the use of renewable fuels have made it a cornerstone of the American fuel supply.

"The one that fits within our current infrastructure and is able to be blended into traditional petroleum fuels is ethanol," says Hepner of the Renewable Fuels Association.

This is part of a larger carbon removal effort: McKinsey estimates the industry could be worth up to $1.2 trillion by 2050.

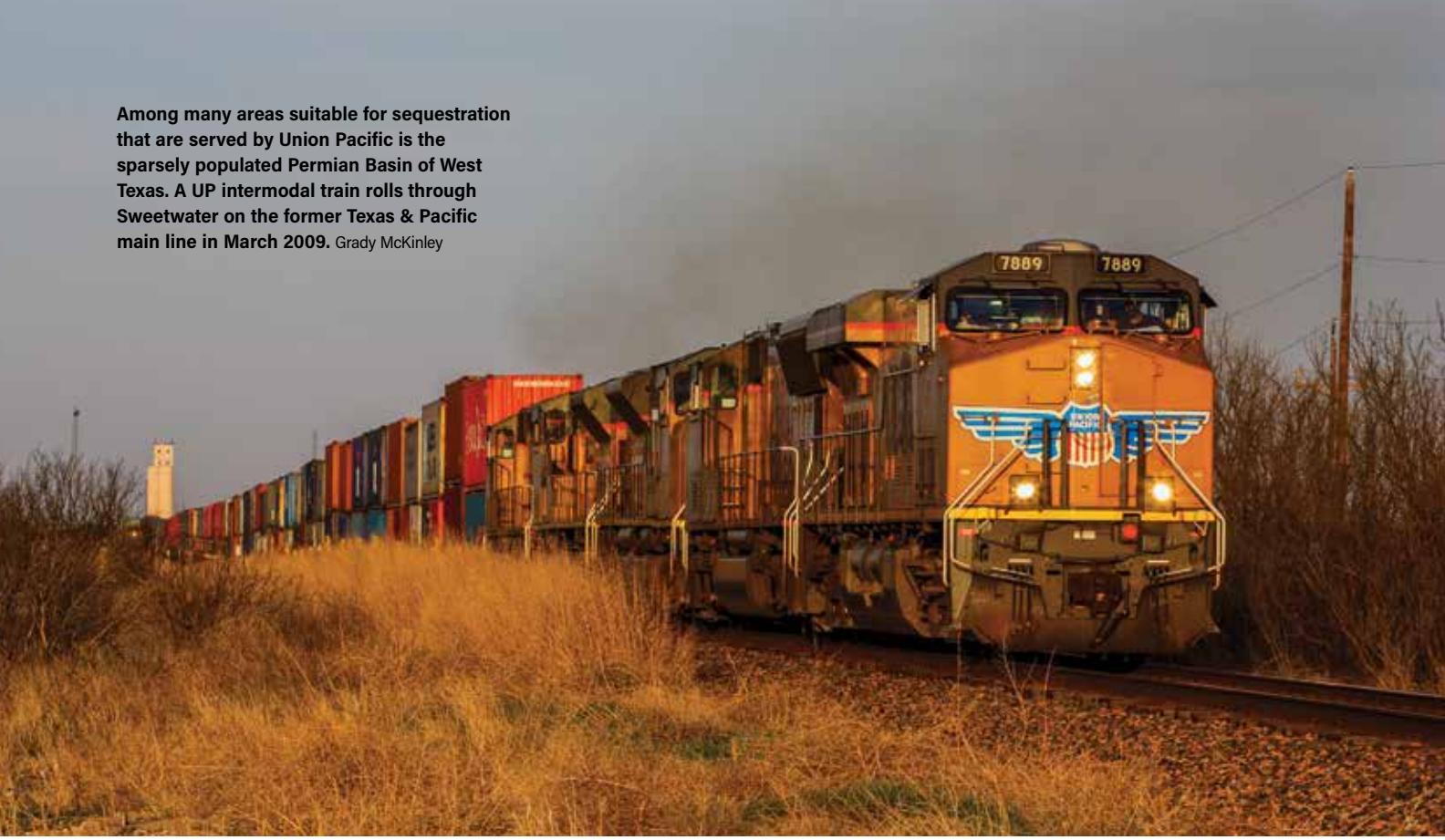
Companies like Microsoft are buying carbon removal credits, and the potential returns are driving innovation, like direct air capture, which uses fans and chemical processes to extract CO_2 directly from the



The Bloomer Line's classic high-nose GP10 works the One Earth Energy ethanol plant on the west side of Gibson City, Ill., on March 6, 2020. Steve Smedley



Startup firm Remora is working with UP and Norfolk Southern to develop a system to capture carbon from locomotive exhaust. Remora



Among many areas suitable for sequestration that are served by Union Pacific is the sparsely populated Permian Basin of West Texas. A UP intermodal train rolls through Sweetwater on the former Texas & Pacific main line in March 2009. Grady McKinley

atmosphere. But the market is still finding itself: some efforts are advancing while others are pausing or pulling back.

Fossil fuels and industry released about 38.1 billion metric tons of CO_2 in 2025, a new high, according to the Global Carbon Project. In the United States, the largest CO_2 emitters are transportation and electrical power generation.

In real terms, capturing tailpipe emissions at scale is not practical. And capturing emissions at the power plant stack is a different challenge. Instead, there's a drive to make engines more efficient or switch to hybrid or electric power. Coal-fired power plants are giving way to natural gas, solar, and wind.

Regulations in the U.S. have mandated lower emissions from locomotive engines: Tier 4 rules regulate pollutants like NOx and particulate matter but not CO_2; reductions in carbon emissions have largely come through better engine design and emissions control technologies.

Still, a climate-tech startup sees an opportunity to capture CO_2 from locomotive exhaust. Remora is developing technology for existing diesel fleets, where exhaust flows into a trailing tender car, CO_2 is trapped, liquefied, and offloaded at fuel stops [see "Startup company aims to capture locomotive exhaust carbon," "News," August 2025]. The CO_2 is then sold for commercial use, like those fizzy beverages.

Remora is working with Norfolk Southern and Union Pacific, along with Anacostia Rail Holdings' Pacific Harbor Line in the Los Angeles area. It has its own GE C40-9W for use as a testbed.

It's a race to find opportunities at the smokestack, and the source.

Ethanol's CO_2 is pure and easy to capture — the low-hanging fruit of carbon sequestration. Getting it from other industrial sources becomes more complicated.

Cement kilns burn fossil fuels to reach temperatures needed in production, releasing CO_2. But there's also a chemistry problem: heat limestone, and it breaks down into calcium oxide and carbon dioxide. This chemical reaction accounts for about 60% of cement's emissions and means a more complex, less pure CO_2 stream that's harder to capture.

But railroads move millions of tons of cement and raw materials. Plants are often well served by rail, which could present opportunities to haul away CO_2 by tank car.

Iron and steel production also share a combustion and chemistry problem. Capturing CO_2 means separating it from a messier mixture, at greater cost.

In oil and gas, CO_2 is a byproduct and a tool. CO_2 has long been injected into oil fields to push out remaining crude, a process called enhanced oil recovery, or EOR. Historically, it's been the focus of most carbon capture operations in the U.S., with CO_2 coming from both underground reservoirs and natural gas processing. Here, CO_2 can move by pipeline, particularly in the Permian Basin in Texas and New Mexico. But EOR's goal is more oil production, not permanent storage.

From niche to network

Rail's role in carbon capture is coming into focus. Tank cars are being built. Offload terminals are being sited. What remains hazy is the timeline and the scale.

It's likely the tank car fleets will follow an established industry pattern, owned by the car builders themselves or lessors like financial institutions. Railroads are loath to tie up precious capital dollars in freight car fleets that are expensive to build and maintain and roam widely. Instead, they invest in expanding and maintaining their networks, optimizing everything for velocity.

But there may be room for a new kind of player, says Greenbrier: third parties who manage the logistics of CO_2 transport and maybe even the credits that come with it.

Greenbrier sees CO_2 moving in blocks of 20 to 40 cars, not loose manifest freight or long unit trains. It says a million tons of CO_2 per year will require some 352 tank cars.

Tom Jackson, Greenbrier's vice president of marketing and general manager, says this is not a Bakken crude oil or frac sand boom. Then, energy companies, manufacturers, and lessors raced to build a great number of cars only to see volumes crater when new pipelines came online and oil prices collapsed.

"This is not like that," he says. "It's an emerging market that didn't exist before, so the fleet's going to get built out. But it's

more of a discrete, deliberate fleet buildout that we're going to do."

Greenbrier is building the car. Now it has to sell the concept, especially to new entrants who have never used rail.

"There's some education to be had out in the industry," says Greenbrier's Wagner. It's an education in logistics. And geography.

There is a certain poetry to where this ends up. The basins of southwestern Wyoming, whose deep rock was formed by the same ancient forces that created oil and gas, are now being asked to reclaim what burning them released. The exhaust of engines. The energy behind ethanol. And a railroad just happens to run through it.

"You're basically putting CO_2 back where it came from," says Saltzer of Stanford. "You know that the geology worked. It held the oil and gas in place for millions of years. So you know it will work to hold the CO_2 in place." T

Lee Powell is a writer and producer in Texas. He has reported for The Dallas Morning News, *the Associated Press, and* The Washington Post.



Tank cars roll through Fort Worth, Texas, on the Fort Worth & Western on July 3, 2026. If railroads have their way, strings of new CO_2 tank cars will become a regular part of the traffic mix. Lee Powell



A westbound Union Pacific merchandise train climbs out of Rawlins, Wyo., in May 2009. Wyoming's geology is ideal for CO_2 sequestration, as is its proximity to major rail lines. Travis Dewitz