

With California mandating zero emissions, Bay Area agencies are split on hydrogen vs. electric

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In September, the governing board of Santa Cruz Metro made a big bet on the future of green public transit when it approved the purchase of 57

buses fueled by hydrogen—the largest order of hydrogen-fueled buses made so far in the U.S.

The brand-new vehicles, which could arrive as soon as the end of 2024, have water as their only tailpipe emissions. They will replace most of the authority's aging [buses](#), which run on compressed natural gas.

There's just one problem: Most of the hydrogen that is currently available is produced from [fossil fuels](#), and that causes more of the greenhouse gas emissions that hydrogen buses are supposed to reduce. Only when hydrogen can be made by using electricity generated from clean sources like solar and wind to split water into hydrogen and oxygen will the fuel be truly "green." And that means Santa Cruz Metro is betting on technology that isn't widely available yet.

"I have a total recognition that it is not perfect," said Michael Tree, CEO of Santa Cruz Metro. "We took a little risk."

By 2040, under rules laid down by the California Air Resources Board, transit agencies across the state must convert their entire fleets to buses with zero tailpipe emissions.

But across the Bay Area and the Central Coast, they are planning different routes to get there, with most investing more heavily in battery-electric buses than hydrogen.

San Francisco Muni, for example, currently runs more than 550 diesel-electric hybrid buses, almost 280 electric trolley buses running off overhead cables, and just 10 battery-electric vehicles. It plans to phase out the hybrids and replace them all with battery-electric and electric trolley buses.

But hydrogen buses have no place in Muni's plans. Marin Transit,

Sonoma County Transit, and the Napa Valley Transportation Authority are similarly planning to switch to entirely battery-electric fleets.

Other agencies are hedging their bets. The region's other giant, AC Transit, which serves Alameda and Contra Costa counties, has 23 hydrogen buses and only seven battery-electric models. As it phases out its more than 550 diesel buses over the coming years, they will be replaced with a mixed fleet—with more than two hydrogen buses to each battery-powered bus. SamTrans, which serves San Mateo County, is similarly planning for a hydrogen-dominated mixed fleet.

So proportionately, Santa Cruz Metro stands out for going all-in on hydrogen. And by placing a big order for hydrogen buses now, it has made an early commitment to the technology.

"We tend to be very innovative and forward-thinking and be on the forefront. We are bold in our response because we see the immediacy of the problem," said Shebreh Kalantari-Johnson, who chairs the Santa Cruz Metro Board.

According to Jack Brouwer, director of the National Fuel Cell Research Center and the Advanced Power and Energy Program at UC Irvine, deciding the right number and type of zero-emission buses depends on many factors, including the electrical grid infrastructure, the bus routes, and the road type.

Battery electric buses, for example, consume more power on hilly roads. Santa Cruz Metro was concerned about that with its current routes, even though San Francisco Muni saw no problem with battery-electric buses ascending the city's peaks. "Our battery buses have been tested on steep hills and can handle any route that our hybrid buses would be assigned to," Marley Miller, associate engineer with San Francisco Muni, wrote in an email.

Kalantari-Johnson sees other advantages to hydrogen buses. Each bus can be fueled in less than 15 minutes before it is ready for a 350-mile drive, while it can take up to eight hours to charge a battery for a much lower range of up to 200 miles. Hydrogen buses are also about 11,000 pounds lighter, which will be easier on Santa Cruz County's roads.

But some experts are not still convinced by the plan, given that genuinely clean hydrogen fuel is not yet available.

"It's putting the cart before the horse," said Ray Minjares, heavy-duty vehicles program director with the International Council on Clean Transportation in San Francisco. "We will not decarbonize our transportation sector on the basis of fossil hydrogen," he said.

Hydrogen buses have electric motors, powered by a fuel cell in which hydrogen combines with oxygen from the air to form water and generate electricity. Currently, buses like those operated by AC Transit depend on hydrogen fuel that is produced through a process called steam-methane reforming, where natural gas is turned into hydrogen and carbon dioxide in the presence of a catalyst and heat.

This fuel is dubbed "gray" hydrogen. According to a 2021 study, the carbon dioxide-equivalent [greenhouse gas emissions](#) from producing gray hydrogen are more than 25 percent higher than burning natural gas for heat.

Right now, Santa Cruz Metro has no hydrogen fueling stations and no access to genuinely green hydrogen. But on November 3, a public-private partnership called ARCHES, the Alliance for Renewable Clean Hydrogen Energy System, received \$1.2 billion from the Biden Administration to help build a clean hydrogen hub in California. The state government is providing another \$2 billion and industry is supposed to invest around \$9 billion.

Santa Cruz Metro is banking on this being a game-changer. "The word on the street was that ARCHES was gonna get funded," said Tree of the board's decision to place its big bet on hydrogen buses. Over the next eight years, the hub will invest in infrastructure including hydrogen production and liquefaction facilities, pipelines to distribute liquefied hydrogen across the state, and fueling stations. Crucially, it aims to produce hydrogen by splitting water into hydrogen and oxygen, by a process called electrolysis, using renewable electricity from sources including solar, wind and biomass.

According to a February 2023 report from the International Council on Clean Transportation, buses fueled by gray hydrogen have more than twice the total emissions of battery-electric buses, given the current mix of fuels used to generate power. But a bus fueled by green hydrogen would have about half the total emissions of a typical battery-electric bus run on a mixed grid.

But if Santa Cruz Metro's bet is to pay off, the cost of making green hydrogen will have to come down. Making gray hydrogen from methane costs about \$2 per kilogram, or about 90 cents a pound. But the current cost of making green hydrogen by electrolysis is between \$9 to \$12 per kilogram (\$4.10 to \$5.40 per pound). And for green hydrogen buses to be as cost-efficient as battery-electric models, that would have to come down to around the same cost as making gray hydrogen.

Santa Cruz Metro currently has a \$16 million operating budget, with about \$4 million of this budget allocated for fueling costs, according to Tree. That isn't sustainable in the long-term. "It would be tough long-term to be paying nine bucks a kilogram," he said.

Tree is confident that the hydrogen hub investment will bring the cost down. But Mark Jacobson, an environmental engineer at Stanford University, believes that hydrogen buses will always struggle to compete,

as storing electricity in a battery is inherently more energy-efficient.

"We're going from electricity to producing hydrogen, to then returning the [hydrogen](#) back to electricity," he said. "It's not very efficient but you can certainly make it clean."

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