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How hard will it be to develop California's electric grid of the future? Like repairing a car while it's still moving

California aims to derive 100 percent of its electricity from carbon-free sources by 2045, if not sooner. (Sarah Hamaker / Associated Press)



Despite the challenges, a top California grid executive says the state's clean energy goals can be reached and the power system will be more reliable

By **ROB NIKOLEWSKI**

The chief operating officer for the [California Independent System Operator](#) — which manages the electric grid for about 80 percent of the state, including San Diego — says California's ambitious clean energy goals can be reached. But he also warns there will be plenty of bumps on the road.

"I'm optimistic because I'm starting to see coordinated, strategic thinking at various levels about the challenge," said [Mark Rothleder, COO and senior vice president at the California ISO](#).

Rothleder was in La Jolla last week [giving the keynote address](#) and participating in one of the panel discussions at an [energy conference sponsored by Cleantech San Diego](#) titled "The Great Transformation: Designing the Grid of the Future."

State policymakers want California's power system to rely on 100 percent carbon-free sources [by 2045 — if not sooner](#) — and make sure the lights come on whenever customers flip a switch, while also keeping rising utility rates from reaching eye-watering levels for many consumers.

In an interview with the Union-Tribune, Rothleder said he's under no illusions that remodeling a grid that drives the fifth-largest economy in the world will be easy.

California has recently demonstrated it can run its grid from [clean energy sources for short periods of time](#).

"The question is now," Rothleder said, "how do you do that with a set of resources for 8,760 hours out of the year (24 hours a day for 365 days), not just a few targeted hours when you have low load and favorable conditions."

One big challenge is developing thousands of a megawatts of renewable energy resources and incorporating them into the electric grid. California's current 50-gigawatt power system needs to expand to 120 gigawatts to include all the carbon-free resources needed to meet the state's 2045 target.

The California ISO, also known as the CAISO for short, estimates 7 gigawatts (or 7,000 megawatts) of clean power needs to be added each and every year for the next two decades. And those additional resources must be integrated while the electric grid keeps delivering power.

One of Rothleder's colleagues likened the job to taking a car and making a major repair job — such as replacing the engine and changing the tires — without stopping the vehicle. "We can't just shut down the system and stop energy flow while we do this transformation," Rothleder said. "We've got to keep the car running."

Hurdles to clear

Another challenge? Coordinating all the cleaner resources while keeping the system reliable. Natural gas makes up the largest single source of California's power, but it is a fossil fuel. In the California Energy Commission's most recent tabulation, [natural gas accounted for 47.46 percent of in-state generation](#) in 2022.

“Frankly, we still need some of those gas resources around for a while longer, while we get those (cleaner) technologies in place,” Rothleder said. “We’re using (natural gas plants) less and less, which is good, but having that capability and using them when you need them is still an important operational” priority.

Mark Rothleder, chief operating officer at the California Independent System Operator, speaks at an energy conference sponsored by Cleantech San Diego earlier this month. (Rob Nikolewski/San Diego Union-Tribune)



The CAISO added 5,660 megawatts of new power onto the grid last year and in the next six to eight months of 2024, a little more than 1,100 of additional megawatts are scheduled go into commercial operation.

Battery storage is one of the state’s largest growth areas, increasing 30-fold to almost 7,200 megawatts in the space of three years. Batteries are considered crucial because wind and solar production onto the grid is intermittent.

Solar production may be abundant during the day but practically vanishes after sunset or when smoke and clouds obscure the skies. And when the wind doesn’t blow, production from wind farms peters out. Battery storage can fill in the gaps. For example, storage can soak up excess power generated by solar during the day and discharge the electricity later, especially from 4 to 9 p.m. when California’s grid is under the most stress.

Coordinating all the resources is imperative for grid operators. “I don’t get any slack in not being able to meet the demand” from electricity customers, Rothleder said. “And reliability is Job 1 ... Their expectation is, ‘Anytime I need it, I want to be able to use it.’”

In the coming years, California is counting on major contributions to its electric grid from floating offshore wind projects. Energy officials expect wind farms planned off the coast of Northern and Central California to generate as much as [5 gigawatts of power by 2030 and 25 gigawatts by 2045](#). For perspective, the Diablo Canyon nuclear plant in San Luis Obispo produces [2.2 gigawatts of capacity](#), which accounts for about [9 percent of the state’s power mix](#) each year.

But while the [first offshore wind project in New York](#) came online last month, the industry has seen [other projects postponed or even canceled](#) due to higher interest rates that have increased financial costs and inflation that has driven up prices for turbines, steel and labor costs.

A rendering of the different types of offshore floating wind turbines that could be used off the coast of California. (Illustration by the National Renewable Energy Laboratory)

The CAISO last year offered a peek into what it imagines the state’s grid will look like when it [unveiled its first 20-year outlook](#). The largest single resource addition is projected to come from 53,212 megawatts of utility-scale solar. But adding that amount will take up a lot of space. The outlook’s appendix estimated that 53,212 megawatts of solar capacity would require using more than 372,000 acres of land. For perspective, that’s about enough to cover Lake Tahoe three times. (Lake Tahoe’s surface area take ups [122,200 acres](#).)



Getting it done ... and at what price?

Rothleder said integrating all the different energy sources into the grid cannot be done in isolation. “If you can do this strategically, holistically and we can all work together, I am confident there are solutions,” he said. “They may not be cheap solutions, but there are solutions. And then the challenge is how do you do this reliably, affordably and at the right pace and the right sequence to minimize the bumps in the road.”

Affordability is a major concern, with utility customers across California seeing [monthly bills rising](#) at a relentless pace.

Switching to a system that’s much more reliant on electricity infrastructure has [critics of the state’s energy transition](#) predicting that costs will keep spiraling upward. CAISO’s 20-year outlook, with its projected portfolio of significantly more renewable energy sources, estimated a price tag of [about \\$30.5 billion in transmission costs alone](#).

Rate-setting is out of the purview of the CAISO but Rothleder suggests looking at rates and costs more broadly, to include a household’s entire energy footprint — not just utility bills, but transportation costs that consumers pay as well.

“If your electricity bill goes up, but your gasoline bill goes down because you’ve converted your car from gasoline to electricity, what’s the entire energy bill cost for a consumer in California? I think you may get a different picture about that,” Rothleder said.

San Diego Gas & Electric last year released a [“Path to Net Zero” study](#) that looked ahead to 2045 and came to a similar conclusion. [The report predicted](#) SDG&E electric and natural gas bills will be higher in constant dollars in 2045 than 2022. But homeowners who electrify will see a dramatic reduction in what they spend on gasoline, and the overall savings at the pump will largely offset the higher utility bills.

“It probably would be helpful to explain that to the public,” Rothleder said, and tell people “what to expect along the way so that they’re not shocked — or if they are shocked, they at least understand what’s happening, why it is happening and what the trade-offs are.”

The threat of blackouts

Last year went relatively smoothly for California’s grid, largely due to moderate weather and a wet winter that boosted generation from hydroelectric facilities. The CAISO did not have to issue a single [Flex Alert](#) — a request for utility customers across the state to voluntarily reduce consumption in the late afternoon and early evening hours, usually during the summer when millions of people crank up their air conditioners and put the grid under strain.

But things were much different in previous years. In August 2020, a “heat dome” that settled over nearly all of California led to [two consecutive days of rotating power outages](#) that caused some areas to go without electricity for up to 2 1/2 hours. The Golden State [narrowly avoided a repeat in 2021](#) and in 2022, the CAISO issued a record [10 straight days of Flex Alerts](#).

A man sits in the shade of his umbrella at a dog park under high tension power lines in Redondo Beach during a statewide power outage on Aug. 16, 2020. (APU GOMES/AFP via Getty Images)



“We’ve tried to build enough redundancy in place and there’s a timing and sequence thing that you have to work out,” Rothleder said. “We bring on new resources with new capabilities in a certain time frame and we have to do this before we retire other resources that we’re relying on. And maybe (it’s advisable to have) a one-to-two-year overlap so that we get secure on those new resources with the new capability before we let the old resources go.”

The state’s grid operator normally imports about one-quarter of its power needs from neighboring states.

The CAISO is one of the members of the [Western Energy Imbalance Market](#) that covers about 80 percent of energy demand in the region. Working with 22 system operators in 11 states across the West, the WEIM uses sophisticated technology to find and deliver energy to members at low costs and in real-time. Since its inception in 2014, the WEIM reports it has produced more than \$1.7 billion in benefits and savings to California consumers.

The CAISO is also working with other stakeholders to establish an [extended day-ahead electricity market called EDAM](#) that aims to take the success of WEIM and expand it over a broader geographic footprint. A few days before Christmas, the Federal Energy Regulatory Commission gave the OK to many of the provisions that will launch the extended day-ahead market in 2026.

“That is a huge benefit,” Rothleder said. “Again, not a single solution but part of the mix of tools you’d want in a comprehensive solution.” While the balancing act can be daunting, Rothleder thinks California’s grid of the future can be more reliable and resilient than the current system. “If done correctly, you will have a lot more tools,” he said. Rather than relying on a few big power plants generating most of the state’s electricity, the power system would be supplied by multiple sources.

“Think about it,” Rothleder said. “If you lose a large nuclear plant, that’s 2,000 megawatts, all at once” that could go offline from the grid. “If you have this distributed over multiple smaller amount of resources, your ability to absorb some of those losses is much greater because it’s not as big a chunk. So I really do think in the long run, we will have a more reliable system out of this. But it has to be thoughtfully designed to achieve that.”

In about 20 years or so, Californians will know how things work out.