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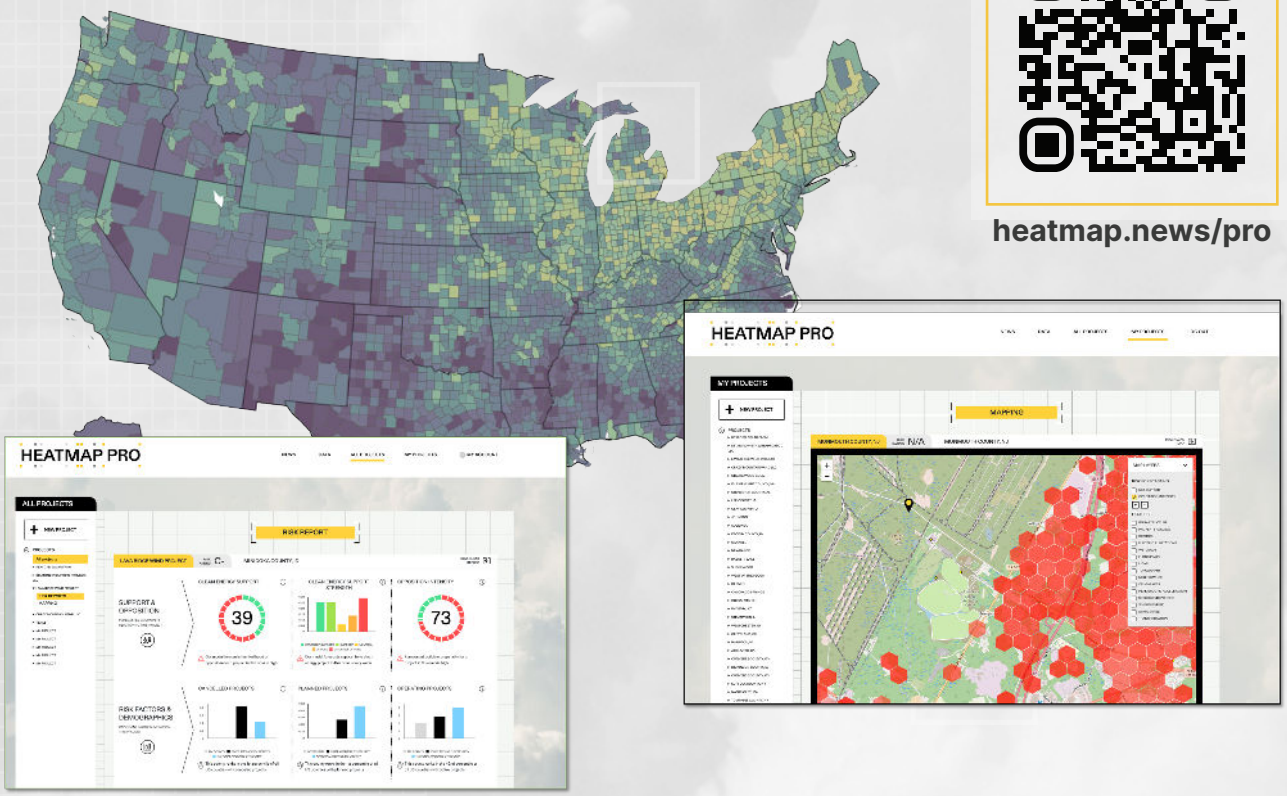

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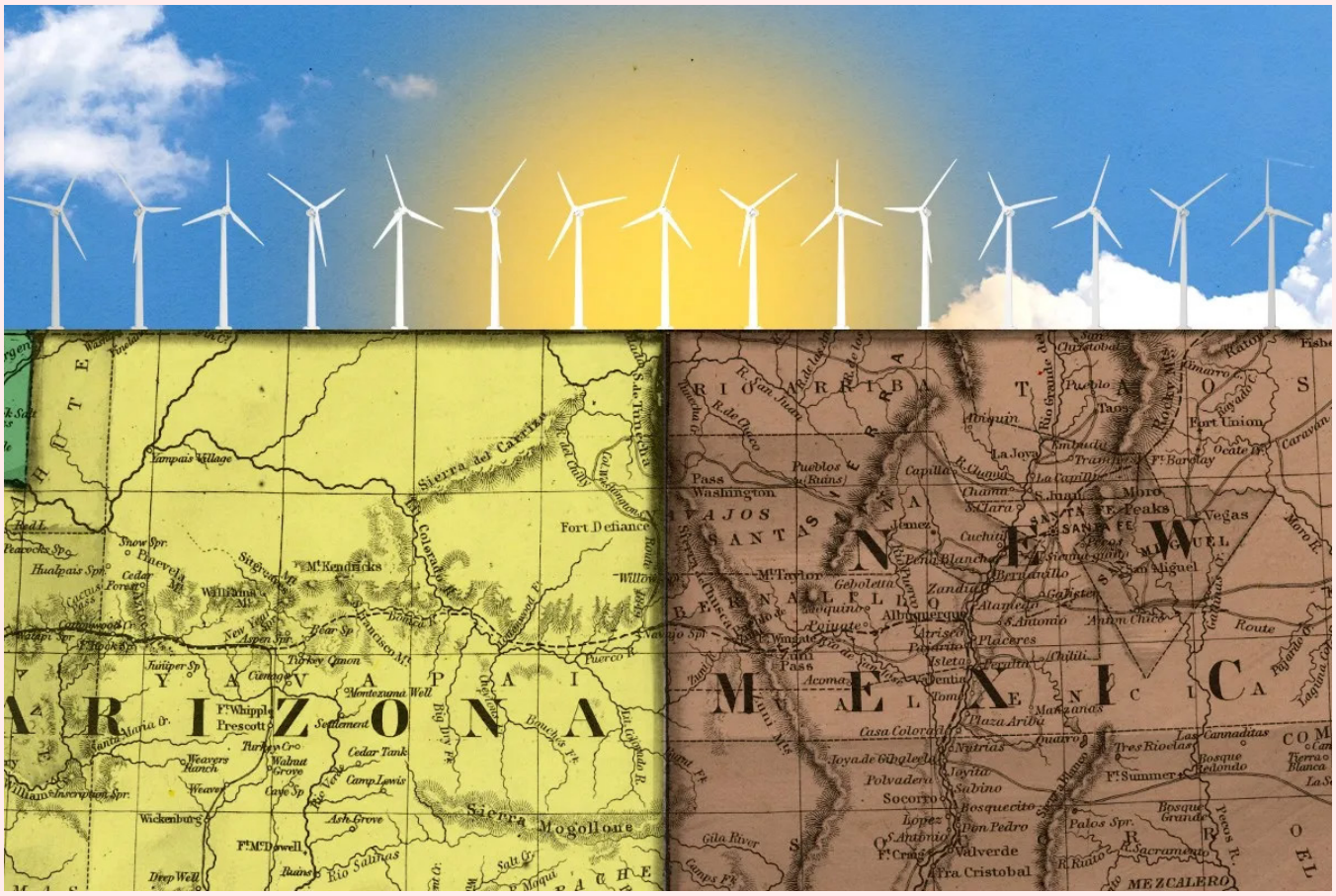
Heatmap News is climate news for the real world. We tell the inside story of the race to fix the planet, with deep reporting on emerging decarbonization trends, like electric vehicles, clean hydrogen, and carbon capture, in addition to climate change and its impact on our economy, politics, and society. (You can read more about us here.)

The Long, Strange Success Story of America's Biggest Clean Energy Project

The roughly 550-mile SunZia power line is crucial to America's climate goals. Here's how it almost didn't happen — and how it was saved.

ROBINSON MEYER ▪ **JUNE 18, 2024**



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Two years ago, John Podesta met with Jennifer Granholm, the U.S. Secretary of Energy. Podesta, a longtime Democratic aide, had just started a new role in the Biden administration, overseeing the Inflation Reduction Act's implementation, and he was going to meet with Granholm about high-priority clean electricity infrastructure.

First on the agenda was a list of transmission projects to ferry electricity from wind and solar farms to cities and suburbs where it would actually be used.

"Up pops the list," Podesta told me later. The first project was a line called SunZia.

"My jaw dropped," he said. "I thought we solved that in 2014!"

No, no, Granholm said. There had been twists and turns. But now it was back.

If you want to understand why the United States can't build infrastructure, look at SunZia.

Envisioned as a roughly 550-mile high-voltage transmission line connecting a sprawling 900-turbine wind farm in central New Mexico to the growing cities of Arizona and California, SunZia is — according to its developer — one of the largest electricity projects in American history. When it's finished, the line will deliver 4,500 megawatts of electricity to consumers. Only two power plants nationwide produce more: the Grand Coulee Dam in Washington, and the Vogtle nuclear power plant in Georgia.

"It's the largest clean energy project in America, and I think the largest clean energy project in *the Americas,*" Podesta told me. "It's huge."

For nearly two decades, SunZia has bounced through successive stages of regulatory review, financial restructuring, and litigation. It has been fought over, bought, sold, and at one point, forcibly relocated by the Department of Defense. Today, 18 years after it was first conceived, it is finally under construction. At least one outstanding lawsuit is contesting its right of way. If all goes according to the current plan, SunZia will begin to deliver power to consumers in 2026.

SunZia's timeline would present an inconvenience — arguably an embarrassment — in any context. In this particular context, it could even invoke despair. "It's a classic example of how we've gotten excellent at stopping things in America, and if we're going to take the climate crisis seriously, we have to get excellent at building things in America," Podesta said.

The stakes are far larger than electricity bills. The United States has pledged to reach net zero greenhouse gas emissions by 2050. Reaching that target will require tripling the size of America's power grid in the next 26 years, according to Princeton University's Net Zero America study. If America were to power its grid entirely with renewable energy — a feat that many experts doubt is possible — then it would need a grid *five times* as large as what it has now.

Even if that study (led by my podcast co-host, Jesse Jenkins) overstates the need for new transmission, the mechanics of renewables dictate that the country must hook up its existing grid to the places where the sun shines brightest and the wind blows hardest. The Desert Southwest — and New Mexico specifically — features some of America's richest solar and wind resources. To decarbonize America, that energy must be harvested and transported from these largely unpopulated areas to the dense urban centers where people actually live.

That is easier said than done. Although transmission projects are unusually important for climate change, they are also unusually difficult to build, especially compared to fossil fuel infrastructure. Or, well, not difficult to *build*, exactly — it's just a big power line, and we know how to put those up — but difficult to *get permission* to build. Ultimately, that permission is in the hands of the government. But when it comes to long, linear infrastructure projects like power lines, there isn't really a single "government" to talk about it with in the first place.

To build a transmission line, a developer has to secure permission from every state, county, city, and property owner along the route. If any of them denies the project, poison-pills it with endless requirements, or even sits on an application, then the entire project stalls. (Building a natural gas pipeline, by contrast, requires getting permission only from a single federal agency.) Electricity utilities don't usually like transmission lines because they erode their local monopoly over power generation and distribution. Those utilities have such great influence at the state and local level — through outright lobbying and by funding local Little League teams, churches, and more — that they can often convince politicians and regulators to slow down or block a line.

For these reasons and more, America's rate of new transmission construction has plummeted over the past few decades. In this history of stasis, though, SunZia presents a special case. SunZia is such a high-profile project that its enormous delays have terrified the rest of its small industry. If SunZia was defeated nearly 20 years after it was first proposed, then it could render the field un-investable, one investor confided to me.

Yet for all the hand wringing, SunZia is a success story. It has now fought off its most credible lawsuits, meaning that it is likely to get built. Within two years, huge amounts of climate-friendly electricity could be coursing through the American desert.

Earlier this year, I went to Arizona to examine more closely why SunZia has been so difficult to build and what finally allowed it to move forward. I spoke to the SunZia's developer and the environmentalists who support the project — as well as those who oppose it. The question I was trying to answer: What did it get right? If America is going to reach its climate goals, learning those lessons — and learning them well — is going to be crucial. When SunZia is completed and running at full blast, it will generate roughly 1% of the country's electricity needs. After that, to fully decarbonize the electricity sector, we will need to run it all back 99 more times.

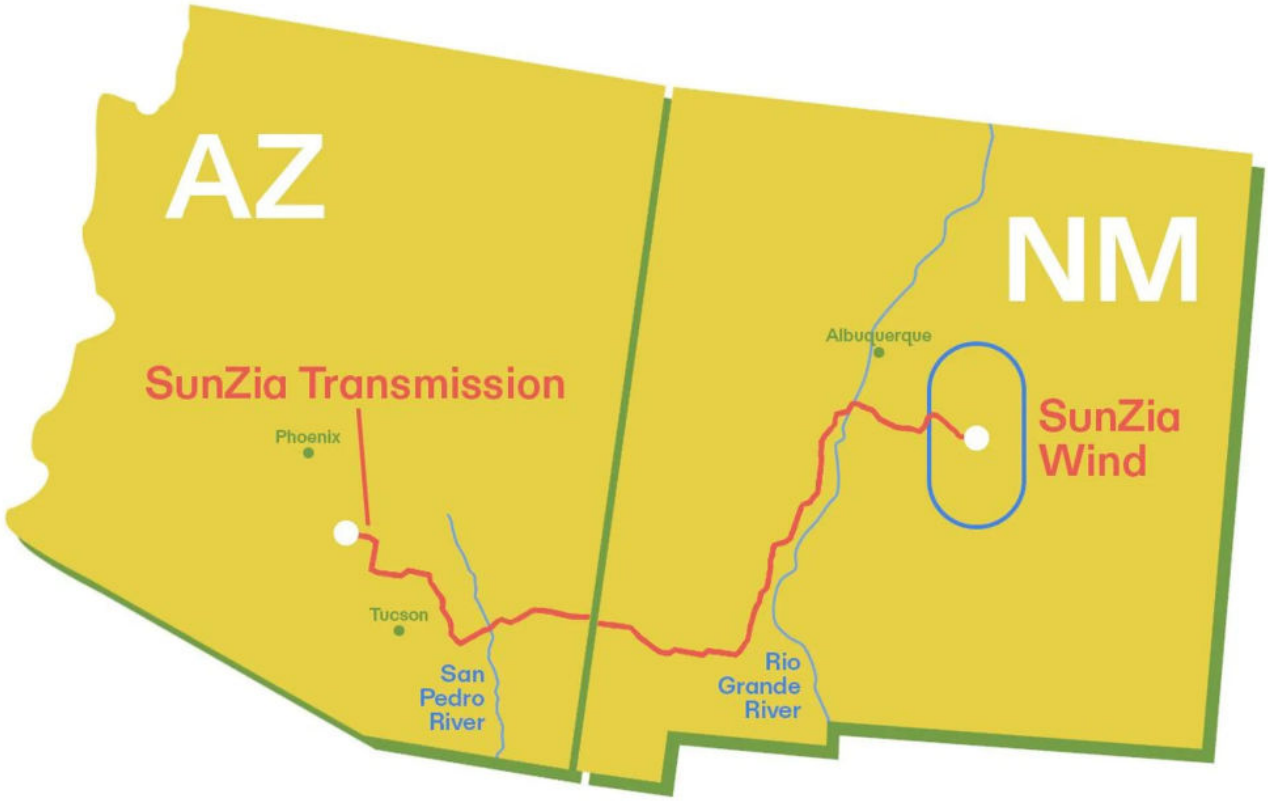
The saga of SunZia begins in the summer of 2006, when representatives from utilities, developers, and government agencies from across the Southwest gathered to discuss expanding the region's power grid. After looking at energy and economic data, the group decided that Arizona and New Mexico needed a powerful new transmission line to connect the swelling populations in the west with New Mexico's abundant wind and solar potential.

The Southwest Power Group, a Phoenix-based energy company that had attended the conference, soon put together an ownership team of four utilities and stepped in to lead the project. They christened the line "SunZia," after the setting sun on Arizona's flag and the sign of the Zia people on New Mexico's flag.

In June 2008, Southwest Power Group applied to the Bureau of Land Management, or the BLM, the national agency tasked with managing federal lands, for the right to build a major new transmission line across the two states. "Local, state, and federal permitting efforts will begin immediately," the coalition announced in an optimistic press release.

The first phase of SunZia was expected to initiate commercial operation by 2013, the developers added.

Back then, when a developer tried to build a transmission line, they had a strong but not definitive sense of the route — in part because the federal government could ask them to change it if needed. Under the National Environmental Policy Act, the government must study how infrastructure projects — or, really, *any* federal action — affect the environment, inviting input from local governments, environmental groups, and nearby Native American nations. (That law does not require the government to *protect* the environment in any substantive way; it simply requires that it consult everyone and study a project's impact.)



Heatmap Illustration/Pattern Energy

Southwest Power Group knew that SunZia would begin in central New Mexico, southeast of Albuquerque, and that it would eventually connect to a large-scale renewable project there. (At the time, the vast wind farm hadn't yet been planned.) Then it would proceed due west, passing below Albuquerque, before veering southwest and passing north of the White Sands Missile Range. After that, SunZia would turn west again, eventually crossing into Arizona. It would pass near Tucson, Arizona — the exact route was uncertain — before finally turning north again and terminating in a substation in Phoenix's southeastern suburbs. From there, the existing grid could ferry electricity into Phoenix or further toward California.

This route presented many difficulties, but two river crossings dominated concerns over the project.

First, SunZia had to cross the Rio Grande. Although that river is best-known back East for forming the U.S.-Mexico border, it begins in the Colorado Rockies and flows in a southerly direction through New Mexico, bisecting the state. In other words, you cannot cross New Mexico without crossing the river.

The Rio Grande creates an environment in New Mexico unlike anywhere else in the United States: a high-desert wetlands, where hundreds of thousands of birds from across North America spend the winter. The BLM and the Southwest Power Group decided that SunZia would shoot through a small gap between two wildlife refuges — the Sevilleta National Wildlife Refuge to the north, and the Bosque Del Apache National Wildlife Refuge to the south — that had been formed to protect these birds.

Second, SunZia would have to pass near Tucson, Arizona by one of three routes, each of which required some kind of sacrifice. The first option involved running the line alongside an existing 345 kilovolt transmission line that passed to the city's south and west. But the city and county opposed that route, and it required securing a permit to cross the Tohono O'odham Nation's land, which the tribe refused to allow.

That left two remaining routes. One option ran near the center of Tucson, passing very close to overwhelmingly poor and Latino neighborhoods. This route raised "environmental justice" concerns, the BLM said, in that it forced poor people of color who already live alongside energy infrastructure to bear even greater environmental costs for it. The other choice was to run SunZia east of Tucson and through the beautiful San Pedro Valley, one of the most pristine desert ecosystems remaining in Arizona. Although vast swaths of that valley are privately owned, Native American relics and cultural sites dot its landscape.

Forced to choose between harming civil rights or damaging the environment, the BLM reluctantly chose the latter. But to blunt some of the damage to the valley, the bureau directed the developers to follow existing pipelines or transmission lines for more than 40% of its mileage. It also ordered SunZia to commission studies of archeological sites along the route's path so they could be mitigated or avoided entirely. (SunZia would later adjust its route to avoid some of the most archaeologically sensitive sites.)

Studying these options took much longer than the Southwest Power Group had ever imagined. The Bureau of Land Management published its final environmental study on SunZia in June 2013 — the same year SunZia was once due to begin operation. Southwest Power Group was finally ready to start construction. Then the Penatagon stepped in.

Scarcely a month after SunZia's course was finalized through New Mexico, the Pentagon filed a formal protest. The approved route passed way too close to the White Sands Missile Range, the complaint said, and the BLM had "not adequately analyzed the significant risks to national security" that would result from building it.

The White Sands Missile Range is the country's largest military installation and is vital to New Mexico's economy. By suggesting that SunZia might imperil the base's activities, the Pentagon was at risk of killing the project. But something about that claim didn't sit right with Senator Martin Heinrich, a first-term Democrat and former Albuquerque city councilman. Heinrich was an engineer by training, and his father had been a utility lineman, giving him at least some familiarity with how the power grid worked. Why did a big power line threaten the military base miles away? He asked MIT's Lincoln Laboratory to investigate whether the line would damage the base as much as the Pentagon said.

Six months later, in March 2014, the study was completed. According to news stories at the time, the classified study found that SunZia would impair the base's activities, but that its effects could be mitigated. After months of intense negotiations with the White House, the Pentagon, the Department of the Interior, and Senator Heinrich's office, Southwest Power Group agreed to bury five miles of the power line — an expensive solution, but one that would allow the project to move forward.

By that point, however, SunZia had captured the public's attention and polarized New Mexicans. The state's Republicans gleefully undermined the project in the press. As the Obama administration prepared to approve the line, a Republican congressman and former oil company CEO intoned that SunZia would "permanently damage" national security.

"Greenlighting the completion of SunZia along the chosen route is a reckless rush to judgment without thorough examination," the congressman, Steve Pearce, said. (The federal government had, by this point, been studying SunZia for seven years.) He worried too that the line would "potentially destroy ancient Pueblo sites."

In 2015, the Obama administration finally approved SunZia's route. After nearly a decade, Southwest Power Group had the federal government's permission to build SunZia.

But that was only the first step: Now, the company had to secure state and local permits. That would prove even more confounding.

The truth is that New Mexico's environmentalists had never been comfortable with what SunZia would mean for the state's wildlife. They hated the Rio Grande crossing. They were particularly stressed about what the structure might mean for sandhill cranes, a regal and crimson-headed bird that migrates to New Mexico from as far away as Alaska and Siberia. Few sights are more treasured by the region's birders than the vast flocks of cranes that form in the Bosque del Apache Wildlife Refuge each winter.

Birders imagined that SunZia's towers and low-hanging wires could maim or kill the elegant cranes. *If SunZia could bury the line to help White Sands Missile Range,* people asked, *why couldn't they also bury it below the Rio Grande and save some birds?* They whispered, too, that the line would transmit not wind-generated electricity as promised, but rather gas-fired electricity from a power plant owned by Southwest Power Group.

When Southwest Power Group applied for a state permit to cross the Rio Grande, the birders' moment came. The developers were still finalizing construction details and didn't seem to have a strong sense of where exactly the line would go. In 2018, New Mexico's utility commission rejected the permit and asked the Southwest Power Group to come back with more information.

SunZia was flailing. Building the line had taken much longer than Southwest Power Group had ever envisioned. Burying the line, even for a few miles, had made it a much more costly project. Now environmentalists doubted that it would help fight climate change at all and were making increasingly expensive demands.

Then a new company came into the picture: Pattern Energy, a San Francisco-based energy developer partially owned by Canadian pension funds. Pattern promised to build a vast wind farm — comprising more than 900 turbines — at SunZia's eastern end. It became the line's "anchor tenant," in the jargon of energy developers, and, more importantly, the project's public face.

"They came in, and they were quite honestly pretty frustrated with the way that [the SunZia project] had approached community engagement and talking with environmental groups," Jon Hayes, a wildlife biologist and the executive director of Audubon Southwest, told me. Up to that point, SunZia had been the story of an "industry just trying to push their lowest-cost alternative through sensitive areas," he said.

But Pattern behaved differently. "Why it was a success is that Pattern acted and negotiated it in good faith with us," Hayes said.

Pattern hired researchers to study how and where the cranes fly. It agreed to install infrared lights on SunZia's towers as an "avian avoidance system" that will be visible to cranes and make the lines shimmer in the dark. It bought a nearby farm to create a sandhill crane reservation (the cranes also eat corn from the fields) and donated the water rights to local conservation organizations. When a coalition of environmentalists, including Audubon, asked it to study the benefits of burying SunZia, Pattern warned that doing so could permanently alter the project's economics — but they studied it anyway. Burying the line would ultimately have been more disruptive than building lines, Hayes said.

Heinrich's office continued its involvement in the negotiation and also helped move the process along. Environmental groups that had initially opposed the project switched their allegiance, Audubon Southwest included.

Pattern's research led it to conclude that the line should be moved *into* Serivetta National Wildlife Refuge so it could be co-located with another transmission line. (Moving it inside the refuge would also, counterintuitively, avoid the largest bird populations.) When Pattern brought the new route to local environmentalists and the Audubon Society, the conservationists agreed. Pattern then took the extraordinary step of applying to the BLM for a new route through New Mexico. By adopting the new route, SunZia could also avoid the White Sands Missile Range entirely, avoiding the costly need to bury the line.

Cary Kottler, Pattern's chief development officer, told me that the project's pre-existing climate credentials incentivized it to find ways to make SunZia more environmentally sound. "I think we did figure out a way for environmental groups to support infrastructure, which has not always been the case in the past," he said.

"Pattern being a company that was willing to have discussions with us in good faith — and that conversation happening before the re-permitting process — was, I think, really important," Hayes agreed.

Heinrich echoed that thought in a statement. "I am especially proud of our work to engage local communities, conservation organizations, and other stakeholders to find pathways forward while securing strong economic and conservation benefits for New Mexico," he told me. He also thanked the BLM, the U.S. Fish and Wildlife Service, and Pattern Energy, for their "hard work and collaborative approach."

"I firmly believe that when we work together, we can build big things in this country," the senator said. "SunZia will have a massive economic impact in New Mexico while bringing us one major step closer to meeting our climate goals and conserving wildlife habitat."

In 2020, Pattern entered into a deal with New Mexico's Renewable Electricity Transmission Authority, a state agency meant to encourage long-distance power lines. The deal allowed New Mexico to reap some of the benefits of owning SunZia, and it spared SunZia from some scrutiny under state permitting law. It had taken 14 years, but SunZia was finally ready to build in New Mexico. It still had to tackle Arizona.

Pattern Energy bought SunZia outright from Southwest Power Group in 2021, and outside fundraising began to pile in. Last year, Pattern Energy announced that it had secured $11.5 billion in financing for the line, making SunZia the largest clean infrastructure project in dollar terms in American history.

But the line's journey through Arizona — and specifically the San Pedro Valley — has remained controversial.

The San Pedro Valley by Robinson Meyer

Throughout last year, a coalition of environmental groups, local property owners, and two tribes — the Tohono O'odham Nation and the San Carlos Apache Tribe — pushed for the project to avoid the San Pedro Valley, alleging that the BLM had failed to study how SunZia would affect the landscape's cultural value to Native Americans. In November, the BLM ordered Pattern Energy to pause construction on SunZia so that it could consult with the tribes again; the groups held a series of meetings in the fall.

But the tribes deemed that effort insufficient. In January, the Tohono O'odham and San Carlos Apache Tribe, along with the Center for Biological Diversity and Archaeology Southwest, sued BLM, alleging that it had not studied how SunZia would erode the valley's cultural value.

Their argument turned on the interplay of two federal laws: NEPA, the law that governs the federal permitting process; and the National Historic Preservation Act, which says that the government must evaluate how its actions will affect archeological sites and Native American cultural sites.

If an infrastructure project will destroy an archeological or cultural site, the National Historic Preservation Act says that the government must mitigate that harm, mapping the relics and preserving what it can from them. Pattern and the BLM say that they have followed this law. After mapping and mitigating archaeological sites along its route, they agreed to move the line to avoid some of the most sensitive areas.

But the tribes argue that the entire San Pedro Valley is a sensitive cultural area. The Tohono O'odham Nation has argued in court and in the press that SunZia abuses its cultural property not by destroying any one cultural site, but rather by entering the San Pedro Valley in the first place. In essence, the tribe is claiming that the entire valley is a cultural site unto itself.

They say that the BLM must do what's called a "cultural landscape" study, investigating not only discrete archeological sites along the route but the cultural value of the San Pedro Valley as a whole. "The tribes have been trying to say that this [valley] has central cultural and religious importance," Robin Silver, an Arizona resident and the cofounder of the Center for Biological Diversity, told me.

Their argument was legally daring. The federal government approved SunZia's route through the San Pedro Valley under NEPA in 2015, meaning that the six-year statute of limitations for that decision had already expired. But the National Historic Preservation Act process only wrapped up last year. The tribes and the environmental groups argue that if *that* law's process had been correctly followed, then the BLM would have been forced to change SunZia's route — even though doing so would essentially re-open the NEPA process.

"Pattern Energy and the Bureau of Land Management, all they do is hire consultants that confuse hard archaeology with anthropology. So they go out and dig in front of the bulldozers and say everything's fine," Silver said. "The fact of the landforms having significant cultural and religious importance has been here as long as the tribes have been here. It's just that when Manifest Destiny became the rule of law, tribal concerns were blown off, and they're still being blown off."

The coalition's argument also raised the specter of old trade-offs — trade-offs that the tribe, by focusing on procedural and cultural matters, did not address in its lawsuit. The San Pedro Valley is incredibly beautiful, for instance, but it is not completely pristine: It is already home to a large natural gas pipeline and a few smaller transmission lines. When I asked Silver why the pipeline did not destroy the valley, but the transmission line did, he said in essence that the pipeline did not have the same visual impact as SunZia.

"There are no 200-foot large power lines going through the San Pedro Valley," he said. "The gas pipeline doesn't have 200 foot towers."

I pointed out that this suggested fossil fuel projects would never face the same scrutiny as transmission lines. "We need to figure out a way to connect the sources of our new energy to the users, and our grid is woefully archaic. No argument," he added. "But we don't need to go up every single valley, we don't need to sacrifice everything else, because of this mantra of climate change."

Yet there is no way to upgrade the grid without building large transmission towers *somewhere*. Silver suggested that the line could be shifted back toward Tucson, but that would seemingly place it back into the low-income, majority-Latino neighborhoods that BLM had hoped to avoid in the first place. The other available route would be to run SunZia west of Tucson, but that would force the line onto Tohono O'odham Nation land. When I asked a tribal spokesperson if the tribe had lifted its decade-old ban on SunZia crossing its land, he didn't respond.

In fact, the Tohono O'odham Nation has not responded to multiple emails and calls requesting comment beginning in March.

Two weeks ago, a district court judge in Arizona tossed the tribe's lawsuit. She said that the statute of limitations had expired and SunZia's route could no longer be altered. While BLM had once suggested that it would do a cultural landscape study on the San Pedro Valley, it did not do so in a way that would change its obligation to the tribes, she ruled. Silver told me that the coalition will appeal.

SunZia hasn't made it out of the desert yet. It still has to clear at least one remaining legal challenge, a lawsuit brought by the Center for Biological Diversity and its allies in Arizona state court. But with the federal lawsuit against it dismissed last month, SunZia now seems more likely than ever to become complete, making it a key piece of American zero-carbon infrastructure.

Which raises the inevitable question: Could SunZia have succeeded more quickly? SunZia required no fundamental technological leaps or engineering miracles; we have known *how* to build a power line of its size and length for years. Yet just the permitting has taken nearly two decades. If we finally get SunZia in 2026, that means that we *could* have had it in 2016. And that means that we *could* have burned less natural gas to meet the country's electricity needs, or at least enjoyed more energy, for lower prices, with less pollution. America's ponderous approach to building infrastructure is often described as an economic problem. But climate change transforms that regulatory torpor into an environmental challenge. What can we learn from SunZia such that we never have to go through this again?

You can see SunZia — as many in New Mexico now do — as a lesson in different approaches to building big new infrastructure projects. Many interests across the Southwest were unhappy with SunZia's initial route in 2013. But in New Mexico, the Pentagon's formal protest to that route led — quite happily — to Pattern Energy, Audubon Southwest, and environmental advocates working out a better plan for everyone involved. In Arizona, meanwhile, the old plans never changed, the same contentiousness remained, and they ultimately gave rise to a lawsuit.

You could also see it as a lesson in political power. Silver, the Center for Biological Diversity cofounder, told me SunZia succeeded in New Mexico for one reason: "Martin Heinrich." Speaking with a mix of resentment and respect, Silver said that Heinrich pushed for negotiations between environmentalists, clean energy advocates, tribes, and the Defense Department, eventually nudging those groups to arrive at a mutually agreeable outcome. In Arizona, Silver said, national and state-level leaders have not taken the same hands-on approach, so the process has been much more acrimonious.

There's some truth to each of these views. To get large-scale infrastructure projects done, it clearly helps to have a federal chaperone — someone who can spur cities, states, tribes, and conservation groups toward a final and constructive conclusion. The Biden administration is playing that role now for some projects, although it lacks local credibility, and Congress has helped to standardize the process by creating a "Fast 41" process where the government can prod along stalled infrastructure efforts.

But there is also something substantively different in New Mexico — you could call it high trust, good will, or a solutions-oriented approach to problem solving. It certainly helped that Pattern Energy was willing to work in good faith with local environmental groups. But that only works if all the other key stakeholders, including environmentalists themselves, respond in kind. The current tangle of state, local, and federal laws that dictate infrastructure permitting do not encourage this kind of constructive engagement, pushing opponents instead toward prolonged and costly legal battles. These laws also fail to substantively protect the environment, guaranteeing only that a process gets followed — not that the environment gets protected.

For decades, developers and conservationists have attacked each other over every project and prepared to fight bitter court battles over every detail. Developers assumed that conservation groups were out to block them at every turn and shut down, even when members of the public asked worthy questions. Environmentalists, meanwhile, suspected that any developers would destroy the land if given the opportunity, whether they were putting in oil pipelines or transmission lines, and would accept no protest to the contrary.

SunZia's story repeats this old, messy tradition, while also laying the model for a new one — one in which clean energy builders and environmental protectors work together to find the best solution for the environment and the climate. We will need many more success stories like it if America is to meet its climate goals — 99 more, to be exact.

Robinson Meyer
Robinson is the founding executive editor of Heatmap. He was previously a staff writer at The Atlantic, where he covered climate change, energy, and technology.

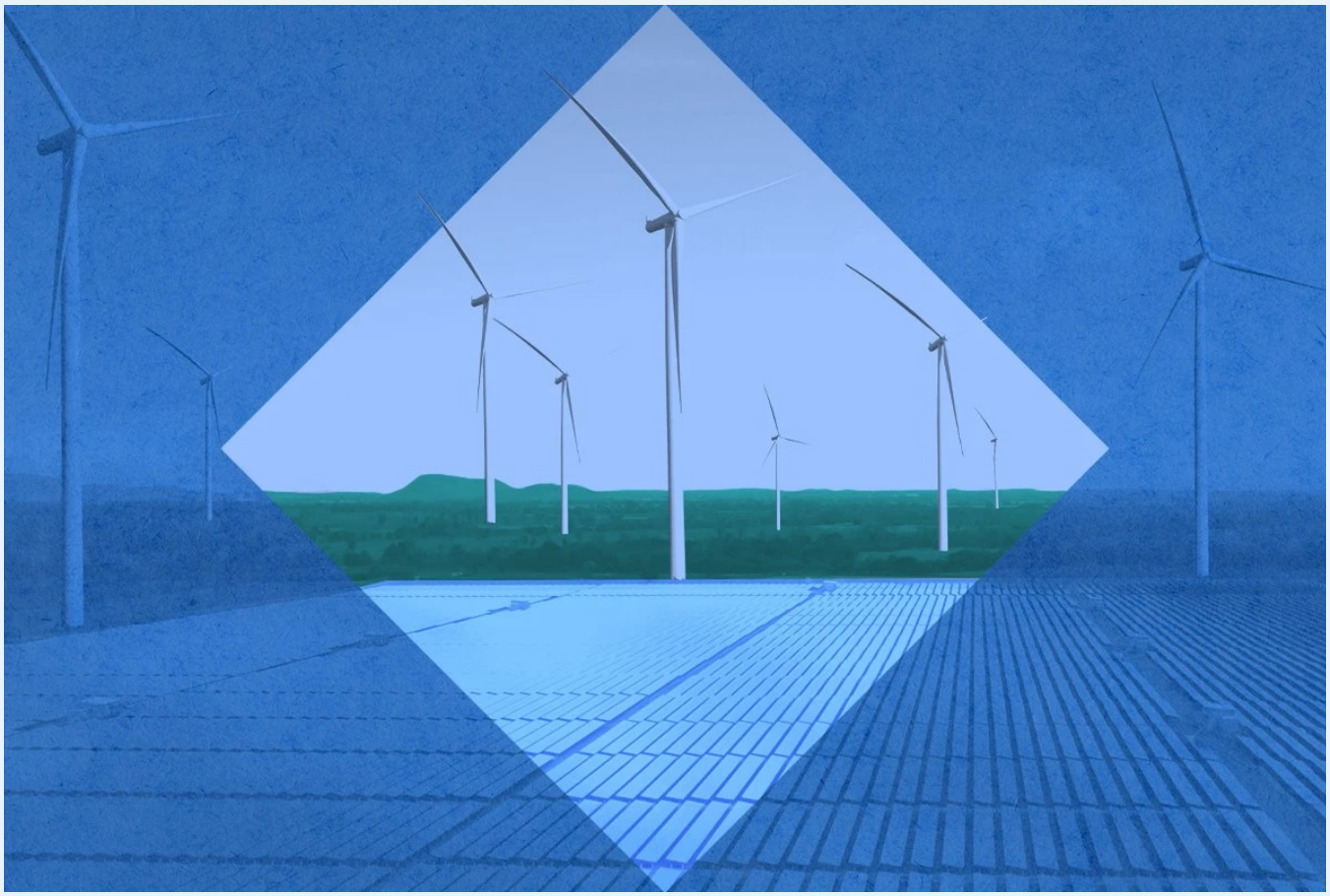
Share this article

Batteries Are the Least Popular Part of a Carbon-Free Grid

That's according to a new Heatmap poll. So what gives?

MATTHEW ZEITLIN ▪ MAY 10, 2024

Here's a shocker: Americans aren't exactly unified in their takes on the energy transition. In a new Heatmap poll conducted by Embold Research, about a third of the more than 2,000 adults surveyed agreed that "renewable energy offers many significant benefits, with few downsides," while about half that number said renewables have "many significant downsides, with few benefits." Go figure.



Heatmap Illustration/Getty Images

Dig beneath the surface, however, and some fascinating fault lines begin to emerge. Often, these divides cut across class, gender, and even party affiliation.

Take the public's opinion on batteries, for instance. Of all the possible sources of zero-carbon power we asked people about, battery storage scored the lowest, with just 23% saying they strongly supported adding them to the energy mix in their state.

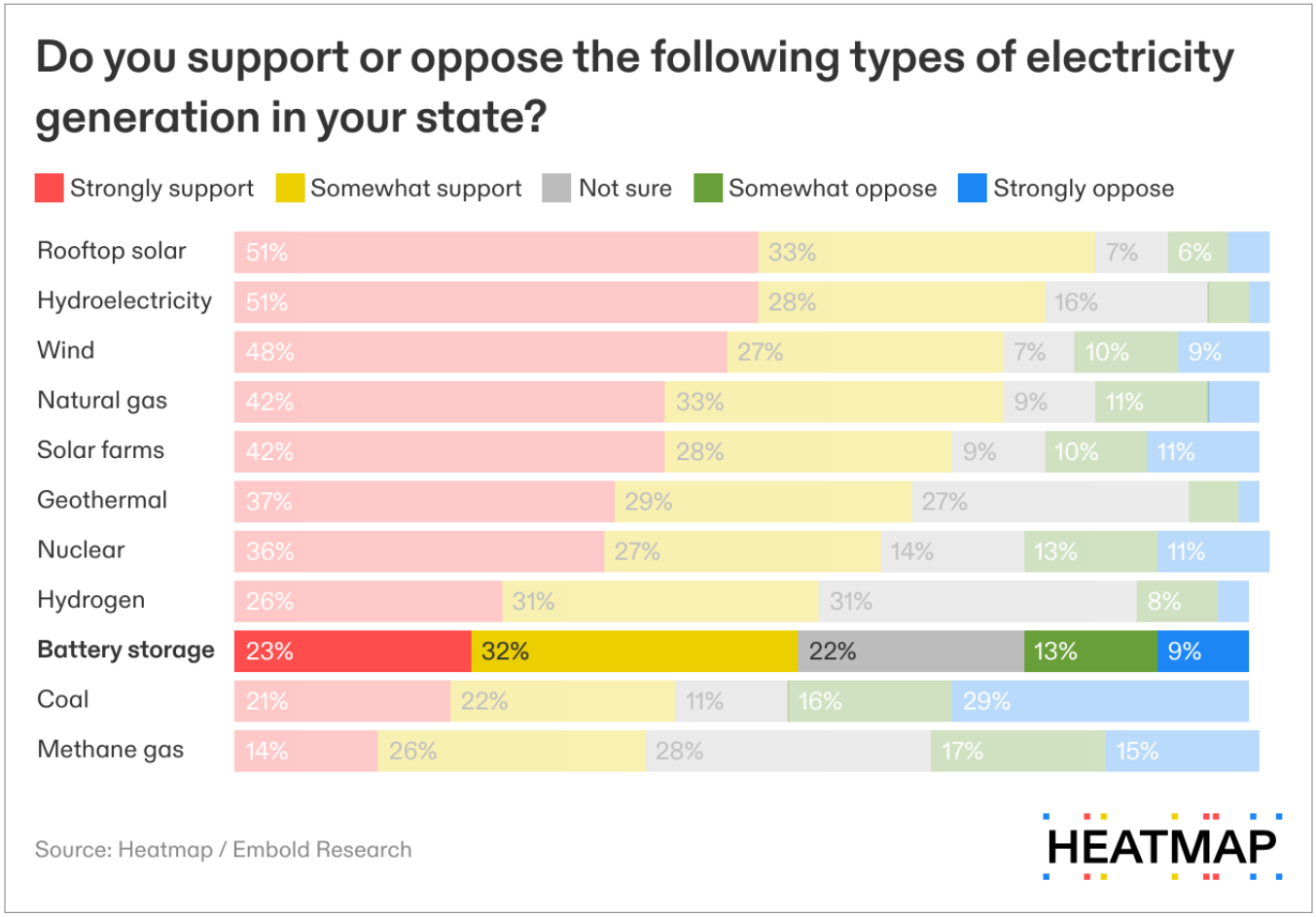
By comparison, 51% said they strongly supported rooftop solar, and 36% said they strongly supported nuclear, typically a controversial energy source.

Only coal and "methane gas" scored lower (although when we called it "natural gas," it polled much higher). What's the problem with batteries? One possibility is that even though utility-scale battery storage system fires are rare — the Electric Power Research Institute database of battery-related "failure events" lists just 15 last year, though one was a multi-day fire in a storage system in Idaho — people may group them together with far more common lithium-ion battery fires with scooters and e-bikes.

"Lithium ion battery fires are rarities when considered in the context of widespread deployment," Lakshmi Srinivasan and Stephanie Shaw, who both work on battery storage policy and research at EPRI, co-signed in an email.

"There are also important differences between grid-scale storage and electric micro-mobility devices like bikes and scooters" — namely that grid-scale batters are subject to regulations and testing requirements that your e-bike's battery is not, which reduces the risk of fires.

As with any major piece of energy infrastructure, the prospect of grid-scale batteries can also spark the public's generic aversion to new construction and the sight of industrial equipment. California — which leads the country in battery storage procurement and deployment — has not been free from local backlash to utility-scale battery storage projects. A long-planned project in San Diego County has faced persistent opposition from nearby residents, even after it was scaled down by 20%, while a project north of San Francisco was rejected entirely due to concerns about safety.



Besides the fire and visual concerns, many people don't understand that battery storage projects fall under the category of clean energy, especially in California where they're most prevalent. When asked to identify which types of power generation they considered "clean," only 19% picked out battery storage, compared to 78% for solar — which is increasingly co-located with battery storage — 76% for wind, and even 37% for natural gas. The only forms of power that ranked below battery storage were, again, "methane gas" and coal.

While solar and wind — which battery systems can support — are well known to just about everyone, widespread deployment of battery storage is still fairly new. While Heatmap's survey showed relatively high disapproval for battery storage, it also was the third most "not sure" energy source behind hydrogen and geothermal, two technologies that have yet to reach mass adoption in the U.S.

"All new technologies are a bit of a black box until education is provided," the two EPRI researchers said.

That education might also include how people might benefit. "Storage is a key driver of grid resilience and reliability," Srinivasan and Shaw explained. That means fewer service interruptions for any reason, and particularly during severe weather, when back-up energy may be necessary to keep food cold and shelters warm. "All that said," they added, "another important benefit of storage is that it supports extensive use of renewables technologies, so the most use can be made of those as well as making the electricity grid cleaner for everyone."

It's true that not all battery storage systems necessarily lead to lower carbon emissions. And yet batteries are absolutely essential to a decarbonized electric grid — and to keeping grids with high levels of weather-dependent resources like wind and solar stable. It's no coincidence that two states with large amounts of renewable power on the grid, California and Texas, are also leaders in battery storage deployment.

"While many members of the public prioritize implementing renewable energy, NIMBY concerns can be strong in some instances, often based on misinformation," Srinivasan and Shaw told me. "Support for renewable technologies is often dependent on the tangible local benefits of the facility, rather than broader decarbonization impacts."

The Heatmap poll of 2,094 American adults was conducted by Embold Research via online responses from April 5 to 11, 2024. The survey included interviews with Americans in all 50 states and Washington, D.C. The margin of sampling error is plus or minus 2.3 percentage points.

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The Make-or-Break Projects of the Energy Transition

Why the grid of the future might hinge on these 10 projects.

MATTHEW ZEITLIN & EMILY PONTECORVO ▪ **MAY 6, 2024**

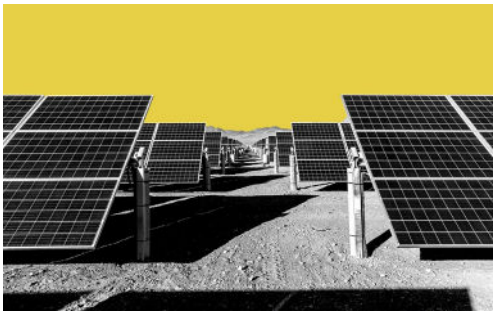
Heatmap Illustration/Getty Images

The energy transition happens one project at a time. Cutting carbon emissions is not simply a matter of shutting down coal plants or switching to electric cars. It calls for a vast number of individual construction projects to coalesce into a whole new energy system, one that can generate, transmit, and distribute new forms of clean power. Even with the right architecture of regulations and subsidies in place, each project must still conquer a series of obstacles that can require years of planning, fundraising, and cajoling, followed by exhaustive review before they can begin building, let alone operating.

These 10 projects represent the spectrum of solutions that could enable a transition to a carbon-free energy system. The list includes vastly scaled up versions of mature technologies like wind and solar power alongside the traditional energy infrastructure necessary to move that power around. Many of the most experimental or first-of-a-kind projects on this list are competing to play the role of "clean firm" power on the grid of the future. Form's batteries, Fervo's geothermal plants, NET Power's natural gas with carbon capture, and TerraPower's molten salt nuclear reactor could each — in theory — dispatch power when it's needed and run for as long as necessary, unconstrained by the weather. Others, like Project Cypress, are geared at solving more distant problems, like cleaning up the legacy carbon in the atmosphere.

But they do not all have a clear path to success. Each one has already faced challenges, and many of them are likely to face a great number more. We call these the make-or-break energy projects because it's still unclear what the clean energy system of the future is going to look like, but the projects from this list are likely to play a big part in it — if, that is, they get there.

1 Easley



Type of project: Solar farm

Developer: Intersect Power

Location: Desert Center, Riverside County, California.

Size: 400 megawatts of generation and 650 megawatts of storage

Operation date: Possibly 2025

Cost: $990 million

Why it matters: Facing opposition from local retirees angered by the large number of projects popping up in the area, as well as from conservation-focused groups — such as Basin and Range Watch, which opposes many utility-scale energy projects in desert areas — Easley will be a test of whether California's reforms to limit the timeframe of appeals to the state's environmental reviews can actually work in getting a project approved and online faster.

The early signs are promising. A nearby solar project by the same developer, Intersect Power, recently went into operation after getting approved by the Bureau of Land Management in January 2022. Easley could be operational "as early as late 2025," according to a Plan of Development prepared for Intersect Power.

Easley is also an example of what's increasingly becoming standard in California, at both the residential and utility-scale level: pairing solar with storage. The California grid increasingly relies on batteries to keep the lights on as solar ramps up and down in the mornings and, especially, the evenings. The state has procured a massive amount of storage and has adjusted how utilities pay for rooftop solar in a way that encourages pairing battery systems with rooftop solar panels. This both stabilizes the grid and helps further decarbonize it, as batteries that are physically close to intermittent renewables are more likely to abate carbon emissions.

2 Cambridge Energy Storage Project

Type: Energy storage

Developer: Form Energy and Great River Energy

Location: Cambridge, Minnesota

Size: 150 megawatt hours

Operation date: End of 2025

Cost: Unknown; Goal of less than 1/10th cost of utility-scale lithium-ion batteries per megawatt hour

Why it matters: Form Energy first made waves in 2020 when it announced a contract with Great River Energy, a Minnesota electric utility, to build a battery that could store 100 hours' worth of electricity, which was simply unheard of. Other energy storage companies were just trying to break the 4-hour limitation of lithium-ion, aiming for 8 hours or, at most, 12. Days-long energy storage would be a game changer for maintaining reliability during extreme weather events, storing renewable energy for stretches of cloudy days or windless nights or kicking in when demand peaks. At first, Form's project was shrouded in mystery. How, exactly, would it do this? But a year later, the company revealed the secret chemistry behind its breakthrough: iron and oxygen. The batteries are filled with iron pellets that, when exposed to oxygen, rust, releasing electrons to the grid. They "charge" by running in reverse, using the electrical current from the grid to convert the rust back to iron.

Since then, the hype has continued to build. Form has raised nearly $1 billion from venture capital and been awarded tens of millions more ingovernment grants. It has signed contracts with six utilities to deploy projects in California, New York, Virginia, Georgia, and Colorado, in addition to Minnesota. All this, despite not having completed a single project yet.

The Great River Energy Project is set to be the first to come online. Originally, the company said it would be operating by the end of 2023; now it's expected to start construction later this year and begin operating in early 2025, Vice President of Communications Sarah Bray told Heatmap. First, the company has to complete construction of its first factory in Weirton, West Virginia, where it will be producing all of the batteries. Bray said it expects to start high-volume production later this year.

3 SunZia Wind

Type: Onshore wind

Developer: Pattern Energy

Location: Lincoln, Torrance, and San Miguel Counties, New Mexico, with transmission into Arizona

Size: 3,500 megawatts

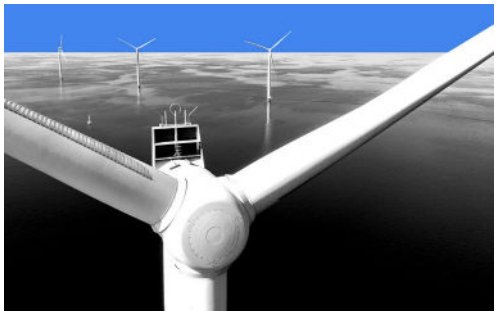
Operation date: 2026

Cost: The project's developer, Pattern Energy, has secured $11 billion in financing for the wind and associated transmission project. The cost of the project is estimated to be $8 billion.

Why it matters: This would be the biggest wind project in the country and a test case for a variety of energy policy objectives at both the state and federal level. For California, it would be a key step in decarbonizing its grid, as the state right now imports a large amount of its power, not all of which is carbon-free. For the federal government, it meets several goals — using public lands for carbon-free energy development, plus long-distance transmission to spur energy development across the country and link clean power resources in rural areas to major load centers.

It would also mean an ambitious project could overcome long and concerted opposition. The project was first proposed in 2006, and its transmission line cleared environmental review back in 2015, but it has been mired in lawsuit after lawsuit. Most recently, a coalition of conservation groups and Indian tribes sued to halt construction on the power line portion of the project in Arizona's San Pedro Valley, claiming that their cultural rights had not been adequately respected. In April, a judge allowed construction to continue, ruling that those claims were barred by the existing federal approvals, which had taken years to attain.

4 Empire Wind



Type: Offshore wind

Developer: Equinor

Location: South of Long Island, New York

Size: 810 megawatts

Operation date: 2026

Cost: Not available, but an earlier estimate for developing two wind farms was $3 billion. Costs have since risen, but the second farm, Empire Wind 2, is no longer under contract.

Why it matters: The Northeast, and especially New York State, have aggressive aims for decarbonization, with a goal of 70% of the state's electricity coming from renewables by 2030. The Biden administration also has a specific goal for 30 gigawatts of offshore wind capacity by 2030, and New York has a goal of 9 gigawatts by 2035. These types of high-capacity projects will be essential for the Northeast to decarbonize. The windy coast of the Atlantic Ocean is the most potent large-scale renewable resource in the region, and many of the region's large load centers, such as New York City and Boston, are on the coast.

Offshore wind, while expensive, can present less permitting hassle and local opposition than onshore wind or utility-scale solar. Empire Wind 1 (along with Sunrise Wind) matters tremendously for New York's offshore wind program, which has been in development for years but has faced escalating costs and project cancellations. Only one offshore wind project is actually operational in the state, South Fork Wind, which was contracted outside the NYSERDA process and has around 130 megawatts of capacity. If Empire manages to get steel in the water and electrons flowing to the coast, it will be a sign that the Northeast's — and thus the country's — decarbonization goals are at least somewhat attainable.

5 Champlain Hudson Power Express

Type: Transmission

Developers: Transmission Developers, which is owned by the Blackstone Group

Size: 339 miles / 1,250 megawatts

Operation date: 2026

Cost: $6 billion

Why it matters: The Champlain Hudson Power Express, often referred to as CHPE (affectionately pronounced "chippy") will deliver 1,250 megawatts of hydropower from Quebec into the New York City grid, which is currently about 90% powered by fossil fuels. It is "the most powerful project you'll never see," according to its developers, as it is the largest transmission line in the country to be installed entirely underground and underwater.

The project is essential to New York's goal to build a zero-emission electricity system by 2040. The line will supply an always-available source of clean power to supplement intermittent wind and solar generation and maintain a reliable grid. It has already overcome a number of barriers, including nearly a decade of environmental reviews, uncertainty over whether New York would buy its power, and opposition from conservation advocates concerned about the negative impacts of hydroelectric dams on the environment and on Native communities in Canada.

When it begins operating, New Yorkers won't just get cleaner power — they should also see air quality benefits almost immediately. The new line is expected to cut air pollution equivalent to that released by 15 of the city's 16 fossil fuel-fired peaker plants.

6 Cape Station

Type: Geothermal

Developer: Fervo

Location: Beaver County, Utah

Size: 400 megawatts

Operation date: 2026, although the project isn't expected to be finished until 2028

Cost: Not disclosed, but Fervo raised $244 million and said that the cash "will support Fervo's continued operations at Cape Station."

Why it matters: This enhanced geothermal project is not the first one for Fervo. The company's Nevada site, Project Red, began providing power for Google data centers in Nevada in November 2023. This planned site, however, will be far bigger: Fervo currently has authorization from the Bureau of Land Management for up to 29 exploratory wells, while the Project Red site had just two. Cape Station broke ground in September 2023, and in the first six months of drilling, Fervo said it reduced costs from drilling by 70% compared to its Project Red wells.

As the grid decarbonizes and major power consumers like technology companies insist on having clean power for their operations, there will be massive and growing demand for so-called "clean firm" power, carbon-free power that is available all the time. Conventional wind and solar is intermittent, and existing battery technology only allows for limited output over time. Fervo's "enhanced geothermal" technology uses techniques borrowed from the oil and gas industry to be able to produce geothermal power essentially anywhere where there are hot enough rocks underneath the surface of the Earth, as opposed to conventional geothermal, which depends on locating hot enough fluid or stream.

If Fervo can demonstrate that it can produce power at scale at costs comparable to existing conventional geothermal projects, it can expect a massive market for it and demand for more projects.

7 Natrium Reactor

Type: Nuclear

Developer: TerraPower

Location: Kemmerrer, Wyoming

Size: 345 megawatts

Operation date: Not available, but the company said in 2021 that it plans to be operational "in the next seven years." Updated to the 2024 application, that would put it on track for a 2030 completion date.

Cost: Not available, but TerraPower has raised around $1 billion and the federal government has pledged around $2 billion to support the project, which TerraPower has said it will "match … dollar for dollar."

Why it matters: TerraPower is just one of many companies flogging designs for advanced nuclear reactors, which are smaller and promise to be cheaper to build than America's existing light-water nuclear reactor fleet. The construction permit application the company submitted in March was a first for a commercial advanced reactor. TerraPower matters as much for the Nuclear Regulatory Commission as it does for anyone else, as it's a test of whether the NRC can meet Congress and the White House's preference for a more accelerated approval process for advanced nuclear power.

TerraPower's design, if successful, would be a landmark for the American nuclear industry. The reactor design calls for cooling with liquid sodium instead of the standard water-cooling of American nuclear plants. This technique promises eventual lower construction costs because it requires less pressure than water (meaning less need for expensive safety systems) and can also store heat, turning the reactor into both a generator and an energy storage system.

While there are a number of existing advanced nuclear designs, several of which involve liquid sodium, Natrium could potentially play well with a renewable-heavy grid by providing steady, unchanging output like a current nuclear reactor as well as discharging stored energy in response to renewables falling off the grid.

8 Mississippi Clean Hydrogen Hub

Type: Hydrogen

Developer: Hy Stor Energy

Location: Project components located throughout Mississippi, with some in Eastern Louisiana

Size: Goal of 340,000 metric tons per year (phase one)

Operation date: 2027

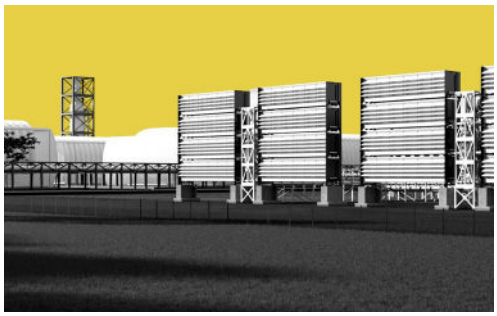
Cost: Initially reported as $3 billion; recently reported as more than $10 billion. (In response to an inquiry from Heatmap, the company replied that it "will be in the multiple billions of dollars."

Why it matters: Truly carbon-free hydrogen could unlock big emissions reductions across the economy, from fertilizer production, to steelmaking, to marine shipping. But few companies are going to the lengths that Hy Stor is going to ensure its product is really clean. The company is building the first off-grid hydrogen production facility powered entirely by wind and solar. That means Hy Stor will have no problem claiming the new hydrogen production tax credit, which requires companies to match their operations with clean energy sources by the hour — a provision that's been contested by large portions of the hydrogen industry.

For a company that has never built anything before, the scale of Hy Stor's Mississippi project is ambitious. The company has acquired about 70,000 acres across Mississippi and Louisiana, along with 10 underground salt domes — mounds of salt buried beneath the Earth's surface that can be dissolved to form cavernous, skyscraper-sized storage facilities for hydrogen. Those salt domes are the key to Hy Stor's approach, and what enables the company to rely on intermittent renewables. By storing vast amounts of hydrogen, the company will be able to deliver a steady supply to customers and will also have a backup source of energy for its own operations when wind and solar are less available.

Chief Commercial Officer Claire Behar told Heatmap the company has obtained many of the necessary permits, including for its salt caverns and the plant's water use. It plans to begin construction at the beginning of 2025, and to have the first phase of the project "in service at scale" by 2027. Hy Stor recently announced a deal to purchase its electrolyzers, devices that split water molecules into hydrogen and oxygen, from a Norwegian company called Nel Hydrogen. It has also signed up a few customers, including a local port and a green steel company.

9 Project Cypress



Type: Carbon removal

Developers: Climeworks, Heirloom, and Battelle

Location: Calcasieu Parish, Louisiana

Size: Goal of capturing 1 million metric tons per year

Operation date: About 2030

Cost: Total project cost unknown; eligible for up to $600 million from the Department of Energy for its Regional Direct Air Capture Hubs Program.

Why it matters: Project Cypress might be the most ambitious project to remove carbon from the atmosphere under development in the world. It is a collaboration by two leading direct air capture companies, Heirloom Carbon Technologies and Climeworks, which were among the first to demonstrate their ability to capture carbon directly from the air and store it at commercial scale. Now, the two will be attempting to scale up exponentially, from capturing a few thousands tons per year to a combined million.

Last August, the Department of Energy selected Project Cypress to be one of four direct air capture hubs it will support with $3.5 billion from the Bipartisan Infrastructure Law. In March, the project was awarded its first infusion of $50 million, but the developers will have to do extensive community engagement to continue receiving funding. Battelle, the project developer, told Heatmap the project has also received an additional $51 million in private investment.

Between financing, permitting challenges, renewable energy sourcing, and community opposition, the project is sure to face a bumpy road ahead. The project and its developers have no ties to the oil and gas industry, but that hasn't done much to win over the support of environmental justice advocates, who see the project as a dangerous distraction from cutting emissions and pollution in Louisiana. But if Project Cypress is successful, it will show the world what direct air capture looks like at climate-relevant scales.

10 Project Permian

Type: Carbon capture
Developer: NET Power
Location: Ector County, Texas
Size: 300 megawatts
Operation date: Late 2027 or early 2028
Cost: About $1 billion

Why it matters: Oil and gas CEOs love to say that the problem is not fossil fuels, the problem is emissions. NET Power's technology — a natural gas power plant with zero emissions, carbon or otherwise — could prove to be the ultimate vindication of that statement. In short, NET Power's system recycles most of the CO2 it produces and uses it to generate more energy. It also utilizes pure oxygen, unlike typical natural gas plants that take in regular air, which is mostly nitrogen. This means that any remaining CO2 not recycled in the plant is relatively pure and easy to capture.

NET Power opened a 50 megawatt demonstration plant in La Porte, Texas, in 2018, and is developing a 300 megawatt commercial plant in Ector County, Texas, in partnership with Occidental Petroleum, Baker Hughes, and Constellation Energy. On a recent earnings call, CEO Danny Rice said the project was "expected to have a lower levelized cost per kilowatt hour than new nuclear, new geothermal, and new hydro."

The company generated a lot of excitement among energy experts in the fall of 2021 when it announced that its La Porte project had successfully delivered power to the Texas grid. It also raised a lot of money when it went public last summer. But things have been somewhat rocky since. During a December earnings call, NET Power's president told investors that its first commercial plant would be delayed by at least a year due to supply chain challenges. According to filings with the Securities and Exchange Commission, the company also applied for funding from the Department of Energy's Office of Clean Energy Demonstrations last year, but was not selected. It has not yet found any third parties to license its technology or offtakers to buy energy from the Ector County plant, and noted in its recent filings that while the La Porte pilot project delivered electricity to the grid, it did not, in fact, deliver "net" power — meaning that it used more power than it generated.

A spokesperson for the company told Heatmap the La Porte facility was solely intended to "prove the technical viability of the NET Power Cycle" and not intended to produce net power. So everything's now riding on Project Permian.

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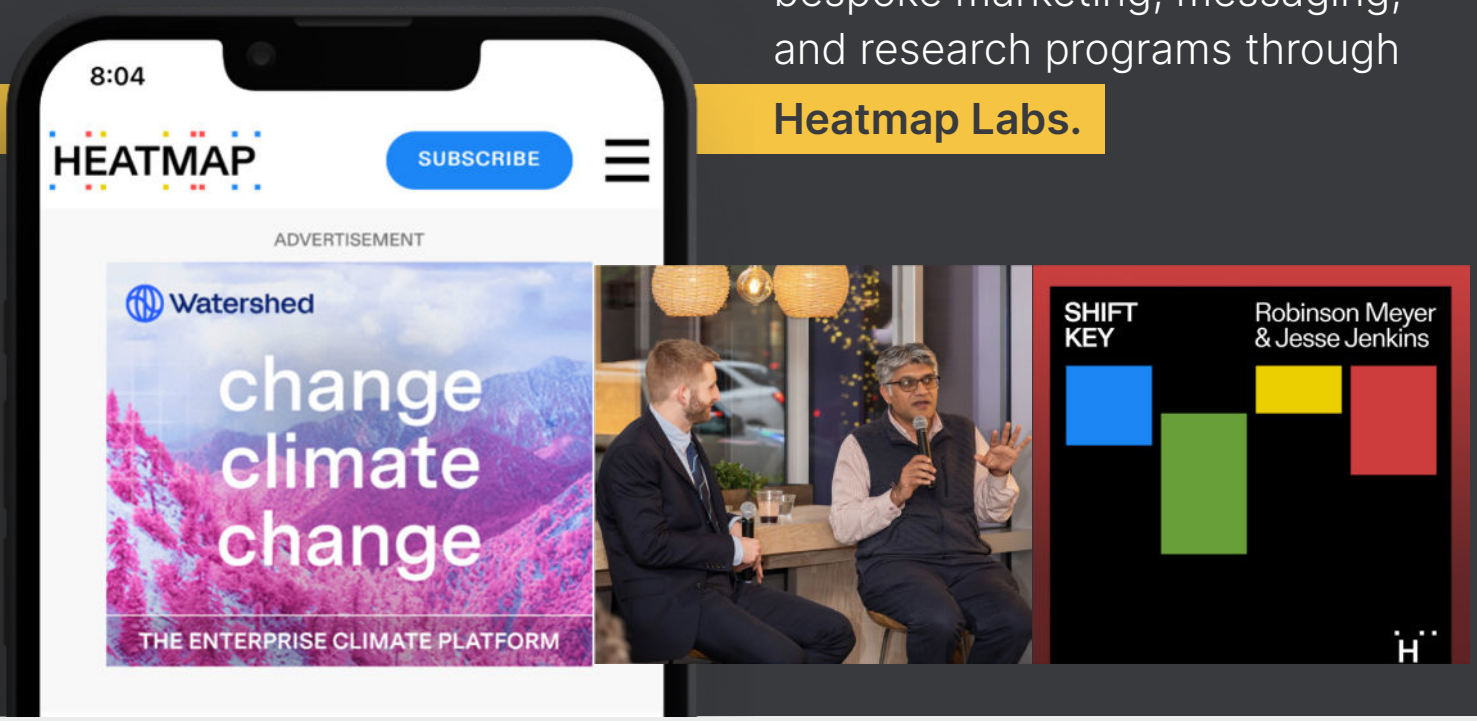

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