

Is nuclear energy the key to saving the planet?

Emma Redfoot stands at a whiteboard in a small conference room, sketching neutrons, protons and nuclei, her voice rising enthusiastically as she explains nuclear fission: A neutron blasted into a uranium-235 atom shatters the atom, releasing energy and yet more neutrons that split other uranium atoms, causing a frenetically energetic chain reaction. “The crazy thing about nuclear energy is that it turns mass into energy,” she says, her gray-blue eyes opening wider. “It. Destroys. Mass!”

On the other side of the thick glass window here at the Center for Advanced Energy Studies (CAES) on the outskirts of Idaho Falls, Idaho, the mercury approaches 100 degrees, the sun an angry orange blob behind the thickening gauze of smoke from wildfires across the region – a reminder of the toll fossil fuels are taking on the planet.

But Redfoot says that the situation isn't hopeless, that we can slash greenhouse gases and still have nice electrified things, including this comfortable climate-controlled room, without making the planet hotter and drier and smokier. To do so, however, we must embrace nuclear power – conquer our irrational fears of radiation and return to “a story that can be told in terms of abundance in the world we live in.”

Redfoot is a nuclear engineer, a devout environmentalist and an unflinching advocate for [nuclear power](#). Renewable energy alone is not enough, she says; only if we use nuclear too can we eliminate fossil fuel burning. Sure, nukes have their problems, she says. But in true technophile form, she assures me that those problems can be fixed – through engineering.

One such problem is nuclear power's inflexibility. Redfoot

explains that when a nuclear plant operator tries to ramp reactor output up or down in response to changes in electricity demand or in solar or wind power production, xenon-135 and samarium-149, or “fission product poisons,” build up. She pauses when she sees my eyes widen with alarm at the term, then looks ruefully back at her whiteboard: “Nuclear is really terrible with names.”

In fact, nuclear is terrible with public perception in general. It’s a problem that even Redfoot, who has a bit of a Sissy Spacek-circa-1975 vibe and wears a cheery “Atoms for Peace” T-shirt, acknowledges can’t be engineered away. “The negatives are usually what people start with when they think of nuclear,” she says.

So Redfoot accentuates the positives. Together with a growing collection of climate-hawk pro-nuclear folks, many of them fellow millennials, she is determined to brighten the view of nuclear energy.

These activists are self-consciously grassroots-scrappy. No slick and polished ad campaigns here; instead, they stage pro-nuclear rallies that emulate the iconography of the 1980s-era no-nukes movement and the playful energy of anti-war agitator Abbie Hoffman’s band of youth activists. They sing opera, tag their tweets with #SplitDontEmit and have developed a pro-nuke smartphone app. They even organized a Nuclear Pride Festival, complete with music, theatre and cartoonish logos of flowers emerging from nuclear cooling towers. Eco-modernist Michael Shellenberger, the high priest of the movement, calls it Atomic Humanism. I think of it as Green Nuclear Evangelism.

“We believe that nuclear power can and will actually save the world,” Matt Bennett, vice president of public affairs for the left-leaning think tank Third Way, told the Nuclear Energy Assembly in 2016. “We are never going to reach our climate goals if we just focus on things that are in vogue at the moment.”

Nuclear engineer and activist – and environmentalist – Emma Redfoot poses outside the Vallecitos Nuclear Center near Livermore, California, where the dome of a nuclear power plant that once produced 40,000 megawatt-hours of electricity still stands.

Sarah Craig

WHEN NUCLEAR POWER FIRST APPEARED in the West, it sundered an environmental community primarily focused on protecting wildlands. Some members of the Sierra Club, including its charismatic director, David Brower, opposed Pacific Gas & Electric's 1966 proposal to build the Diablo Canyon nuclear generating station on the Central Coast of California mainly because it would industrialize the coastline, not because they were ideologically opposed to nuclear power. Others saw nuclear plants as preferable to river-killing, wilderness-drowning dams. The issue divided the Sierra Club, but ultimately the group supported the plant, which got licensed in 1968.

Brower left the club and started Friends of the Earth, where he continued his fight against Diablo Canyon. He was joined by the anti-nuclear San Luis Obispo Mothers for Peace and the Abalone Alliance, which rose up alongside the reactor containment domes in the 1970s. In 1979, some 30,000 protesters, musicians and politicians – including Gov. Jerry Brown, then in his first period as governor – attended a Stop-Diablo concert and rally. That same year, Pennsylvania's Three Mile Island suffered its meltdown, the Church Rock spill in New Mexico sent millions of gallons of radioactive effluent onto the Navajo Nation, *The China Syndrome* hit theaters, and a rousing, star-studded "No Nukes" concert rocked Madison Square Garden, with Jackson Browne, Carly Simon, John Hall and Bonnie Raitt imploring the world to "take all your atomic poison power away."

Neither the growing wave of popular opinion and pop culture, however, nor the discovery of new seismic faults near the

plant, could stop Diablo Canyon – not even the revelation that its blueprints were flawed. In 1985 – the year before the Chernobyl incident – the two reactors began churning about 18 million megawatt-hours of low-emissions juice into the electrical grid each year, powering some 1.7 million homes.

Emma Redfoot was born several years later. She grew up in Montana, spending a good part of her childhood outdoors in the woods and mountains. After high school, she pursued environmental studies at Lewis and Clark College. During that time, she traveled to Latin America to work on a permaculture farm and then to research service tourism. It came to her that the two most pressing issues facing her generation were global warming and global poverty. And energy was the key to tackling both.

“Energy is the ideal thing to empower people,” she told me at CAES, a part of the sprawling, federally run Idaho National Laboratories that boasts a strangely Silicon Valley-like feel, right down to the brightly colored beanbags in the lobby. Millions of people who lack access to the grid are forced to burn wood, coal, dung or even tires and other garbage for cooking and heating, to the detriment of their health and the planet’s. They need electricity, she said, but getting it from fossil fuels merely centralizes the pollution. Wind and solar have problems, too; they are intermittent and require lots of space.

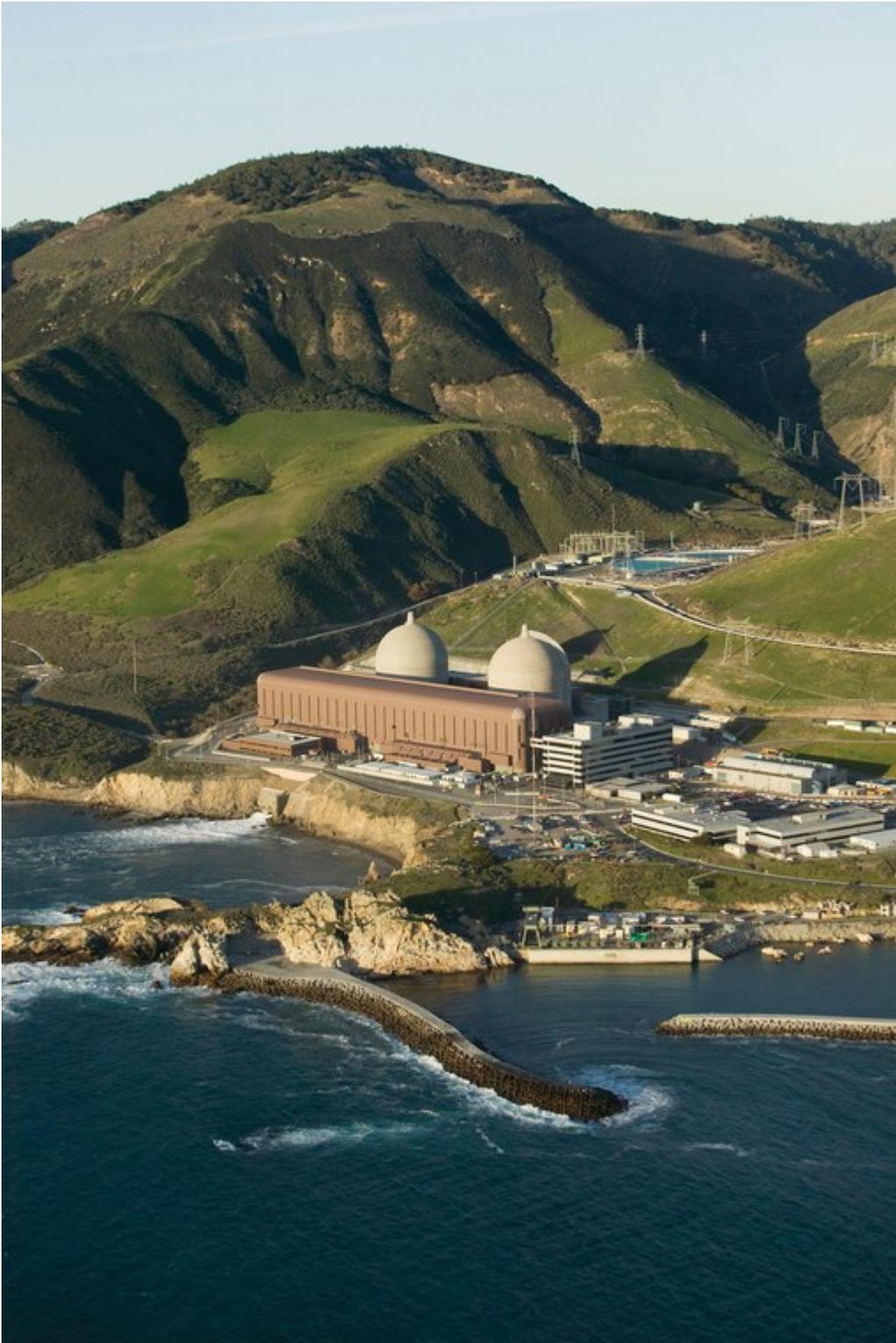
No source of electricity is truly clean or carbon-free. Material for solar panels or batteries must be mined, wind turbines manufactured. Uranium mining, milling and enrichment are energy-intensive, and coal mines and natural gas wells ooze methane. When the entire fuel life cycle is taken into account, however, nuclear is among the most climate-friendly, emitting 100 times less carbon per megawatt-hour than coal and 50 times less than natural gas – even less than photovoltaics. Fission spews none of the nasty air pollutants emitted by burning coal, and only a fraction of the solid waste. Nuclear,

Redfoot concluded, is the best way to pull people out of poverty without contributing to climate change, so she headed back to school at the University of Idaho to pursue a master's degree in nuclear engineering.

To members of Gen X and their elders – the now-middle-aged baby boomers who grew up under the threat of nuclear annihilation – Redfoot's path can seem a little jarring. They remember the No Nukes movement, *99 Luftballons*, Three Mile Island, *War Games* and *The Day After*; in the West, they witnessed firsthand the deadly legacy of uranium mining and milling and nuclear tests. But Redfoot, like much of the self-proclaimed Generation Atomic, was brought up after the Cold War ended and the term "mutually assured destruction" had faded from the lexicon. The alarm over the Chernobyl disaster had ebbed; "No Nukes" was merely a graying relic of her parents' generation, like the vinyl recordings of its soundtrack.

This lack of baggage, combined with the existential angst induced by climate change, allows millennials to see nuclear power much as their grandparents might have, back when Dwight D. Eisenhower delivered his 1953 "Atoms for Peace" speech. Nuclear energy would help redeem the world from the terrible scourge of atomic weapons, the president said; it would be used to "serve the needs rather than the fears of the world – to make the deserts flourish, to warm the cold, to feed the hungry, to alleviate the misery of the world."

That optimism drew Redfoot to Diablo Canyon for an internship. But when she arrived, she found the plant – and nuclear energy in general – facing its own existential crisis. Before a new generation of safer, more nimble nuclear power plants could be deployed to save the climate, the atomic evangelists would first have to save the existing infrastructure.



Diablo Canyon Power Plant in central California, contentious from the start, is scheduled to close in 2025.

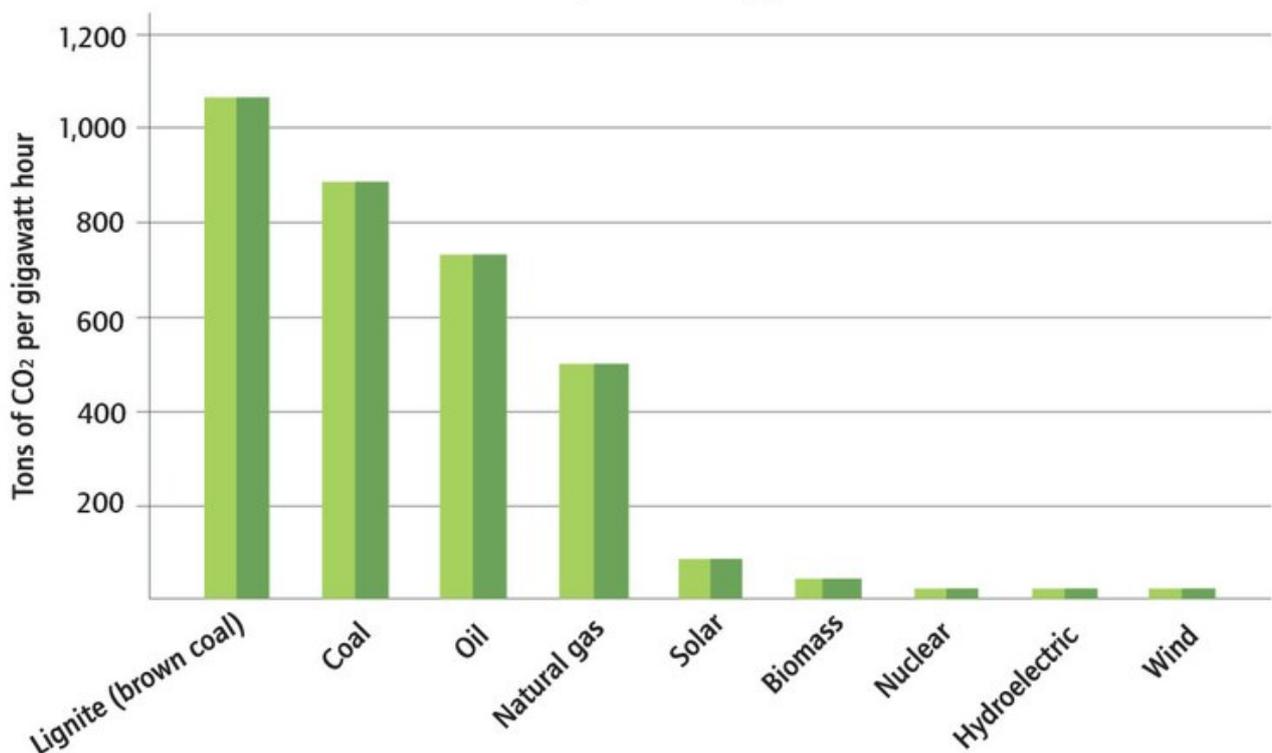
Herb Ling

WHEN REDFOOT ARRIVED at San Luis Obispo in 2014 to take her engineering prerequisites at Cal Poly, PG&E's effort to renew its 40-year operating license with the Nuclear Regulatory Commission and its lease on state lands was well underway. The

plant's two reactors, which comprise the Western Grid's third-largest generator after Arizona's Palo Verde nuclear plant and Washington's Grand Coulee Dam, had been fissioning for years without any major incidents. Yet PG&E officials knew the renewals were no slam dunk; Friends of the Earth, Mothers for Peace and other opposition groups, concerned about nearby earthquake faults, the waste problem and the plant's fish-killing cooling system, would make sure of that.

Each day, Diablo Canyon sucks up about 2.5 billion gallons of ocean water to generate steam and cool the reactors, before spitting it out – 20 degrees warmer – back into the Pacific. The process kills an estimated 5,000 adult fish and 1.5 billion fish eggs and fry every year. The warm-water discharges also alter the aquatic ecosystem in Diablo Cove. In 2010, the state of California ordered coastal plants to do away with so-called "once-through" cooling systems. To keep its lease, PG&E would have to retrofit the plant with less deadly cooling technology. That would cost billions, and in today's electricity market, it's just not worth it.

Average greenhouse gas emission intensity of energy sources



When emissions from all phases of power sources' life cycles are accounted for, from mining to manufacturing to generating power, nuclear rivals even solar power in terms of climate friendliness.

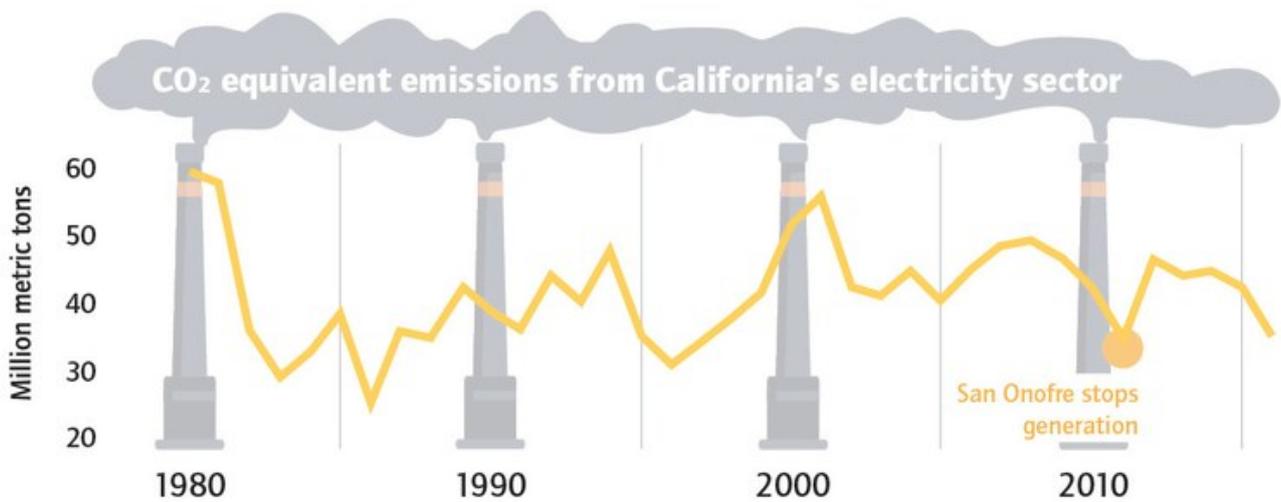
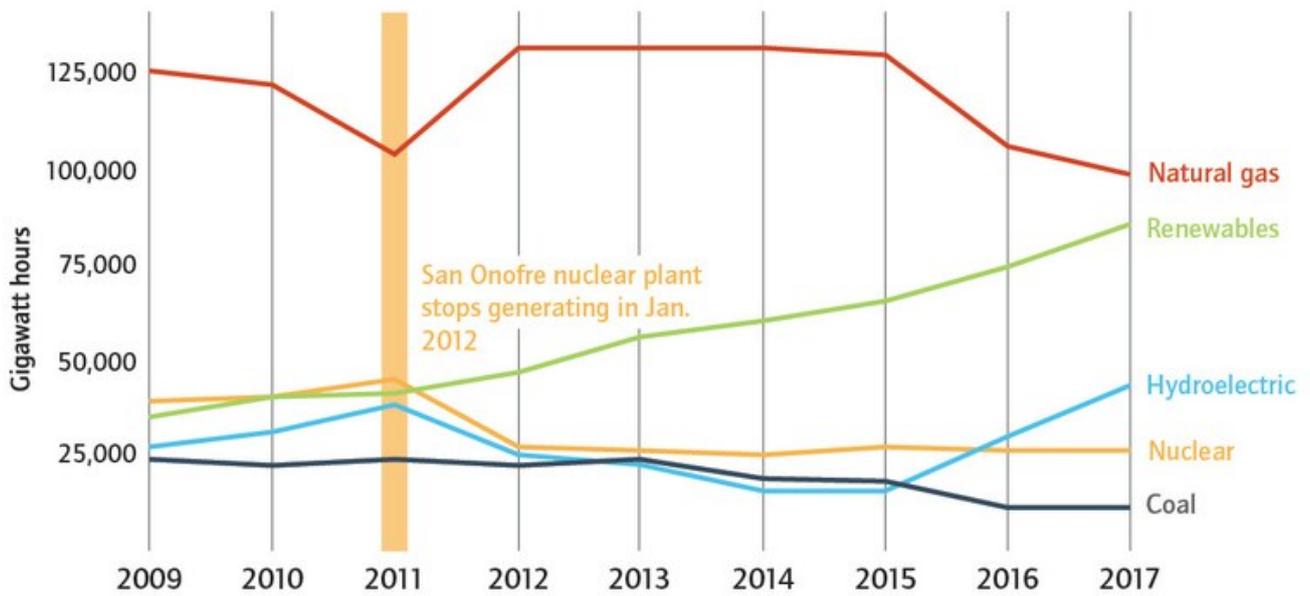
Source: World Nuclear Association

An abundance of cheap natural gas and the rise of renewables have brought wholesale electricity prices down, making both nuclear and coal plants less cost-effective, even without the expensive cooling-system upgrades. Plus, the variability of solar and wind, which produce only when the sun is shining and the wind is blowing, has increased the need for flexible generation that can quickly increase or decrease the amount of juice going into the grid. Natural gas is limber in that way but nuclear is less so, thanks in part to those darned fission poisons Redfoot described, which make the reaction less efficient. PG&E was increasingly seeing the bottom-line appeal of letting the plant go dark.

All this helped spark the nuclear evangelism movement. Shellenberger left the Breakthrough Institute and started the pro-nuclear advocacy group Environmental Progress. Diablo Canyon engineer Kristin Zaitz and reactor operator Heather Matteson founded Mothers for Nuclear to lobby for keeping the plant running for another 20 years or more. Zaitz, who wrote that she "grew up on the writings of John Muir," was dumbfounded that environmentalists wanted to shutter the plant, even at the expense of the climate.

The advocates argued that closure would not only rob the community of 1,500 high-paying jobs, it would deprive the state's grid of its single largest generator of low-emissions juice. They cited the 2012 shutdown of the San Onofre Generating Station near San Diego, due in part to radioactive-steam leaks, as a prelude to what would happen when Diablo Canyon shut down.

Power generation industry balance in California 2009-2017



When the San Onofre nuclear plant stopped producing power in early 2012, California grid operators filled the void with natural gas, reversing the downward trend of greenhouse gas emissions from the state's electricity sector. The problem was exacerbated by the loss of hydropower that year, thanks to drought, and by increased electricity consumption due to heat. Since then, renewable power sources have gained a larger share of the state's power mix, and overall power consumption has decreased, bringing emissions back to pre-2012 levels.

Source: California Energy Commission

In order to fill the 18,000 gigawatt-hour void left by San Onofre's departure and to meet increasing electricity demand due to rising temperatures, California grid operators turned to natural gas. Generation from gas jumped by a whopping 30,000 gigawatt-hours, resulting in an annual increase of more than 20 million tons of additional carbon emissions – about half of which could be directly attributed to San Onofre's closure. It was as if by taking a nuclear plant offline, California had fired up a massive coal-fired power plant and run it full-bore.

The green evangelists predicted the same carbon surge if Diablo Canyon were to close. But PG&E believed it could avoid that scenario: Demand for electricity was actually going down, the company said, because of an increase in distributed generation from solar and wind, efficiency measures and a changing electricity market. In 2016, the utility announced it would shut Diablo Canyon down in 2025, following a plan endorsed by greens and unions that would provide a "just transition" for the community and the workers, and replace lost power capacity with low-carbon sources other than natural gas.

The nuclear evangelists are skeptical of this plan, which outgoing Gov. Jerry Brown signed off on in September. Shellenberger calls it a "back-room" deal "negotiated by corrupt institutions behaving unethically and perhaps illegally." The activists' complaint, though, goes beyond the politics: Jettisoning Diablo Canyon, they say, will delay the move away from fossil fuels.

"Diablo Canyon acts as the reliable ground on which wind and solar can be built," Emma Redfoot told California land commissioners in June 2016. "I cannot see how replacing a clean source of energy with a clean source of energy is a step forward."



At an Environmental Progress-sponsored pro-nuclear march in Chicago in October 2016, Emma Redfoot, center back, stands beside pro-nuclear activists, including Mothers for Nuclear founders Heather Matteson (braid) and Kristin Zaitz, front row, right.

Courtesy of Emma Redfoot

BUT THE SIMPLE ARGUMENT that nuclear plants should stay because they are cleaner is increasingly complicated these days by the economic and political factors involved. When coal plants face a shutdown for economic reasons, they have a huge domestic coal-mining industry willing to spend millions on lobbyists and campaigns to try to keep them open. Nuclear plants facing retirement get far less help, despite the fervent support of their green proponents.

That's in part because globalism has reduced the domestic uranium-mining lobby to a mere shadow of its Cold War self. In 2017, U.S. uranium producers kicked out a record low of just 1,150 tons of uranium concentrate (compared to the 600 million tons of U.S. coal mined for power production last year), or

about 5 percent of the fuel consumed by domestic nuclear plants. The other 95 percent comes mainly from Canada, Australia, Russia and Kazakhstan. Only about 400 people currently work in the U.S. uranium-mining industry. That's not exactly a formidable voting bloc, nor are its members easily transformed into the kind of "real America" working-class icons that coal miners have become.

Rather than spend political capital on fighting for Diablo Canyon, the two largest domestic uranium producers, Ur-Energy and Energy Fuels – which owns the Daneros Mine and White Mesa Mill near Utah's Bears Ears National Monument – petitioned the Trump administration to force utilities to collectively purchase at least 25 percent of their fuel domestically. Nuclear boosters, including the Nuclear Energy Institute, the industry's biggest lobbyist, aren't so keen on the idea, however. Limits or tariffs would increase the cost of uranium and therefore the operating costs for nuclear plants, making them even less competitive with natural gas.

The Trump administration made a feeble attempt to throw imperiled nuclear plants a lifeline this past summer by forcing utilities to buy coal and nuclear power regardless of the cost, but that rule is currently on hold. Green nuclear evangelists, meanwhile, don't want that kind of help. "Nuclear people are so unhappy that we keep getting saddled with coal," says Redfoot. After all, nuclear's strongest marketing asset is that it's *not* coal. If Trump were genuinely interested in helping nuclear, Redfoot said, he would have kept President Barack Obama's Clean Power Plan, which limited emissions from coal-fired plants, as well as rules limiting methane pollution from oil and gas production. A high price on carbon emissions would also give nuclear a leg up on natural gas and coal.

That's not to say that nuclear power isn't getting a boost from the federal government. On the contrary: Over the past decade, substantial federal dollars have been invested in a new generation of so-called advanced reactor designs. This

summer, the Department of Energy's Gateway for Accelerated Innovation in Nuclear doled out \$53 million to various endeavors, and in September, a bipartisan coalition led by Sens. Lisa Murkowski, R-Alaska, and Cory Booker, D-N.J., introduced a bill that would direct the department to support the development of advanced reactors.

At the head of these politically sexy innovations is a project pushed by a Portland, Oregon-based company called NuScale, which would include 12 60-megawatt reactors installed on the vast landscape near Idaho Falls co-opted by the Idaho National Laboratory. Utah Association of Municipal Power Suppliers, or UAMPS. With 46 members scattered across the Interior West, UAMPS will own the euphemistically named Carbon Free Power Project – if it gets built.

An artist's rendering of a 60-megawatt micro-nuclear reactor similar to what is proposed for the area near Idaho Falls.
Courtesy of NuScale

NuScale claims that its small modular reactors, or SMRs, will be safer and use less water than conventional reactors. But the big selling point is their relatively low buy-in cost. A utility could, theoretically, build a micro-nuke plant for less than \$2 billion upfront, a bargain next to the \$27 billion or so currently being spent to construct new reactors at the Vogtle plant in Georgia. The reactors would be manufactured in a facility, then trucked to the installation; what NuScale loses in economies of scale, it hopes to offset with the volume of reactors produced.

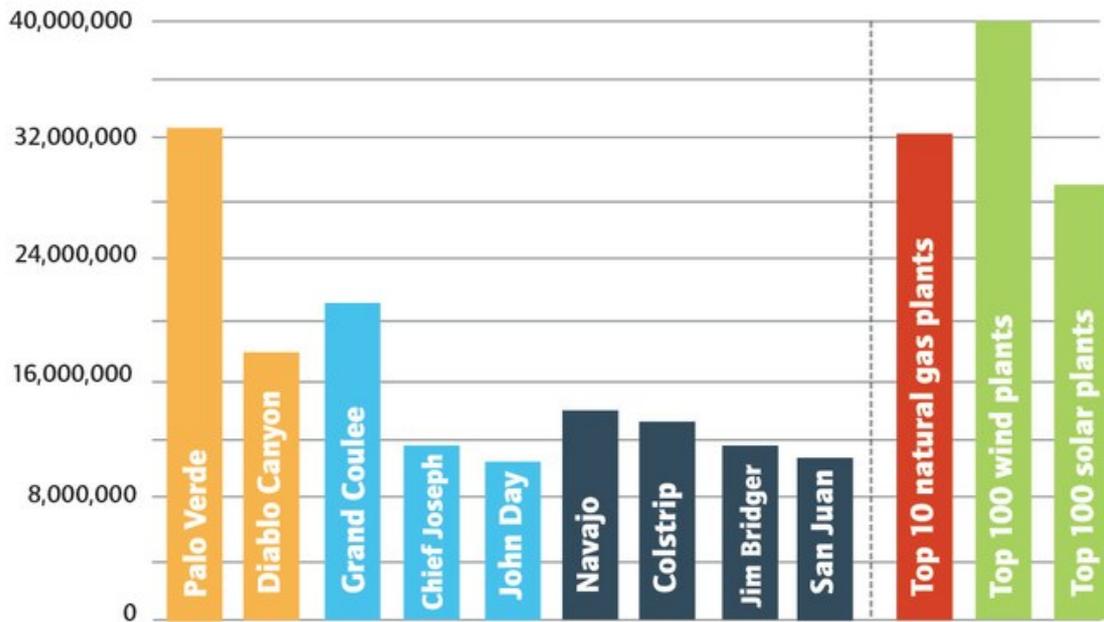
NuScale's corporate demeanor screams scrappy startup, but it's actually mostly owned by Fluor Corporation, the global construction conglomerate that was the lead contractor on the \$60 billion cleanup of the former Hanford nuclear weapons complex in eastern Washington. (*See story on nuclear waste cleanup efforts on page 18.*) Fluor has spent over \$12 million on lobbyists over the last three years; it has been a major

political donor, primarily to Republican campaigns, and it put \$250,000 into Trump's Inauguration Day fund. The feds have been generous in return: NuScale has received nearly \$288 million in grants from the federal government since 2014, including \$47 million in 2018.

NuScale hopes to be generating power in 2026. It has already cleared the first licensing hurdle with the U.S. Nuclear Regulatory Commission and is well into the second phase. But nothing will happen unless UAMPS succeeds in selling the concept to its members. Thus far, it's run into resistance in Price, Utah, where leaders fear it would help kill the local coal industry; in Truckee, California, because it would hamper the community's efforts to go 100 percent renewable; and in Los Alamos, New Mexico, where people are leery of investing in unproven technology, not to mention the high projected operating costs relative to other energy sources. Anti-nuclear activists in Utah and Idaho are battling the project, too, mostly because it will use a lot of water and add to the growing stockpile of radioactive waste.

Redfoot said she is "impressed" that UAMPS finds value in nuclear, but for all of her desire to keep existing nuclear generation online, she's decidedly cooler on new construction, including the UAMPS project. Beginning in about 2006, domestic electricity consumption stopped its long and steady climb and hit a plateau. Until it starts rising again due to mass electrification of transportation or industry, Redfoot said, "it's hard to make an argument to build new reactors now in the U.S."

The West's top generators



Nuclear power plants are among the largest generators on the Western Grid, each with annual outputs equal to dozens of the biggest wind or solar installations combined.

Source: Energy Information Administration

IN SEPTEMBER, THE DEPARTMENT OF ENERGY posted a video on Twitter. It's in black-and-white, with artificial scratches added to give it a vintage look, and stars Generation Atomic founder Eric Meyer, belting out an aria in a smooth baritone. "Clean Power Forever," he sings, "within our grasp. By splitting atoms, it's come to pass. Saving 2 million lives, just in this past century."

The video was filmed as part of a CAES advocacy training session at Experimental Breeder Reactor number 1, west of Idaho Falls, where in 1951, nuclear fission was first used to generate and transmit electricity. EBR-I is now a museum that serves as a church of sorts for nuclear evangelists. Its mid-century, retro-futuristic, sleek and chunky control panels and knobs and valves evoke a more optimistic era – a time when the same terrible yet elegant process that annihilated two Japanese cities and ended World War II prophesied the dawn of a more prosperous Atomic Age and might even be employed "in

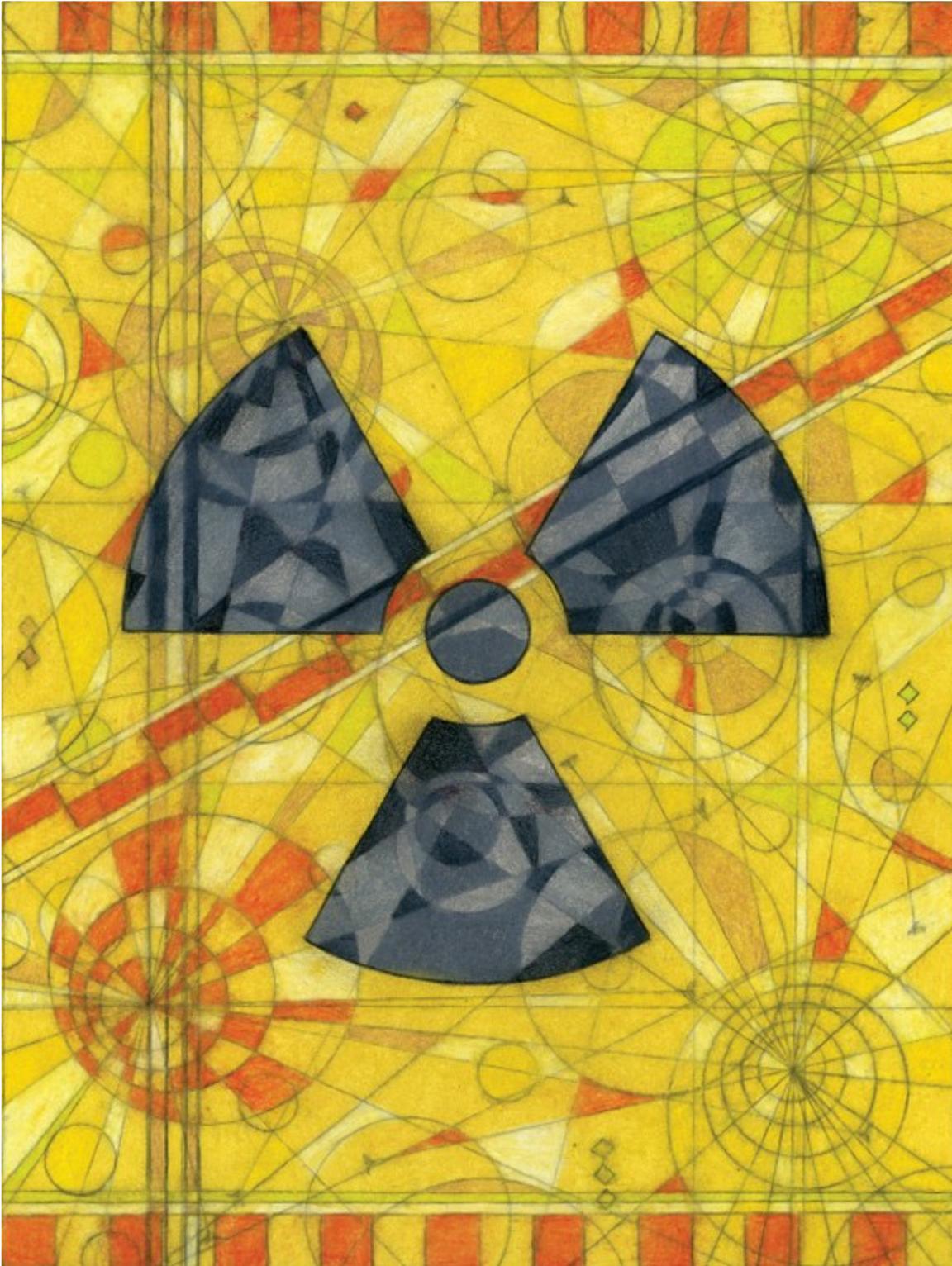
accomplishing such bizarre tasks as irrigating the Sahara and melting the ice cap on Greenland.”

The difference is that today’s nuclear evangelists hope to employ atomic fission to keep those same ice caps frozen – and to save lives. The 2 million lives Meyer sang about come from a 2013 paper by NASA scientists Pushker Kharecha and James Hansen, who brought the looming climate change catastrophe into the public eye three decades ago. It estimated that nuclear power had prevented 1.84 million air pollution-related deaths. That figure does not include mortality caused by climate change, such as the scores of lives lost this fall to climate-exacerbated fires in California, or, for that matter, the non-air-pollution-related deaths caused by coal or natural gas extraction.

Yet it also misses the human and environmental cost of mining and milling uranium, the countless Western uranium miners and millworkers, and the people who lived nearby – both Navajo and white – who have gotten cancer, kidney disease or other maladies from exposure to uranium and its radioactive “daughters.” The nuclear evangelists’ assurances that mining is safer now are belied by the fact that one of the few uranium facilities left in the U.S. – Ur-Energy’s Lost Creek in-situ operation in Wyoming – has had at least 40 violations, spills or “reportable events” since 2013, including a release of 1,625 gallons of uranium-containing production fluid this summer.

“Nuclear needs to take ownership of its history, of the harm done to the Navajo people,” says Redfoot, even as she notes that all the uranium mining and milling up until the late 1960s was intended for weapons, not energy production, including the activities at Rocky Flats and Hanford. But it also needs to move forward, she says, and the policymakers, the influencers and the environmentalists must rationally weigh the risks of continuing to generate power with nuclear fission against the far more pressing risk of burning fossil

fuel at anywhere near the current rate.



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Nuclear reactor waste – evangelists prefer the term “spent fuel” – is also a risk, Redfoot acknowledges. But the Atomic Action app points out that the 80,000 or so metric tons of spent fuel that U.S. reactors have produced since 1968, stacked 24 feet high, could all fit onto a single football

field; and that all of that material is accounted for, and its storage in dry casks is highly regulated and closely monitored. Compare that to coal power plants, which annually kick out tens of *millions* of tons of nasty fly ash, slag and other solid waste, in addition to all the toxins and particulates that spew from the smokestacks, as well as the billions of gallons of briney, contaminated “produced water” that oil and gas wells vomit each year. These fossil fuel waste streams are toxic and can be radioactive, while federal regulations on their disposal are virtually nonexistent.

Though the nuclear evangelist movement is far from monolithic, its acolytes generally believe that the current spent-fuel situation – with waste stored on site in large, sealed canisters – is perfectly adequate. Shellenberger has written that he would like to see the idea of a national depository abandoned altogether. Instead, he thinks that the \$45 billion or so in an industry-funded depository savings account should be given back to existing nuclear plants like Diablo Canyon to keep them running.

Either way lies risk. On the one hand, there is the possibility of reactor meltdowns, of bomb-building terrorists acquiring enriched uranium or the plutonium that is a component of nuclear waste. On the other hand, the Intergovernmental Panel on Climate Change recently warned that without immediate and severe cuts in greenhouse gas emissions, the global temperature will rise 2.7 degrees Fahrenheit or more above pre-industrial times within just a couple of decades, manifesting in rising seas, crippling drought, pestilence, megafires and devastating floods. If something's not done soon, the climate change catastrophe may grow far worse by the time Generation Atomic reaches middle age.

What's a little radioactive steam, a football field's worth of waste and a few thousand or so dead fish next to that?

This is the calculus that drove Meyer to quit his jobs as a

Minnesota labor organizer and professional opera singer to head to California to support Diablo Canyon and then start Generation Atomic, and travel the world serenading anti-nuclear protesters with “I can’t help falling in love with U (as in U-235).” It’s even pushed the consistently anti-nuclear Union of Concerned Scientists in November to change its tune and join the green nuclear evangelists’ fight to keep some existing nuclear plants running for the sake of the climate.

And it’s what inspired Redfoot to get her degree this August and head to California to work as a fellow for Oklo, a startup that’s developing a very small fast reactor that could be deployed in places like India, where some 300 million people lack grid access – a number, Redfoot says, “that breaks my heart.”

“For me,” she concluded, “being an environmentalist is being pro-nuclear.”

Jonathan Thompson is a contributing editor at High Country News and the author of River of Lost Souls: The Science, Politics and Greed Behind the Gold King Mine Disaster. Follow @jonnypeace

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