

Utility Dive

Anatomy of a nuke closure: How PG&E decided to shutter Diablo Canyon

In a policy environment that prizes renewables, PG&E saw no cost-effective route to keeping the giant nuclear plant open

By [Herman K. Trabish](#) | July 7, 2016

One of the biggest tests of all time for renewable electricity was just proposed in California. It didn't get the attention it deserves because everybody called it the closure of the [Diablo Canyon Nuclear Power Plant](#) (<http://www.nrc.gov/reactors/operating/licensing/renewal/applications/diablo-canyon.html>).

The closure will test whether the facility's [18,000 GWh of yearly output](#) (http://www.pge.com/en/safety/systemworks/dcпп/index.page?Wt.mc_id=Vanity_diabolocanyon) can be replaced entirely by new zero carbon resources and reduced usage. Under PG&E's retirement plan, the utility says it can make up the generation gap entirely with energy efficiency, renewable resources and energy storage — all while costing customers less than continuing to operate the plant.

An unprecedented collaboration between PG&E, environmental advocates, anti-nuclear activists, and labor groups agreed on the closure. Their [Joint Proposal](#) (http://webiva-downton.s3.amazonaws.com/877/8a/5/8546/Signed_joint_proposal_20160620122548.pdf) details how California's planners, regulators, and stakeholders can meet the test by working together to build the grid of the future.

The proposal was the product of "a coalition of labor and environmental partners that came to the table with diverse points of view," PG&E President and CEO Tony Earley said in announcing the agreement. "We ultimately got to a shared point of view on the best way forward with regard to Diablo Canyon. We believe this is a textbook win-win solution and reflects California's changing energy landscape."

In the weeks since its decision, PG&E's plan has garnered passionate reactions from renewable energy advocates, who say it could be a model for other nuclear closures, and pro-nuclear activists, who argue the proposal is unworkable and irresponsible. Both sides, however, point out that the utility's decision highlights the difficulties for nuclear power in a utility system increasingly focused on building out renewable and distributed energy.

Joint proposal timeline and key components

Step 1:			Step 2:			Step 3:		
2018	2019-2023	2024	2025	2026-2030	2031 and Beyond			
Diablo Canyon:	Unit 1 Retirement	Unit 2 Retirement						

Potential for Additional GHG-free Resources

In addition to the specific energy efficiency and renewables provisions, parties agree to strongly support (before the CPUC and CAISO) use of additional GHG-free resources, including but not limited to pumped hydroelectric storage, for reliability and resource integration solutions that may be required to replace Diablo Canyon.

The proposed timeline for Diablo Canyon's retirement.

Credit: [Joint Proposal](#) (http://webiva-downton.s3.amazonaws.com/877/8a/5/8546/Signed_joint_proposal_20160620122548.pdf)

Diablo Canyon's backstory

Diablo Canyon's story goes back to nuclear power's glory years in the 1970s. After public hearings concluded the plan for the facility was safe, construction on the two units began in 1968 and was completed in 1973. By then, the [Hosgri tectonic fault line](#) (https://en.wikipedia.org/wiki/Hosgri_Fault) had been identified just off the facility's coastal site and the plant had accrued a sizable opposition over questions of its [ability to withstand earthquakes](#) (<http://www.pge.com/en/safety/systemworks/dcпп/seismicsafety/index.page?>).

PG&E upgraded construction standards, gained approval for them from the Nuclear Regulatory Commission (NRC) and continued operation. In the aftermath of the near-disaster at Pennsylvania's Three Mile Island nuclear facility, Diablo Canyon was the site of the [one of the biggest anti-nuclear protests ever](#) (<https://books.google.com/books?id=Kn6YhNlVigC&pg=PA44&dq=PA44&dq=shoreham+nuclear+power+plant+protests&source=web&sots=r-mz3LV6tR&sig=SHGK4uiUQ8KKAYnuBqZa7NWqYz0&hl=en#v=onepage&q=shoreham%20nuclear%20power%20plant%20protests&f=false>) in 1979.

Concerns about adequate seismic reinforcement at Diablo Canyon was also widely thought to be part of the basis for the 1979 film "[The China Syndrome](#)" (<http://www.imdb.com/title/tt0078966/>), which portrays a near core meltdown at a Diablo Canyon-like nuclear facility.

PG&E currently generates 8.6% of California's electricity at the plant, [according to NEI](#) (<http://www.nei.org/CorporateSite/media/filefolder/Backgrounders/Fact-Sheets/2015-California-State-Fact-Sheet.pdf?ext=.pdf>). In 2009, the utility applied to the NRC for a 20 year license extension to run Diablo Canyon through 2045. After the 2011 disaster at Japan's Fukushima Daiichi nuclear facility, the NRC slowed the relicensing approval process and activists' efforts to close Diablo Canyon was renewed.

In 2012, [mechanical failures](#) (<https://sanonofresafety.org/2012/02/06/san-onofre-and-other-nuclear-plants-mechanical-failures/>) at California's 2,200 MW San Onofre Nuclear Generating Station (SONGS) caused a release of radioactive steam and led to the plant's temporary shutdown. Suddenly, SCE's southern territory faced supply shortages and potential outages. SONGS owner-operator Southern California Edison (SCE) and the California ISO took emergency interim steps to meet demand.

Environmental organization Friends of the Earth (FOE) called for planning in anticipation of the plant's permanent retirement. But instead, SCE and the CPUC debated retrofitting the facility. When the utility and the regulators finally agreed retrofitting would be an uneconomic use of ratepayer funds, [SONGS was shuttered](#) (<http://www.nrc.gov/docs/ML1501/ML15015A419.pdf>).

SCE and CAISO then scrambled to replace the SONGS generation. In the end, some milestone demand response and energy storage projects made up 261 MW of the needed supply, but the 1,800 MW balance was replaced with new, more flexible natural gas capacity.

In the weeks after PG&E's Diablo Canyon announcement, nuclear advocates seized on the SONGS experience as a cautionary tale.

"The California Air Resources Board said in 2014 that the state's carbon dioxide emissions had increased by 9 million metric tons in the 12 months following the 2012 closure of two San Onofre reactors," Revis James, vice president of policy development at the Nuclear Energy Institute, [recently wrote](#) (http://www.realclearenergy.org/articles/2016/06/27/closing_diablo_canyon_california_rolls_the_dice_with_renewables_and_natural_gas_109179.html).

Backers of the PG&E plan, however, say there's a better plan in place this time around to replace the generation with zero-carbon resources.

Inside the retirement decision

In the aftermath of the SONGS closure, FOE leaders Damon Moglen and S. David Freeman petitioned the CPUC for a proceeding to consider Diablo Canyon's future. The commission rejected their proposal.

In response, the senior FOE advisors commissioned a study from the Center for Energy Efficiency and Renewable Technologies (CEERT) to assess whether it could be cost-effective to replace Diablo with

zero-carbon resources. The result was FOE's "[Plan B](http://webiva-downton.s3.amazonaws.com/877/6d/5/8551/PlanBfinal.pdf)," which formed the underpinnings of the retirement proposal.

The study's financial analysis was based on numbers in [PG&E's 2017 general rate case](http://www.pge.com/en/about/company/regulation/grc/index.page?WT.mc_id=Vanity_grc). It concluded a Diablo Canyon license extension would cost the utility's ratepayers at least \$17 billion. Four alternative generation portfolios based on differently sourced zero-carbon resources ranged in cost from \$12 billion to \$15 billion.

"We thought the CEERT paper was so convincing that we decided to send it in draft form to PG&E instead of releasing it to the public," Moglen said.

At the time, PG&E was publicly undecided on the future of Diablo Canyon. Study in hand, Moglen and Freeman obtained a meeting with Melissa Lavinson, vice president of policy and federal affairs at the utility.

"We presented her with the Plan B from CEERT and that started the discussions," Freeman said.

Lavinson told them the utility's leaders had not made a decision about Diablo Canyon but were seriously considering alternatives. The Plan B work and the discussions were useful in helping them reach the decision to not pursue a license extension, Freeman said.

"There was agreement in principle on the objective pretty early on in the discussions," he recalled. "It was how to implement a Plan B that was tough because replacing the reactors was more complicated than just buying replacement kWh."

As the discussions expanded to include energy efficiency, [Natural Resources Defense Council](https://www.nrdc.org/) (NRDC) Senior Attorney and Energy Program Co-Director Ralph Cavanagh was invited to bring in his expertise in that area.

As the contours of the agreement began to emerge, other environmental organizations were included. When concerns about Diablo Canyon's nearly 1,500 workers were raised, Freeman and others reached out to the [International Brotherhood of Electrical Workers Local 1245](http://ibew1245.com/) and the Coalition of California Utility Employees.

The negotiators pushed for worker protections like retraining programs and retention bonuses to encourage plant workers to stay until the closure.

"When the unions saw the \$350 million package being offered, it helped bring them into the agreement along with environmental groups, anti-nuclear groups, consumer advocates, and the utility," Moglen said.

Expected Life Cycle Costs of Alternatives

Diablo Canyon License Extension	\$17+ B
Portfolio A: Diverse Renewables	\$13- B
Portfolio B: High Solar Renewables	\$13 B
Portfolio C: Central Valley Solar	\$15- B
Portfolio D: 75% Diverse Renewables, 25% Energy Efficiency (PG&E only)	\$12- B

Extending Diablo Canyon's license would be more costly than replacing it with zero-carbon resources and efficiency, CEERT found.

Credit: [CEERT's Plan B study](http://webiva-downton.s3.amazonaws.com/877/6d/5/8551/PlanBfinal.pdf)

The joint proposal

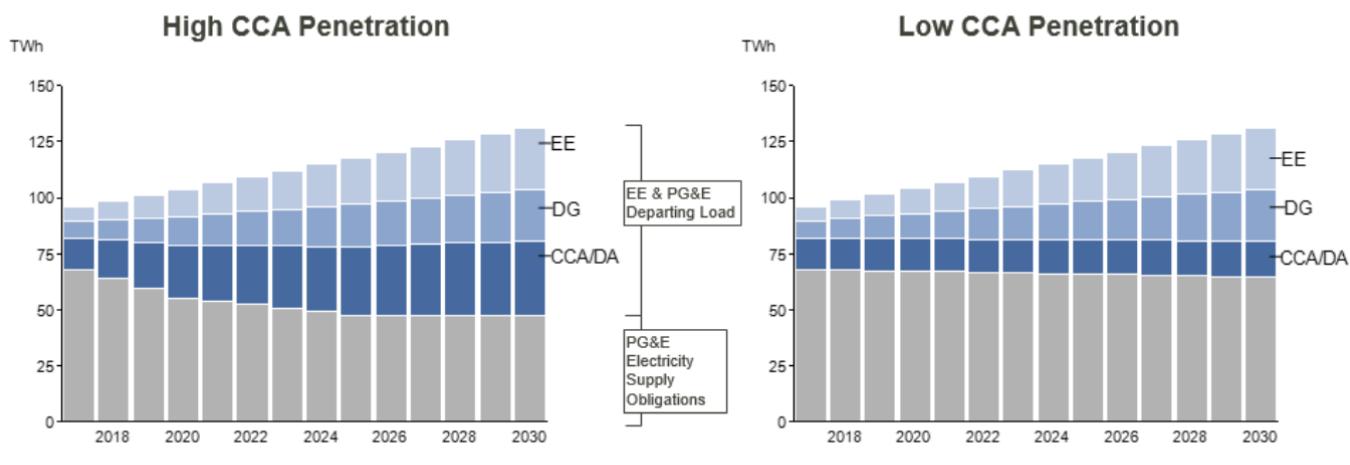
If approved by California regulators, the plan described by PG&E's joint proposal will officially kick off when the operating licenses for the plant's two reactors expire in 2024 and 2025, respectively.

While it does not lay out the exact megawatt-for-megawatt replacements for Diablo Canyon's output, the proposal gives a roadmap for how PG&E plans to procure enough renewables and reduce usage enough to replace the nuclear plant. Under the plan, PG&E would promise to obtain 2,000 GWh from efficiency by January 2025 and issue requests for offers for 2,000 GWh per year of greenhouse gas-free energy resources or efficiency by 2020.

The joint proposal also lays out the challenges the utility would face if it continued to operate Diablo Canyon.

The first is the uncertainty of electricity demand. As customers add distributed generation, upgrade their energy efficiency and some cities move to [Community Choice Aggregation programs](http://www.cpuc.ca.gov/general.aspx?id=2567), the outlook for how much electricity PG&E can expect to sell is anything but certain.

The utility is facing "massive changes in the market," Moglen said. "There are estimates the utility could lose 30% to 60% of its load" in coming decades, reducing the need for Diablo.

Figure 3. PG&E electricity supply obligations after accounting for EE, distributed generation, and DA/CCA

Source: MJB&A analysis based on data provided by PG&E

Even in a case with low community choice aggregation, PG&E expects to serve significantly less load in the future.
Credit: [MJ Bradley report on Diablo Canyon \(\[http://www.pge.com/includes/docs/pdfs/safety/dcpp/MJBA_Report.pdf\]\(http://www.pge.com/includes/docs/pdfs/safety/dcpp/MJBA_Report.pdf\)\)](http://www.pge.com/includes/docs/pdfs/safety/dcpp/MJBA_Report.pdf)

The second challenge is a decreasing need for baseload generation. As renewables penetrations rise across a widening geographic region, the wind is likely to be blowing or the sun is likely to be shining somewhere, making those resources' variability less of a problem.

The new need, the joint proposal argues, is for more flexible resources like [geothermal power](http://newenergynews.blogspot.com/2016/04/todays-study-value-of-geothermal.html) (<http://newenergynews.blogspot.com/2016/04/todays-study-value-of-geothermal.html>), concentrating solar with thermal storage, and pumped hydro storage. These would replace the highly inflexible baseload generation from the nuclear plant, allowing for better moment-to-moment grid balancing.

The third challenge is solar and wind over-generation during off-peak periods.

"On cooler spring and fall days you still have to generate from renewables to meet your 50% renewable requirement, because that's the state law," Earley said on a press call following the June 21 announcement. "There's just not going to be enough need to have to run your nuclear plant."

Because most of its costs are fixed, reducing the generation output of the plant can raise its per-kWh cost significantly.

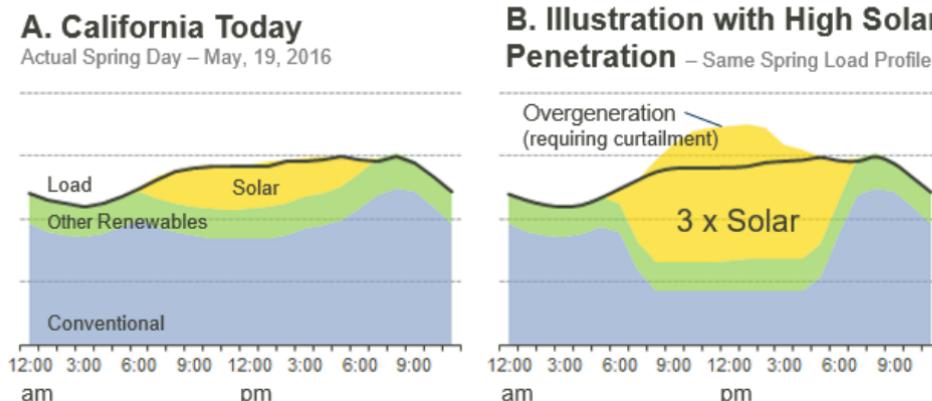
"Let's just take a number," Earley said on the press call. "If the capacity factor drops 50% that effectively doubles the cost per kWh. And when you calculate the cost of the whole package including the cost of renewable energy and all of the other provisions, our conclusion is it's going to cost less as a total package than if you just continued to operate Diablo Canyon."

That evolving resource mix influenced the structure of the joint proposal, Moglen said.

"This changing environment is having a massive but unpredictable impact on the utility market," he said. "That is the reason there are three tranches of procurement scheduled to replace Diablo Canyon and why the first tranche is relative small, the second tranche begins to move into renewable energy, and the third tranche is completely alterable to fill in that uncertain gap when the plant goes offline."

The precise composition of each tranche has yet to be decided. That will come with oversight from the California Public Utilities Commission (CPUC) and other regulatory agencies already deeply engaged in guiding the state's landmark efforts to grow renewables and [fight climate change](http://www.cpuc.ca.gov/General.aspx?id=5932) (<http://www.cpuc.ca.gov/General.aspx?id=5932>).

"Given these and other uncertainties, [PG&E and other signatories] cannot, and it would be a mistake to try to, specify all the necessary replacement procurement now," the joint proposal reads. "[W]hat the Parties have proposed in the Joint Proposal are significant and appropriate steps in the journey."

Figure 5. Illustration of overgeneration requiring curtailment under a high solar output scenario

Source: Left-hand chart is plot of actual historic production and load data from CAISO (Renewables Watch website). Right-hand chart is an illustrative example assuming 3x increase in May 19, 2016 solar production and minimum baseload. This level of PV is expected in early 2020s.

As solar and other renewable generation increases, PG&E sees more of a need for flexible generation than large baseload plants like Diablo.
Credit: [MJ Bradley report on Diablo Canyon \(\[http://www.pge.com/includes/docs/pdfs/safety/dcpp/MJBA_Report.pdf\]\(http://www.pge.com/includes/docs/pdfs/safety/dcpp/MJBA_Report.pdf\)\)](http://www.pge.com/includes/docs/pdfs/safety/dcpp/MJBA_Report.pdf)

Nuclear advocates don't buy a word of it.

"If they cared about climate change, why would they want to close our single largest source of clean energy?" said Michael Shellenberger, president of Environmental Progress, a pro-nuclear environmental group. "It is Orwellian to say they want to fight climate change by eliminating so much of the state's clean energy."

Shellenberger and other nuclear supporters see the open-ended structuring of procurement under the joint proposal as deceptive.

"It is hand waving. There is no requirement to replace anything beyond the first 2,000 GWh," he said. "It might increase greenhouse gas emissions more in an attempt to keep rates lower or it might increase rates in an attempt to reduce emissions, depending on whether they use more solar or more natural gas. There is no binding commitment."

The proposal itself explains the measured rollout of new resources differently. The three tranches "are not intended to specify everything that will be needed," it reads.

"The full solution will emerge over the 2024-2045 period, in consultation with many parties and with the oversight of the CPUC, the California Independent System Operator, the California Energy Commission, the California Air Resources Board, the Governor, and the Legislature," the joint proposal promises. "Additional procurement beyond that specified in the three tranches will be needed on a system wide basis to replace the output of Diablo Canyon and the Parties envision that this issue will primarily be addressed through the CPUC's [Integrated Resource Planning (IRP) process.]"

Still, Shellenberger is skeptical.

"If they care about climate change, they should add more clean energy without closing Diablo," he said. "They have added so much solar that it has to be curtailed but why is that the fault of nuclear? This is more Orwellian language."

A new, more distributed grid

What makes the closure of Diablo Canyon possible is "a fundamental shift in PG&E's thinking about its resource needs going forward," NRDC's Cavanagh said in describing his interactions with the utility's representatives during the joint proposal negotiations.

California climate and energy policies are making base load generation "less relevant and less economic all the time" and placing "an increasing premium on flexibility," Cavanagh said. "A giant resource operating 24/7 is increasingly disconnected from the needs of the system."

The change that led to this new thinking about the grid did not come from talks with environmentalists, he said. It came from a "mutual acceptance of reality based on [a body of work \(http://ceert.org/programs/law-carbon-grid/\)](http://ceert.org/programs/law-carbon-grid/) that shows the role of base load power generation is changing dramatically."

Shellenberger disagrees. Closing Diablo Canyon would be a mistake because it produces electricity "at \$0.04/kWh to \$0.05/kWh in a state where we pay \$0.18/kWh," he told Utility Dive.

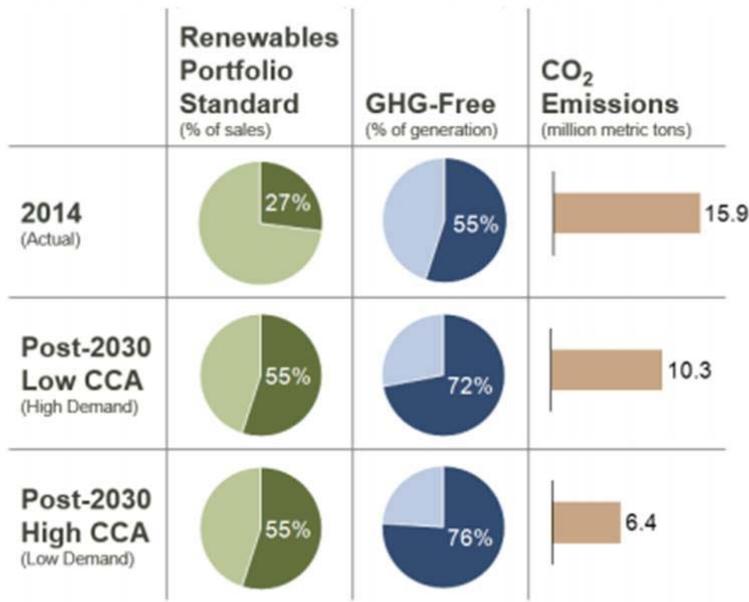
But Diablo Canyon's output can be an "impediment" that drives up costs if CAISO is required to curtail zero-fuel-cost solar or wind to run it, Cavanagh countered.

"PG&E's [\[post-2020 needs assessment\] report \(http://www.pge.com/includes/docs/pdfs/safety/dcpp/MJBA_Report.pdf\)](http://www.pge.com/includes/docs/pdfs/safety/dcpp/MJBA_Report.pdf) makes the changing role of base load generation a core rationale for the Diablo Canyon closure and suggests the state's energy and climate goals might not be achievable as cheaply and reliably if the system is burdened with giant base load power plants," he added.

[Over-generation \(http://www.utilitydive.com/news/the-epic-fail-on-solars-doorstepand-how-the-grid-can-help/324411/\)](http://www.utilitydive.com/news/the-epic-fail-on-solars-doorstepand-how-the-grid-can-help/324411/) "is projected to become a more acute problem" because of "inflexible generating resources such as Diablo Canyon," the needs assessment concludes. "The grid will need to be transformed with more flexible supply and load resources."

The joint proposal offer three options for resolving solar over-generation, none of which are mutually exclusive. The system can add [flexible resources \(http://www.utilitydive.com/news/for-grid-flexibility-utilitiespushed-to-think-beyond-gas-plants-and-store/417991/\)](http://www.utilitydive.com/news/for-grid-flexibility-utilitiespushed-to-think-beyond-gas-plants-and-store/417991/) that allow more stop-start and cycling. Some load can be shifted from the evening demand peak period to the midday peak solar generation period. And energy storage technologies can be used to allow renewables generation to serve peak load.

Projections of renewable and GHG-free energy deliveries and CO₂ emissions under the joint proposal



Source: MJB&A analysis based on data provided by PG&E

If the parties can deliver on the joint proposal, PG&E estimates emissions could drop significantly, even without Diablo.

Credit: [Joint Proposal \(http://webiva-downton.s3.amazonaws.com/877/8a/5/8546/Signed_joint_proposal_20160620122548.pdf\)](http://webiva-downton.s3.amazonaws.com/877/8a/5/8546/Signed_joint_proposal_20160620122548.pdf)

Toward a nuclear-free California

Beyond the specifics of the plan, nuclear advocates object to the underlying policy focus on increasing renewables and distributed generation, even at the expense of California's last nuclear generator.

"Policy is driving California's generation mix composition but that does not make it desirable," NEI's James said. "From a technical perspective, validated by power company experience and analysis, using policy to pre-determine the generation mix has not proven to be efficient in terms of cost or emissions."

Unintended outcomes are possible from shutting down Diablo Canyon, James warned. "In Wisconsin, [emissions jumped more than 15 percent following the shutdown of the Keweenaw \(http://www.nei.org/News-Media/News/News-Archives/5-Reasons-Nuclear-Energy-Is-Vital-to-EPA-s-Clean-P\)](http://www.nei.org/News-Media/News/News-Archives/5-Reasons-Nuclear-Energy-Is-Vital-to-EPA-s-Clean-P) nuclear facility. In New England, [emissions increased by 7 percent in 2015 compared to 2014 \(http://www.rtoinsider.com\)](http://www.rtoinsider.com)

[/co2-new-england-22278/?utm](#)) because of the shutdown of Vermont Yankee and they will jump again in 2019 when Entergy's Pilgrim reactor closes in Massachusetts."

"It is a dirty deal," Shellenberger added. "Natural gas went from 45% to 61% of our generation mix after San Onofre was closed and if Diablo Canyon is shut down it will go to 70%. They say they will figure out how to avoid that after 2020, but I say that is irresponsible."

The biggest obstacle in drafting the joint proposal was uncertainty about PG&E's future load, Freeman said. "You don't have to be an economist to figure out that if they lose half their load they won't need Diablo Canyon or a replacement for it," he said.

That uncertainty made it difficult to decide how much procurement PG&E would commit to in advance and how much would go into each future tranche, he added. The proposal goes as far as possible to ensure procurement will be "in addition to what the utility would do for the SB 350 mandate [for 50% renewables by 2030]" and will "drive the use of natural gas down."

Caldwell put the issue more bluntly. Those who want to keep the plant open "would be right if the plan was to turn Diablo Canyon off tomorrow," he said. "There would be no way to avoid replacing it with natural gas."

But good planning for 2024 will guarantee that doesn't happen, he said. By making the decision now, the utility and other stakeholders can plan for the replacement of the plant's output with zero-carbon generation in a way that is more cost-effective than keeping Diablo Canyon in operation.

Planning must begin now for transmission, storage, and generation infrastructure, Caldwell added, because the decision-making process is likely to take two years and bringing the infrastructure online will take another three to five years.

"This will be the first opportunity to apply the principles of integrated resource planning with the low carbon grid strategy," noted CEERT Executive Director V. John White. "The key is a deliberate [planning process](#) ([http://www.cpuc.ca.gov/lipp/](#)) that fits California's resource options together in a cost-effective, reliable, low-carbon portfolio."

At present, the utility is working on the initial 2,000 GWh energy efficiency procurement tranche, PG&E Electricity President Geisha Williams told Utility Dive. "The second tranche, due between 2020 and 2025, will procure 2,000 GWh of least-cost, best-fit non-GHG-emitting resources through a competitive offering."

Over the next nine years, she added, "our approach will be to have a highly integrated portfolio of renewable and other sources so we don't have to increase natural gas usage."

The major takeaway from the Plan B study and joint proposal "this is an opportunity [to plan wisely](#) ([http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M155/K503/155503162.PDF](#)) instead of waiting until December of 2023," Caldwell said. "We have to start now and we have to rethink how things were done in the past. It has become clear that big infrastructure decisions have to be made from a long term perspective."

FOE is planning a stakeholder meeting by mid-July, Moglen said. "We don't want the decision to be seen, like the San Onofre settlement, as a backroom deal. We want it debated and made better."

The next step would be a broad, Diablo Canyon-specific CPUC proceeding that would affirm the prudence of not relicensing Diablo Canyon," he said. "It would also affirm "a plan to replace the nuclear facility with GHG-free renewables, efficiency, and energy storage."

Further work could be done as part of [the commission's IRP proceeding](#) ([http://www.cpuc.ca.gov/General.aspx?id=9147](#)). "We would like to see that work start yesterday," Moglen added. "The wind is blowing in our direction and a lot of powerful forces see this as an historic agreement and a good thing and they want to make it happen."

NEI is not on board.

"The anti-nuclear lobby says that a future primarily powered by renewable sources of energy is upon us but we've done the math, and the equation doesn't balance," James said. "Rather, this seems more like a flawed experiment that will put greater pressure on consumers through higher electricity prices while increasing, not decreasing, CO2 emissions."

Shellenberger and his organization are determined to stop the plan.

"We would like to stop it at the CPUC but if we can't we will consider a lawsuit to stop it because it is a really lousy deal for ratepayers," he said. "It completely undermines our climate and environment goals and everybody who negotiated it should be ashamed of themselves."

Top Image Credit: Nuclear Regulatory Commission ([https://www.flickr.com/photos/nrcgov/6517596951/in/photolist-aWw0e-btdSSk-btdSEn-btdSaT-btdSKF-btdSKH-btdSFi-bfuOKM-btdShc-btdT52-9tC9eS-btdT1x-9tzcm6-hmDzH4-9tzczt-dQTndR-9tC9Vb-d0YwfW-dxhCxj-oKcw7L](#))

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