MEMORANDUM

To: File

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Date: December 17, 2021 (this revision)

Cc:

Subject: **RECONCILING THE CEERT, THE PG&E AND THE STANFORD/MIT ESTIMATES OF THE COST OF POWER FROM THE DIABLO CANYON NUCLEAR POWER PLANT**

Introduction

The recent Stanford/MIT report, *Assessment of the Diablo Canyon Nuclear Plant for Zero-Carbon Electricity, Desalination, and Hydrogen Production*, used an estimated busbar cost of power from Diablo at $42.48/MWh, inclusive of the remaining cost of relicensing and a new water intake system and denominated in 2020 dollars.[1]

This estimate is lower than estimates made in 2016 by The Utility Reform Network (TURN), the Center for Energy Efficiency and Renewable Technologies (CEERT) and Friends of the Earth (FOE). They estimate costs ranging from $69 to $72/MWh denominated in 2014 dollars, or $97 to $102/MWh in nominal dollars.[2] The public discussion attributes these numbers sometimes to one or to another of these organizations. Since they appeared in testimony filed by CEERT, we call them the CEERT estimates.

[1] *Stanford/MIT Report*, Table 2-14, p. 73. The report is available at this link: https://energy.stanford.edu/publications/assessment-diablo-canyon-nuclear-plant-zero-carbon-electricity-desalination-and

[2] *A Cost Effective and Reliable Zero Carbon Replacement Strategy for Diablo Canyon Power Plant*, James H. Caldwell, William Perea Marcus, V. John White and Liz Anthony PhD, June 22, 2016, Appendix A to Opening Prepared Testimony of CEERT, witness James H. Caldwell, January 27, 2017. Hereafter, the *CEERT Report*. The cited figures appear on p. 33.

The Stanford/MIT estimate is also lower than estimates made in 2016 by PG&E. They estimated costs ranging from $102 to $211/MWh in 2025 and from $107 to $219/MWh in 2030, with the ranges reflecting alternative assumptions about plant generation needed to serve PG&E's customer base.[3]

The objective of this memo is to reconcile these divergent cost estimates by identifying divergent assumptions, missing elements or mistaken calculations. It will start by focusing on reconciling the Stanford/MIT $42.48/MWh estimate against the CEERT $97/MWh estimate.[4] It will then take up a reconciliation with the PG&E estimates.

Summary in re the CEERT Cost Estimate

Figure 1, below, summarizes the result of our reconciliation. On the left, the blue bar shows the CEERT estimate, which is $97.79/MWh. On the right, the dark red bar shows the Stanford/MIT estimate, which is $42.48/MWh. The bars in between walk from the one estimate to the other as different calculations are varied.

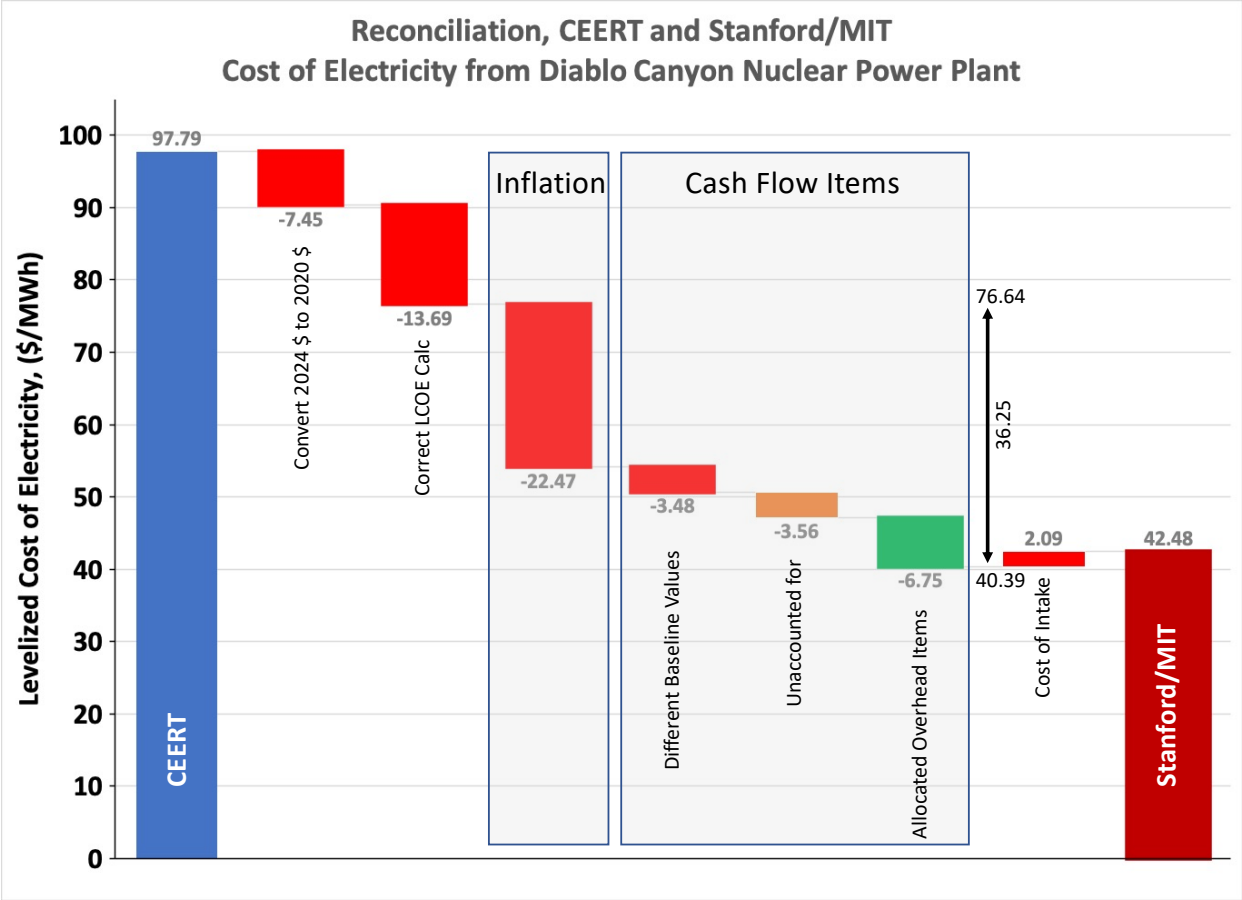
First, three adjustments are needed to make the comparison apples-to-apples:

- The Stanford/MIT estimate is in 2020 dollars, while the CEERT estimate is in 2024 dollars. Putting the CEERT estimate in 2020 dollars reduces it by $7.45.
- The Stanford/MIT estimate calculates an LCOE fixed in real terms. The CEERT estimate calculates an LCOE fixed in nominal terms, despite the fact that it assumes a 2% inflation rate. This choice produces a higher headline number in 2024 for the same total cost paid over time. Recalculating the CEERT estimate to be fixed in real terms reduces it by $13.69/MWh.
- The Stanford/MIT estimate is inclusive of the cost of an intake needed to be compliant with California's Once-Through-Cooling regulations. The CEERT estimate includes nothing towards compliance. Excluding the cost of intake from the Stanford/MIT estimate reduces it by $2.09/MWh, as shown on the right.

[3] Pacific Gas and Electric Company, Retirement of Diablo Canyon Power Plant, Implementation of the Joint Proposal, and Recovery of Associated Costs Through Proposed Ratemaking Mechanisms, Prepared Testimony, August 11, 2016, California Public Utilities Commission (CPUC), Docket A 16-08-006.

[4] CEERT's four values reflect two different quotation methods—real, in 2014 dollars, and nominal—and a low and high base case reflecting alternative assumptions on fuel disposal costs and the rate of return to be earned on fuel inventory. Most of the benefit of a reconciliation is accomplished by focusing on any one of the values.

Figure 1



Once the two estimates have been stated in common terms, we are left with a re-stated CEERT estimate at $76.64/MWh in 2020 dollars and a re-stated Stanford/MIT estimate at $40.39/MWh in 2020 dollars. The remaining discrepancy between the two is $36.25/MWh, as shown with the black arrow on the right-hand-side of the figure. We call this the substantive discrepancy. The re-stated CEERT estimate is 90% greater than the Stanford/MIT estimate—almost double.

Second, the majority of the substantive discrepancy is due to different assumptions about the real inflation rate at Diablo—i.e., the rate of growth in Diablo's costs above and beyond the general rate of inflation. The Stanford/MIT estimate assumes that costs are constant in real dollars, increasing in nominal dollars at a rate equal to the general inflation rate. The CEERT estimate assumes that costs increase in real dollars, increasing in nominal dollars at rates usually much greater than the general inflation rate.

Figure 2

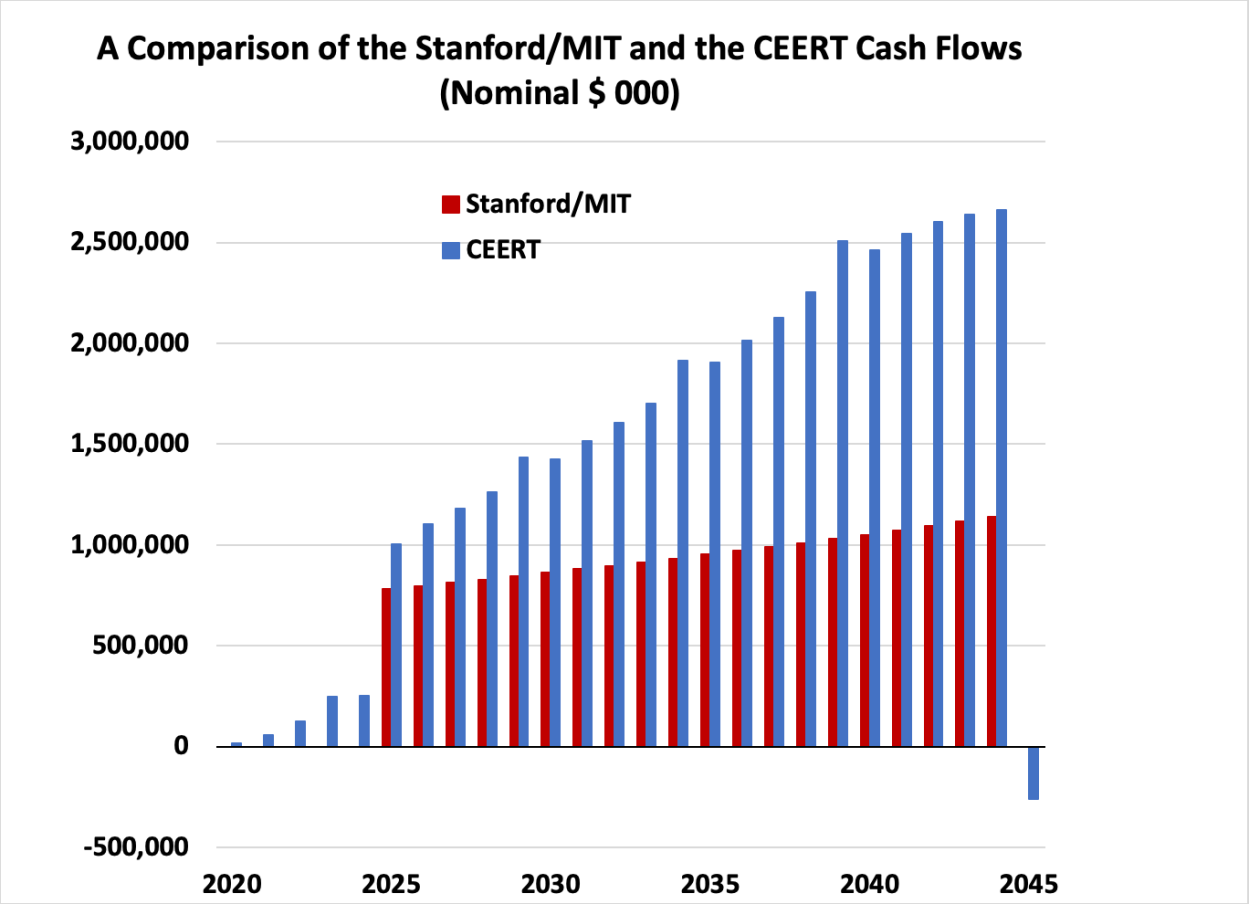


Figure 2, above, shows the impact of these different assumptions on the inflation rate on the time profile of cash flows in the Stanford/MIT estimate and the CEERT estimate. In the first year of extended life at Diablo—2025—the CEERT cash flow is only 27% higher than the Stanford/MIT cash flow. However, by the last years of extended life—from 2040 to 2044—the CEERT cash flows are anywhere between 132 and 141% higher than the Stanford/MIT cash flows.

At the time CEERT's estimate was made, there was no sound foundation underlying its aggressive inflation assumption. With the benefit of hindsight, we can see that it has not been borne out for Diablo Canyon in the few years since the forecast was made. Moreover, for nuclear

power plants across the country we do not see any persistent escalation in costs above the general rate of inflation over the last 17 years.[5]

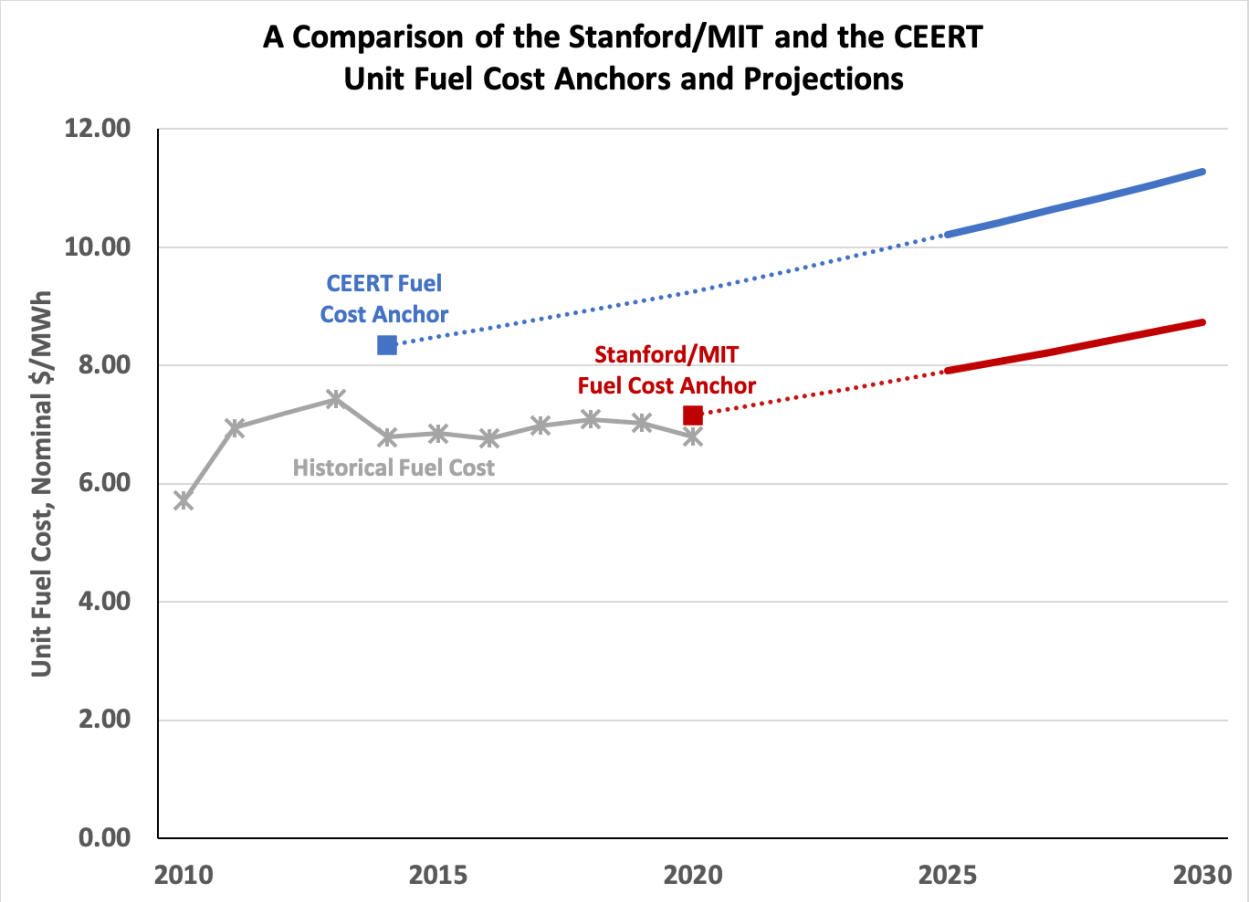
Recalculating the CEERT estimate with the 2025-2044 costs constant in real dollars reduces it by $22.47/MWh. This is 62% of the substantive discrepancy. Revising the CEERT estimate to include this reduction brings it to $54.18/MWh.

Third, differing estimates of various cash flow items are the source of the remaining $13.79/MWh discrepancy. Individual items are estimated from various sources, so it is difficult to easily crystallize the differences. For convenience, we have groped them under two main categories—different baseline estimates of key items, and allocated overhead items—and a residual labeled 'unaccounted for' in Figure 1.

- Figure 3, below, shows the different baseline estimates for the fuel costs as an example of the first category. The gray line shows the historical cost of fuel from 2010-2020 reported by PG&E to FERC on the Form 1. The blue marker shows the CEERT baseline estimate made at 2014, and the projection in later years, using CEERT's assumed inflation rate of 1.74% between 2014 and 2020 and 2% thereafter. Fuel cost is one of the few line items on which CEERT assumed the cost was constant in real terms. The red marker shows the Stanford/MIT baseline at 2020 and the projection in later years, using an assumed inflation rate of 2% consistent with CEERT's assumption. In 2020, the CEERT estimated cost of fuel is $9.23/MWh, which is approximately 30% greater than the Stanford/MIT estimate of $7.16/MWh. ***The CEERT estimated baseline is higher than any of the historical data before or after the baseline date***. Adjusting the CEERT fuel cost estimate to match the Stanford/MIT estimate reduces the CEERT value by $2.20/MWh.
- Other items on which there are obvious discrepancies in the baseline estimates include the O&M costs, capital additions, spent fuel costs and relicensing. Choosing just the spent fuel cost and relicensing, in addition to the regular fuel costs, Figure 1 shows an aggregate impact of the baseline discrepancies totaling $3.48/MWh. However, this is a very crude and not particularly definite estimate. For one thing, we do not have the detail on annual cash flows for each of the CEERT line items, nor for a corresponding breakdown of Stanford/MIT line items. The fuel cost item detailed above is one of the few that can be matched across the two. For another thing, there is an interaction between the impact of the inflation assumption and the baseline assumptions, and it is difficult to separate out the marginal impact of the baseline assumption once the inflation assumption has been adjusted. Once again, since the fuel cost was constant in real terms for both estimates, it is one of the few free of this confounding effect.

[5] Nuclear Energy Institute, Nuclear Costs in Context, October 2020, p. 3.

Figure 3



- The CEERT estimate includes costs recorded at PG&E's central or overhead accounts which would be incremental if the Diablo Canyon plant's life were extended. These include administrative, insurance and certain employee benefit costs. The Stanford/MIT estimate did not make any such attribution. In Figure 1, the green bar shows a possible $6.75/MWh added to the Stanford/MIT estimate for these overhead accounts. Making this adjustment would bring the Stanford/MIT estimate to $47.14.

Summary in re the PG&E Cost Estimates

There are two major differences between the Stanford/MIT cost estimate and the PG&E estimate.

The first difference regards sunk costs. Both Stanford/MIT and CEERT attempt to estimate the incremental cost of extending the life of Diablo. Sunk costs are not included. The PG&E estimate, in contrast, includes sunk costs.

In particular, during the years prior to 2016, PG&E made significant capital investments to enable a 20-year life extension. For example, it replaced the steam generators and the reactor vessel heads on both units, as well as other investments in turbines and a generator. PG&E's future revenue requirements are set to recover the cost of these investments. PG&E's cost estimate includes the depreciation and capital return associated with doing so.

It is important to appreciate that these costs have already been sunk. A decision now to extend the life of Diablo Canyon does not create these costs. Even more importantly, a decision to proceed with the closure of Diablo Canyon as planned does not avoid these costs.

Indeed, in 2018, when the California Public Utilities Commission (CPUC) approved the decision to retire the Diablo Canyon plant at the termination of its original licenses, it effectively accelerated the depreciation required to recover these costs, forcing an increase in the current retail electricity rates to recoup these costs by the 2024 and 2025 retirement dates.[6] Therefore, current annual depreciation charges and retail rates are unusually high relative to either (i) a case in which no investment had been made toward a life extension, or (ii) a case in which the operating life had been extended and the capital costs trend had continued as before.

The second difference between the Stanford/MIT cost estimate and the PG&E estimate regards the assumption about the cost of addressing California's Once-Through Cooling (OTC) rule. The PG&E estimate assumes that the rule will be satisfied by means of (i) a reduction in annual

[6] Pacific Gas and Electric Company, 2020 General Rate Case, Exhibit (PG&E-10), Results of Operations, Workpapers Supporting Chapter 10, December 13, 2018. See Table 10-5, Proposed Changes to Depreciation Elements, Average Service Life, Nuclear Production – 2002 & Subsequent, footnote (b). See also Pacific Gas and Electric Company, FERC Form No. 1, Depreciation and Amortization of Electric Plant (Account 403, 404, 405), Section C. Factors Used in Estimating Depreciation Charges, Average Remaining Life (g), 2014 versus 2016.

generation, and (ii) other possible mandatory investments.[7] The reduction in annual generation from 18,000 to 16,300 GWh per year increases the per unit fixed costs by 10% from a baseline with the larger amount of generation. The other possible mandatory investments were evaluated as alternative scenarios with probabilities attached to them:[8]

- the construction of freshwater cooling towers at a cost of $13.3 billion and a probability of 10%,
- the installation of saltwater cooling towers at a cost of $6.3 billion and a probability of 15%,
- alternate mitigation measures costing $1 billion and a probability of 50%,
- alternate mitigation measures costing $500 million and a probability of 15%, and
- alternate mitigation measures costing $180 million and a probability of 10%.

The expected value of these scenarios is $2.868 billion. In contrast, the Stanford/MIT estimate is based on a $500 million investment in the water intake option identified in our report.

Conclusion

We have carefully reviewed CEERT's and PG&E's cost estimates. This analysis strengthens the case made in our original report, that the cost of power from Diablo Canyon Nuclear Power Plant is economical and extending the plant's operating life may offer good value to Californians.

[7] Pacific Gas and Electric Company, Retirement of Diablo Canyon Power Plant, Implementation of the Joint Proposal, and Recovery of Associated Costs Through Proposed Ratemaking Mechanisms, Opening Brief, May 26, 2017, California Public Utilities Commission (CPUC), Docket A 16-08-006, p. 15, fn. 49, and p. 20.

[8] Pacific Gas and Electric Company, Retirement of Diablo Canyon Power Plant, Implementation of the Joint Proposal, and Recovery of Associated Costs Through Proposed Ratemaking Mechanisms, Reply Brief, June 16, 2017, California Public Utilities Commission (CPUC), Docket A 16-08-006, p. 10.