Docket No.: R.20-11-003
Exhibit No.: SC–03
Witness: Cara Bottorff

BEFORE THE PUBLIC UTILITIES COMMISSION

OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking to Establish Policies, Processes, and Rules to Ensure Reliable Electric Service in California in the Event of an Extreme Weather Event in 2021.	Rulemaking 20-11-003 Filed November 19, 2020

PREPARED PHASE 2 REPLY TESTIMONY OF

CARA BOTTORFF

ON BEHALF OF SIERRA CLUB

SEPTEMBER 10, 2021

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Sierra Club submits the following reply testimony on the Order Instituting Rulemaking to Establish Policies, Processes, and Rules to Ensure Reliable Electric Service in California in the Event of an Extreme Weather Event in 2021, proceeding R.20-11-003. This reply testimony responds to the opening testimony submitted in the above-referenced proceeding on September 1, 2021, pursuant to August 10, 2021 Assigned Commissioner's Scoping Memo and Ruling for Phase 2 and Administrative Law Judge Stevens' August 11, 2021 e-mail guidance on proposals, and is timely served.

PREPARED PHASE 2 REPLY TESTIMONY OF CARA BOTTORFF

I. INTRODUCTION & VERIFICATION

Q. What are your main recommendations in this testimony?

A. Through this testimony, I recommend that the Commission reject the arguments made by parties proposing additions of new or "incremental" gas capacity. Instead, the Commission should specifically exclude any new or incremental gas-fired capacity in its procurement, including incremental capacity from existing gas units. Additionally, the Commission should not prioritize or allow so-called "renewable" natural gas ("RNG") or hydrogen blending as these fuels do not decrease emissions as assumed and may in fact increase both greenhouse gases ("GHGs") and harmful criteria pollutants.

Q. Was this material prepared by you or under your supervision?

A. Yes, it was.

Q. Insofar as this material is factual in nature, do you believe it to be correct?

A. Yes, I do.

Q. Insofar as this material is in the nature of opinion or judgment, does it represent your best judgment?

A. Yes, it does.

Q. Do you adopt this testimony as your sworn testimony in this proceeding?

A. Yes, I do.

Q. On whose behalf are you testifying?

A. I am testifying on behalf of Sierra Club.

Q. What is the purpose of your testimony?

A. In this testimony, I respond to the testimony of parties promoting additional gas procurement, including procurement that involves RNG and hydrogen blended into fossil gas.

II. ADDITIONAL GAS

Q. In its opening testimony, Calpine proposes to "allow upgrades to gas plants to count towards the recently implemented Mid-Term Reliability procurement mandates."[1] Do you support this proposal?

A. No. In Decision ("D.") 21-06-35, the Commission was very clear that it was not allowing any new gas capacity, stating that "we are not authorizing fossil-fueled resources to count toward the 11,500 MW of total capacity required by this order."[2] The Commission should not reverse itself in this proceeding. It is beyond the scope of this proceeding to consider altering the terms of ordered procurement in the Integrated Resources Planning proceeding that led to D.21-06-035. Furthermore, a reversal here would be a major step backwards on climate targets at the very time when California must remain focused on ending reliance on fossil fuels to power the electric grid. As I detailed in my opening testimony, gas plants exacerbate the climate crisis and harm communities already overburdened by pollution. To improve reliability, clean, zero emissions resources such as increased reliance on demand-side resources, solar, and storage are available and should be carefully considered. In particular, the testimony submitted highlighted a number of demand-side proposals that are consistent with California's climate and air quality goals and requirements, including the California Environmental Justice Alliance's Just Flex Rewards proposal,[3] GRID Alternatives' Smart Controlled Thermostat – Low

[1] Calpine Opening Testimony, p. 5.
[2] D.21-06-035, p. 43.
[3] CEJA-05 at 2:8-12; *see, generally*, CEJA-03 and CEJA-04.

Income Deployment ("SCT-LID") pilot,[4] and Google Nest's recommended improvements to the smart communicating thermostat recommendations in the August 16th Energy Division Staff Concept Paper.[5]

There is scientific consensus about the urgency of the climate crisis and the severity of California's health crisis, and the Commission should not ignore this fact. Since California committed to decarbonization in Senate Bill ("SB") 100, SB 32, SB 350, and the Commission's Loading Order, the global climate crisis has become more dire,[6] California's health equity crisis has become deadlier,[7] and income inequality has worsened.[8] In my view, this means that California must take even bolder action now to end reliance on gas plants and achieve a zero-emissions grid.

Q. Does Calpine's statement that the gas plant upgrades would provide "limited volumes" on a "temporary basis"[9] address your concerns?

No. No amount of additional gas is acceptable given the severity of the climate crisis, the alternatives available, and the disproportionate burden that the gas fleet imposes on California's disadvantaged communities.[10] Further, it is clear the Calpine's proposal is neither limited nor temporary. Calpine states that, under its proposal, it would provide a minimum of 30MW[11] and that "the actual impact likely would be higher given that other

[4] GRID Alternatives Opening Testimony at 3:7-25.
[5] Google Nest Opening Testimony at 4:2-22.
[6] IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf.
[7] Sammy Roth, *Boiling Point: These Maps Show How Air Pollution and COVID-19 Can Be A Deadly Mix, L.A. Times* (Oct. 8, 2020) https://www.latimes.com/environment/newsletter/2020-10-08/boiling-point-air-pollution-and-covid-19-can-be-a-deadly-mix-boiling-point.
[8] Jackie Botts, *How COVID is Deepening California's Income Inequality in 5 Charts*, Cal Matters (Jul. 20, 2020), https://calmatters.org/economy/2020/07/california-covid-deepening-income-inequality-data/.
[9] Calpine Opening Testimony, p. 8.
[10] Brightline Defense, *California Offshore Wind: Winding Up for Economic Growth & Environmental Equity*, (Dec. 2020), pp.12-13, https://static1.squarespace.com/static/5f434962cbc7a227a863c879/t/5fd959830384a13720d3d61e/1608079766544/Brightline-OffshoreWind-Report-12-6-2020.pdf (finding that 78% of California's gas plants are located within 5 miles of a disadvantaged community).
[11] Calpine Opening Testimony at 7:10-11.

suppliers may have similarly-sized potential upgrades."[12] The Commission should reject Calpine's attempt to minimize the risks and impacts of allowing more gas into the system.

Q. Do you agree with Calpine's statement that the Governor's July 30, 2021 Emergency Proclamation ("Emergency Proclamation") supports its argument for a modification of the D. 21-06-35 to allow additional gas capacity?[13]

A. No. If anything, the Emergency Proclamation points in the opposite direction as it highlights the climate emergency and the need to rapidly reduce our use of fossil fuels.

Also, Governor Newsom's statement on "California's Electricity System of the Future"— which was issued the same day as the Emergency Proclamation— underscores the need for the Commission to take bold and rapid steps towards a reliable, zero-emissions electric grid.[14] Governor Newsom aptly noted in the July 30, 2021 statement on California's Electricity System of the Future that "[a]s we navigate the road to clean energy we must focus on all communities and address the injustices that currently exist. Low-income and disadvantaged communities have borne the burden of polluting fossil-fuel energy sources for too long."[15] Moreover, as Governor Newsom acknowledges, "[a]lthough California has made great strides in eliminating coal power plants and increasing renewable energy resources, our current electricity system is still producing greenhouse gas emissions and contributing to unhealthy air quality in communities…Moving away from natural gas now will take planning to ensure that emerging technologies will be able to support our 100 percent clean electricity system."[16]

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[12] Calpine Opening Testimony, FN 11, p. 7 (citing that the CEC recently estimated that approximately 200 MW of additional upgrades are available for summer 2022. *See* slide 81 of https://efiling.energy.ca.gov/GetDocument.aspx?tn=239554&DocumentContentId=72991).
[13] Calpine Opening Testimony at 6:11-13.
[14] California's Electricity System of the Future, (July 30, 2021), https://www.gov.ca.gov/wp-content/uploads/2021/07/Electricity-System-of-the-Future-7.30.21.pdf, p.7 ("We must remove carbon emissions from our energy sources to support a sustainable future.").
[15] *Id*. at p. 36.
[16] *Id.*

This direction from the Governor is clear: the Commission must move rapidly now to reduce our reliance on fossil fuels.

Q. To support its argument for more gas, Diamond Generating points to the fact that the Sentinel Energy Center ("Sentinel") gas plant ran between August 16 and 19, 2020 and contributed 26 MW to the grid.[17] Are you familiar with the Sentinel Energy Center?

A. Yes.

Q. Please describe what you know about Sentinel Energy.

A. Sentinel has a long history of air violations. It is located in the city of Desert Hot Springs in the Coachella Valley, an area with extremely poor air quality. The U.S. Environmental Protection Agency designates the Coachella Valley as an area in extreme nonattainment for ozone and serious nonattainment for coarse particulate matter.[18] To my knowledge, Sentinel was only permitted for construction after a protracted legal battle regarding offsetting its air quality impacts.

Q. Will further reliance on gas plants like Sentinel exacerbate already poor air quality?

A. Yes. As I detailed in my prior testimony, gas plants emit numerous criteria pollutants that are harmful to human health. For gas plants like Sentinel, even operating 26MW of additional capacity will increase harmful emissions in an already highly impacted community. Especially in places in severe non-attainment like the Coachella Valley, this additional pollution exacerbates health risks to the communities that must breath this fouled air. Therefore, the Commission should not look to gas plants like Sentinel as a solution to the state's energy needs or allow any amount of additional emissions from gas plants; such actions would only renew environmental injustices. The Commission should instead plan to replace these resources with clean alternatives and to organize an orderly retirement of these harmful and unjust sources of pollution.

[17] Diamond Opening Testimony, pp. 1-2.
[18] United States Environmental Protection Agency, *Green Book: Current Nonattainment Counties for All Criteria Pollutants* (last visited Sept. 8, 2021), available at https://www3.epa.gov/airquality/greenbook/ancl.html.

Q. Wartsila calls for streamlining permits for gas facilities "capable of reducing the energy shortfall by October 31, 2021."[19] Do you support such streamlining?

A. No. Streamlining the permitting process could lead to even less protection for impacted communities. Given the fact that California's gas plants tend to be located in areas that are already in serious or extreme non-attainment[20] and given the evidence that increased emissions harm public health and worsen the impacts of the COVID-19 pandemic, [21] California should not risk exacerbating the grave harms associated with increased air pollution. All permits should undergo full review and provide opportunity for public comment.

Q. Middle River Power ("Middle River") states that "retaining thermal generation in no way threatens California's ability to progress towards its decarbonization goals. As California adds additional zero-emitting resources, the energy from these resources will displace the energy from thermal generation, and thermal generation will run less, producing fewer emissions."[22] Do you agree?

A. No. Maintaining our reliance on the gas fleet thwarts California's ability to meet its climate and air quality goals. Senate Bill 100 requires that 100 percent of all retail electricity sales come from zero-carbon sources by 2045. California's mandate is clear: it must obtain a zero-emissions electric grid, not a "fewer emissions" grid, as Middle River suggests.

Second, keeping gas plants online—even for limited use—perpetuates harm to impacted communities. Gas units that spin and operate at partial load emit more pollutants per

[19] Wartsila Opening Testimony, p. 4.
[20] Brightline Defense, *California Offshore Wind: Winding Up for Economic Growth & Environmental Equity*, (Dec. 2020), pp.12-13 (citing nearly 80% of California's gas plants are located within 5 miles of a disadvantaged community).
[21] *See* X. Wu et al, Air pollution and COVID-19 mortality in the United States: Strengths and limitations of an ecological regression analysis, Science Advances (2020), available at https://projects.iq.harvard.edu/covid-pm; *see also* https://www.hsph.harvard.edu/news/hsph-in-the-news/air-pollution-linked-with-higher-covid-19-death-rates/.
[22] Middle River Power Opening Testimony, p. 10.

megawatt hour than units operating at full capacity.[23] The cycling of gas plants produces significant amounts of pollution as emissions control systems are not as effective at capturing pollutants when plants are starting and stopping, and it is not clear whether these plants will produce power to be sold to other markets.

While increased zero-emissions resources will displace our need for gas plants, there is no way to reliably ensure that gas plant use is avoided unless they are fully retired.

Q. Wartsila states that "in addition to providing immediate reliability benefits, adding fast, flexible, and convertible thermal capacity now can actually accelerate carbon reductions, allowing California to reach its carbon goals even sooner."[24] What is your response?

A. I strongly disagree. Wartsila's argument does not make sense because this thermal capacity would be fueled by the combustion of fossil fuels, resulting in incrementally more carbon emissions. Wartsila provides no evidence to support its claim that adding additional fossil fuel capacity will accelerate the achievement of California's climate goals. The Commission should reject Wartsila's proposal.

III. RELIABILITY

Q. Middle River testifies that the inclusion of gas resources as part of the SB 100 modeling resource mix suggests that gas plants should not be retired.[25] Do you agree?

A. No, I disagree. The SB 100 Report also demonstrated the feasibility of running the system without *any* gas in the resource mix.[26] Moreover, the SB 100 Report bases its assumption of "economic" gas retention on outdated cost assumptions, not an analysis of what level of GHG emissions is necessary to meet California's economy-wide climate

[23] Aspen Environmental Group, Cal. Independent System Operator SB 350 Studies, Volume 9, Table 4.4-3, p. 100 (2016), https://www.caiso.com/Documents/SB350Study-Volume9EnvironmentalStudy.pdf.
[24] Wartsila, pp. 4-5.
[25] Middle River Power Opening Testimony at 12:21-13:2.
[26] SB 100 study and workshop documents, available at https://www.energy.ca.gov/event/workshop/2020-12/notice-senate-bill-100-draft-report-workshop.

requirements. When E3 evaluated potential scenarios to achieve carbon neutrality economy-wide, it found that a scenario that assumed continued reliance on the gas fleet represents the "highest risk scenario" that would result in the highest air quality impacts of the futures it analyzed and an "overshoot of emissions, with a risk of missing the state's climate goals."[27]

In addition to not meeting climate goals, retention of gas plants is likely not economic in any sense. As the SB 100 report describes, a comparison to the Commission's average resource adequacy prices show that they are likely underestimating retention costs, and "[h]igher than modeled gas fleet maintenance costs may decrease economic gas retention or increase total scenario cost or both."[28]

Q. Middle River states that "[a] s the 2019 Energy and Environmental Economics ("E3") Long-Run Resource Adequacy Analysis concluded, retaining existing duration-unlimited thermal generation is a far more cost-effective way to maintain reliability than replacing that existing generation with much greater nameplate capacity amounts of use- and duration-limited generation."[29] Do you agree?

A. No. Middle River's characterization does not provide a complete picture. The recent CEC analysis demonstrates that a future based on gas is less reliable than a future that relies on preferred resources.[30] In addition, there are many costs of retaining gas that make them economically risky, including high maintenance costs (especially for cycling units), the costs to maintain aging fossil fuel pipelines and infrastructure, the costs of additional air pollution including potential methane leaks, the social costs of carbon, and the high market costs due to market power.

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[27] Achieving Carbon Neutrality in California, PATHWAYS Scenarios Developed for the California Air Resources Board, available at https://ww2.arb.ca.gov/sites/default/files/2020-10/e3_cn_final_report_oct2020_0.pdf, p. 4.
[28] SB 100 Report (March 2021), p. 79.
[29] Middle River Power Opening Testimony at 7:18-22.
[30] California Energy Commission, Presentation for August 30 Lead Commissioner Workshop on Mid-Term Reliability Analysis, Slides 33-34 (Aug. 30, 2021), available at https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=21-ESR-01 [hereinafter referred to as "CEC August 30 Analysis on Mid-Term Reliability Presentation"].

Q. Middle River states that "[n]umerous analyses…have shown that the grid needs the entire thermal fleet along with all other existing resources in 2022 and beyond to ensure reliability."[31] Do you agree?

A. No. First, Middle River fails to specifically cite the "analyses" upon which it relies for this sweeping statement that thermal generation is needed in 2022 "and beyond."[32] In fact, many studies show that the thermal fleet is failing us in extreme heat. As I explained in my opening testimony, during the August 2020 heat event, there were many forced outages at California gas plants.[33] The Final Root Cause Analysis found that gas plants derate during extreme weather events and cannot perform at their usual capacity.[34] This summer, CAISO reported that during the June 17 and 18, 2021 heat events, the grid lost about 2,200 MW of gas capacity.[35] Also, the forced outage rate of gas plants has been increasing in recent years, with some types of gas facilities experiencing an average forced outage rate of 14%,[36] which is likely to be higher in extreme heat.[37] These findings suggest that California should not be relying on gas plants for reliability. Gas plants are simply not delivering reliability during extreme heat.

Second, the CEC's August 30 Analysis on Midterm Reliability finds that replacing clean resources with an equivalent amount of gas net qualifying capacity results in a *less*

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[31] Middle River Opening Testimony, at 9:22-24.
[32] *Id*.
[33] See Sierra Club Opening Testimony (SC-01), p. 3 (citing CAISO, CPUC, and CEC, Preliminary Root Cause Analysis of the Mid-August 2020 Heat Storm, p. 8 (the gas fleet experienced 1,400 to 2,000 MW of forced outages during the August 2020 heat wave).
[34] California Public Utilities Commission (Commission), California Energy Commission, and the California Independent System Operator (CAISO), *Final Root Cause Analysis: Mid-August 2020 Extreme Heat Wave*, Jan. 13, 2021, p. 47-48.
[35] CAISO, 2021 Summer Readiness – July Update, EPR Joint Agency Workshop on Summer 2021 Electric and Natural Gas Reliability (July 8, 2021), https://efiling.energy.ca.gov/getdocument.aspx?tn=238737, Slide 3; see also https://www.politico.com/states/california/story/2021/06/30/old-clunkers-california-power-plants-break-down-during-heat-wave-1387507.
[36] *See, e.g.,* CEC August 30 Analysis on Mid-Term Reliability Presentation, Slide 22.
[37] Another study showed the connection between increased forced outage rates and extreme heat. *See, e.g.,* https://reader.elsevier.com/reader/sd/pii/S0306261919321117?token=A1B23660D16B41FCF5F331F2A907B5776790AB57C25CCE9CD9F56810067076363D2D924AE908A7E61BF161CACD023C12&originRegion=us-east-1&originCreation=20210910011122.

reliable system.[38] The CEC's analysis further found that "[a] portfolio of preferred resources can provide equivalent system reliability to gas resources."[39]

Third, as described above and in my opening testimony, to meet climate and air quality goals and mandates, California must reduce its reliance on gas plants, and this necessarily means retiring gas plants.

Q. In your view, what steps should California take to improve reliability in the next two summers?

A. Initially, it is not clear whether there is a need for more procurement as the potential magnitude of a shortfall has likely been overstated. The CEC's August 30 Analysis on Midterm Reliability found that if a need exists, it likely only potentially exists in 2022 if the projected resources are built.[40] This potential need for 2022 is also likely significantly smaller than the CEC analysis suggests because as UCS describes, "the CEC's analysis does not consider the possibility of Redondo Beach operating[41] and it does not consider all the new resources that have been authorized in this proceeding.[42] Even without considering these new resources, it is unclear whether a need exists as the CEC's Analysis on Midterm Reliability found that there was no unserved energy for a 1-in-10 year if all of the Preferred System Plan resources were built.[43] Furthermore, the CEC provided an additional Revised 2022 Summer Stack Analysis on September 8, 2021 which acknowledges some of these ideas, noting the need to update assumptions following the State Water Board's upcoming vote on Redondo Beach and the need to use loss of load expectation ("LOLE") considerations in procurement planning.[44] Given all this, it is unclear whether there is even a residual need for more procurement.

[38] CEC August 30 Analysis on Mid-Term Reliability Presentation, Slide 33.
[39] *Id*. at Slide 41.
[40] *Id*.
[41] UCS Opening Testimony at 6:1-8.
[42] *Id*. at 7:1-18.
[43] CEC August 30 Analysis on Mid-Term Reliability Presentation, Slide 35.
[44] CEC Docket Log 21-ESR-01, Staff Paper - Revised 2022 Summer Supply Stack Analysis (Sept. 8, 2021), available at https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=21-ESR-01.

Nevertheless, if a need for more procurement is found after all likely resources are considered, any potential need can and should be met through zero-emitting resources such as an enhanced residential ELRP as described by CEJA, increased penetration of smart thermostats, and increased usage of EVs and behind the meter renewables and storage. California has many zero-emitting resources that can help improve the reliability of the grid while protecting the climate and our air.

IV. RNG AND GREEN HYDROGEN

Q. Diamond Generating states that the Commission should prioritize RNG and hydrogen blending into the fuel supply for peakers.[45] What is your response?

A. I do not agree that use of RNG or hydrogen should be prioritized or authorized in this proceeding. With respect to RNG, there is no assurance that using it at gas plants will actually reduce greenhouse gases. RNG credit markets currently lack environmental integrity, and it is nearly impossible to ensure that the environmental attributes of RNG are not double-counted.[46]

Also, combustion of RNG could be more polluting than fossil gas. The Commission has found that biogas plants produce more emissions that fossil gas plants.[47] Other research finds that biogas plants emit three times the nitrogen oxide emissions as natural gas plants and high levels of volatile organic compounds, including formaldehyde[48] and sulfur dioxide.[49]

Like RNG, hydrogen is also not a climate or air quality solution for California's energy sector. In fact, use of hydrogen blends at gas plants could *increase* pollution. Most

[45] Diamond Generating Corporation Opening Testimony at 4:75-77.
[46] *See, e.g.,* R.13-02-008, Sierra Club Reply Comments on Ruling Directing Parties to File Comments on Phase 4A Staff Proposal and Related Questions (July 16, 2021), p6-7.
[47] CPUC, Updated Criteria Pollutant Analysis, (Feb. 21, 2020), available at https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-power-procurement/long-term-procurement-planning/2019-20-irp-events-and-materials, pp. 6-7.
[48] *Id*. (citing Gallego, E. et al. Impact of Formaldehyde and VOCs from Waste Treatment Plants Upon the Ambient Air Nearby an Urban Area (Spain). SCI. TOTAL ENVIRON. 2016, *568*, 369–380. DOI:10.1016/j.scitotenv.2016.06.007).
[49] *Id*.
[49] Cal. Pub. Util. Code Section 454.52(I) (showing high SO2 levels).

hydrogen produced in California and across the United States comes from splitting hydrogen atoms from fossil gas through a highly polluting technology called steam methane reformation ("SMR"). SMR emits pollution that harms public health in neighboring communities, including nitrogen oxides, fine particulate matter, carbon monoxide, and volatile organic compounds.[50] SMR plants contribute to the climate crisis, and their local impacts are concentrated in the same communities bearing the brunt of health-harming pollution from oil refineries. Thus, the Commission should squarely reject use of hydrogen produced by SMR.

Although it is possible to produced hydrogen through others methods such as electrolysis powered by 100% clean, zero-emitting resources, supply of this "green" hydrogen is very limited and should be reserved for end-uses that are difficult to electrify, not used at gas plants to produce electricity for the grid.

Furthermore, regardless of their production method, hydrogen blends may increase emissions at gas plants. The combustion of natural gas blended with hydrogen produces significant quantities of criteria pollution, particularly NOx emissions. Two studies have found that burning this mix can lead to much higher NOx emissions,[51] up to six times that of burning methane.[52] In their joint application to the Commission to research the

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[50] *See* Pinping Sun et al., *Criteria Air Pollutants and Greenhouse Gas Emissions from Hydrogen Production in U.S. Steam Methane Reforming Facilities*, Env't Sci. & Tech., Vol. 53 Issue 12, (Apr. 30, 2019), https://www.osti.gov/pages/servlets/purl/1546962.

[51] Sadler, Dan, et. al. H21 Leeds CityGate Project Report." City of Leeds, 2017, https://www.h21.green/wp-content/uploads/2019/01/H21-Leeds-City-Gate-Report.pdf, p. 163, Table 5.15 (Flame combustion of hydrogen resulted in "relatively high NOx," compared to natural gas flame combustion).

[52] Cellek, Mehmet Salih, and Ali Pınarbaşı. "Investigations on Performance and Emission Characteristics of an Industrial Low Swirl Burner While Burning Natural Gas, Methane, Hydrogen-Enriched Natural Gas and Hydrogen as Fuels." International Journal of Hydrogen Energy 43, no. 2 (January 11, 2018): 1194–1207. https://doi.org/10.1016/j.ijhydene.2017.05.107 ("In the case of using hydrogen-enriched natural gas or pure hydrogen instead of natural gas as the fuel, the combustion emissions … such as CO and CO2 are remarkably decreased compared to the natural gas. However, the NOx emissions are significantly increasing especially due to thermal NO."). See also ETN Global, Hydrogen Gas Turbines, https://etn.global/wp-content/uploads/2020/01/ETN-Hydrogen-Gas-Turbines-report.pdf, p. 9, (recognizing that one of the challenges for hydrogen combustion is that "[t]he higher adiabatic temperature of H2 will result in higher NOx emissions if no additional measures are undertaken" and recommended that "[s]ome flexibility might be needed on NOx limits in future" for decarbonization through hydrogen.)

compatibility of hydrogen blends with their infrastructure, PG&E, SDG&E, and other California gas utilities acknowledged that blends of hydrogen and methane "may yield higher NOx emissions than natural gas because hydrogen burns faster than natural gas, which increases combustion temperatures and reduces ignition lag. . . . therefore, additional emissions testing should be completed with natural gas end-use equipment operating with hydrogen blends."[53] Given these serious risks, the Commission should not rely on or prioritize hydrogen in this proceeding.

Q. Do you agree with Diamond Generating that blending RNG and/or hydrogen will reduce gas plants' overall emissions profile within the 2022 and 2023 timeframes?[54]

A. No. As discussed above, use of RNG and hydrogen will not reduce emissions and could instead *increase* both greenhouse gas and criteria pollutant emissions.

Q. Diamond Generating states that 30% hydrogen blending is feasible within the 2022 and 2023 timeframes.[55] Do you agree?

A. No. Hydrogen blending is highly complicated and highly unlikely to be achieved by 2022 or 2023. First, hydrogen is difficult to store and only a very small number of gas plants in the United States have the capability to do so on-site. The vast majority of gas plants, if they seek to blend hydrogen, will likely need to use the gas pipeline system. That system is currently not ready for hydrogen because the gas presents numerous problems for pipeline safety.

In their recent application to the Commission, California gas utilities identified numerous safety and reliability risks that they would study before injecting hydrogen into the gas distribution system.[56] For example, the elastomers and rubbers that seal many pipeline

[53] Prepared Direct Testimony of Kevin Woo et al. on Behalf of Southern Cal. Gas Co. et al., at 17, A.20-11-004 (Cal. P.U.C. Nov. 2020), https://www.socalgas.com/sites/default/files/2020-11/H2_Application-Chapter_4-Technical.pdf.
[54] Diamond Generating Corporation Opening Testimony at 3:65-68.
[55] Diamond Generating Corporation Opening Testimony at 4:72-74.
[56] Prepared Direct Test. of Kevin Woo et al. on Behalf of Southern Cal. Gas Co. et al., at 17, A.20-11-004 (Cal. P.U.C. Nov. 2020), https://www.socalgas.com/sites/default/files/2020-11/H2_Application-Chapter_4-Technical.pdf. At Section III.

components can swell or develop voids after exposure to pure hydrogen; hydrogen can cause embrittlement of steel pipes; and the utilities do not know how much hydrogen they can safely store in the underground formations that they rely on for gas storage.[57] To my knowledge, there is no estimate of the infrastructure costs for delivering low-hydrogen blends in California. Additional research is needed to determine what investments will be necessary. Given these challenges and our lack of knowledge of what it will take to blend hydrogen for safe use in pipelines, I strongly disagree with Diamond Generating's statement.

Q. Does this conclude your testimony?

A. Yes.

[57] *Id*.