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Calpine Corporation Response to Clean Energy Resources for Reliability RFI

Additional submitted attachment is included below.

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November 30, 2022

California Energy Commission
Energy Assessment Division, Energy System Reliability
Docket Number 21-ESR-01
517 P Street
Sacramento, CA 95814

Re: Calpine Corporation's Response to the Request for Information on Clean Energy Resources for Reliability

Pursuant to the November 7 Request for Information on Clean Energy Resources for Reliability ("RFI"), Calpine Corporation ("Calpine") submits these comments. Calpine operates the largest fleet of natural gas combined-cycle and combined heat and power facilities in both California and the United States, and is the nation's largest producer of electricity from renewable, geothermal resources at The Geysers in Northern California. The RFI requests responses to inform staff on the resources and attributes that should be considered in the analysis required by the multiple legislative requirements of SB 846 and AB 205. Calpine appreciates the opportunity to offer responses, and does so as answers to the questions outlined in the RFI.

Are the categories (indicated in Tables 1, 2 and 3) appropriately representing how the CEC should be evaluating resources?

Yes.

Are there resources that should be added to or removed from the preliminary list under each of the categories (shown in Tables 1, 2, and 3)?

Yes -- existing natural gas combined cycle plants retrofit with carbon capture and storage technology (NGCC-CCS) should be added to Table 1.

Are there other attributes that should be considered, in addition to the ones listed in Table 4? If so, should those be considered for the qualitative and/or quantitative evaluation?

No.

How should the attributes be weighted relative to each other? Should some attributes be weighted more than others?

Since this proceeding is focused on characterizing clean energy for reliability, cleanliness and dispatchability should be weighted more heavily. This emphasis is also sensible based on the legislative direction. For example, SB 846 outlines that the Clean Energy Reliability Investment Plan should "accelerate the deployment of clean energy resources, support demand response, assist ratepayers, and increase energy reliability."

Please provide a general overview of the resource, including the following: Resource category (e.g., supply, demand) and type (e.g., solar) and scale (e.g., utility, distributed)?

A potential resource that should be included is existing natural gas combined cycle plants retrofit with carbon capture and storage technology ("NGCC-CCS"). NGCC-CCS plants are utility-scale supply resources.

How does the resource compare to conventional generation in terms of greenhouse gas and priority pollutant emissions?

By retrofitting conventional generation with carbon capture equipment, carbon dioxide emissions are reduced by 90-99% depending on the design specifications of each individual project. Additionally, because CCS tends to work better on exhaust streams with lower levels of criteria pollutants, some retrofits may entail reductions of priority pollutants.

How does the resource support reliability (e.g., supply, permanent load reduction, net peak reduction, or emergency asset?) (List all that apply.) How can the resource be used as an incremental on-call resource during emergencies?

An NGCC-CCS supports reliability by providing clean supply with the same level of reliability as traditional natural gas combined cycle plants. In addition, NGCC-CCS plants can provide additional peaking capacity by operating temporarily without the carbon capture equipment running (which under normal circumstances uses significant amounts of electricity/steam), albeit with non-CCS NGCC emissions.

How many new MWs and MWhs can the resource provide per year, taking into account resource characteristics and known barriers between now and 2035? How is that different if used incrementally as an emergency asset during an extreme heat event?

Carbon capture and storage ("CCS") retrofits to existing plants would not provide new MWs – instead, they would decarbonize and help to retain existing resources. The plants retrofit with this equipment would see capacity declines of 10-20%, but could recover that capacity under emergency situations (see above). Additionally, the mitigation of carbon emissions from a traditionally emitting resource paired with the availability of federal funding would allow for these retrofit plants to operate at higher capacity factors, so existing plants would provide more MWhs annually and obviate the need for other clean energy resources.

The Energy Futures Initiative and Stanford University performed a screen of existing NGCCs in California and identified 14,000 MW of capacity as well-suited to CCS retrofits. This same report looked at what levels of CCS retrofits would be cost effective in the near future and determined that "having approximately four GW of NGCC-CCS reduces the solar photovoltaic (PV) and battery capacity required, and costs are approximately $750 million lower than the scenario without any NGCC-CCS…. The capacity of NGCC-CCS that is cost-effective in a 2030 grid, and the corresponding operating patterns, are consistent across a wide range of technology cost assumptions…. Four GW of NGCC-CCS on average corresponds to approximately six NGCC power plants being retrofit by 2030[.]"[1]

What is the levelized cost for the resource in $/MW-yr. and $/MWh-yr. from 2023 to 2035?

The table below from the National Energy Technology Laboratory lists costs based on turbine type. More recently, the 2022 California Air Resources Board Scoping Plan describes conducting a literature review to evaluate the cost of NGCC-CCS – this effort could be leveraged here as well.[2] More information can be found beginning on page 7 of this document ("Calpine Corporation's Informal Comments on the 2022-23 IRP Cycle Inputs and Assumptions," submitted to the California Public Utilities Commission Energy Division Staff).

[1] Energy Futures Initiative and Stanford University, "An Action Plan for Carbon Capture and Storage in California: Opportunities, Challenges, and Solutions," October 2020, https://sccs.stanford.edu/sites/g/files/sbiybj17761/files/media/file/EFI-Stanford-CA-CCS-FULL-rev2-12.11.20_0.pdf.

[2] California Air Resources Board, "Appendix H: AB 32 GHG Inventory Sector Modeling," in *2022 Scoping Plan*, 2022, https://ww2.arb.ca.gov/sites/default/files/2022-11/2022-sp-appendix-h-ab-32-ghg-inventory-sector-modeling.pdf. Page 13.

Exhibit 3-6. Summary costs of the retrofit equipment

Case	1c	2c	3c
Turbine	7FA.05	H-frame	J-frame
Technology	CCS	CCS	CCS
Bare Erected Cost by Account			
A3 – Feedwater & Misc. BOP Systems	3,889,314	6,557,812	6,625,859
A5A – Gas Cleanup & Piping	0	0	0
A5B – CO_2 Removal & Compression	323,350,158	370,848,878	401,183,099
A6 – Combustion Turbine and Accessories	0	0	0
A7 – HRSG, Ducting & Stack	0	0	0
A8 – Steam Turbine Generator	0	0	0
A9 – Cooling Water System	10,201,509	14,614,238	15,267,406
A11 – Accessory Electric Plant	24,031,374	28,196,105	30,676,684
A12 – Instrumentation & Controls	7,575,195	9,294,292	10,224,445
A13 – Improvements to Site	108,816	213,284	310,262
A14 – Building & Structures	941,457	1,221,291	1,274,019
Total BEC	**370,097,823**	**430,945,901**	**465,561,774**
Eng'g CM, H.O.& Fee	30,650,962	35,679,592	38,548,948
Process Contingencies	59,129,013	67,599,099	72,980,544
Project Contingencies	88,587,420	102,631,975	110,858,722
Total Plant Cost (TPC)	**548,465,218**	**636,856,567**	**687,949,986**
Total Plant Cost (TPC) ($/kW)	**1,004.7**	**895.6**	**802.1**
Total Overnight Costs (TOC)	**660,601,111**	**767,227,408**	**828,825,911**
Total Overnight Costs (TOC) ($/kW)	**1,210.1**	**1,079.0**	**966.4**
Total As-spent Cost (TASC)	**712,127,997**	**827,071,146**	**893,474,332**
Total As-spent Cost (TASC) ($/kW)	**1,304.5**	**1,163.1**	**1,041.8**
Total Fixed Operating Costs	30,616,639	35,290,868	37,919,284
Maintenance Material Cost (100%CF)	10,575,361	12,403,497	13,431,497
Consumables (100%CF)	7,335,971	9,464,257	10,189,102
Fuel (100%CF)	224,096,139	279,984,214	318,256,872
CO_2 T&S (100%CF)	17,694,674	22,100,462	25,104,408
Total O&M (100%CF)	**290,318,785**	**359,243,298**	**404,901,163**

All costs are in June 2011 dollars

Chou et al. "Cost and Performance of Retrofitting NGCC Units for Carbon Capture." National Energy Technology Laboratory, November 19, 2013. https://www.netl.doe.gov/projects/files/CostPerformanceRetrofittingNGCCforCarbonCapture_040119.pdf.

What is the average length of time from ordering or purchasing the resource to operation? How long does that typically take in today's market? What conditions must be met to deploy the technology rapidly? (e.g., transmission interconnection, building electrification or upgrades, etc.)

Studies on construction time indicate that, in a perfect environment, construction lasts about one year. However, based on various timelines outlined by the Department of Energy, the time from ordering a front-end engineering design study (the first major step to designing how a CCS retrofit will be built) to operation ranges from 4 to 6 years.[3]

One condition key to seeing this technology deployed within California is a clear permitting path. Legislative progress has been made – SB 905 (The Carbon Capture, Removal, Utilization, and Storage Program) requires the adoption of a unified permit application for CCS projects by 2025 and the expedition of the issuance of permits for the construction and operation of those projects.

Because retrofits utilize existing plants that are already interconnected, they do not require new transmission. However, the carbon dioxide will need infrastructure for transport to a suitable storage location. Some facilities may be able to store carbon on site, convert captured carbon into usable products such as construction materials on site, or utilize existing rights-of-way to reach geology ideal for storage,[4] but many facilities will require entirely new pipelines.

[3] Timeline can be found on https://oced-exchange.energy.gov/ under DOE NOI 2806-BIL (CCS Demos), published July 2022

[4] Even in cases where there is an existing right-of-way, new pipelines will still need to be built.

For an emerging technology, when will it be ready for deployment, and at what scale?

NGCC-CCS retrofits use existing technology that is already at the demonstration phase. For example, a 1 MW pilot will be operational in Pittsburg early next year.[5] The construction window for the 45Q federal tax credit ends in 2033, incentivizing construction before then.[6] Other projects are also underway. For example, a pair of Class VI wells (the required wells for storing captured carbon dioxide) have received administrative approval from the EPA, with one of the carbon sources listed in the administratively approved application as “the Elk Hills 550 MW natural gas combined cycle power,” suggesting the potential for near-term deployment.[7]

What are the key non-financial barriers to the development and implementation of this resource (including, but not limited to, permitting, interconnection, supply chain, customer acceptance, and alignment with policy goals)?

Key barriers include permitting, policy goal alignment, and customer acceptance. The passage of SB 905 lessens the permitting barrier, however, uncertainty remains. Similarly, direction from the legislature in SB 905 and AB 1279 (The California Climate Crisis Act) calls for the study and deployment of CCS, and CCS has had a Protocol since 2018, allowing for its participation in the Low Carbon Fuel Standard.[8] However, the current definitions of zero carbon electricity in agency materials (CPUC, CEC, CARB, etc.) do not clearly define the role for NGCC-CCS. Due to the potential permitting barriers and regulatory uncertainty, customer acceptance is hampered.

What are the key financial barriers to the development and implementation of this resource?

While CCS retrofits remain expensive, the federal government has effectively removed many financial barriers through Bipartisan Infrastructure Law-funded grants, the Loan Programs Office, and the 45Q tax credit.

What types of benefits or impacts is the resource anticipated to have on low income and disadvantaged communities, and tribes, if any in terms of development and deployment?

CCS retrofits to NGCCs have positive impacts on nearby disadvantaged communities, including increased employment and tax revenue. For example, a typical CCS retrofit adds approximately 20 full-time

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[5] CEC Order Approving Post Certification Petition in the Matter of Los Medanos Energy Center, Order Number 22-1012-11, https://efiling.energy.ca.gov/GetDocument.aspx?tn=246551&DocumentContentId=80767.

[6] Inflation Reduction Act of 2022 (P.L. 117-169) Sec. 13104. Extension and Modification of Credit for Carbon Oxide Sequestration

[7] US Environmental Protection Agency, “UIC Permits in EPA’s Pacific Southwest (Region 9),” August 30, 2021, https://www.epa.gov/uic/uic-permits-epas-pacific-southwest-region-9.

[8] CARB. 2022. Carbon Capture & Sequestration. https://ww2.arb.ca.gov/our-work/programs/carboncapture-sequestration.

operational positions to the existing plant workforce,[9] as well as 1.5 million labor hours during construction. Furthermore, accessing various forms of federal funding for CCS projects is contingent on paying workers prevailing wages, employing apprentices, and performing frontline community-focused analysis and outreach.[10]

Calpine appreciates the opportunity to identify clean, reliable resources. Please reach out with any questions or requests for additional information.

Sincerely,

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[9] Global CCS Institute, "The Value of Carbon Capture and Storage," 2020, https://www.globalccsinstitute.com/wp-content/uploads/2020/05/Thought-Leadership-The-Value-of-CCS-2.pdf.
[10] The labor requirements are necessary for 45Q tax credit maximization, while the frontline community measures are necessary to apply for DOE grants or loans (more information can be found here: https://www.energy.gov/fecm/justice-engagement-planning-societal-considerations-impacts-fecm-projects)

Calpine Corporation's Informal Comments on the 2022-23 IRP Cycle Inputs and Assumptions
October 6, 2022
Emily Turkel, emily.turkel@calpine.com

Calpine appreciates the opportunity to comment on the 2022-23 IRP cycle inputs and assumptions. Calpine's comments focus on the representation of carbon capture and storage ("CCS"). Calpine believes that gas generation with CCS is a viable and cost-effective form of firm low-carbon generation to complement the renewable and limited-duration storage resources that have been the focus of IRP planning and procurement. Calpine's main recommendation with respect to the representation of CCS in IRP modeling is for an explicit representation of CCS retrofits to existing gas generation. While the Zero-Carbon Technology Assessment Report ("Report") includes cost estimates for completely new build NGCC-CCS units,[11] based on Calpine and others' development efforts and given the underlying economics, Calpine believes that CCS retrofits to existing NGCCs are more likely and cost-effective.

As requested by Energy Division, our more detailed comments below identify the specific section of the Report on which we are commenting.

3.2. Emerging Zero-Carbon Technologies

Calpine is actively pursuing CCS projects at existing natural gas combined cycle ("NGCC") plants, including a DOE-sponsored capture system test at Los Medanos Energy Center in Pittsburg, California,[12] a partnership with San Francisco Bay Aggregates to transform captured carbon into construction materials,[13] and a DOE-sponsored front end engineering design study at Delta Energy Center.[14] Accordingly, Calpine suggests that CCS retrofits to existing NGCC plants should be modeled as a candidate resource in RESOLVE.[15]

The Report finds that one "key advantage of post-combustion CCS is that it offers an option for existing power plants to mitigate emissions through retrofitting, presenting an option to repurpose existing natural gas infrastructure."[16] However, the Report does not include a representation of CCS retrofits

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[11] Page 66 of "CPUC IRP Zero-Carbon Technology Assessment." Energy + Environmental Economics, September 2022. https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2022-irp-cycle-events-and-materials/cpuc-irp-zero-carbon-technology-assessment.pdf.
[12] Fine, Nathan. "Engineering-Scale Demonstration of Transformational Solvent on NGCC Flue Gas (Project Enterprise)." Presented at the Carbon Management and Natural Gas & Oil Research Project Review Meeting, National Energy Technology Laboratory, August 13, 2021. https://netl.doe.gov/sites/default/files/netl-file/21CMOG_PSC_Fine_0.pdf.
[13] SF Bay Aggregates. "Carbon Negative Aggregate," 2021. https://www.sfbayaggregates.com/.
[14] Department of Energy. "DOE Invests $45 Million to Decarbonize the Natural Gas Power and Industrial Sectors Using Carbon Capture and Storage." Calpine Acts on Climate (blog), October 6, 2020. https://calpineactsonclimate.com/doe-invests-45-million-to-decarbonize-the-natural-gas-power-and-industrial-sectors-using-carbon-capture-and-storage/.
[15] Calpine is not alone in studying and deploying CCS retrofits on NGCCs – see the Elk Hills CalCapture FEED Study.
[16] Page 35 of "CPUC IRP Zero-Carbon Technology Assessment." Energy + Environmental Economics, September 2022. https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-

that could be used in RESOLVE for IRP. During the September 22 MAG workshop, E3 and CPUC staff stated that they "did not have a resource that exactly outlined which generators could and could not be retrofitted to CCS, thus [they] chose to rely on new builds" in order to incorporate CCS in the IRP modeling. In Calpine's experience, it is possible to retrofit most NGCCs, with the key constraints being land for capture equipment and proximity to storage and pipeline infrastructure. Furthermore, the Energy Futures Initiative and Stanford University performed a screen of existing NGCCs in California and identified 25 units totaling 14 GW of capacity that are well-suited to CCS retrofits.[17] While Calpine considers this a conservative estimate, the results provide a plausible bound on the potential.

With respect to the representation of CCS costs, Calpine has found that capture costs are basically separable from the cost of the underlying NGCC so that retrofit costs can be estimated as the difference between the costs of new build NGCCs with and without capture.[18] This is aligned with the process used in the most recent California Air Resources Board Scoping Plan, where "[t]he cost to retrofit an existing plant was assumed to be the incremental cost of a new plant with CCS compared to a new plant without CCS, adjusted by a retrofit factor to account retrofit-specific costs" for the purpose of modeling.[19] This calculation could be based on the 2021 National Renewable Energy Laboratory's Annual Technology Baseline, which is already being used in part for new NGCC-CCS cost inputs in the Report, as well as the other sources cited in the Report.[20] Retrofit costs could also be assessed based on carbon captured. For example, the previously cited Energy Futures Initiative and Stanford study found that the "costs of retrofit for the identified NGCC power plants range from \$62/tCO_2 to \$96/tCO_2."[7] Energy Division could derive a similar value independently by using each plant's characteristics to determine the amount of carbon emitted and publicly available data on specific capture capital cost estimates, ultimately converting to a \$/kW value. Additionally, several publicly-available tools and resources also could be used to derive retrofit costs.[21,22]

Beyond capital costs, it is important to reflect the impact of CCS retrofits on an NGCC's operating characteristics. Operation of the CCS equipment results in a 15-20% energy penalty, shaving a plant's capacity and heat rate.[23] However, during periods of grid stress, a plant can shut down the carbon

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plan-and-long-term-procurement-plan-irp-ltpp/2022-irp-cycle-events-and-materials/cpuc-irp-zero-carbon-technology-assessment.pdf.

[17] Page 49 of Energy Futures Initiative and Stanford University. "An Action Plan for Carbon Capture and Storage in California: Opportunities, Challenges, and Solutions," October 2020. https://sccs.stanford.edu/sites/g/files/sbiybj17761/files/media/file/EFI-Stanford-CA-CCS-FULL-rev2-12.11.20_0.pdf.

[18] In performing this calculation, it is important to account for the decline in the net output of a NGCC with CCS. Carbon capture equipment requires 15-20% of the capacity of the host NGCC plan in order to operate.

[19] Page 11 of California Air Resources Board. "Appendix H: AB 32 GHG Inventory Sector Modeling." In *Draft 2022 Scoping Plan*, 2022. https://ww2.arb.ca.gov/sites/default/files/2022-05/2022-draft-sp-appendix-h-ab-32-ghg-inventory-sector-modeling.pdf.

[20] Feron, P., Cousins, A., Jiang, K., Zhai, R., Thiruvenkatachari, R., & Burnard, K. (2019). Towards zero emissions from fossil fuel power stations. *International Journal of Greenhouse Gas Control*, 87, 188–202.

[21] Chou, Vincent, Dale Kearins, Norma Kuehn, Eric Lewis, Lora Pinkerton, Elsy Varghese, and Mark Woods. "Cost and Performance of Retrofitting NGCC Units for Carbon Capture." DOE Contract. National Energy Technology Laboratory, November 19, 2013. https://www.netl.doe.gov/projects/files/CostPerformanceRetrofittingNGCCforCarbonCapture_040119.pdf.

[22] Kuehn, Norma. "Natural Gas Combined Cycle Carbon Capture Retrofit Database." National Energy Technology Laboratory, April 2, 2019. https://netl.doe.gov/energy-analysis/details?id=2950.

[23] Calpine internal engineering study, public sources have a range of results.

capture component and operate the full capacity of the underlying plant pre-retrofit. Consequently, for RA/capacity purposes, Calpine believes that NGCC plants with CCS retrofits should continue to be modeled at the full capacity of the underlying plants pre-retrofit.

Finally, as noted in the Report, the Inflation Reduction Act ("IRA") includes large volumetric subsidies of up to $85 per ton of carbon dioxide captured. Calpine agrees with the Report that "the effect of the IRA on the relative competitiveness of deploying zero-carbon firm generation technologies [will] need to be addressed by modeling" and looks forward to providing feedback on how Energy Division incorporates this important incentive into the modeling.

Thank you for your consideration. Calpine welcomes the opportunity to work with staff and other stakeholders to refine the representation of CCS in IRP modeling.