Application No.: A.22-06-XXX
Exhibit No.: ______
Witness: Andrew Scates

PREPARED DIRECT TESTIMONY OF

ANDREW SCATES

ON BEHALF OF

SAN DIEGO GAS & ELECTRIC COMPANY

PUBLIC VERSION

**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA**

JUNE 1, 2022

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ACRONYM GLOSSARY

Due to the large size of these confidential attachments, these documents are being sent electronically via the CPUC Kiteworks SFTP.

PREPARED DIRECT TESTIMONY OF
ANDREW SCATES
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I. INTRODUCTION

This testimony presents San Diego Gas & Electric Company's ("SDG&E") compliance with least-cost dispatch ("LCD") requirements during the record period of January 1, 2021 through December 31, 2021, as specified by applicable California Public Utilities Commission ("Commission") decisions. LCD pertains to the day-ahead and intra-day dispatch and trading of SDG&E's portfolio of resources, including utility-owned generation ("UOG") and power purchase agreements ("PPA"). The following summarizes Commission decisions on LCD and how SDG&E implemented these decisions in a manner consistent with its current Commission-approved Bundled Procurement Plan ("BPP").[1]

Standard of Conduct 4 ("SOC 4") was adopted by the Commission in D.02-10-062 and further discussed in D.02-12-069, D.02-12-074, D.03-06-076, and D.05-01-054. The decisions established standards of conduct by which an IOU must administer its portfolio, specifically SOC 4, which states that "[t]he utilities shall prudently administer all contracts and generation resources and dispatch the energy in a least-cost manner."[2]

During 2021, SDG&E filed four quarterly advice letters ("AL") covering the record period as required in D.02-10-062. AL 3749E for Q1 2021 was approved on January 10, 2022 and was effective January 7, 2022; AL 3819-E-A for Q2 2021 was approved on February 15, 2022 and was effective December 23, 2021; AL 3883-E for Q3 2021 is pending approval with a requested effective date of November 29, 2021 and AL is 3949-E for Q4 2021 is still being audited. These advice letters provide detailed information on transactions that SDG&E executed while following its LCD process, as well as other data (*e.g.*, customer load, resource schedules and fuel transactions) pertinent to the LCD process during the record period. SDG&E's Quarterly Compliance Reports ("QCRs") for 2021 were in compliance with SDG&E's Commission-approved BPP and applicable procurement-related rulings and decisions.

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[1] For purposes of the Commission's review and the compliance findings requested herein, the relevant BPP is SDG&E's 2014 BPP, approved by the Commission and in compliance with Decision ("D.") 15-10-031.

[2] D.02-10-062 at 52 and Conclusion of Law ("COL") 11 at 74.

II. SDG&E'S COMPLIANCE SHOWING

SDG&E testimony and attachments will demonstrate compliance with LCD based on applicable regulatory requirements, notably D.15-05-005 (the "Decision") and D.18-10-006 ("Decision Approving Settlement Between San Diego Gas & Electric Company and the Office of Ratepayer Advocates").[3]

A. SDG&E Showing is in Accordance with D.15-05-005

Based on the Decision, SDG&E's testimony will include the following:

- Overview/narrative of LCD in the California Independent System Operator ("CAISO") markets.
- Description of SDG&E's bidding and scheduling processes.
- Summary of reports/tables documenting aggregated annual exceptions for:
  - Incremental cost bid calculations
  - Self-commitment decisions
  - Master File data changes
- Narratives reviewing significant strategy changes, internal software and/or process changes and CAISO market design changes during the record period.
- A background summary table outlining baseline annual data, including:
  - Total capacity of the dispatchable (bid in) portfolio
  - Total dispatchable capacity lost due to planned or forced outages
  - Total capacity of non-dispatchable (exclusively self-scheduled) portfolio
  - Total non-dispatchable capacity lost due to planned or forced outages

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[3] The Office of Ratepayer Advocates has been renamed as the California Public Advocates Office (hereinafter referred to as "Cal PA").

    - Total Energy awards (dispatchable and non-dispatchable by resource type and broken down by self-scheduled versus market awards)
- Demand Response ("DR") metrics will be provided for dispatchable DR programs with economic triggers including the following:
    - Capacity Bidding
    - AC Saver
- Annual Summary of results reporting requirement related to dispatch of DR resources including when all programs were dispatched and an explanation of when DR resources could have been dispatched but were not.
- Calculation of the number of hours when the utility forecasts that trigger criteria will be reached, as a percentage of hours in which the trigger conditions were reached in the same period.
- Total energy actually dispatched as a proportion of maximum available energy for each DR program broken down monthly and annually.
- Explanation as to why a DR resource was not dispatched despite its maximum availability.
- Cost impact on overall resource dispatch of not calling DR programs up to their maximum available amounts when program was forecasted to be triggered.
- Consideration of whether the selection of the DR events called minimized overall portfolio cost of dispatching supply resources.
- Explanation of SDG&E's opportunity cost methodology and demonstration of its application during the Record Year.

B. SDG&E's LCD Showing is in Accordance With the SDG&E/Cal PA Settlement[4]

As in last year's testimony and in accordance with the Settlement mentioned above, this testimony will include the following:

- Settlement Provision 1.2: Reasons in Attachment F- Master File Change exceptions for selecting proxy or registered costs. See Section VI. of testimony, below, and Attachment F.
- Settlement Provision 1.3: Calculations for determining whether a discretionary self-schedule has a cost impact. See Section VI. below and Attachments D and E.
- Settlement Provision 1.4: Detailed explanation of the unique operating characteristics and parameters related to SDG&E's hydro resource scheduling. See Section IV. below and Attachment L.
- Settlement Provision 1.5: Report instances in which the locational marginal price ("LMP") is greater than the bid price, but no dispatch was awarded. See Section VI. below and Attachment C.
- Settlement Provision 1.6: Identify in testimony, on a month-to-month basis, which dates the Demand Response Programs were unavailable, and therefore not dispatched, due to a lack of nominations from the aggregators. See Section X. below and Attachment H-K.

III. SDG&E PORTFOLIO OVERVIEW

For the record period, most of SDG&E's energy requirements were met with SDG&E PPAs and UOGs. SDG&E's PPAs included qualifying facility ("QF") contracts and contracts for renewable energy, dispatchable generation and out-of-state resources, all of which are described in the Direct Testimony of SDG&E witness Michelle Menvielle. SDG&E's UOG assessment included combined-cycle ("CC") plants, combustion turbines ("CT") generators, and non-generating resources ("NGRs") such as energy storage batteries.

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[4] *See* D.18-10-006.

The tables below provide summary data for resources in SDG&E's portfolio as of January 1, 2021. The must-take resources in Table 1a are non-dispatchable; SDG&E has an obligation to accept the generation that is produced from these resources without regard to variable cost and therefore are exempt from SDG&E's LCD process described in this testimony. The total of their generation in part determines SDG&E's net long or short position, which did factor into LCD. The resources in Table 1b are dispatchable and were therefore the focus of SDG&E's least-cost process during the record period. The "Capacity" column in Tables 1a and 1b below are derived from CAISO Master File Resource Data Template ("RDT") maximum capacities for resources where SDG&E is the scheduling coordinator ("SC") and contract capacities for resources where SDG&E is not the SC.

Table 1a: Must-Take, Wind, Solar Resources

Resource	Contract MW	Dispatch Profile	Ancillary Service Capability
QF contracts (Natural Gas)	31	Baseload As-Available	None
QF Renewable	2	Intermittent As-Available	None
Renewable non-intermittent resources	42.9	Baseload (as available)	None
Renewable Intermittent Resources	2183.7 (maximum)	Intermittent	None

Table 1b: Dispatchable Resources

Resource*	Capacity MW	Dispatch Profile	Ancillary Service Capability
Palomar CCGT Natural Gas SP15	588.21[5]	Load Following	Spinning Reserve Regulation
Cuyamaca CT Natural Gas SP15	45.42	Peaker	Non-Spinning Reserve
Miramar 1 CT Natural Gas SP15	48	Peaker	Non-Spinning Reserve
Miramar 2 CT Natural Gas SP15	47.9	Peaker	Non-Spinning Reserve
YCA CT Natural Gas NGila	55	Peaker	None
Orange Grove CT Natural Gas SP15	96	Peaker	Non-Spinning Reserve
El Cajon Energy Center CT Natural Gas SP15	48.1	Peaker	Non-Spinning Reserve
Escondido Energy Center CT (Wellhead) Natural Gas SP15	48.71	Peaker	Non-Spinning Reserve
Desert Star CCGT Natural Gas SP15	494.58	Load Following	Spinning Reserve
Goal Line CT Natural Gas SP15	49.9	Peaker	None
Lake Hodges Unit 1 Hydro SP15	20	Pumped Storage	None

5 Palomar increased Capacity MW limit from 575 to 588.21 effective July 7th, 2021.

Resource*	**Capacity MW**	**Dispatch Profile**	**Ancillary Service Capability**
Lake Hodges Unit 2 Hydro SP15	20	Pumped Storage	None
Eastern Battery NGR SP15	7.5	Battery – Energy Storage	Spinning Reserve Regulation
Escondido Battery 1 NGR SP15	10	Battery – Energy Storage	Spinning Reserve Regulation
Escondido Battery 2 NGR SP15	10	Battery – Energy Storage	Spinning Reserve Regulation
Escondido Battery 3 NGR SP15	10	Battery – Energy Storage	Spinning Reserve Regulation
Pio Pico 1 Natural Gas SP15	111.3	Peaker	Non-Spinning Reserve
Pio Pico 2 Natural Gas SP15	112.7	Peaker	Non-Spinning Reserve
Pio Pico 3 Natural Gas SP15	112	Peaker	Non-Spinning Reserve
Carlsbad 2 Natural Gas SP15	105.5	Peaker	Non-Spinning Reserve
Carlsbad MSG Natural Gas SP15	422	MSG/Peaker	Spinning Reserve Regulation
Miguel Battery NGR SP15	2	Battery – Energy Storage	Spinning Reserve Regulation
Top Gun Battery NGR SP15?	30	Battery-Energy Storage	None
Valley Center Battery NGR SP15	54	Battery-Energy Storage	None

*CCGT= Combined Cycle Gas Turbine; CT= Combustion

IV. OVERVIEW OF LEAST-COST DISPATCH IN CAISO MARKETS

On April 1, 2009, following Federal Energy Regulatory Commission ("FERC") approval of its market redesign application, the CAISO implemented the Market Redesign Technology Upgrade ("MRTU") now simply referred to as the "Market", which introduced fundamental changes in the way resources are committed and dispatched. The most significant of these changes was the implementation of a centralized energy market which requires load-serving entities ("LSEs") to procure energy and ancillary services ("A/S"), and generators to sell energy and A/S, through the CAISO markets based on self-schedules and economic bids.

The CAISO established a centralized spot market that enables all resources, through standardized bidding and scheduling rules, to be competitively dispatched based on costs to serve total system load, subject to operational and transmission constraints. These resources are not matched up to any LSE's load; LSEs now meet their needs by self-scheduling or bidding for energy in the CAISO market. However, LSEs may rely on bilaterally procured resources to hedge the day-to-day cost of buying energy and A/S from the CAISO markets, to the extent these contracted resources pass on the revenues for energy and A/S awards received from those same CAISO markets back to the LSE.

SDG&E periodically revises and improves its LCD processes to meet tariff rules and operating requirements while maintaining compliance with SOC 4, particularly with regard to self-schedules, convergence bids and economic bids for its dispatchable resources. These self-schedules and bids for dispatchable units must accurately reflect variable costs to enable the CAISO market to produce energy and A/S awards for SDG&E's resources that are consistent with LCD. SDG&E utilizes a cross-validation procedure for bids to ensure the accuracy of its resource bids with respect to cost and the accuracy of its self-schedules in the CAISO market.

The CAISO market solves for the least-cost unit commitment and dispatch solution incorporating self-schedules and economic bids from generators and load which takes into account resource operational characteristics and constraints, resource and transmission outages, impact of convergence bids, inter-temporal constraints and the effect of adjacent balancing authorities impacted by the CAISO system. It is important to note that CAISO is solving for the lowest system cost over a 24-hour time horizon, not the highest revenue for a resource; therefore, looking at a resource's awards in isolation may not yield expected results on an hourly basis. If a resource is awarded in a manner below their costs for a given 24-hour period, the resource may qualify for bid cost recovery ("BCR"). The nodal ("Pnode") market prices explicitly account for the economic effects of re-dispatching resources to relieve congestion constraints.

The CAISO optimizes the dispatch of the several hundred generators across its system to find the overall lowest-cost mix of resources to meet CAISO system load requirements (including those of SDG&E). The CAISO market also co-optimizes the allocation of dispatchable capacity between generation and A/S capacity, based on prices submitted for each of these services in the resource bids.[6] The resulting allocation of awards between generation and A/S across the system therefore reflects the economic tradeoff between capacity used for generation and what is reserved for A/S.

The CAISO employs an iterative mixed-integer programming methodology to account for the numerous constraints cited above. A technical bulletin published by the CAISO describes in greater detail its LCD optimization processes with respect to the IFM ("Integrated Forward Market"). Specifically, Section 2.3 states:

> The SCUC [Security Constrained Unit Commitment] engine determines optimally the commitment status and the Schedules of Generating Units as well as Participating Loads and Resource-Specific System Resources.
>
> ***The objective is to minimize the Start-Up and Minimum Load costs and bid in Energy costs and Ancillary Services, subject to network as well as resource related constraints over the entire Time Horizon***, e.g., the Trading Day in the IFM. The time interval of the optimization is one hour in the DAM and 5 or 15 minutes in the RTM depending on the application.
>
> In IFM the overall production (or Bid) cost is determined by the total of the Start-Up and Minimum Load Cost of CAISO-committed Generating Units, the Energy Bids of all scheduled Generating Units, and the Ancillary Service Bids of resources selected to provide Ancillary Services. ***This objective leads to a least-cost multi-product co-optimization methodology that maximizes economic efficiency, relieves network Congestion and considers physical constraints***. The economic efficiency of the market operation can be achieved through a least cost resource commitment and scheduling with co-optimization of Energy and Ancillary Services.[7]

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6 For example, if a generator's energy bid price is $10/MWh in-the-money relative to the clearing price, then the IFM may award the generator an A/S award only if the A/S clearing price exceeds $10 or the generator's bid, whichever is greater.

7 California ISO, Technical Bulletin 2009-06-05: Market Optimization Details (November 19, 2009) at 2-8 – 2-9 (emphasis added), *available at* http://www.caiso.com/Documents/TechnicalBulletin-MarketOptimizationDetails.pdf.

A feature of the CAISO market is the ability for market participants to submit self-schedules rather than economic (or price) bids for load and generation. A self-schedule is a price-taker bid that is awarded, regardless of the Pnode clearing price (even if negative), subject to operational constraints. SDG&E submits a self-schedule for its forecasted load in the Day Ahead Market ("DAM"). SDG&E also submits self-schedules for its (non-intermittent resources) must-take resources in the DAM.[8] This approach is needed because SDG&E has an obligation to receive energy from these resources, regardless of the market price, and self-scheduling in the DAM ensures that revenues paid to these resources effectively offset costs charged to SDG&E load.

Generally, self-schedules do not support the least-cost objective if a resource is capable of responding to price signals. As described earlier, self-schedules are price-taker bids which may provide no assurance that market revenues will pay for fuel and other operating costs, and thereby may expose SDG&E ratepayers to unnecessary risk of losses. Furthermore, self-schedules could affect the CAISO's ability to optimally procure energy and A/S which are necessary for grid reliability. Operational constraints will at times make self-scheduling preferable to cost based bids.

Consequently, SDG&E primarily submits cost-based price bids for its dispatchable generation rather than self-schedules. Under CAISO market rules, cost-based bids provide SDG&E ratepayers a means to recover variable costs associated with start-up, minimum load, and dispatch from the market. Moreover, price bids enable the CAISO to perform its co-optimization between energy and A/S awards.

Finally, with respect to LCD, price bids allow for CAISO market results to meet the least-cost dispatch solution across the entire system, including SDG&E's service territory, because the CAISO selects the mix of resources with the lowest total variable cost (as represented by their price bids) to meet load requirements. To the extent SDG&E submits cost-based price bids reflecting variable costs per D.02-09-053, and most accurately represents operational parameters and constraints to the CAISO, the results produced by the CAISO markets for SDG&E's supply portfolio are consistent with the Commission's LCD requirements.

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[8] For brevity, this prepared direct testimony does not distinguish between SDG&E or the resource owner performing the Scheduling Coordinator functions for SDG&E's resources.

V. LEAST-COST DISPATCH SCHEDULING AND BIDDING PROCESS

SDG&E's LCD process is managed by SDG&E's Energy Supply and Dispatch Group ("ES&D"). Key personnel involved in daily LCD activity in the 2021 record period included fuel traders and schedulers, power traders, day-ahead (pre)schedulers and real-time transaction schedulers and analysts. The LCD process consisted of numerous functions, which are described in this section.

A. Pre-Day-Ahead Planning

During the record period, LCD forecasts for a particular delivery date began with a weekly production cost model that optimized resources to serve SDG&E's load requirement for the following 12-day period. The model software ("GenTrader")[9] was set up with numerous parameters, including load forecast, plant operating data, resource availabilities/outages, forecasted Locational Marginal Pricing ("LMP") prices for all relevant pricing points and dispatch constraints which allowed the model to perform complex analysis to produce a preliminary forecast of generation dispatch and market transactions that minimized total cost to serve the forecasted load requirement. The GenTrader model produced expected utilization of resources for the planning horizon, including dispatch levels, fuel requirements and market transactions. A detailed description of the inputs to GenTrader which SDG&E used for determining an LCD forecast is as follows:

1. <u>Load forecasts</u>: SDG&E produced load forecasts using a load forecasting model developed by Pattern Recognition Technologies, Inc. ("PRT"). The PRT model utilizes multiple AI technologies such as artificial neural networks, fuzzy logic, genetic algorithms, and evolutionary computing,[10] and special proprietary

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[9] SDG&E uses GenTrader, a production cost and optimization software application produced by Power Costs Inc. ("PCI"). GenTrader employs an optimization algorithm to calculate the optimal, constraints-bound mix of market transactions and generation from SDG&E's resource portfolio over the study period. SDG&E acquired GenTrader as part of a PCI product suite in preparation for the new Market. PCI introduced GenTrader in 1999 and continues to implement modeling and technology enhancements that SDG&E receives under its license agreement. GenTrader is used by other clients across the country in nodal and traditional markets to optimize generation portfolios. Additional product description is available at PCI, Speeding Decisions, Optimization & Analytics, *available at* http://www.powercosts.com/solutions/optimization-analytics/.

[10] As defined by Drilling Info, Future Technology Today, Ensemble of Adaptive Intelligent System Models, *available at* http://www.prtforecast.com/technology/.

algorithms analyzed relationships between historical system load and weather data to develop the load forecast for SDG&E's system. SDG&E's load forecast for bundled customers was determined by adjusting SDG&E's system load for transmission losses, accounting for rooftop solar production which fluctuates and were calculated as a percentage estimate of the forecasted system load based on historical data, less the load forecast for Direct Access customers and Community Choice Aggregation (CCA) customers. Direct Access and CCA load forecasts were provided by SDG&E's Electric Load Analysis group based on the historic load for current Direct Access and CCA accounts in the SDG&E billing system. These load forecasts were produced weekly as inputs to the GenTrader 12-day LCD forecast.

2. <u>Master File Updates and Operating constraints</u>: The GenTrader model also required a variety of cost inputs for each dispatchable resource to properly determine its dispatch cost. The Master Files included a subset of data accessible by the resource's scheduling coordinator which is referred to as the Resource Data Template ("RDT"). SDG&E periodically submitted master file changes via an RDT update process that was validated by CAISO. Such data included but was not limited to heat rates, ramp rates and variable operation and maintenance costs ("VOM"), minimum and maximum operating points, fuel delivery charges and start-up and minimum load costs. In addition, numerous operating constraints/parameters, included in the RDT, were also fed into the model including start-up time, minimum shutdown and run times, multi-stage generation ("MSG") transitions and ramp rates. The GenTrader model optimized the dispatch of each resource given its generation cost and operating constraints.

3. <u>Forecast of resource availability</u>: A significant portion of SDG&E's resource portfolio was comprised of must-take resources (QF and renewable energy), as listed in Section II. SDG&E received weekly, and in some cases daily, forecasts of hourly deliveries from the resource operator. In addition, SDG&E generated availability forecasts for some smaller contracts based on historical performance. If the unit availabilities varied from the full operating capability or were on

outage, they were communicated to the CAISO via the Outage Management System application ("OMS").

4. Market prices: The GenTrader LCD forecast model required a forecast of fuel prices for each of the dispatchable resources in SDG&E's portfolio, and a forecast of hourly power prices for various market delivery points where SDG&E generation units were located. Fuel prices were based on forward natural gas price curves at SoCal Border and Kern Delivered (derived from the New York Mercantile Exchange ("NYMEX"), Intercontinental Exchange ("ICE") and broker quotes) and tariff or contract gas transportation costs. Power prices were based on forward power price curves for block power (derived from ICE and broker quotes) and shaped for each hour using price weighting factors derived from historical prices and load profiles.

5. Miscellaneous: Use-limited resources including the Lake Hodges pumped-storage project, NGR resources and demand response products were not modeled by GenTrader due to unique operating constraints and were therefore optimized separately on a day-ahead/weekly basis based on market conditions, LMP price forecasts and operating parameters.

GenTrader was then used to calculate the hourly dispatch level of dispatchable resource over the modeled period that was economic, or "in-the-money," relative to forecasted LMP prices. This determination considered up-front commitment costs (start-up and minimum load costs), incremental dispatch costs which varied by output level, and various operational constraints mostly consistent with resource data template ("RDT") data used by the CAISO in its market processes. For must-take resources, generation was assumed to equal their forecasted availabilities. If the sum of must-take and in-the-money dispatchable generation was less than that hour's load requirement, the short position, or Residual Net Short ("RNS"), was considered to be met with market purchases. If the sum of must-take and in-the-money generation was greater than that hour's load requirement, the long position was considered to be surplus generation available for economic market sales.

B. Day-Ahead Planning

On a day-ahead basis by approximately 6:00 a.m., preschedulers updated the PCI software with updated values, specifically the load forecast, forecasted market prices and resource availabilities. Other resource operational data such as heat rates are relatively static between the 12-day plan and day-ahead plan and were not typically updated. Key distinctions between the 12-day and day-ahead model parameters were as follows:

1. Load forecast: SDG&E used updated temperature and humidity forecasts from SDG&E's weather forecasting service to re-run its PRT load forecasting model. In addition, pre-schedulers applied manual adjustments to the PRT result when warranted to offset known limitations to the model. For example, because PRT forecasts were based on historical data, PRT made adjustments to reflect sudden changes to the weather forecast such as the onset of a heat wave. The prescheduler also benchmarked the PRT forecast to that published by the CAISO for SDG&E's service area (when available) to identify and resolve significant deviations.
2. Resource availabilities: SDG&E received updated and more accurate availability information for its resources on a day-ahead basis. These updates captured information that may not have been included in the 12-day model, such as ambient derates, forced derates, unit testing and outages. These updates were also submitted to the CAISO via OMS as required.
3. Market prices: Spot natural gas and power trade actively in the day-ahead market. SDG&E used two different price forecasts as inputs into optimization models. One price forecast is developed internally, early before and during Day-Ahead ("DA") trading, and the second was provided by an external entity after most of the DA trading subsided. For the first price forecast, SDG&E used an internal forecasting tool using Microsoft Excel to forecast load and resource prices for the DA Market. This DA price forecast was generated by applying historical price spreads and hourly shapes to the SP15 prices traded in the DA market to create a 24-hour price forecast. The second forecast was normally received after 8:00AM which is normally after most of the DA trading volume is completed. Because of the receipt time, SDG&E's internally developed price forecast is used for early morning optimization runs, to provide an initial forecast CAISO generation awards. In 2018, SDG&E began receiving nodal DA LMP price forecasts from an outside entity called Genscape, Inc. Genscape, Inc. is an independent, energy

industry provider of "market intelligence" which includes nodal DA LMP forecasts and possible transmission congestion risks associated with SDG&E's generation portfolio of resources. Genscape produces price forecasts daily. Weekend and holiday forecasts are provided the last day before that weekend or holiday period. SDG&E has provided a record of price forecast accuracy with respect to forecasted LMP (SP15 Trading Hub and SDG&E's DLAP) for 2021 and a comparison of forecast accuracy from the previous year in Attachment A - *2021 Summary Load Data and LMP price forecasts.xls*). Both editions of forecasted LMPs are entered into PCI to reflect updated market conditions to run the optimization model.

After updating the GenTrader model with these inputs, SDG&E then re-optimized the mix of market transactions and resource dispatches. As with the 12-day plan, GenTrader produced a plan for unit commitments, dispatch levels and economic purchases and sales. These results helped inform gas and power trading requirements and analyze the potential for self-scheduling of dispatchable resources.

C. Day-Ahead Trading and Scheduling

The CAISO runs the DAM to economically clear load and resources that were scheduled or bid in. The DAM required SDG&E to submit separate schedules and bids for each resource and load. Results of the DAM became financially binding at the market clearing price for each resource and load that was awarded, and the sum of SDG&E's awarded resources did not necessarily balance with SDG&E's load award. The process to self-schedule and bid in SDG&E's load and resources is discussed below.

- <u>Load</u>: During the record period, SDG&E began bidding a small portion of its bundled load forecast. SDG&E still sought to self-schedule the majority of the day-ahead bundled load forecast. Self-scheduling ensured that SDG&E would purchase its forecasted load requirement in the DAM rather than rolling the requirement into the real-time market which produces more volatile prices. The DAM was preferred for two other reasons. The first reason was that SDG&E was required to self-schedule or bid in its (non-use limited) resources into the DAM under Resource Adequacy must-offer rules in the CAISO Tariff. Therefore, while balanced schedules were not mandated, the DAM did provide a means for supply revenues to effectively offset the load costs provided that SDG&E self-scheduled its load in the DAM. The second reason was that the depth of the day-ahead bilateral market allowed SDG&E to hedge its self-scheduled load exposed to the CAISO DAM clearing price via market transactions.

The portion of forecasted load in which SDG&E elected to bid into the market rather than self-schedule was bid at prices based on the Real Time pricing forecasts provided by Genscape. Attachment A - *2021 Summary Load Data and LMP Price Forecasts.xlsx* contains detailed summary load data and results.

- Non-intermittent must-take resources: SDG&E continued to self-schedule available must-take generation on a day-ahead basis to offset DAM load awards. For resources that were scheduled by sellers and not SDG&E, sellers continued to self-schedule their available generation into the DAM. Credit for the DA revenues was transferred back to SDG&E either via an Inter-SC Trade ("IST") for the self-scheduled quantity or settled after the fact by the settlements group.
- Generation convergence bids: One of SDG&E's intermittent resources that is a Variable Energy Resource ("VER") was scheduled in the hour-ahead scheduling process as required by the CAISO. SDG&E utilized convergence bids to effectively shift the CAISO's payment for this VER resource from the real-time market to the DAM, thereby providing a better offset to load charges which, as discussed above, settle against DAM prices. The Commission authorized Convergence Bidding in D.10-12-034.[11] The daily process consists of three main steps: (1) retrieval of the day-ahead VER forecast for the relevant resource; (2) creation of convergence bid quantities considering (a) the percentage of the day-ahead

[11] D.10-12-034 allows the IOUs to recover the costs associated with Convergence Bidding in ERRA.

VER MW volume forecast to be shifted into the DAM, (b) convergence bid quantity limitations imposed by the CAISO and (c) reduction of quantities in hours that have expected forecasted negative returns and/or historically produced negative returns on the convergence bids SDG&E would have submitted; and (3) pricing of convergence bids such that the virtual supply was not sold at unreasonably low price levels. SDG&E's Convergence Bidding activity for the Record Year was reported and was already approved for the first two quarters of 2021 (third quarter is pending approval and fourth quarter is being audited) in the Quarterly Compliance Reports ("QCRs") that SDG&E submits to the Procurement Review Group as required by D.10-12-034.[12] The remaining VER resources in the portfolio utilized energy bids to also attempt to shift the CAISO's payment for VER resources from the real-time market to the DAM.

- <u>Dispatchable resources</u>: SDG&E's objective, with respect to self-schedules and price bids for dispatchable resources, was to maintain adherence to LCD principles. This objective was primarily met by bidding generation into the DAM at cost–based prices consistent with the LCD modeling.
- <u>Generator price bids</u>: Energy bids consist of three basic components - startup cost, minimum load cost and incremental energy bids. Startup and minimum load costs, which can be declared as registered or proxy, were used in the CAISO DAM. In addition, bidding rules required that incremental energy bids be monotonically increasing over the range of output. Other components of the price bid that pertained to A/S-certified units are bids for Regulation, Spinning Reserve and Non-Spinning Reserve. As discussed in Section V below, the DAM algorithm co-

[12] SDG&E includes a summary of its Convergence Bidding activities in this testimony as it is seeking to recover the costs associated therewith pursuant to D.10-12-034. However, SDG&E is not seeking a compliance review of its specific Convergence Bidding activities as those have already been approved in the QCRs.

optimized dispatchable capacity between generation and A/S awards; and the generator was paid an amount greater than or equal to its opportunity cost of forgoing a profitable day-ahead energy sale. However, co-optimization did not consider lost energy sales in the real-time market. Therefore, SDG&E incorporated an estimate of expected real-time energy market net revenues that the A/S capacity could otherwise derive from that market.

- Lake Hodges Pumped-Storage Unit: As noted in the LCD modeling discussion, SDG&E performed a separate optimization analysis of Lake Hodges due to its unique operational characteristics. For example, its cost was based on the cost of power required to pump water into the upper reservoir such that the generator could generate power at a later time. Secondly, it was only economic to operate the plant (from an LCD perspective) when the cost of pumping water into the upper reservoir was recovered by revenues from using that water for generation. Given that these unique features presented significant modeling challenges that only applied to 40 MW of generation capacity, SDG&E chose to develop an in-house spreadsheet tool to determine the optimized dispatch of this resource rather than devoting resources to upgrade its GenTrader application. The spreadsheet tool produced a daily bid or self-schedule for the unit for both pump and generation through the following steps: (1) retrieval of an hourly power price forecast over the current week (Monday-Sunday) through Sunday night; (2) determination of economically rational pump and generation hours based on the power price forecast, pump efficiency parameters, variable O&M costs and load uplift charges; and (3) modification of the hours from step 2 based on operational constraints such as water usage restrictions. Trading or scheduling personnel manually reviewed the results, modified as needed to ensure all other operational constraints were respected, and uploaded the final pump and generation self-schedules or bids into SDG&E's scheduling application for submittal into the CAISO market.

SDG&E has provided Attachment B, entitled “2021 Hydro and Pump Storage,” which includes summary reporting on bidding and dispatch of dispatchable hydro and pumped storage resources. Also, as a guide to the unique constraints and bidding considerations for Lake Hodges, SDG&E is providing a presentation for reference (*see* Attachment L).

- Battery Storage: Similar to Lake Hodges, SDG&E performed a separate optimization analysis of Battery Storage due to its unique operational characteristics and opportunity costs associated with potential Ancillary Service revenues and real-time prices. For example, its cost was based on the cost of power required to charge the battery such that the battery can generate power at a later time. Secondly, it was only economic to operate the battery (from an LCD perspective) when the cost of charging the battery was recovered by revenues from discharging the battery. Battery storage is a technology with unique features which presented significant modeling challenges that only applied to 113.5 MW of generation capacity. SDG&E has developed a process to submit bids to optimize the dispatch of this resource. The factors considered in determining bids for battery Storage resources are: (1) Forecasted and historical DA, RT and A/S prices (2) charge efficiency parameters, (3) variable O&M costs and (3) State of Charge, charge/discharge capacity, and cycling limitations. Trading and scheduling personnel reviewed the bids, to ensure all other operational constraints were respected, and processed the final bids for charge and discharge bids in SDG&E’s scheduling application for submittal into the CAISO market.
- Power Trades: During the 2021 record period, SDG&E primarily traded day-ahead financial power to hedge the risk of unknown DAM clearing prices, and their effect on the magnitude of market awards on SDG&E’s resources. Financial power was traded in lieu of physical power due to greater market liquidity but provided the same hedge. Like physical power purchases, SDG&E purchased financial power to lock in energy prices below its marginal generation cost or sold financial power to lock in

sales of surplus generation above variable cost. The volume of energy purchased or sold was informed by the results of the GenTrader LCD model and a position analysis spreadsheet developed in-house; both tools calculated SDG&E's hourly short or long position based on similar inputs and provided a more robust result of hedging needs than a single model. SDG&E traded these products on the ICE or through voice brokers to ensure competitive prices and submitted these trades for Commission review in its QCR.

D. Hour-Ahead Scheduling and Real-Time Dispatch

The CAISO operated the Real-Time Market ("RTM") that performed several important functions related to LCD while matching generation and demand to maintain the frequency of the grid. Like the DAM, the RTM established financially binding awards for awarded hour-ahead self-schedules and bids, but only at intertie scheduling points. In addition, the RTM enabled SDG&E to submit updated self-schedules and cost-based bids for its dispatchable resources, so the CAISO could issue incremental or decremental dispatches in the real-time market based on this updated data. SDG&E also self-scheduled its VER resources in RTM as required under VER rules. Of note, the CAISO did not allow load self-schedules and bids to be updated in RTM; any differences between actual load and the load quantity cleared in the DAM were automatically settled at the real-time market price.

The CAISO issued incremental and decremental awards an hour before delivery for intertie bids and in real-time (5 to 15 minutes ahead) for online or fast-start internal generation through its Automated Dispatch System ("ADS"). Decremental energy awards essentially caused resources to buy back the day-ahead award if the RTM or real-time price fell below the bid price submitted in RTM; incremental awards caused resources to sell additional energy or A/S relative to the day-ahead award. SDG&E's resources responded directly to these ADS instructions. If a resource experienced an unplanned outage or other change in operational capability, these updates were submitted to the CAISO via OMS as required to notify the CAISO of the status and preclude infeasible real-time dispatch instructions.

Because real-time prices are historically more volatile than, and can deviate significantly from, the day-ahead price, the impact of the real-time market on SDG&E's LCD results varied day-to-day. This impact could be particularly negative if real-time market prices spiked when

SDG&E's portfolio was significantly short. The short position could arise for several reasons, including:

- SDG&E generally self-scheduled 100% of its forecasted load in the DAM; if actual load exceeded the forecast, the result was a short real-time position;
- Resources (must-take and dispatchable) that were awarded in the DAM carried a delivery obligation in the real-time market for the awarded quantity; thus, an outage or curtailment to any of these resources that prevented it from meeting its day-ahead obligation resulted in a short real-time position;
- Awarded convergence bids in the DAM triggered a buyback in the real-time market; if this buyback was not fully covered by physical generation, the convergence bid resulted in a short real-time position; and
- If real-time prices were lower than day-ahead, the CAISO could dispatch resources below their day-ahead award, as described earlier in this section; these decremental dispatches would result in a short real-time position (albeit a desirable one should real-time prices continue to remain low).

If real-time prices spiked under any one or more of these scenarios, SDG&E's dispatchable resources may not have been able to ramp quickly enough to fully eliminate the short position. The combination of real-time price spikes and short portfolio position was and continues to be a constant risk to ratepayers, depending on the severity of each.

E. Award Retrieval and Validation

SDG&E retrieved CAISO day-ahead awards and communicated them to its resources. While dispatchable generators in fact respond to CAISO ADS or regulation dispatch in real-time, they required timely notice of day-ahead awards in order to adequately prepare to meet startup, shutdown and MSG transition requirements. Furthermore, advance notification of regulation awards ensured that generators would be prepared to operate in Automated Generation Control ("AGC") in order to follow regulation dispatch. Lastly, the day-ahead notification allowed enough time to address any inconsistencies between a generator's day-ahead award and its stated operational constraints previously communicated to the CAISO through OMS.

SDG&E performed a post-market assessment to review market results and validate that the CAISO process resulted in LCD of SDG&E's portfolio. The assessment is referred to as the Bid Evaluator report, provided through the PCI software package. Bid Evaluator compared SDG&E's expected day-ahead awards for its dispatchable generation based on published market prices with actual DAM results. Generally, the market results aligned closely with Bid Evaluator results (subject to operational constraints), confirming that LCD of SDG&E's portfolio was achieved.

Although SDG&E investigated substantive deviations between CAISO market solutions and Bid Evaluator optimization, any deviations did not necessarily indicate an incorrect dispatch or need for further action. Upon citing a deviation, SDG&E could modify inputs or bidding strategy, initiate a change proposal to PCI for development, or notify CAISO of deviations to determine the cause which may be recognized as a market flaw through Customer Inquiry Dispute and Information ("CIDI") tickets.

VI. CONSTRAINTS TO LEAST-COST DISPATCH

As stated in the discussion of LCD principles, SDG&E performed its LCD activities within limits established by numerous types of constraints that range from operational, regulatory and contractual to risk mitigation and market conditions. An after-the-fact review of a particular day's dispatch may show a deviation from LCD because of the effects of such constraints.

Some constraints were operating limits inherent to the resources in the portfolio. For example, generators cannot continually cycle back and forth between online and offline because of minimum run time and shutdown time of each combustion turbine. Therefore, the lowest cost unit may not have been dispatched if adequate time for startup was not available. Some other common examples of LCD constraints include, but are not limited to, the following:

- Exceptional Dispatch ("ED") is a form of dispatch the CAISO relies on to meet reliability requirements that cannot be resolved through market processes. The CAISO orders EDs to address local generation requirements, system capacity needs, transmission outages, software limitations and other operational issues. Because EDs are reliability-driven, they are outside the scope of LCD and likely to be uneconomic relative to market prices or other resources. All CAISO resources are obligated to comply with these dispatches.

- Residual Unit Commitment ("RUC") is a market award for capacity, which the CAISO issues to ensure that sufficient capacity is committed to meet system load. Although RUC resulted from the market process, it is required to manage grid reliability and is outside the scope of LCD. SDG&E resources were obligated to be available to provide the RUC capacity if awarded, which required that they could be committed uneconomically relative to other resources.
- Unit testing and maintenance, such as Relative Accuracy Test Audit ("RATA") tests and heat treats, require generators to run at pre-defined load points to achieve an objective. During these periods, generation is considered must-take and cannot be dispatched according to LCD economics.
- Constrained pipeline operations may impact LCD. A generator may be constrained in its ability to provide real-time dispatch because of limited gas balancing rights on a pipeline. Another example of pipeline constraints was Operational Flow Orders ("OFOs") declared by Southern California Gas Company ("SoCalGas"). Under a high-inventory OFO, if a resource failed to consume 90% of the scheduled natural gas quantity, the pipeline assessed penalties. Therefore, resources were constrained from following real-time LCD economics to decrease generation.
- Use-limited resources are resources that are only available for a limited number of hours or starts per period. For example, annual environmental restrictions limit the number of startups on certain combustion turbines. Other resources that were use-limited include Demand Response programs that can be triggered for limited hours each month.
- CAISO market solutions look at 24-hour time horizons and to come up with the most economic "system" solution, individual resources may need to be awarded uneconomically or may not be awarded even though a specific resource may appear to be economical with respect to its clearing

prices to satisfy specific reliability requirements. Therefore, LCD is achieved on a system basis while satisfying unique transmission and reliability constraints as opposed to evaluating an individual unit on an hour by hour basis.

VII. SUMMARY REPORTS AND TABLES

In this Section, SDG&E provides additional detailed information that support SDG&E's execution of the LCD process during 2021, as described in Section IV. The following provides a description of information provided as well as tables which summarize annual exceptions for incremental cost bid calculations, self-commitment decisions and Master File data changes:

1. Incremental Cost Bid - Incremental bids submitted to the CAISO are calculated using the heat rate, fuel costs, fuel transportation fees, GHG costs, and variable operations and maintenance costs and any other costs used in the calculation. For the record period, the annual and monthly tables below provide a listing of all variances between calculated and submitted bids that are greater than $0.10 and the related cost impacts. In addition, the table provides any occurrences where dispatchable resources were not bid into the CAISO markets when available. Attachment C – 2021 *Incremental Bid Cost Calculations.xslx* provides details of incremental bids submitted to the CAISO and any potential exceptions. Potential reasons for LMP clearing higher than incremental bid costs include but are not limited to the consideration of start-up and minimum load costs, MIP ("Mixed Integer Processing") gap, inter-temporal constraints, transmission constraints, conditions used as initial conditions for next day and the effect of adjacent balancing authorities' areas.

Table 2 below summarizes the potential impact of the bid exceptions.

Table 2			
Summary of 2021 Incremental Bid Cost Exceptions			
Month	**No. of Variances (2B)**	**% of Bids Submitted**	**Cost Impact $ (2C)**
January	[redacted]		
February*			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December**			
Total/Avg.			

*Submitted bids had variances due to CAISO Market Bid Cap resulting in no units being incrementally dispatched, therefore no incremental cost impact

**Variance were due to unit testing and had no cost impact

Self-Commitment – The summary tables 3-a and 3-b below contain the costs of self-schedule decisions for dispatchable thermal resources during the record period. Also contained are details including total energy self-scheduled and supporting data of daily forecasts of schedules if bid or self-scheduled, forecast revenues and bid costs if bid or self-scheduled, and decisions to self-schedule or bid. Attachment D - *2021 Self Schedules Supporting Data 1.xlsx* and Attachment E - *2021 Self Schedules Supporting Data 2.xlsx* contain the details of self-commitment costs and the reasons to self-schedule. Table 3-a and 3-b below summarize cost impacts of self-scheduling.

Table 3-a								
Summary of 2021 Self Schedules								
Month	**1) Self**	**2) Market Awards**	**3) Self Schedule**	**4) Self Schedule**	**5) Revenue - Costs for**	**6) Bid Cost**	**7) Revenues**	**8) Revenue - Costs**
January	[redacted]							
February								
March								
April								
May								
June								
July								
August								
September								
October								
November								
December								
2020 Total								
Note: Assumes $0 costs for potential hot start.								

Table 3-b Summary of 2021 Hypothetical Non-Self Schedules			
Month	1) Estimated	2) Estimated	3) Estimated
January	[redacted]		
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			
2020 Total			
Note: Assumes $0 costs for potential hot start.			

2. Master File Data Changes – SDG&E can change Master File submissions to reflect Proxy or Registered Start-Up or Minimum Load costs for its dispatchable resources depending on market conditions. In 2021, SDG&E solely submitted Proxy costs for its dispatchable resources. Table 4, the annual table below, summarizes the number of times and the reasons for selecting proxy or registered costs. In addition, the tables provide the frequency of calculations that differed from values submitted to the CAISO, and the cost impacts, by month. Attachment F – 2021 *Master File (RDT) Change Exceptions.xlsx* provides the details of changes made during the record period. Table 4 below summarizes proxy and registered cost change exceptions.

[redacted]

VIII. MARKET DESIGN AND PROCESS CHANGES

The following is a summary of certain CAISO market design changes that may have affected SDG&E's business processes during 2021:

1. Summer 2021 Readiness Market Enhancements: Following the August 2020 events, the CAISO, CPUC, and California Energy Commission (CEC) jointly produced the Root Cause Analysis. The Summer 2021 Readiness Market Enhancements initiative took many of the recommendations from that report and

made short term enhancements to the market rules and procedures to help ensure grid reliability in summer 2021. Areas of focus included:

a) Export, load, and wheeling priorities – one of the key drivers of the blackouts was a large amount of exports clearing in the day-ahead market inappropriately. This interim fix helped mitigate that problem[13].

b) Demand response dispatch and real-time price impacts – this changes how Reliability Demand Response clears the CAISO market to better send accurate price signals.

c) Bid Cost Recovery (BCR) – during tight system conditions, CAISO proposed to expand BCR to help incentivize additional import bids.

d) Short term scarcity price enhancements – during tight system conditions, CAISO proposed to allow the import bid cap to float to $2,000/MWh instead of $1,000/MWh.

e) A review of the EIM resource sufficiency evaluation (RSE)– the August 2020 events prompted concern from several parties that the RSE was not working properly. CAISO identified some issues and fixed them.

2. Resource Adequacy Enhancements Phase 1: Also resulting from the August 2020 events, the CAISO committed to developing actions to prevent supply gaps in advance of summer 2021. The initiative is planned in two phases, with the first phase implemented in the summer of 2021. The first phase included changes to the Planned Outage Substitution Obligation (POSO) and implementation of the Minimum State of Charge (MSOC) to support operationalizing storage.

a) POSO: CAISO implemented the POSO functionality to ensure that all planned outages on Resource Adequacy (RA) resources will have substitute capacity within 24 hours of submission of the outage. It will also prevent the extension or expansion of planned outages without additional substitute capacity.

[13] http://www.caiso.com/Documents/Final-Root-Cause-Analysis-Mid-August-2020-Extreme-Heat-Wave.pdf

b) MSOC: The MSOC requirement tool implemented in the real-time market sets a minimum threshold state of charge for each RA storage resource with a day-ahead discharge award. The MSOC triggers when a Residual Unit Commitment (RUC) shortage is identified in the Day-Ahead Market. These infeasibilities are very infrequent and are an indicator of tight system conditions. There have been several occasions where this has occurred, but overall battery participation on days when hot weather is experienced has been adequate, and there have been minimal intervals when the MSOC constraints have imposed restrictions.

3. FERC Order 831 Compliance and Enhancements Project: Focused on process and system modifications related to CAISO's FERC Order 831 compliance filing, which included revising the tariff to raise the energy bid cap from \$1,000/MWh to \$2,000/MWh with required cost verification of bids above \$1,000/MWh for internal CAISO BAA and resource specific system resources only. Related to the Commitment Costs & Default Energy Bids Enhancements (CCDEBE) initiative from 2020, this policy initiative aims to ensure all supply bids priced above \$1,000/MWh represent verified costs, when supply is needed to meet the CAISO's load responsibility. This initiative consisted of two phases both implemented in 2021 – Phase 1 focused on implementing "compliance" provisions related to raising the bid cap and the after-the-fact-cost recovery process; and Phase 2 implemented the "enhancements" provisions to address penalty prices at which CAISO markets would relax market constraints under the increased energy bid cap and a price-screening methodology for import bids greater than \$1,000/MWh.

4. Energy Storage and Distributed Energy Resources ("ESDER") Phase 4: This phase aimed to continue CAISO's goal to improve and enhance interaction and participation models for both storage and distributed energy resources in the CAISO market. This phase implemented market rule changes to enable the application of market power mitigation to storage resources, which resulted in a default energy bid (DEB) formulation distinct from the DEBs for conventional resources. Additionally, two recommendations from the Market Surveillance

Committee were adopted – the exclusion of the opportunity cost component in the day-ahead storage DEB and the exclusion of small storage resources of less than 5 MW from the local market power mitigation measures. The multi-phase ESDER initiative allows these resources to participate more efficiently, thus allowing for more robust market solutions while reducing carbon emissions.

IX. ANNUAL TABLE

The following table summarizes, by resource type, the total capacity bid or self-scheduled into the market as well as capacity lost due to planned or forced outages. The table also includes total energy awards for each resource broken down by self-schedules versus market awards. Attachment G - *2021 Annual Summary.xlsx* provides the details of dispatchable and non-dispatchable resources. Table 5 is an annual summary of dispatchable and non-dispatchable resources including capacity available and unavailable, self-schedules and DAM awards.

Table 5
Background Summary- 2021 Annual Summary

Dispatchable	Resource Type	Capacity (PMAX in MWh)	Unavailable Capacity (MWh)	DA SS Awards (MWh)	Award due to Market	Total Awards
[redacted]						
Non-Dispatchable	Resource Type	Capacity (PMAX in	Unavailable Capacity	DA SS Awards (MWh)	Award due to Market	Total Awards
[redacted]						
Total		38,683,699	5,162,363	401,986	6,715,908	7,117,893

X. FUEL PROCUREMENT

During the record period, SDG&E supplied fuel for gas-fired, dispatchable resources in the portfolio. SDG&E performed as the pipeline-registered Fuel Manager and Fuel Supplier for most of its dispatchable resources. These included SDG&E-owned or -contracted resources (Miramar, Cuyamaca, Palomar, Desert Star, Orange Grove, Carlsbad, Pio Pico, Escondido Energy Center, El Cajon Energy Center and Goal Line). The fuel costs for these SDG&E resources are charged to SDG&E's Energy Resource Recovery Account ("ERRA") balancing account with the exception of Goal Line which is charged to SDG&E's Transition Cost Balancing Account ("TCBA"). The fuel costs for Pio Pico Energy Center, Carlsbad Energy

Center, and Escondido Energy Center are charged to the Local Generating Balancing Account ("LGBA").

As discussed in the Commission-approved BPP, SDG&E's procurement process is to secure approximately 90% of forecasted fuel volumes required to serve SDG&E's load forecast (but not economic sales) as firm monthly baseload supply. The advantages of baseload supply are that: (1) it shields ratepayers from potentially volatile day-ahead natural gas prices; (2) it is scheduled by market participants as a higher priority delivery than day-ahead supply; and (3) it reduces the day-to-day trading and scheduling requirements, thereby reducing overall operational requirements. While the cost of baseload supply may be lower or higher than the spot price on any given day, over time, these price differentials average toward zero, leaving SDG&E with the benefits cited above.

While most fuel supply was procured as firm monthly baseload, during the Record Year, SDG&E used prevailing day-ahead or intra-day market prices to price out day-ahead or intra-day generation costs, which is consistent with LCD. For example, if the portfolio was short fuel, relative to day-ahead requirements, fuels traders purchased incremental supply at the DAM price. Or, if the portfolio was long on fuel relative to real-time requirements, fuels traders sold the surplus baseload supply at the same-day market price. This coordination between fuel and power trading enabled SDG&E to accurately price variable generation costs so that the benefits of market transactions could be properly evaluated. Both baseload and daily natural gas trades for the record period were executed at competitive prevailing market prices and in compliance with the BPP. All SDG&E natural gas transactions for 2021 were reported and are reviewed by the Commission in SDG&E's QCR under the advice letters cited in Section I, above.

During the period flow dates February 13, 2021 through February 18, 2021, SDG&E experienced extremely high gas prices to fuel two generating resources (*i.e.*, DSEC and YCA) for which SDG&E is the scheduling coordinator and as to which such high gas prices were not accounted for in the commitment costs that the CAISO used to dispatch these resources. Section 30.12 of the CAISO Tariff authorizes a scheduling coordinator to submit a filing to the FERC seeking reimbursement of actual fuel costs that were not recovered through the Bid Cost

Recovery process. SDG&E submitted the requisite filing with FERC on June 23, 2021.[14] The submitted costs sought in the application represent actual incurred fuel costs that reflected reasonable and prudent procurement practices by SDG&E.

During the record period, SDG&E held Backbone Transportation Service ("BTS") to transport natural gas from the various SoCal Border trading points to the SoCal Citygate. SDG&E purchased the BTS capacity from SoCalGas pipeline to increase the priority of fuel delivery to its dispatchable resources. The decision to purchase BTS is determined by several factors including: the price spread between the SoCal Border point and the SoCal Citygate, the quantity of BTS offered by SoCal Gas, and if SDG&E has purchased Firm Interstate capacity that can feed into specific SoCal BTS points. Firm Interstate capacity represent fixed costs and therefore are not considered in the LCD process.

The CAISO's DAM process creates uncertainty of gas quantities to be traded in the DAM. Day-ahead generation awards are not known until approximately 1:00 p.m., well after next-day natural gas finished trading. Because of the time lag, fuels traders need to rely on generation award forecasts and judgment to establish their next-day fuel position. When actual results deviated from forecasted fuel quantities, fuels traders primarily relied on gas balancing services offered on SoCalGas' system and, the Kern and Southwest Gas pipelines. SDG&E also traded and/or scheduled gas supplies in later pipeline scheduling cycles to avoid potential imbalance penalties. Activity in these later scheduling cycles was avoided to the extent lower availability of competitive bids and offers caused incremental transactions to cost more to SDG&E.

XI. DEMAND RESPONSE

SDG&E has developed and offered a variety of Demand Response ("DR") programs to its customers since 2001. The scope of these programs has changed as the concept of DR has evolved and has become an integral part of resource planning and energy management. DR programs have design objectives (reliability, economic, emergency, etc.) as well as specific tariffs or guidelines which describe set trigger conditions such as heat rate, system load, temperature forecast and/or emergency conditions. When triggers are met, SDG&E has

[14] *See* Application of SDG&E to Recover Fuel Costs (Docket No. ER21-2193-000). As of the date of this testimony, SDG&E's application remains pending.

discretion to dispatch a program, which allows SDG&E to assure event hours are available for times of greater need and optimize the value of the programs.

During the record period, SDG&E utilized its DR programs primarily to reduce electricity consumption during peak demand or to respond to system reliability needs. SDG&E's portfolio consists of programs that have economic triggers as well as programs with all non-economic triggers. Pursuant to D.15-05-005, as discussed above,[15] SDG&E's Capacity Bidding Program ("CBP") and AC Saver Saver Program[16] demand response programs, are subject to the LCD standard as they have economic triggers and have been bid into the CAISO market during 2021. SDG&E has a Reliability Demand Response Resource ("RDRR") that is also bid into the CAISO. The Base Interruptible Program ("BIP") will be dispatched by the CAISO only if there is a stage one emergency and prices are at least $950 Per MWh. BIP was triggered by SDG&E on June 17, 2021 after CAISO issued a warning due to system conditions. In the remainder of this section, SDG&E provides information pertaining to both the CBP and AC Saver programs in SDG&E's DR portfolio and explains how the programs were utilized in 2021.

A. Capacity Bidding Program

Capacity Bidding Program ("CBP") is an optional Demand Response program available to all commercial and industrial customers in the SDG&E's territory. CBP is operational from May 1st to October 31st each year. Program operation hours are Monday through Friday, excluding holidays, from 11 A.M. to 7 P.M. or from 1 P.M. to 9 P.M. Participants receive a monthly capacity payment in exchange for reducing their load when requested by the utility. Participating customers who are also receiving bundled services from SDG&E receive an additional energy payment during CBP events.

CBP participating customers can choose to participate in one of two CBP products: (1) CBP Day-Ahead, and (2) CBP Day-Of. The distinction between the product types is the pre-event notification timing. Under the Day-Ahead Product, customers are notified by no later than 3 P.M. the day prior to the actual event. The Day-Of Product, provides event notification two hours prior to the start of the event. SDG&E bids all products in the day-ahead CAISO market

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15 *See* pp. AS-2 – AS-3 above.

16 D.16.-06-029 in conjunction with AL 3050-E-A and AL 3050-E-B approved on July 21, 2017 and effective January 1, 2017.

because the CAISO has limitations on dispatching in real time. The CAISO is addressing the issue and planning to implement a solution for Fall 2021. SDG&E can dispatch in real-time based on the two-hour notification mentioned above.

CBP is capped at 24 events per product in May through October. The program triggers are:

- SDG&E may call an event when SDG&E's DLAP or when applicable, an established PNode price, reaches a price of $80 in the Day-Ahead product. The Day-Of product trigger is a price of $95 for the 11am-7pm product and $110 for the 1pm-9am product.
- SDG&E may call an event if SDG&E system conditions warrant; or
- At the request of CAISO (though still SDG&E's discretion to deploy).

Although the CBP tariff outlines program triggers, SDG&E is not required to dispatch the CBP program every time the economic trigger is reached. Therefore, SDG&E takes forecasted system demand, program limitations, and customer fatigue into account before making a final decision about dispatching the program.

SDG&E incorporates a bid strategy to select the maximum of the highest price (for at least two consecutive hours and up to four) occurrences in a particular month. Each day, SDG&E forecasted the applicable PNode's LMP for every remaining program operation hour (between 11am and 7pm or 1pm and 9pm) of the month. With this forecast, the National Gas Intelligence ("NGI") monthly index of the SoCal Citygate gas price or the balance of the month price was applied to produce an hourly heat rate forecast. SDG&E then calculated the twelfth highest consecutive two-hour price average for the balance of operation hours of each month. If the twelfth highest forecasted price was above a $80,[17] SDG&E used that value to formulate a bid price. If the twelfth price was below $80, SDG&E used a fixed price of $80 as a bid price. After the CBP was dispatched the first time, SDG&E then would take the eleventh highest price of the remaining days of the month and so on until the twelfth dispatch. Bid prices may vary daily depending on revised, daily price forecast and/or the number of times CPB was dispatched. The CBP was activated on forty-four (69) occasions during the 2021 event season. Twenty-One

[17] The Day-Of Product trigger is a price of $95 for the 11-7 product and $110 for the 1-9 product.

(37) events were day-ahead and twenty-three (32) were day-of events. In all cases when CBP events were initiated during the 2021 record period, the quantified economic triggers from the tariff were met, and SDG&E determined that the system needs warranted such actions.

B. AC Saver Program

The AC Saver Day-Ahead program (ACSDA) is a voluntary program that utilizes thermostats to reduce air-conditioning use. Thermostat settings are adjusted when events are triggered. The AC Saver Day-Of program (ACSDO) is a voluntary Air Conditioner ("AC") cycling program that utilizes one-way Direct Load Control switches to obtain predictable load reduction. The air conditioner unit is cycled off based on customer's elected cycling option. Residential100% or 50%, Commercial 30% or 50%. Both programs are available to all residential customers and commercial customers with central air conditioning in SDG&E's territory. AC Saver is operational from April 1st to October 31st each year. Program operation hours are Monday through Sunday from 12 P.M. to 9 P.M. Events may range from two to four hours with a 20 event or 80-hour annual maximum per program. Five additional events may be called for emergency CAISO or local emergency purposes. Participants receive an annual incentive of $20 for participating in the thermostat program and those with direct load control switches receive an SDG&E annual bill credit in December for enrollment in the program based on air conditioner tonnage and cycling option elected.

The AC Saver trigger is 35,000 Btu/kWh heat rate for April through May and October, 25,000 Btu/kWh heat rate for July through September and available for imminent statewide or local emergencies.

SDG&E incorporates a bid strategy to select the 40th highest heat rate (for two consecutive hours) occurrences in a season. Each day, SDG&E forecasted the applicable PNode's LMP for every remaining program operation hour (between 12pm and 9pm) of the season. With this forecast, the National Gas Intelligence monthly index of the SoCal Citygate gas price or the balance of the month price was applied to produce an hourly heat rate forecast. SDG&E then calculated the 40th highest market heat rate (for a consecutive two-hour period) for the balance of operation hours of the year. If the highest forecasted heat rate was above the trigger, SDG&E used that value to formulate a bid price. If the highest forecasted heat rate was below the trigger, SDG&E used the heat rate associated with the month to formulate a bid price. The bid price was calculated by taking the higher of the trigger heat rate and the highest forecasted heat rate and multiplying that value times the SoCal Citygate[18] price for the next day. After the AC Saver is dispatched the first time, SDG&E then would take the 39th highest forecasted heat rate of the remaining days of the month and so on until the 40th dispatch. Bid prices may vary daily depending on revised, daily forecasted heat rates and/or the number of times PDR was dispatched.

AC Saver Commercial DA, AC Saver Residential DA, and AC Saver DO were activated on twelve (12) occasions during the 2021 event season. In all cases when AC Saver events were initiated during the record year of 2021, the quantified economic triggers from the tariff were met, and SDG&E determined that the system needs warranted such actions.

C. Demand Response Metrics

In D.14-05-025, the Commission approved various reporting requirements proposed by Cal PA. The following discussion outlines those requirements as well as the manner in which SDG&E responded to them for Record Year 2021.

1. An annual summary of the results of the reporting requirement (related to dispatch of DR resources) adopted in D.14-05-025. At a minimum, the utilities should provide a summary of:
    a. The times and duration that all programs were dispatched;
    b. All cases where the DR program's trigger conditions were forecast to be met, and all cases where these trigger conditions were met;
    c. A list of occurrences when DR resources should have been dispatched but were not (*i.e.,* a DR resource's economic trigger conditions were forecast by the utility, but it was not dispatched). Each occurrence should be accompanied by an explanation detailing the reason for non-dispatch.
2. In addition to the Reporting Requirement in D.14-05-025, a calculation should be provided of the number of hours when the utility forecasts that trigger criteria will be reached, as a percentage of hours in which trigger conditions were reached in the same time period (monthly and annual basis).
3. The total energy dispatched as a proportion of maximum available energy for each DR program under scope of the proceeding (monthly and annual

[18] SDG&E switched from ICE Socal Citygate to CAISO published gas price on August 18, 2017.

breakdowns). This comparison should be provided in both percentage and nominal (MWh) terms. An example of the format is provided below:

a. In 2021 record year, utility A's CBP program dispatched 100MWh. This is compared to a total maximum available dispatch of 200 MWh for that program.

b. Therefore, utility A's CBP program did not dispatch 100 MWh of its total maximum available energy.

c. In 2021 record year, utility A dispatched 50% of the available energy in the CBP program.

4. For each event the full capacity was not dispatched, an explanation should be provided as to why the DR resource was not dispatched to its maximum availability during the record period.

5. If the metrics in (3.) above show that available energy was not dispatched for a program, provide an estimate of the net cost impact on overall resource dispatch of not utilizing maximum available amounts when the program triggers have been forecasted to be reached. This metric should focus on the net cost of dispatching metric (3)(b).

6. Metrics should be provided by the utility to identify whether the selection of DR events called minimized the utility's overall portfolio costs of dispatching supply resources. This assessment should include the average hourly net cost impact by program.

a. For events dispatched in the record year.

b. For all time periods when DR program triggers were forecasted by the utility (whether dispatched or not).

c. Comparison of a) and b) in both percentages and nominal (MWh) terms.

7. An explanation of how opportunity cost analyses were used to make the decision to call or not call an event. This should include an explanation of the opportunity cost methodology and demonstration of its application.

SDG&E has reviewed the preceding requirements, and in the following, discusses how the metrics SDG&E supplied in the accompanying attachments to this testimony for record period 2021 comply with these requirements.

1. Attachment H - *2021 ERRA Demand Response Metric 1.xslx* provides CBP summary results of when program was dispatched, when trigger conditions were forecasted and/or met, a list of occurrences when CBP was not dispatched but hit triggers, as well as the reason for non-dispatch.
2. In the 2021 record period, SDG&E used the DAM clearing prices as the forecast trigger criteria for CBP Day-Ahead because the deadline to call the event is after the Day-Ahead final schedules are published. With respect to CBP Day-Of, SDG&E used the published DAM clearing prices and other real-time market conditions to determine if the CBP Day-Of should have been dispatched but did not forecast price triggers. As a result, the hours when the utility forecasts the trigger will be the same as the number of hours when the trigger conditions were met and no further data was provided.
3. *Attachment* I - *2021 ERRA Demand Response Metric 2.xslx* provides CBP summary results of total energy dispatched as a proportion of the maximum available energy for CBP Day-Ahead and Day-Of. The comparison provides the metric in percentage and nominal (MWh) terms.
4. *Attachment H - 2021 ERRA Demand Response Metric 1.xslx* provides an explanation when CBP was not dispatched but hit triggers. CBP Day-Ahead Product and Day-Of was dispatched to full capacity each time SDG&E triggered an event.
5. *Attachment* J - *2021 ERRA Demand Response Metric 5.xslx* provides a net cost impact of CBP Day-Ahead and Day-Of when triggers were met and resource was not dispatched to its maximum available capacity.
6. Attachment *K - 2021 ERRA Demand Response Metric* 6 provides the average hourly net cost CBP events called in the 2021 record period compared to the average hourly potential next cost from all times when trigger conditions were forecast (Dispatched or Not).
7. As described above in Section X, SDG&E utilized its DR programs during the record period primarily to reduce electricity consumption during peak demand or in response to system reliability needs. The instances in which SDG&E did not call events when triggers were met, were based on a combination of current

system needs, and the benefit of reserving the resource to provide for a greater system need.

XII. CONCLUSION

My prepared direct testimony describes SDG&E's plans and processes used during the record period for serving load from its fully integrated portfolio of utility-owned resources, power purchase contracts and market transactions, consistent with the Commission-approved BPP in effect. SDG&E consistently complied with applicable Commission's decisions addressing LCD requirements for the 2021 record period. In summary, SDG&E's LCD processes are fully consistent with and satisfied the Commission's requirements by considering variable costs and utilizing the lowest-cost resource mix, subject to constraints in the day-ahead, hour-ahead and real-time markets. Therefore, SDG&E requests that the Commission find that SDG&E demonstrated compliance with the Commission's LCD and SOC 4 standards during the 2021 record period.

This concludes my prepared direct testimony.

XIII. QUALIFICATIONS

My name is Andrew Scates. My business address is 8315 Century Park Court, San Diego, CA 92123. I am currently employed by SDG&E as a Market Operations Manager. My responsibilities include overseeing a staff of schedulers involved in dispatching the SDG&E bundled load portfolio of supply assets for the benefit of retail electric customers. This includes transacting in the real-time wholesale market and managing scheduling activities in compliance with CAISO requirements. I assumed my current position in January 2011.

I previously managed the Electric Fuels Trading desks for SDG&E, primarily managing day ahead and forward procurement of Natural Gas. Prior to joining SDG&E in 2003, my experience included five years as an energy trader/scheduling manager.

I hold a Bachelors degree in Business Administration with an emphasis in Finance from California State University, Chico.

I have previously testified before the Commission.

ATTACHMENT A
2021 SUMMARY LOAD DATA AND LMP PRICE FORECASTS.XLSX

CONFIDENTIAL
THIS DOCUMENT IS CONFIDENTIAL IN ITS ENTIRETY

ATTACHMENT B
2021 HYDRO AND PUMP STORAGE.XLSX

CONFIDENTIAL

THIS DOCUMENT IS CONFIDENTIAL IN ITS ENTIRETY

ATTACHMENT C
2021 INCREMENTAL BID COST CALCULATIONS.XSLX

CONFIDENTIAL
THIS DOCUMENT IS CONFIDENTIAL IN ITS ENTIRETY

ATTACHMENT D
2021 SELF SCHEDULES SUPPORTING DATA 1.XLSX

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ATTACHMENT E
2021 SELF SCHEDULES SUPPORTING DATA 2.XLSX

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ATTACHMENT F
2021 MASTER FILE (RDT) CHANGE EXCEPTIONS.XLSX

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ATTACHMENT G
2021 ANNUAL SUMMARY.XLSX

CONFIDENTIAL

THIS DOCUMENT IS CONFIDENTIAL IN ITS ENTIRETY

ATTACHMENT H
2021 ERRA DEMAND RESPONSE METRIC 1.XSLX

ATTACHMENT I
2021 ERRA DEMAND RESPONSE METRIC .XSLX

ATTACHMENT J
2021 ERRA DEMAND RESPONSE METRIC 5.XSLX

ATTACHMENT K
2021 ERRA DEMAND RESPONSE METRIC 6

ATTACHMENT L
CALPA – PUMP STORAGE (LAKE HODGES) OVERVIEW PRESENTATION

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ATTACHMENT M
ENERGY STORAGE OPERATIONAL OVERVIEW

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ATTACHMENT N

CONFIDENTIALITY DECLARATION OF ANDREW SCATES

BEFORE THE PUBLIC UTILITIES
COMMISSION OF THE STATE OF
CALIFORNIA

DECLARATION
OF ANDREW SCATES

A.22-06-XXX

Application of San Diego Gas & Electric Company (U 902-E) for Approval of: (i) Contract Administration, Least Cost Dispatch and Power Procurement Activities in 2021, (ii) Costs Related to those Activities Recorded to the Energy Resource Recovery Account and Transition Cost Balancing Account in 2021 and (iii) Costs Recorded in Related Regulatory Accounts in 2021

I, Andrew Scates, do declare as follows:

1. I am the Market Operations Manager for San Diego Gas & Electric Company ("SDG&E"). I have included my Direct Testimony ("Testimony") in support of SDG&E's Application for Approval of: (i) Contract Administration, Least Cost Dispatch and Power Procurement Activities, and (ii) Costs Related to those Activities Recorded to the Energy Resource Recovery Account, incurred during the Record Period January 1, 2021 through December 31, 2021, and (iii) the Entries Recorded in Related Regulatory Accounts. Additionally, as Market Analysis Manager, I am thoroughly familiar with the facts and representations in this declaration and if called upon to testify I could and would testify to the following based upon personal knowledge.

2. I am providing this Declaration to demonstrate that the confidential information ("Protected Information") in support of the referenced Application falls within the scope of data provided confidential treatment in the IOU Matrix ("Matrix") attached to the Commission's Decision D.06-06-066 (the Phase I Confidentiality decision). Pursuant to the procedures adopted in D.08-04-023, I am addressing each of the following five features of Ordering Paragraph 2 in D.06-06-066:

- that the material constitutes a particular type of data listed in the Matrix;
- the category or categories in the Matrix the data correspond to;
- that SDG&E is complying with the limitations on confidentiality specified in the Matrix for that type of data;
- that the information is not already public; and
- that the data cannot be aggregated, redacted, summarized, masked or otherwise protected in a way that allows partial disclosure.

3. The Protected Information contained in my Testimony constitutes material, market sensitive, electric procurement-related information that is within the scope of Section 454.5(g) of the Public Utilities Code.] As such, the Protected Information provided by SDG&E is allowed confidential treatment in accordance with Appendix 1 - IOU Matrix in D.06-06-066.

Confidential Information	Matrix Reference	Reason for Confidentiality
Table 2- Column Cost Impact	XI	Monthly Procurement Costs (Energy Resource Recovery Account), Confidential for three years
Table 3-a Table 3-b	XI	Monthly Procurement Costs
Attachment A	VI.B XI II.A.2	Utility Bundled Net Open Position for Energy (for MWh), Confidential front three years Monthly Procurement Costs Utility Electric Price Forecast, Confidential for three years
Attachment B	IV.A VI.B	Forecast IOU Generation Resources, Confidential for three years Utility Bundled Net Open Position for Energy (for MWh)
Attachment C	II.B XI	Utility Retained Generation (URG) Confidential for three years Monthly Procurement Costs
Attachment D, E	XI	Monthly Procurement Costs

Attachment F	IX.B IV.A	Recorded data on specific resources (rather than broad categories of supply sources) used to serve bundled load; Appendix I IOU Matrix does not specify effective period of confidentiality. Forecast of IOU Generation Resources
Attachment G	XI VI.B	Monthly Procurement Costs Utility Bundled Net Open Position for Energy (for MWh)
Attachment L	XI	Monthly Procurement Costs
Attachment M	XI	Monthly Procurement Costs

4. I am not aware of any instances where the Protected Information has been disclosed to the public. To my knowledge, no party, including SDG&E, has publicly revealed any of the Protected Information.

5. I will comply with the limitations on confidentiality specified in the Matrix for the Protected Information.

6. The Protected Information cannot be provided in a form that is aggregated, partially redacted, or summarized, masked or otherwise protected in a manner that would allow further disclosure of the data while still protecting confidential information.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct.

Executed this 24th day of May, 2022, at San Diego, California.

Andrew Scates
Market Operations Manager
San Diego Gas & Electric Company

ACRONYM GLOSSARY

A/S	Ancillary Services
ADS	Automated Dispatch System
AL	Advice Letter
BCR	Bid Cost Recovery
BIP	Base Interruptible Program
BPP	Bundled Procurement Plan
BTS	Backbone Transportation Service
CAISO	California Independent System Operator
CAL PA	California Public Advocates Office
CBP	Capacity Bidding Program
CCGT	Combined Cycle Gas Turbine
CIDI	Customer Inquiry Dispute and Information
CPUC	California Public Utilities Commission
CT	Combustion Turbines
D	Decision
DA	Day Ahead
DAM	Day Ahead Market
DLAP	Default Load Aggregation Point
DR	Demand Response
DSEC	Desert Star Energy Center
ECEC	El Cajon Energy Center
ED	Exceptional Dispatch
EEC	Escondido Energy Center
ERRA	Energy Resource Recovery Account
ES&D	Energy Supply and Dispatch
FERC	Federal Energy Regulatory Commission
GHG	Greenhouse Gas
HASP	Hour-Ahead Scheduling Process
ICE	Intercontinental Exchange
IFM	Integrated Forward Market
IST	Inter-SC Trade
LCD	Least Cost Dispatch
LMP	Locational Marginal Price
LSE	Load Serving Entity
LTPP	Long Term Procurement Plan
LTSA	Long Term Service Agreement
MIP	Mixed Integer Processing
MRTU	Market Redesign Technology Upgrade
MSG	Multi-stage Generation
MW	Megawatt
NGI	National Gas Intelligence
NGR	Non-generating Resources
Non-spin	Non-spinning Reserve
NYMEX	New York Mercantile Exchange

O&M	Operations and Maintenance
OFO	Operational Flow Order
OG	Orange Grove
OMEC	Otay Mesa Energy Center
OMS	Outage Management System
ORA	Office of Ratepayer Advocates (Now California Public Advocates Office)
OTC	Over-the-counter
PCI	Power Costs Inc.
PDR	Proxy Demand Response
PEC	Palomar Energy Center
Pnode	Pricing Node
PPA	Power Purchase Agreement
PRG	Procurement Review Group
PRT	Pattern Recognition Technologies
QCR	Quarterly Compliance Report
QF	Qualifying Facility
RA	Resource Adequacy
RATA	Relative Accuracy Test
RD	Regulation Down
RDRR	Reliability Demand Response Resource
RDT	Resource Data Template or Master File
RNS	Residual Net Short
RT	Real-Time
RTM	Real-Time Market
RU	Regulation Up
RUC	Residual Unit Commitment
SC	Scheduling Coordinator
SDG&E	San Diego Gas & Electric Co.
SIBR	Scheduling Infrastructure & Business Rules
SOC	Standard of Conduct
SOC	State of Charge
SoCalGas	Southern California Gas Company
SP15	South Path 15
Spin	Spinning Reserve
UOG	Utility Owned Generation
VER	Variable Energy Resources
VOM	Variable Operations and Maintenance