California Peaker Power Plants

nergy Storage Replacement Opportunities

Across California, nearly 80 gas-fired power plants help meet statewide peak electric demand. These plants include 65 combustion turbines designed to ramp quickly to meet peak demand, and over ten aging steam and combined cycle turbines now used infrequently to meet peak needs. Half of these facilities are located in areas designated as *disadvantaged communities* by the state of California due to high cumulative socioeconomic, environmental, and health burdens. California peakers also disproportionately operate on days when ozone concentrations exceed federal standards, exacerbating local air quality conditions. A number of the aging plants are poised for retirement, and some of the peakers are kept online only through expensive reliability contracts, suggesting many of these would be prime candidates for replacement. The state has also set numerous targets to support the deployment of renewable energy and energy storage and reduce dependence on fossil fuels, providing an opportunity to replace inefficient, high-emitting peaker plants in vulnerable communities throughout the state with energy storage, solar+storage, demand response, and other clean alternatives.

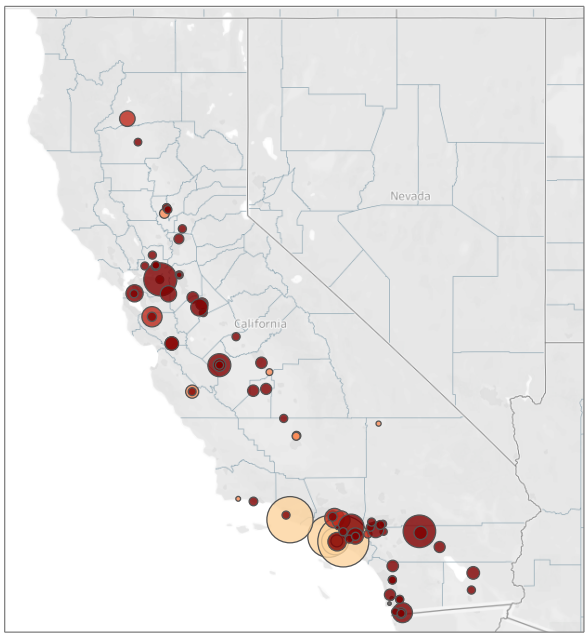

Figure 1: Peaker plants across California

California Policy and Regulatory Environment

California has enacted numerous policy targets and incentives that could both directly and indirectly facilitate replacement of peakers with solar and storage. Key initiatives include but are not limited to:

Ongoing: Minimum of 35 percent of California Climate Investments (from greenhouse gas cap-and-trade funds) earmarked to reduce emissions and support clean energy in disadvantaged communities.

2020: 1,325 megawatt (MW) energy storage target; additional 500 MW of distributed storage.

2020-2025: Inclusion of equity and resilience carve-out for distributed storage in the Self-Generation Incentive Program.

2030: Phase-out of once-through cooling plants, which are often used to meet peak; 60 percent renewable electricity; recommended guidance to procure 12.1 gigawatts of energy storage; 46 million metric ton greenhouse gas emission target for the power sector.

2045: Full carbon neutrality.

2050: 80 percent reduction in greenhouse gas emissions below 1990 levels.

The majority of the California grid is operated by the California Independent System Operator (CAISO), which identifies resource needs in load zones across the state. CAISO has identified *local reliability areas* which rely on local generation resources to meet peak demand. Deployment of energy storage and solar in these transmission-constrained areas may help mitigate need for the

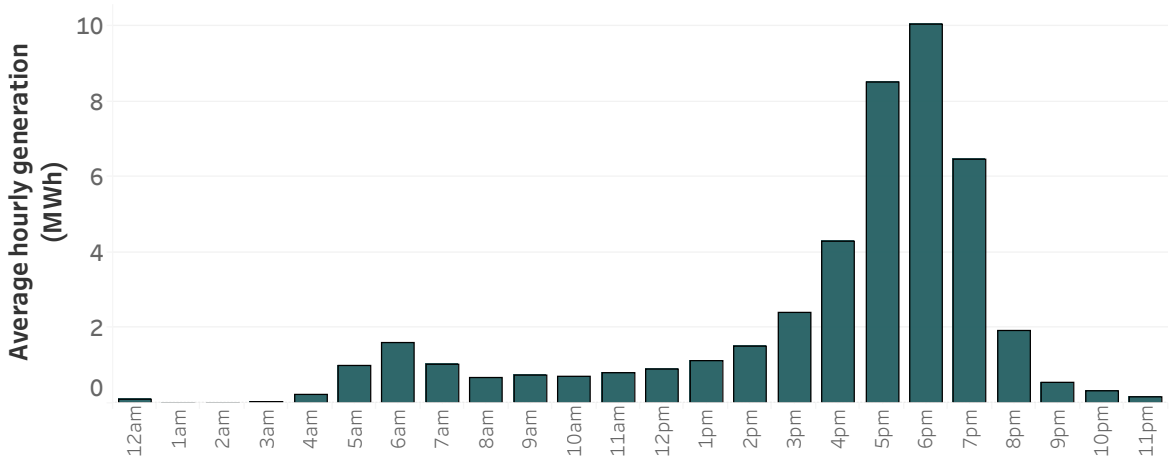

Figure 2: Average hourly generation from the CalPeak Power Vaca Dixon plant. The plant occasionally meets some morning loads and reduces output during peak solar hours, but it is most frequently used to meet peak evening demand. It runs an average of 2.8 hours every time it starts up and has a capacity factor of 2.6 percent. Batteries can serve a similar grid role.

peakers currently used to meet local peak demand, including in the Greater Bay Area, Stockton, Fresno, Kern, San Diego and the Los Angeles Basin, part of which is managed by the Los Angeles Department of Water & Power and has significant electricity import constraints. CAISO has also given reliability-must-run contracts to otherwise unprofitable peaker plants, which have the potential to be replaced with energy storage to meet these grid needs.

California Peaker Plants

Peak electricity demand in California is partially met by nearly 80 gas turbines, internal combustion units, and underutilized aging gas steam and combined cycle plants that run at capacity factors less than 15 percent (they generate 15 percent or less of the electricity that they would if they were running constantly at full power all year). Many of these plants are used at capacity factors as low as one percent. Features of these plants suggest that many would be good targets for replacement with energy storage, including:

Short runtimes: Two-thirds of the gas turbines for which we have data (29 of 45) run less than five hours on average every time they are started up, which could likely be met with standalone batteries or solar+storage (see **Figure 2**).

Aging: The once-through cooling plants are over 40 years old and slated for retirement, providing an opportunity to replace them with energy storage.

Infrequently used: Twenty of the gas turbine peaker plants operate at a capacity factor of 2 percent or less.

California currently has 7.1 gigawatts (GW) of gas turbine or internal combustion peaker plants along with 5.9 GW of once-through cooling plants and 4.3 GW of combined cycle plants currently used as peakers (having capacity factors under 15 percent). Across California, energy storage procurements are beginning to replace fossil-fired power plants. For example, the Oakland Power Plant, an aging facility with a very low capacity factor, is currently facing retirement and will be replaced with a mix of solar and energy storage as part of the Oakland Clean Energy Initiative. Plants with long runtimes may be best replaced with a portfolio mix of multiple resources, such as solar, storage and demand response.

Nearby Populations

Some of California's peakers serve load pockets in dense urban areas in California, including more than twenty facilities which have more than 100,000 people living within a three-mile radius of the plant. Half of the state's peakers are located in disadvantaged communities, defined by the California's environmental justice screening

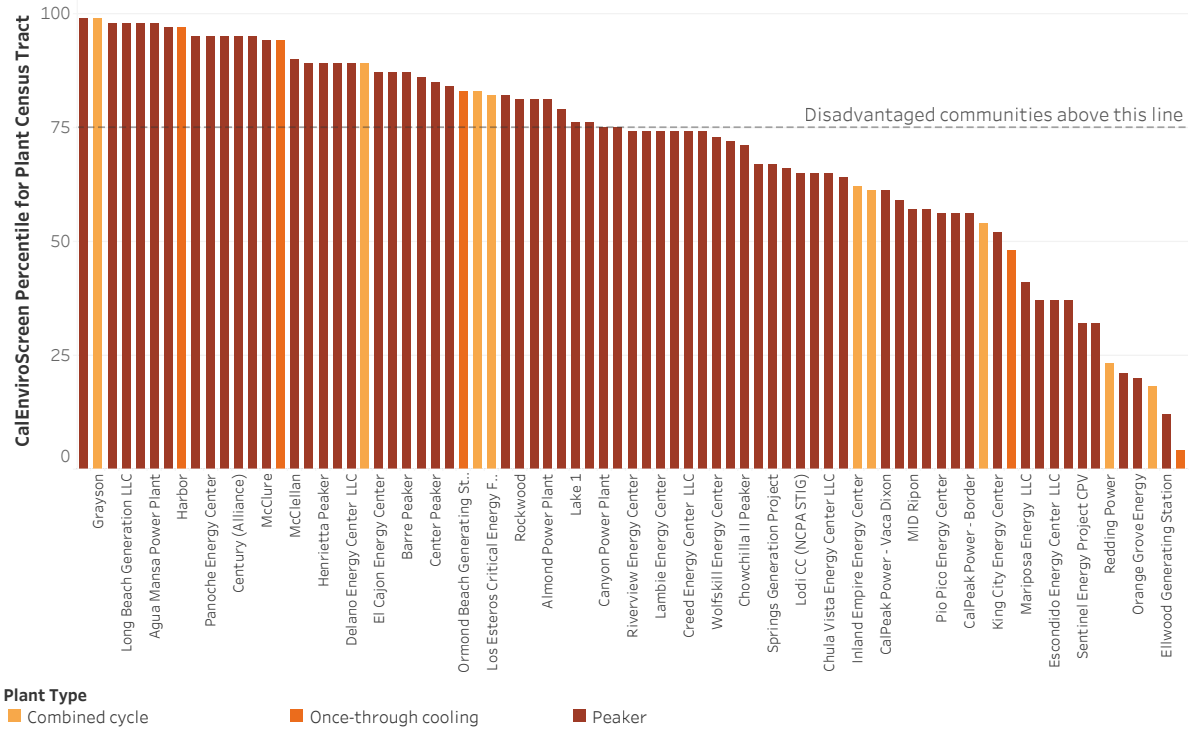

Figure 3: Half of California peakers are located in disadvantaged communities. A CalEnviroScreen percentile score of 75 or above indicates that a plant is located in a disadvantaged community. The score is based on a set of health (e.g. asthma), socioeconomic (e.g. linguistic isolation) and environmental burden (e.g. air quality) indicators to identify cumulative environmental health burdens in California communities. Plot includes gas turbine peaker plants and once-through cooling and combined cycle plants used as peakers.

tool CalEnviroScreen as the 25 percent most environmentally overburdened and socioeconomically vulnerable census tracts. The CalEnviroScreen score for the census tracts within which each plant is located are shown in **Figure 3**. Scores above 75 indicate a disadvantaged community.

Emissions and the Environment

The plants used to meet peak demand in California are typically less efficient and have higher emission rates of greenhouse gas and criteria pollutants per megawatt-hour of electricity generated than the natural gas-fired combined cycle plants used more frequently to meet load. Most of California is designated as out-of-attainment for federal ozone and fine particulate matter concentration standards; while the source of much of this pollution is transportation, peaker plants often operate on hot summer days to meet air conditioning demands and can exacerbate these poor air quality conditions. California peakers tend to operate disproportionately on high ozone days. For example, in the San Joaquin Valley Air Basin, one-third of days exceed federal ozone standards, but some of the peakers in the Valley generate two-thirds of the electricity they produce on days exceeding these standards. **Figure 4** shows the percent of electricity generation on high ozone days and total annual emissions of nitrogen oxides (an ozone precursor) from California peakers. Energy storage, demand response, and other cleaner technologies could be preferentially sited in these areas and dispatched on poor air quality days to reduce reliance on these plants in polluted regions.

Summary

California's peak electricity demand is met with dozens of power plants across the state, many of which operate at low capacity factors, have short runtimes, or are aging and slated to retire. In addition, many of these plants have high rates of pollutant emissions per megawatt-hour of electricity generated as compared with other plants in the state, and they tend to operate dis-

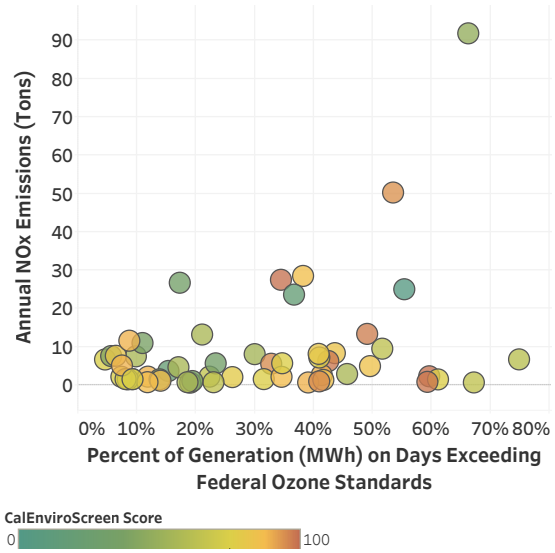

Figure 4: Annual average nitrogen oxide emissions and percent of generation on high ozone days from California peakers. Colors indicate the CalEnviroScreen score of the plant census tract. Energy storage can help replace plants with high emissions or plants that often operate when air quality is poor.

proportionately on days when air quality exceeds federal ozone standards, exacerbating local air quality conditions. Half of California's peaker plants are also located in areas designated as disadvantaged communities by the state. The state has ambitious energy storage targets as well as funding earmarked for emission reductions and clean energy access in disadvantaged communities. The state's energy storage deployment goals and clean energy investment incentives provide a clear opportunity to target the more inefficient and polluting facilities for replacement with cleaner alternatives. Clean energy deployment in communities near plants located in transmission-constrained load pockets can help mitigate the need for those plants as well. In the attached table, we provide operational, environmental and demographic data for California peakers and nearby populations. Indicators such as nearby population, rates, heat rate (fuel used per megawatt-hour), operation on poor air quality days, capacity factor, typical run hours, or location in an environmental justice community or in an import-constrained load area, can help inform whether a given plant might be a good target for replacement with storage, solar + storage, demand response, or a portfolio of these resources. These data should be accompanied by engagement with a ected communities to determine replacement priorities and strategies.

California peaker plant operational and demographic data
For methods see www.psehealthyenergy.org.

	Plant description					Operation and emissions							Demographics (3-mile radius)			
Name (EIA ID)	**Status**	**County**	**Fuel**[1]	**MW**[2]	**Local reliability area**[3]	**Age**[4]	**Capacity factor**[5]	**Run hours/ start**[6]	**Heat rate**[7] MMBtu/ MWh	**CO_2 rate**[8] tons/ MWh	**NO rate**[9] lbs/MWh	**% MWh high ozone days**[1]	**Pop.**	**% Non-white**[11]	**% Poverty**[12]	**CES score**[13]
Agua Mansa (55951)	Operating	San Bernardino	Natural gas	61	LA Basin	16	1.8	8	9.8	0.58	0.17	59	67,236	82	20	98*
Alameda (7450)	Operating	Alameda	Natural gas	50	Greater Bay Area	33	2.0	NA	15.9	NA	NA	NA	141,999	71	22	74
Alamitos (315)	Operating; retirement proposed	Los Angeles	Natural gas	1,970	LA Basin	63	5.5	163	12.3	0.73	0.11	54	119,565	32	10	95*[14]
Almond Power Plant (7315)	Operating	Stanislaus	Natural gas	223	NA	24	8.4	18.9	9.8	0.59	0.1		52,274	75	26	81*
Anaheim CT (7693)	Operating	Orange	Natural gas	49	LA Basin	28	12.3	7.7	9.5	0.57	0.2	35	169,119	63	14	75*

[1]Primary fuel.
[2]Installed nameplate capacity (plant size).
[3]Local reliability area as designated by CAISO.
[4]Age of oldest unit in 2020.
[5]Percent of time running as compared to running all year at full capacity for 2016-2018.
[6]Average number of hours plant runs each time it is turned on. Steam plants are slower to ramp up so tend to run longer.
[7]Heat rates are energy burned per unit of electricity generated; high heat rates re ect low efficiency.
[8]Direct carbon dioxide emissions per unit of electricity generated; does not include upstream emissions.
[9]Nitrogen oxides (NO) emitted per unit of electricity generated; NO contributes to ozone and particulate matter formation.
[1] Percent of generation on days monitors in the same air basin record exceedances of federal ozone standards.
[11]Percent non-white-only populations.
[12]Percent of population below the federal poverty limit.
[13]CalEnviroScreen 3.0 Score for plant census tract. *Indicates plant is in a disadvantaged community.
[14]This tract has a CalEnviroScreen environmental score but no population score.

Barre Peaker (56474)	Operating	Orange	Natural gas	49	LA Basin	12	7.6	4.3	9.8	0.58	0.1	35	278,142	73	17	87*
CalPeak Power-Border (55510)	Operating	San Diego	Natural gas	50	San Diego	18	2.8	3.1	10.7	0.63	0.1	19	7,801	72	4	56
CalPeak Power-Enterprise (55513)	Operating	San Diego	Natural gas	50	San Diego	19	2.9	3.0	10.6	0.62	0.2	19	109,861	57	19	37
CalPeak Power-Panoche (55508)	Operating	Frenso	Natural gas	50	NA	18	3.7	3.0	10.9	0.64	0.1	41	90	95	25	95*
CalPeak Power-Vaca Dixon (55499)	Operating	Solano	Natural gas	50	NA	17	2.6	2.8	10.9	0.63	0.1	19	13,938	32	4	61
Canyon Power Plant (57027)	Operating	Orange	Natural gas	200	LA Basin	8	9.2	5.8	10.2	0.6	0.1	41	176,991	63	14	75*
Carlsbad (59002)	Proposed; postponed	San Diego	Natural gas	632	NA	NA	NA	NA	NA	NA	NA	NA	51,723	26	9	14
Center Peaker (56475)	Operating	Los Angeles	Natural gas	49	LA Basin	12	4.7	4.2	10.2	0.61	0.1	42	246,567	85	12	85*
Century (Alliance) (55934)	Operating	San Bernardino	Natural gas	40	LA Basin	18	0.4	NA	15.5	NA	NA	NA	84,529	80	24	95*
Chowchilla II Peaker (56185)	Operating	Madera	Natural gas	50	Greater Fresno	19	8.6	NA	10.5	NA	NA	NA	12,533	50	30	71
Chula Vista Energy Center (55540)	Operating	San Diego	Natural gas	44	San Diego	13	0.8	3.6	26.0	1.5	0.5	23	196,455	86	18	65
Clearwater (56356)	Operating	Riverside	Natural gas	49	LA Basin	15	5.7	NA	7.6	NA	NA	NA	77,419	65	16	83*
Coachella (6060)	Operating	Riverside	Natural gas	92	NA	47	0.2	NA	16.6	NA	NA	NA	47,780	96	31	81*
Creed Energy Center (55625)	Operating	Solano	Natural gas	47	Greater Bay Area	17	3.0	4.2	11.3	0.67	0.2	9	152	58	6	74

Cuyamaca Peak Energy Plant (55512)	Operating	San Diego	Natural gas	47	San Diego	17	2.7	4.3	10.9	0.64	0.1	12	158,011	39	20	87*
Delano Energy Center (55625)	Operating	Solano	Natural gas	47	Greater Bay Area	17	1.8	4.5	11.2	0.66	0.1	39	28,699	91	20	89*
Drews-Agua Mansa (55935)	Operating	San Bernardino	Natural gas	45	LA Basin	18	0.3	NA	17.4	NA	NA	NA	67,718	83	20	98*
El Cajon Energy Center (57001)	Operating	San Diego	Natural gas	50	San Diego	9	3.2	3.6	10.6	0.63	0.2	14	158,028	39	20	87*
Ellwood Generating Station (8076)	Operating; retirement proposed; RMR	Santa Barbara	Natural gas	57	Big Creek/ Ventura	45	1.3	NA	14.3	NA	NA	NA	36,273	45	35	12
Escondido Energy Center (55538)	Operating	San Diego	Natural gas	50	San Diego	13	7.9	4.0	10.3	0.61	0.08	14	133,202	58	19	37
Etiwanda Peaker (Grapeland) (56472)	Operating	San Bernardino	Natural gas	49	LA Basin	12	5.5	4.0	10.0	0.59	0.1	32	80,175	71	9	76*
Feather River Energy Center (55847)	Operating; retirement proposed; RMR	Sutter	Natural gas	48	Sierra	17	7.0	7.4	11.5	0.68	0.9	21	61,052	55	21	57
Gianera(7231)	Operating	Santa Clara	Natural gas	64	Greater Bay Area	33	0.8	NA	13.9	NA	NA	NA	97,693	82	9	82*
Gilroy Energy Center (55810)	Operating	Santa Clara	Natural gas	141	Greater Bay Area	18	2.0	4.2	11.7	0.7	0.4	7	27,115	74	17	89*
Glenarm (422)	Operating	Los Angeles	Natural gas	249	LA Basin	45	3.1	8.7	10.5	0.62	0.7	37	232,462	72	16	18

Goose Haven Energy Center (55627)	Operating	Solano	Natural gas	48	Greater Bay Area	17	3.0	4.3	11.5	0.68	0.2	8	159	59	6	74
Grayson (377)	Operating	Los Angeles	Natural gas	287	NA	78	5.5	251	12.9	0.9	0.4	34	204,896	41	16	99*
Hanford Energy Park Peaker (55698)	Operating	Kings	Natural gas	92	Greater Fresno	17	2.6	3.7	10.5	0.65	0.9	52	7,600	79	21	64
Harbor Generating Station (399)	Operating; retirement proposed	Los Angeles	Natural gas	548	NA	48	0.7	7	9.9	0.58	0.3	49	130,575	84	24	97*
Huntington Beach (335)	Operating; retirement proposed	Orange	Natural gas	430	LA Basin	61	10.6	125	11.7	0.7	0.1	55	105,604	34	9	4
Indigo Generation (55541)	Operating	Riverside	Natural gas	135	LA Basin	18	4.0	4.5	0.61	0.2		23	1,799	73	25	32
Inland Empire Energy Center (55853)	Operating; retirement proposed	Riverside	Natural gas	405	LA Basin	10	9.3	201	7.0	0.42	0.04	75	31,561	47	18	62
King City Energy Center (55811)	Operating	Monterey	Natural gas	47	NA	17	1.7	NA	11.3	NA	NA	NA	13,313	89	27	52
Lake 1 (7987)	Operating	Los Angeles	Natural gas	61	NA	17	2.7	12.2	10.4	0.62	0.2	61	156,883	41	13	76*
Lambie Energy Center (55626)	Operating	Solano	Natural gas	48	Greater Bay Area	17	3.1	4.4	11.3	0.67	0.2	8	166	58	6	74
Larkspur Energy (55542)	Operating	San Diego	Natural gas	90	San Diego	18	6.1	5.0	10.0	0.59	0.2	17	7,916	72	4	56
Lodi (7451)	Operating	San Joaquin	Natural gas	25	Stock-ton	34	1.5	NA	16.1	NA	NA	NA	8,644	68	16	65
Lodi CC (NCPA STIG) (7449)	Operating	San Joaquin	Natural gas	50	Sierra	23	2.0	7.3	8.1	0.48	0.1	67	8,644	68	16	65

Long Beach Generation (341)	Operating	Los Angeles	Natural gas	260	LA Basin	42	1.2	5.9	16.7	0.99	0.5	43	130,535	87	32	99*[15]
Los Esteros Critical Energy Facility (55748)	Operating	Santa Clara	Natural gas	309	Greater Bay Area	17	9.7	14.6	7.9	0.47	0.06	6	98,882	82	9	82*
Malaga Peaking Plant (56239)	Operating	Fresno	Natural gas	98	Greater Fresno	14	3.1	4.6	10.2	0.61	0.2	60	44,557	89	36	99*
Mariposa Energy (57483)	Operating	Alameda	Natural gas	200	Greater Bay Area	7	6.8	5.5	10.2	0.6	0.13	6	3,821	73	10	41
Marsh Landing Generating Center (57267)	Operating	Contra Costa	Natural gas	828	Greater Bay Area	6	2.2	10.6	11.2	0.66	0.08	5	51,781	56	14	74
McClellan (535)	Operating	Sacra-mento	Natural gas	74	NA	34	1.1	NA	13.0	NA	NA	NA	102,627	46	29	90*
McClure (151)	Operating	Stanislaus	Natural gas	112	NA	39	0.3	NA	17.3	NA	NA	NA	89,819	66	19	94*
McGrath Peaker (56471)	Operating	Ventura	Natural gas	49	Big Creek/ Ventura	7	8.1	4.7	9.7	0.58	0.1	12	33,795	59	10	89*
MID Ripon (56135)	Operating	San Joaquin	Natural gas	100	NA	13	7.1	30.4	10.5	0.62	0.09	46	28,511	43	10	57
Midway-Starwood Power (56639)	Operating	Fresno	Natural gas	120	NA	10	5.1	3.8	11.1	0.66	0.2	33	91	95	25	95*
Mira Loma Peaker (56473)	Operating	San Bernardino	Natural gas	49	LA Basin	12	6.5	4.1	9.8	0.58	0.1	26	91	95	5	95*
Miramar Energy Facility 1 & 2 (56232)	Operating	San Diego	Natural gas	95	San Diego	14	13.4	5.1	9.8	0.58	0.2	11	58,049	74	10	79*
Niland Gas Turbine Plant (56569)	Operating	Imperial	Natural gas	121	NA	7	6.9	7.3	9.6	0.57	0.06	22	1,412	65	28	67[16]

[15]This tract has a CalEnviroScreen environmental score but no population score.
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Oakland Power Plant (6211)	Retiring; solar + storage replacement	Alameda	Jet fuel	224	Greater Bay Area	42	0.2	NA	15.5	0.20	7.4	NA	196,253	69	20	72[17]
OLS Energy Agnews (50748)	Operating	Santa Clara	Natural gas	32	Greater Bay Area	29	6.3	NA	9.8	NA	NA	NA	101,340	83	9	61
Orange Grove Energy (56914)	Operating	San Diego	Natural gas	100	San Diego	9	4.8	4.4	10.4	0.62	0.2	15	2,303	69	13	20
Ormond Beach Generating Station (350)	Operating; retirement proposed; RMR	Ventura	Natural gas	1,613	Big Creek/ Ventura	48	1.3	42.4	11.4	0.68	0.09	44	59,074	87	19	83*
Panoche Energy Center (56803)	Operating	Fresno	Natural gas	400	NA	10	15	6.1	9.0	0.54	0.1	40	93	95	25	95*
Pio Pico Energy Center (57555)	Operating	San Diego	Natural gas	300	San Diego	3	4.9	4.3	9.5	0.57	0.12	10	7,689	72	3	56
Red Blu (56184)	Operating	Tehama	Natural gas	44	NA	19	5.1	NA	10.5	NA	NA	NA	16,462	28	24	59
Redondo Beach (356)	Operating; retirement proposed	Los Angeles	Natural gas	1,310	LA Basin	65	3.3	74	12.4	0.74	0.5	66	16,462	68	24	59
Riverside Energy Resource Center (56143)	Operating	Riverside	Natural gas	192	LA Basin	13	5.3	4.4	10.1	0.6	0.1	50	115,673	70	18	84*
Riverview Energy Center (55963)	Operating	Contra Costa	Natural gas	47	Greater Bay Area	16	4.7	4.3	11.1	0.66	0.2	7	62,292	59	15	74
Rockwood (7824)	Operating	Imperial	Natural gas	50	NA	40	0.4	NA	14.5	NA	NA	NA	25,231	85	29	81*
Roseville (7452)	Operating	Placer	Natural gas	50	NA	33	0.4	NA	15.7	NA	NA	NA	48,094	29	7	21

[17]This tract has a CalEnviroScreen environmental score but no population score.

Sentinel Energy Project (57482)	Operating	Riverside	Natural gas	800	LA Basin	6	7.9	5.9	9.6	0.57	0.1	17	2,478	61	26	32
Springs Generation Project (56144)	Operating	Riverside	Natural gas	40	LA Basin	17	0.2	NA	13.7	NA	NA	NA	86,301	69	18	67
Stanton Energy Reliability Center[18] (60698)	Proposed	Orange	Natural gas	98	NA	NA	NA	NA	NA	NA	NA	NA	276,662	73	17	87*
Sutter Energy Center (55112)	Operating	Sutter	Natural gas	578	NA	18	4.3	51.2	6.7	0.4	0.07	30	915	57	19	54
Vernon (inc. H. Gonzales) (56039)	Operating	Los Angeles	Natural gas	12	LA Basin	33	2.1	NA	13.5	NA	NA	NA	368,664	98	31	99*[19]
Walnut (4256)	Operating	Stanislaus	Natural gas	48	NA	33	0.1	NA	11.9	NA	NA	NA	22,055	59	23	97*
Walnut Creek Energy Park (57515)	Operating	Los Angeles	Natural gas	500	LA Basin	7	9.5	6.5	9.0	0.54	0.1	38	167,639	91	13	86*
Wellhead Power Panoche (55874)	Operating	Fresno	Natural gas	50	Greater Fresno	18	2.5	NA	16.0	NA	NA	NA	90	95	25	95*
Wolfskill Energy Center (55855)	Operating	Solano	Natural gas	48	NA	17	3.4	4.2	11.2	0.67	0.2	9	30,608	65	17	73
Yuba City Energy Center (55813)	Operating	Sutter	Natural gas	48	Sierra	17	7.9	NA	11.7	NA	NA	NA	72,282	50	19	67

[18]Proposed hybrid gas turbine/battery energy storage peaker plant.
[19]This tract has a CalEnviroScreen environmental score but no population score.