Diesel Back-Up Generator Population Grows Rapidly in the Bay Area and Southern California[1]

Executive Summary

California hosts a largely hidden grid of dispersed diesel generators, the population of which is growing rapidly. In December 2018 there were 6,497 back-up generators (BUGs) with 3,810 megawatts (MW) of collective capacity in the Bay Area Air Quality Management District (BAAQMD). In 2021 – less than three years later – BUG deployment had reached 8,722 generators, reflecting 4,840 MW of capacity, a 34 percent jump in the back-up generator fleet.

Similarly, in 2020 there were 12,104 back-up generators totaling 2,697 MW of capacity in the South Coast Air Quality Management District (SCAQMD). Just a year later this population had grown to 14,785 BUGs, with 7,360 MW capacity, a 22 percent increase in the fleet.[2]

Throughout the state larger generators are being deployed more rapidly. Nearly 90 percent of back-up generators located in the two air districts are diesel fueled.

Diesel generators tend to be located close to where people live, work, and attend school. They are a significant air pollution source, releasing greenhouse gases, particulate matter (PM), volatile organic compounds (VOCs), nitrous oxides (NOx), and sulfur dioxide (SO_2), which can create smog and exacerbate respiratory conditions, like asthma, chronic obstructive pulmonary disease, and lung cancer, especially for children and older adults.

Data on the number of hours that diesel generators operate is self-reported, with little regulatory scrutiny. The degree to which BUGs run is influenced by multiple factors, including wildfires, Public Safety Power Shut-offs (PSPS), severe weather, and potentially their use to arbitrage electricity prices and programs.

---

[1] This survey is a continuation of work by Steven Moss, M.Cubed Partner and Andy Bilich, Research Associate, http://www.lgsec.org/wp-content/uploads/2020/05/BUGs-in-5-CA-Air-Districts.pdf, which was updated at the request of Bloom Energy. Steven@moss.net, 415.643.9578, www.mcubed-econ.com
[2] Data discrepancies are noted in the report; estimates are based on best available information.

Estimated Population of Backup Generators, BAAQMD and SCAQMD

Overview

The risks of electricity outages caused by wildfires and efforts to manage them – particularly PSPS – has significantly increased over the past several years. In response, **California's population of backup generators has grown rapidly**. An analysis of the number and characteristics of BUGs permitted in the Bay Area (i.e., Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, and Sonoma counties) and South Coast (i.e., Los Angeles, Orange, Riverside, and San Bernadino counties) air quality management districts found that the **generator population jumped by 22 percent in South Coast over the last year, with 34 percent growth in less than three years in the Bay Area**.[3]

In **2021 the two districts were collectively home to 23,507 BUGs, with a capacity of 12.2 gigawatts (GW) or 87,223 MWh a year.** California's electricity grid has a capacity of roughly 80 GW; BUGs in the Bay Area and South Coast alone can generate about 15 percent of the entire grid.

Based on conservative estimates, BUG use in the two districts alone produces annual emissions of 86,899 metric tons of carbon dioxide (MTCO$_2$), roughly 20 MT of fine particulate matter, 62 MT of VOCs, and almost 1,000 MT of haze-inducing NO$_x$.[4] This pollution, in turn, may trigger upwards of $136 million of health costs a year, due to increases in mortalities, heart attacks, hospital visits and other adverse consequences.[5] Costs associated with the statewide fleet of BUGs are obviously much higher.

In California, BUGs are individually permitted by one of 35 air districts in which they are located. The cumulative magnitude is largely hidden; data from individual districts is not meaningfully aggregated or reported at the state level.[6]

2021 BAAQMD BUGs Portfolio

There are at least 8,722 backup generators operating in BAAQMD. Collectively, these machines have an estimated capacity of 4.84 gigawatts; 91 percent are used principally to generate electricity. Most of these assets – 90 percent – are diesel gensets, with six percent fueled by natural gas, three percent by liquified petroleum gas (LPG), as shown in Table 1.

---

[3] Informal conversations with air district staff suggest that higher capacity gensets are being deployed, in part to safeguard reliability at data centers and other large facilities. Likewise, investor-owned utilities and local governments have been fielding large gensets as part of wildfire resiliency-related efforts.

[4] Based on data obtained from the districts in May and June 2021.

[5] Based on U.S. Environmental Protection Agency's CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool.

[6] An analysis published in 2020 found a total of 18,600 BUGs in the two air districts, with 6.5 GW of capacity. BUGs-in-5-CA-Air-Districts.pdf (lgsec.org).

Table 1: BAAQMD BUGs Portfolio, June 2021

Fuel	Count	MW Size	MW Capacity	Operating Hours[7]	MWh Generation[8]
Diesel	7,864	0.603	4,739.0	79,717	27,296
Gasoline	19	0.086	1.6	73	4
Natural Gas	495	0.125	61.8	13,335	1,068
Propane	15	0.193	2.9	179	15
Biodiesel	28	0.175	4.9	82	8
LPG	300	0.086	25.8	23,874	1,726
Jet Fuel	1	0.820	0.8	313	192
Total	**8,722**	**0.555**	**4,836.8**	**117,573**	**30,310**

Reported use data suggest that altogether the BUGs emit at least 35,350 metric tons of carbon dioxide (CO_2) a year. The generators also produce criteria air pollutant emissions which adversely affect respiratory health: more than six MT of fine PM, 24 MT of volatile organic compounds, and in excess of 321 MT of haze-inducing NO_x.[9] Criteria air pollutants have unpleasant public health impacts at much lower concentrations than CO_2, with the worst consequences generally visited on disadvantaged communities.

Table 2: Annual MT Emissions from the BAAQMD BUGs Fleet

Fuel	CO_2	PM	Organics	NO_x
Diesel	26,449.9	5.7	19.1	304.5
Gasoline	2.8	0.0	0.0	0.0
Natural Gas	796.8	0.1	3.0	7.3
Propane	14.8	0.0	0.0	0.2
Biodiesel	6.6	0.0	0.0	0.1
LPG	7,839.5	0.2	2.2	8.0
Jet Fuel	239.2	0.1	0.1	0.8
Total	**35,350**	**6**	**24**	**321**

LOCATION OF BUGs

In 2014, more than 9.3 million Californians lived in communities that were identified as "disadvantaged" by the California Environmental Protection Agency (CalEPA) due to environmental conditions and community members' vulnerability to a degraded ecosystem. CalEnviroScreen is a method to evaluate multiple pollution sources in a geographically defined

---

[7] These values are *self-reported* from individual genset operators and exclude hours for new or nonreporting assets.
[8] These are estimates based on reported horsepower, generator loading percent, and total usage hours. When generator loading was not provided, 75 percent was assumed based on the average of reported profiles.
[9] Not all assets reported usage. Some District-calculated emissions are significant statistical outliers and have been excluded from the totals. It is quite likely that the emissions are notably higher.

Estimated Population of Backup Generators, BAAQMD and SCAQMD

area that accounts for the population's sensitivity to pollution's adverse effects. Percentiles reflect the relative environmental burden in a given census tract.[10]

       As show in the map below,[11] seventeen percent of generators are located in communities highly vulnerable to pollution, classified as being in the 80th to 100th percentile in the CalEnviroScreen Fourth Assessment.[12] Six percent are above the 90th percentile.

Bay Area Air Quality Management District Back-up Generators

CalEnviroScreen Percentile
- 0-10
- 10-20
- 20-30
- 30-40
- 40-50
- 50-60
- 60-70
- 70-80
- 80-90
- 90-100
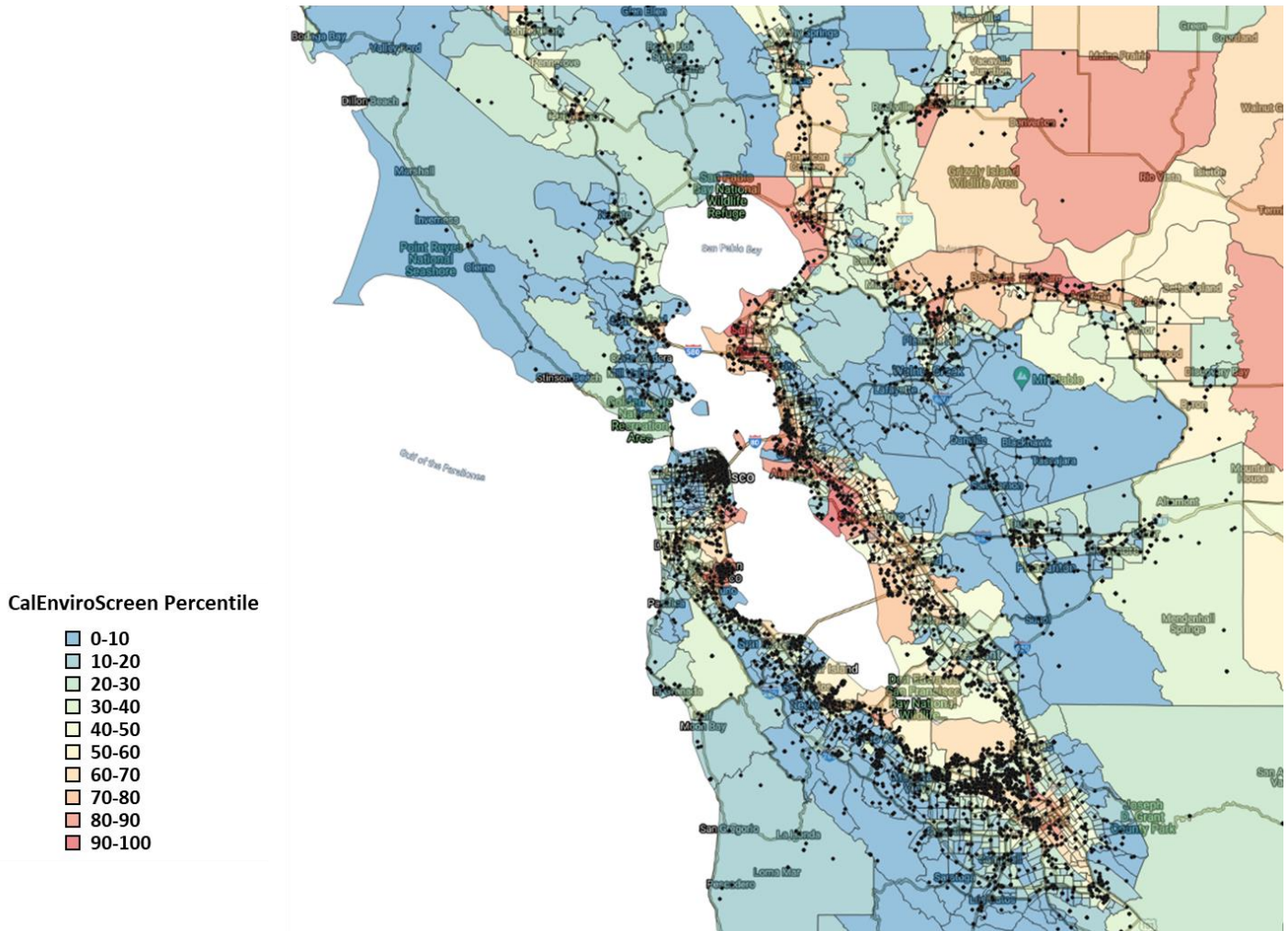
There are more than 8,700 BUGs capable of generating 4.8 GW in the Bay Area. The map shows the siting of these generators in the context of CalEnviroScreen; red/orange indicates the most environmental burdened, vulnerable communities, blue/green the least.

Figure 1: Map of BAAQMD BUGS[13]

---

[10] CalEnviroScreen 3.0.
[11] City-specific BUG counts and capacity are shown in Annex 1.
[12] CalEnviroScreen 4, available at: https://calenviroscreen-oehha.hub.arcgis.com/#Data.
[13] Multiple gensets can be represented by individual points.

Estimated Population of Backup Generators, BAAQMD and SCAQMD

Compared to data collected in 2018, BUG population in the Bay Area has significantly expanded, growing from 6,497 to 8,722 today, a 34 percent jump. However, the two datasets do not compare perfectly.[14] Assets were also analyzed based on the "Initial Permit Date" field using the most recent District dataset. This approach found that 518 assets with an estimated 270 MW of capacity have been newly permitted since April 2020, reflecting a more modest eight percent increase in the BUG population over the last year, as shown in Table 3.[15] Given patterns exhibited in South Coast, as well as anecdotal evidence, it seems likely that the higher population increase estimate better reflects reality.

An additional 6,253 BUGs with 3.6 GW of capacity have renewed their permit[16] since December 2018, as reflected in Table 4.[17]

Table 3: Newly Permitted BUGS in BAAQMD since April 1, 2020

Fuel	Number	Average Size (MW)	Total Capacity (MW)
Diesel	402	0.642	257.9
Gasoline	0	0.000	0.0
Natural Gas	48	0.121	5.8
Propane	0	0.000	0.0
Biodiesel	0	0.000	0.0
LPG	68	0.092	6.3
Jet Fuel	0	0.000	0.0
Total	**518**	**0.521**	**270.0**

Table 4: Gensets with Permits Renewed after April 1, 2020

Fuel	Count	Average Size (MW)	Total Capacity (MW)
Diesel	5,721	0.628	3,592.6
Gasoline	12	0.094	1.1
Natural Gas	301	0.123	37.1
Propane	8	0.205	1.6
Biodiesel	24	0.176	4.2
LPG	186	0.090	16.7
Jet Fuel	1	0.820	0.8
Total	**6,253**	**0.584**	**3,654.3**

---

[14] Quality issues were identified with the March 2021 datasets, prompting the District to develop new information formats.

[15] Based on South Coast data, as described later in this report, it seems more likely that the Bay Area's BUG population has grown by upwards of one-third than less than one-tenth.

[16] Forty-one percent of generators were able to renew their permit without updating or reporting new data.

[17] Dataset provided through Public Records Request, No. 2021-04-0291, June 28, 2020.

METHODOLOGY

A public records request for data on the universe of permitted backup gensets was filed with BAAQMD on March 17, 2021.[18] Quality issues were identified in initial datasets provided; corrected information was transmitted on June 28, 2021.[19] District data included facility information, locations, horsepower (HP), estimated emissions, and reported operating hours.[20]

Reported runtimes and District-calculated emissions were utilized as the basis for estimates for most assets, with a few outlier observations dropped due to quality issues. In total, 11 assets reported annual operations that exceeded 8,760 hours. Another 156 BUGs included a statistical outlier[21] for reported hours or calculated emissions per hour for CO_2, PM, organics, and NOx, which suggests potential issues with observations for those generators. Gensets with outlier data were included in overall count and capacity calculations, excluded from totals for hours, generation, and emissions estimates.

BUG owner/operators are required to report usage when their permits are renewed, but these data are not always reflected in the database. Altogether, 1,843 of the generators – 21 percent of the portfolio – last reported use to the District in 2018 or earlier despite being permitted for current operations. The population with missing data may be notably higher, as many facilities had blank or zero values for reporting date, which could indicate a new permit or a missing report.[22]

2021 SCAQMD BUGs Portfolio

There are 14,785 backup generators operating in SCAQMD.[23] Collectively, these generators have an estimated capacity of 7.36 gigawatts. Eighty-eight percent are diesel gensets, with 7.1 percent fueled by natural gas, as shown in Table 5.

---

[18] Public Records Request No. 2021-04-0291.

[19] This dataset excludes small unpermitted BUGs, of the kind used to support residences. It is likely that the population of these generators has similarly increased over the past couple of years.

[20] HP figures were converted to MW by multiplying by 0.7457 and dividing by 1000.

[21] Calculated through z-score comparisons. Observations with a z score >3 or <-3 were excluded.

[22] While the estimates contained herein are likely representative of the BUGs portfolio in the District there are underlying uncertainties. The District identified three potential data weaknesses: 1) reported operating hours collected during permit renewals and associated calculated emissions; 2) recently permitted facilities that have not gone through renewals, so do not show use or emissions; 3) due to reporting inaccuracies some reported data may be off by a magnitude of 1,000.

Table 5: SCAQMD BUGs Portfolio, May 2021

Fuel	Count	Average Capacity (MW)	Capacity (MW)	Total Operation (Hours)	Estimated Generation (MWh)
Diesel	13,043	0.543	7,085.6	134,474.3	54,789.9
LPG	395	0.117	46.2	4,072.5	357.2
Natural Gas	1,029	0.174	178.9	10,609.1	1,383.0
Oil	97	0.198	19.2	1,000.1	148.7
Other fuel	97	0.219	18.6	1,000.1	143.8
Gasoline	105	0.096	8.9	1,082.6	68.5
Methanol	19	0.150	2.8	195.9	22.0
Total	**14,785**	**0.498**	**7,360**	**152,434**	**56,913**

Based on conservative use assumptions, this fleet has the potential to emit an estimated 51,549 metric tons of carbon dioxide a year. Further, the BUGs produce other criteria air pollutants on the order of 13.25 MT of fine particulate matter, 37.8 MT of volatile organic compounds, and 645.56 MT of NO_x.

Fuel	Emissions ($MTCO_2$)	Emissions MTPM	Emissions (MTOrg)	Emissions ($MTNO_x$)
Diesel	49,842	13.15	33.31	638.46
LPG	355	0.01	0.22	0.50
Natural Gas	1,004	0.06	3.76	3.95
Oil	139	0.01	0.21	1.55
Other fuel	134	0.01	0.14	0.63
Gasoline	54	0.00	0.17	0.36
Methanol	21	0.00	0.01	0.11
Total	**51,549**	**13.25**	**37.80**	**645.56**

The map below shows the fleet of BUGs located in SCAQMD overlaid with CalEnviroScreen Fourth Assessment results.[24,25] Forty-seven percent of generators are sited in communities classified as being in CalEnviroScreen's 80th to 100th percentile; 33 percent are above the 90th percentile. These patterns are indicative of a BUG concentration in environmentally vulnerable communities in South Coast, but also reflect the incidence of above 80th percentile communities in the District more broadly.

---

[24] CalEnviroScreen 4; Available at: https://calenviroscreen-oehha.hub.arcgis.com/#Data

[25] BUGS count and capacity by city can be seen in Annex 2.

Estimated Population of Backup Generators, BAAQMD and SCAQMD

South Coast Air Quality Management District Back-up Generators
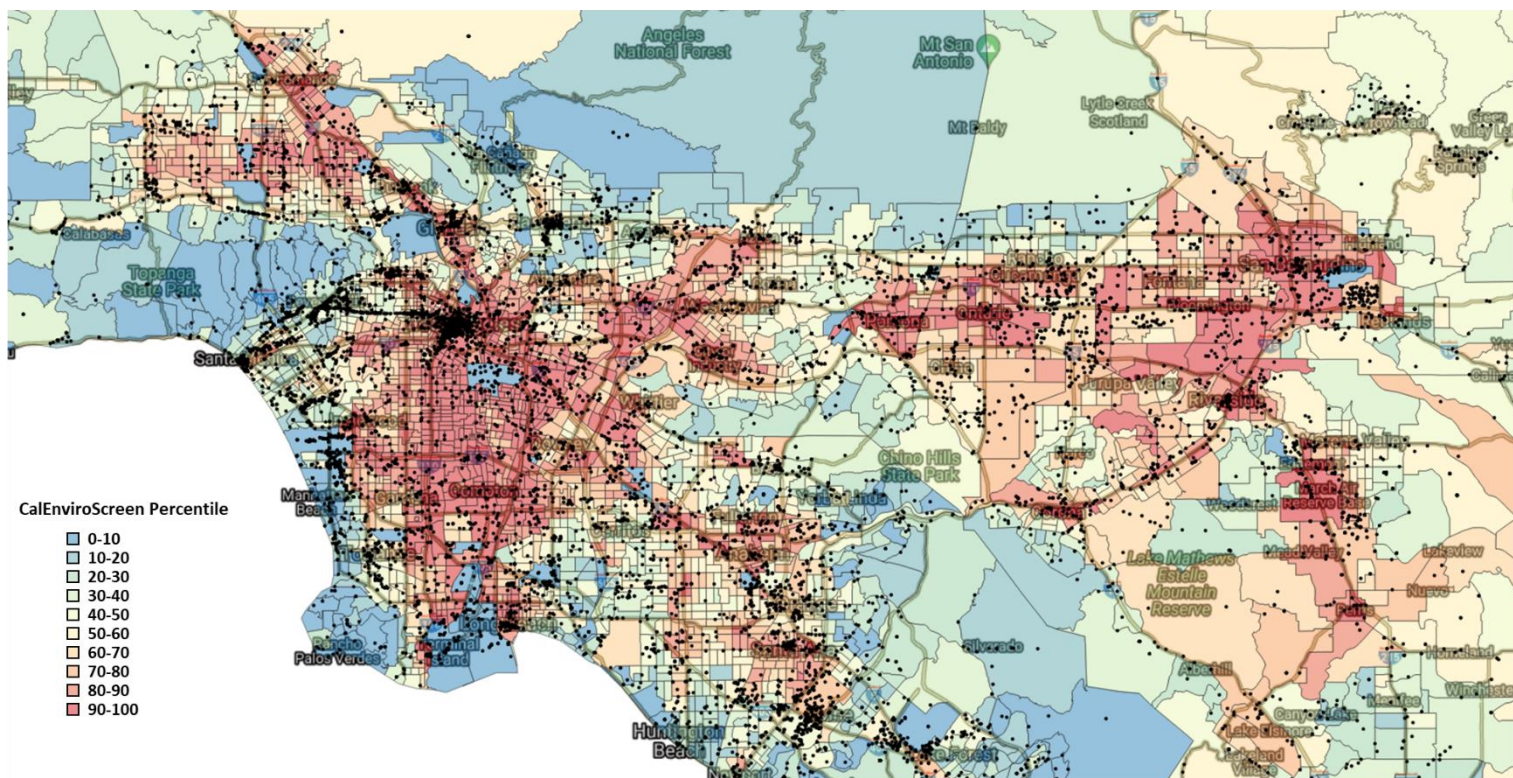
There are almost 14,800 BUGs capable of generating 7.3 GW in South Coast. The map shows the siting of these generators in the context of CalEnviroScreen; red/orange indicates the most environmental burdened, vulnerable communities, blue/green the least.

Figure 2: Map of SCAQMD BUGs[26]

BUG population in South Coast has significantly expanded over the past year**, growing from 12,104 in 2020 to 14,785 today, a 22 percent jump**. This roughly matches with the new dataset, which indicates that 3,331 assets, with an estimated 1.66 GW of capacity have a "permit issue date[27]" since April 1, 2020, a 23 percent increase.[28] As reflected in the table below, the biggest rise was in diesel generators, 2,849, followed by natural gas, 239, and LPG, 147.

---

[26] Multiple assets can be represented by individual points.

[27] It is unknown whether the "Permit Issue Date" includes permits that are reissued. The data looks as though it is first permit date, but it is uncertain.

[28] Dataset provided through Public Records Request, PRR #1401086, April 29th, 2020.

Estimated Population of Backup Generators, BAAQMD and SCAQMD

Table 6: BUGs permitted in SCAQMD since April 1, 2020

Fuel	Count of Assets	Average Capacity (MW)	Capacity (MW)	Total Operation (Hours)	Estimated Generation (MWh)
Diesel	2,849	0.551	1,569.0	29,373.4	12,132.2
LPG	147	0.139	20.4	1,515.6	157.7
Natural Gas	239	0.227	54.3	2,464.1	419.9
Oil	31	0.204	6.3	319.6	48.8
Other fuel	38	0.230	7.6	391.8	58.6
Gasoline	24	0.125	2.0	247.4	15.3
Methanol	3	0.227	0.7	30.9	5.3
Total	**3,331**	**0.499**	**1,660**	**34,343**	**12,838**

METHODOLOGY

A public records request was filed with SCAQMD on March 17, 2021 to obtain information on the universe of permitted gensets.[29] Data was provided on May 14, 2021.[30] SCAQMD only reported general descriptions for generator sizes (i.e., 50 to 500 horsepower, greater than 500 horsepower, and emergency generators). Different size classifications were assigned a HP value based on averages from the genset portfolio located in the Bay Area Air Quality Management District, as shown in Table 7 below.[31] Horsepower figures were converted to estimated MW capacity by multiplying by 0.7457 and dividing by 1000.

Operating hours and emissions rates were also estimated based on averages from the BAAQMD portfolio.[32] To account for the outliers described above, median data by fuel type were utilized. The accuracy of relying on assumptions derived from the Bay Area is unknown. Differences in outage rates, particularly related to Public Safety Power Shutoffs, risk perceptions, and risk tolerances, especially associated with the reliability needs of distinct economic segments, could influence BUG population and operating characteristics.

---

[29] Public Records Request PRR #1405618.
[30] This dataset excludes small unpermitted BUGs, of the kind used to support residences. It is likely that the population of these generators has similarly increased over the past couple of years.
[31] http://www.lgsec.org/wp-content/uploads/2020/05/BUGs-in-5-CA-Air-Districts.pdf.
[32] For the "Emergency" HP class the Diesel >500 HP values were utilized. Where values were unavailable for higher horsepower, lower horsepower averages were utilized.

Estimated Population of Backup Generators, BAAQMD and SCAQMD

Table 7: Average HP, Operating Hours, and Emissions for SCAAMD based on BAAQMD Portfolio

Fuel	HP Class	Average Horsepower	Operating Hours	CO_2 MT/MWh	PM mt/MWh	Organics mt/MWh	NO_x mt/MWh
Diesel	50-500 HP	218.3	10.3	0.906	0.000240	0.000608	0.011653
Diesel	>500 HP	1618.7	10.3	0.911	0.000240	0.000608	0.011653
Gasoline	50-500 HP	115.4	4.3	0.795	0.000055	0.003102	0.006798
Gasoline	>500 HP	0.0	4.3	0.795	0.000055	0.003102	0.006798
Natural Gas	50-500 HP	124.8	27.7	0.726	0.000059	0.003907	0.004100
Natural Gas	>500 HP	1102.0	27.7	0.726	0.000059	0.003907	0.004100
Oil	50-500 HP	98.5	11.9	0.932	0.000066	0.002069	0.015510
Oil	>500 HP	700.0	11.9	0.932	0.000066	0.002069	0.015510
Methanol	50-500 HP	153.1	3.1	0.936	0.000225	0.000322	0.006797
Methanol	>500 HP	606.4	3.1	0.936	0.000225	0.000322	0.006797
LPG	50-500 HP	111.6	85.3	0.993	0.000073	0.001088	0.002502
LPG	>500 HP	687.5	85.3	0.993	0.000073	0.001088	0.002502
Jet Fuel	50-500 HP	0.0	312.6	1.244	0.000295	0.000328	0.004009
Jet Fuel	>500 HP	1100.0	312.6	1.244	0.000295	0.000328	0.004009
Diesel	Emergency	2220.0	2.4	0.911	0.000240	0.000608	0.011653
Other fuel	50-500 HP	117.4	65.0	0.933	0.000145	0.001632	0.007338
Other fuel	>500 HP	830.7	65.0	0.934	0.000145	0.001632	0.007338

HEALTH AND ECONOMIC IMPLICATIONS

Particulate matter, volatile organics, and NOx emissions from back-up generators induce adverse health and economic impacts. These effects were examined using the U.S. Environmental Protection Agency's CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA), an analytical instrument crafted to estimate air quality and health consequences of different emission scenarios. COBRA approximates the influence polluting air has on mortality, hospital admissions, respiration, work loss, and the like, and associates a monetary value to those elements.

The simplified web-based COBRA tool was utilized to develop order of magnitude estimates of potential health and economic benefits of reducing PM, volatile organics, and NOx emissions from BUGs located in the Bay Area and South Coast. Estimated annual pollutant emissions from the two districts are summarized in the table below.

Table 8: PM, VOC, and NOx emissions from BUGs in the Bay Area and South Coast

District	PM, MT	Organics, MT	NO_X, MT
BAAQMD	6	24	321
SCAQMD	13	38	646

Estimated Population of Backup Generators, BAAQMD and SCAQMD

COBRA projects emissions for PM, SO₂, NOₓ, Ammonia (NH₃), and VOC based on economic sectors and subsectors in selected geographies.[33] No sector precisely matches with "back-up generation." Given that BUGs in the districts are mostly commercially owned and more than 90 percent diesel powered, the closest sector is "Fuel Combustion: Industrial," with the sub-sector "Internal Combustion." However, baseline emissions in this subsector are below those estimated for the BUGs fleet, prompting the use of "All sub-sectors."

To illustrate the impact of phasing out BUGs – or, conversely, the harms caused by their present use – as well as capture uncertainties in underlying BUG emission estimates, collective reductions for PM, NOₓ, and volatile organics of 25 percent, 50 percent, and 100 percent were modeled.[34] COBRA outputs for 25 percent and 100 percent reductions in Bay Area counties are shown in Figure 3 below. Overall, the economic benefits of reducing BUG emissions range from $3.5 to $7.9 million annually for a 25 percent reduction, $7 to $15.9 million for a 50 percent reduction, and $14.1 to $31.8 million for 100 percent.

Results for: California

Export: All results | Current filter

Health Endpoint	Change in Incidence (cases, annual)		Monetary Value (dollars, annual)	
	Low	High	Low	High
Mortality *	0.317	0.718	$3,470,310	$7,854,492
Nonfatal Heart Attacks *	0.026	0.238	$4,102	$38,119
Infant Mortality	0.002	0.002	$19,840	$19,840
Hospital Admits, All Respiratory	0.081	0.081	$3,713	$3,713
Hospital Admits, Cardiovascular **	0.072	0.072	$3,262	$3,262
Acute Bronchitis	0.545	0.545	$336	$336
Upper Respiratory Symptoms	9.849	9.849	$421	$421
Lower Respiratory Symptoms	6.925	6.925	$187	$187
Emergency Room Visits, Asthma	0.136	0.136	$77	$77
Asthma Exacerbation	10.289	10.289	$763	$763
Minor Restricted Activity Days	301.340	301.340	$26,417	$26,417
Work Loss Days	51.204	51.204	$10,250	$10,250
💠 **Total Health Effects**			**$3,539,679**	**$7,957,878**

* The Low and High values represent differences in the methods used to estimate some of the health impacts in COBRA. For example, high and low results for avoided premature mortality are based on two different epidemiological studies of the impacts of PM₂.₅ on mortality in the United States.
** Except heart attacks.

Results for: California

Export: All results | Current filter

Health Endpoint	Change in Incidence (cases, annual)		Monetary Value (dollars, annual)	
	Low	High	Low	High
Mortality *	1.269	2.871	$13,881,144	$31,417,482
Nonfatal Heart Attacks *	0.103	0.953	$16,410	$152,473
Infant Mortality	0.007	0.007	$79,361	$79,361
Hospital Admits, All Respiratory	0.323	0.323	$14,852	$14,852
Hospital Admits, Cardiovascular **	0.290	0.290	$13,049	$13,049
Acute Bronchitis	2.179	2.179	$1,345	$1,345
Upper Respiratory Symptoms	39.394	39.394	$1,683	$1,683
Lower Respiratory Symptoms	27.699	27.699	$748	$748
Emergency Room Visits, Asthma	0.545	0.545	$307	$307
Asthma Exacerbation	41.154	41.154	$3,054	$3,054
Minor Restricted Activity Days	1,205.349	1,205.349	$105,667	$105,667
Work Loss Days	204.816	204.816	$41,001	$41,001
💠 **Total Health Effects**			**$14,158,620**	**$31,831,021**

* The Low and High values represent differences in the methods used to estimate some of the health impacts in COBRA. For example, high and low results for avoided premature mortality are based on two different epidemiological studies of the impacts of PM₂.₅ on mortality in the United States.
** Except heart attacks.

Figure 3: COBRA Outputs for 25 percent (left) and 100 percent reduction (right) in PM, VOC, and NOx emissions in Bay Area counties

The COBRA outputs for reducing 25 percent, 50 percent, and 100 percent of BUG emissions in South Coast counties are shown in Figure 4 below. Overall, the economic benefits of reducing BUG

---

[33] To 2023.
[34] The COBRA default discount rate of 3 percent was utilized.

Estimated Population of Backup Generators, BAAQMD and SCAQMD

pollution range from $11.5 to $25.9 million annually for a 25 percent reduction, $23.1 to $51.9 million for a 50 percent reduction, and $46.2 to $103.9 million a year for a 100 percent reduction.

Results for: California

Health Endpoint	Change in Incidence (cases, annual)		Monetary Value (dollars, annual)	
	Low	High	Low	High
Mortality *	1.037	2.346	$11,342,379	$25,673,018
Nonfatal Heart Attacks *	0.047	0.434	$7,128	$66,232
Infant Mortality	0.005	0.005	$64,573	$64,573
Hospital Admits, All Respiratory	0.229	0.229	$10,616	$10,616
Hospital Admits, Cardiovascular **	0.208	0.208	$9,292	$9,292
Acute Bronchitis	1.834	1.834	$1,132	$1,132
Upper Respiratory Symptoms	33.211	33.211	$1,419	$1,419
Lower Respiratory Symptoms	23.330	23.330	$630	$630
Emergency Room Visits, Asthma	0.396	0.396	$223	$223
Asthma Exacerbation	34.517	34.517	$2,561	$2,561
Minor Restricted Activity Days	1,027.265	1,027.265	$90,055	$90,055
Work Loss Days	174.630	174.630	$34,959	$34,959
💜 **Total Health Effects**			**$11,564,966**	**$25,954,709**

* The Low and High values represent differences in the methods used to estimate some of the health impacts in COBRA. For example, high and low results for avoided premature mortality are based on two different epidemiological studies of the impacts of $PM_{2.5}$ on mortality in the United States.
** Except heart attacks.

Results for: California

Health Endpoint	Change in Incidence (cases, annual)		Monetary Value (dollars, annual)	
	Low	High	Low	High
Mortality *	4.149	9.392	$45,406,934	$102,774,880
Nonfatal Heart Attacks *	0.187	1.736	$28,535	$265,131
Infant Mortality	0.021	0.021	$258,502	$258,502
Hospital Admits, All Respiratory	0.918	0.918	$42,498	$42,498
Hospital Admits, Cardiovascular **	0.833	0.833	$37,200	$37,200
Acute Bronchitis	7.342	7.342	$4,531	$4,531
Upper Respiratory Symptoms	132.957	132.957	$5,680	$5,680
Lower Respiratory Symptoms	93.394	93.394	$2,522	$2,522
Emergency Room Visits, Asthma	1.584	1.584	$892	$892
Asthma Exacerbation	138.184	138.184	$10,254	$10,254
Minor Restricted Activity Days	4,112.440	4,112.440	$360,517	$360,517
Work Loss Days	699.098	699.098	$139,950	$139,950
💜 **Total Health Effects**			**$46,298,016**	**$103,902,557**

* The Low and High values represent differences in the methods used to estimate some of the health impacts in COBRA. For example, high and low results for avoided premature mortality are based on two different epidemiological studies of the impacts of $PM_{2.5}$ on mortality in the United States.
** Except heart attacks.

Figure 3: COBRA Outputs for 25 percent (left) and 100 percent reduction (right) in PM, VOC, and NOx emissions in South Coast counties

DISTRICT DATA ISSUES

It is challenging to secure comprehensive, reliable, data from the districts. The Public Records Request process can take several months and may not yield dependable or actionable information. For example, the initial Public Records Request fulfilled by BAAQMD had numerous data quality issues, including negative and impossible usage values (e.g., greater than 8,760 hours for a year), as well as use levels that did not match permitted values.[35] The dataset exhibited incompatible units and labels, complicating portfolio level analyses. According to the District, inconsistencies between different vintage databases caused most of the errors.

BUG usage data is self-reported by the facilities themselves. BUG operators are supposed to describe use when their permits are renewed, but this information is not always reflected in the database. Altogether, 1,843 of the generators – 21 percent of the portfolio – last reported usage to BAAQMD in 2018 or earlier despite being permitted for current operations. What's more, 23

---

[35] Of the 8,722 generators in the new dataset, 11 generators reported annual operational hours greater than 8,760 hours. A further 156 assets included likely errors in reported usage hours or calculated emissions per hour for CO_2, PM, organics, and NOx.

Estimated Population of Backup Generators, BAAQMD and SCAQMD

percent of the BUGs conveyed operational hours that were higher than their permit allowed. It is unclear whether these discrepancies reflect actual higher use, missing reports, data quality issues or problems with the database itself.

SCAQMD does not provide data on generator size, instead reporting BUGs as "50-500 horsepower", ">500 horsepower", or "emergency generator," nor does South Coast deliver usage or emissions calculations for their BUGs portfolio. Data access and quality challenges in the state's two largest air quality districts are likely replicated in the rest of the districts.

Diesel-powered BUGs potentially represent a substantial hurdle to achieving greenhouse gas goals, and likely contribute to localized public health harms associated with pollution, particularly in vulnerable communities. Giving the large and growing generator population and its potential to adversely impact public health it is critical to have confidence in underlying deployment and use data. Information should be easily accessible and comparable across the districts and include estimated usage and emissions. Resulting data streams should be integrated into the State's ongoing climate and clean energy planning.

Annex 1: Count of BUGs by City in BAAQMD

City	Dec-18	Jun-20	Increase	City	Dec-18	Jun-20	Increase
Alameda	42	58	16	Millbrae	21	24	3
Alamo	2	3	1	Milpitas	72	117	45
Albany	14	16	2	Moffett Field	10	10	0
Alviso	4	7	3	Montara	4	4	0
Amer. Canyon	13	20	7	Moraga	8	10	2
Angwin	5	10	5	Morgan Hill	32	35	3
Antioch	42	49	7	Moss Beach	3	4	1
Atherton	12	23	11	Mount. View	142	192	50
Bay Point	1	2	1	Muir Beach	0	1	1
Belmont	25	27	2	Napa	92	156	64
Belvedere	0	2	2	Newark	47	58	11
Benicia	22	35	13	Nicasio	4	4	0
Berkeley	131	149	18	Novato	59	74	15
Bethel Island	2	6	4	Oakland	229	348	119
Birds Land.	1	1	0	Oakley	18	21	3
Bolinas	4	4	0	Oakville	3	11	8
Brentwood	23	27	4	Orinda	14	16	2
Brisbane	22	31	9	Pacheco	2	3	1
Burlingame	50	68	18	Pacifica	11	18	7
Byron	13	17	4	Palo Alto	203	231	28
Calistoga	19	42	23	Penngrove	0	1	1
Campbell	18	24	6	Pescadero	3	3	0
Castro Valley	20	22	2	Petaluma	50	65	15
Clayton	10	11	1	Pinole	11	14	3
Colma	5	7	2	Pittsburg	52	62	10
Concord	100	118	18	Pleasant Hill	16	17	1
Corte Madera	8	8	0	Pleasanton	65	78	13
Cotati	3	3	0	Point Reyes	4	4	0
Coyote	1	4	3	Pope Valley	1	3	2
Crockett	7	13	6	Portola Val.	4	7	3
Cupertino	63	70	7	Redwood Cit.	147	190	43
Daly City	49	53	4	Richmond	69	129	60
Danville	12	14	2	Rodeo	4	13	9
Deer Park	0	1	1	Rohnert Park	26	30	4
Dillon Beach	1	1	0	Ross	1	2	1
Discovery Bay	8	8	0	Rutherford	7	13	6
Dublin	40	47	7	Saint Helena	27	84	57
East Palo Alto	10	10	0	San Anselmo	2	5	3
El Cerrito	7	10	3	San Bruno	33	43	10
El Granada	2	3	1	San Carlos	35	46	11
El Sobrante	3	3	0	San Francisco	841	1190	349

Estimated Population of Backup Generators, BAAQMD and SCAQMD

El Verano	1	1	0	S. Geronimo	1	1	0
Eldridge	5	5	0	San Gregorio	1	1	0
Emeryville	46	59	13	San Jose	589	772	183
Fairfax	1	1	0	San Leandro	61	73	12
Fairfield	97	138	41	San Lorenzo	11	20	9
Forest Knolls	1	1	0	San Martin	8	9	1
FORESTVILLE	1	1	0	San Mateo	76	110	34
Foster City	45	74	29	San Pablo	3	6	3
Freestone	1	2	1	San Quentin	4	10	6
Fremont	148	203	55	San Rafael	73	98	25
Fulton	1	1	0	San Ramon	45	47	2
Gilroy	60	76	16	Santa Clara	515	668	153
Glen Ellen	2	8	6	Santa Rosa	143	192	49
Greenbrae	3	8	5	Saratoga	14	14	0
Half Moon By	26	25	-1	Sausalito	19	22	3
Hayward	140	179	39	Sebastopol	13	22	9
Healdsburg	1	1	0	Sonoma	20	45	25
Hercules	17	18	1	S. San Fran.	151	202	51
Hillsborough	3	6	3	Stanford	15	20	5
Hollister	3	4	1	Stinson Bea.	1	3	2
Inverness	0	1	1	Suisun City	16	24	8
Kensington	2	3	1	Sunnyvale	219	274	55
Kentfield	1	3	2	Sunol	13	19	6
Kenwood	3	10	7	Tiburon	16	23	7
La Honda	5	6	1	Tomales	2	3	1
Lafayette	5	6	1	Tracy	1	1	0
Lagunitas	1	1	0	Travis AFB	45	59	14
Larkspur	6	6	0	Union City	36	48	12
Livermore	150	176	26	Vacaville	0	1	1
Loma Mar	0	2	2	Vallejo	62	72	10
Los Altos	18	23	5	Valley Ford	1	1	0
Los Altos Hills	8	10	2	Walnut Creek	79	103	24
Los Gatos	46	55	9	Windsor	14	18	4
Martinez	63	98	35	Woodacre	2	2	0
Menlo Park	88	101	13	Woodside	8	14	6
Mill Valley	23	29	6	Yountville	12	21	9

Estimated Population of Backup Generators, BAAQMD and SCAQMD

Annex 2: Count of BUGs by City in SCAQMD

City	Apr-20	May-21	Change	City	Apr-20	May-21	Change
ACTON	4	3	-1	LYNWOOD	15	21	6
AGOURA	4	4	0	LYTLE CREEK	3	3	0
AGOURA HILLS	10	16	6	MALIBU	49	56	7
AGUA DULCE	2	2	0	MANHATTAN BEACH	25	31	6
AGUANGA	3	4	1	March Air Reserve B.	10	7	-3
ALHAMBRA	51	63	12	MARINA DEL REY	30	33	3
ALISO VIEJO	39	47	8	MAYWOOD	3	4	1
ALTA LOMA	1	2	1	MECCA	8	9	1
ALTADENA	14	14	0	MENIFEE	17	22	5
ANAHEIM	263	299	36	MENTONE	3	3	0
ANAHEIM HILLS	2	2	0	MIDWAY CITY	1	1	0
ANGELUS OAKS	1	1	0	MIRA LOMA	37	47	10
ANZA	8	11	3	MISSION HILLS	10	10	0
APPLE VALLEY	0	2	2	MISSION VIEJO	58	64	6
ARCADIA	50	62	12	MONROVIA	30	31	1
ARLETA	3	3	0	MONTCLAIR	17	17	0
ARLINGTON	1	1	0	MONTEBELLO	40	47	7
Arrowbear Lake	4	6	2	MONTEREY PARK	49	63	14
ARTESIA	3	5	2	MONTROSE	1	3	2
AVALON	15	27	12	MORENO VALLEY	91	116	25
AZUSA	46	51	5	MOUNT WILSON	26	32	6
BAKER	0	1	1	MOUNTAIN CENTER	6	7	1
BALDWIN PARK	28	34	6	Mount Baldy	1	4	3
BANNING	33	41	8	MURRIETA	62	75	13
BARSTOW	0	1	1	Murrieta Hot Springs	1	3	2
BEAUMONT	36	42	6	MUSCOY	1	1	0
BELL	7	8	1	North Hollywood	1	1	0
BELL GARDENS	11	12	1	NEEDLES	0	2	2
BELLFLOWER	18	23	5	NEWBURY PARK	0	1	1
Bermuda Dunes	5	5	0	NEWHALL	7	10	3
BEVERLY HILLS	119	132	13	NEWPORT BEACH	123	135	12
BIG BEAR	2	3	1	NEWPORT COAST	5	6	1
BIG BEAR CITY	16	19	3	NILAND	1	1	0
BIG BEAR LAKE	49	70	21	NORCO	15	23	8
BLOOMINGTON	24	32	8	NORTH HILLS	9	12	3
BLUE JAY	6	8	2	NORTH HOLLYWOOD	38	44	6
BLYTHE	1	5	4	North Palm Springs	6	9	3
BRADBURY	1	2	1	NORTH SHORE	1	1	0
BREA	59	66	7	NORTH TUSTIN	1	3	2
BUENA PARK	45	48	3	NORTHRIDGE	62	71	9
BURBANK	161	176	15	NORWALK	44	60	16

Estimated Population of Backup Generators, BAAQMD and SCAQMD

City	A	B	C	City	A	B	C
CABAZON	4	4	0	NUEVO	4	4	0
CALABASAS	28	31	3	ONTARIO	170	190	20
CALIMESA	4	4	0	ORANGE	136	138	2
CANOGA PARK	32	35	3	PACIFIC PALISADES	12	13	1
CANYON COTRY	4	5	1	PACOIMA	18	19	1
CANYON LAKE	7	7	0	PALM DESERT	78	88	10
CAPISTRANO B.	3	3	0	PALM SPRINGS	56	61	5
CARSON	58	69	11	PALMDALE	0	6	6
CASTAIC	31	61	30	Palos Verdes Estates	8	10	2
CATALINA	2	1	-1	PANORAMA CITY	18	19	1
Cathedral City	16	17	1	PARAMOUNT	18	32	14
CEDAR GLEN	6	6	0	PASADENA	213	246	33
CERRITOS	40	48	8	PERRIS	71	93	22
CHATSWORTH	33	48	15	PICO RIVERA	26	25	-1
CHERRY VALLEY	1	1	0	PLACENTIA	9	13	4
CHINO	70	92	22	PLAYA DEL REY	15	28	13
CHINO HILLS	32	33	1	PLAYA VISTA	13	13	0
Chiriaco Summit	2	2	0	POMONA	84	97	13
City of Industry	72	1	-71	PORTER RANCH	2	2	0
CLAREMONT	62	78	16	QUAIL VALLEY	4	4	0
COACHELLA	19	27	8	RANCHO CUCAMGA	125	151	26
COLTON	38	43	5	RANCHO DOMIGUEZ	8	9	1
COMMERCE	43	52	9	RANCHO MIRAGE	41	44	3
COMPTON	36	43	7	Rancho Mission Viejo	3	3	0
CORONA	137	157	20	Rancho Palos Verdes	22	22	0
Corona Del Mar	5	4	-1	Rancho Santa Magar.	29	29	0
COSTA MESA	110	133	23	REDLANDS	110	128	18
COTO DE CAZA	3	3	0	REDONDO BEACH	78	85	7
COVINA	27	30	3	RESEDA	14	17	3
CREST PARK	1	1	0	RIALTO	69	83	14
CRESTLINE	22	24	2	RIMFOREST	1	1	0
CUDAHY	4	6	2	RIVERSIDE	339	387	48
CULVER CITY	76	85	9	RIVERSIDE	1	3	2
CYPRESS	31	36	5	ROLLING HILLS	2	1	-1
DANA POINT	18	21	3	Rolling Hills Estates	8	9	1
DESERT CENTER	16	24	8	ROMOLAND	4	4	0
Desert Hot Spri.	27	38	11	ROSEMEAD	23	29	6
Devore Heights	2	2	0	ROWLAND HEIGHTS	7	7	0
DIAMOND BAR	28	575	547	RUBIDOUX	9	9	0
DOWNEY	53	67	14	RUNNING SPRINGS	37	35	-2
DUARTE	15	19	4	SAN BERNARDINO	210	252	42
EAGLE ROCK	3	3	0	SAN CLEMENTE	57	81	24
East Los Angeles	3	3	0	SAN DIMAS	43	46	3
EASTVALE	12	14	2	SAN FERNANDO	8	9	1
EL MONTE	40	46	6	SAN GABRIEL	14	14	0

Estimated Population of Backup Generators, BAAQMD and SCAQMD

EL SEGUNDO	167	189	22	SAN JACINTO	26	33	7
EL TORO	7	7	0	San Juan Capistrano	37	40	3
ENCINO	33	35	2	SAN MARINO	13	14	1
ESCONDIDO	0	1	1	SAN PEDRO	59	68	9
ETIWANDA	3	3	0	SANTA ANA	165	208	43
FAWNSKIN	6	8	2	SANTA CLARITA	57	65	8
FONTANA	134	152	18	SANTA FE SPRINGS	55	66	11
Foothill Ranch	11	14	3	SANTA MONICA	135	140	5
FOREST FALLS	4	4	0	SAUGUS	14	10	-4
FOUNTAIN VALY	46	61	15	SEAL BEACH	49	63	14
FULLERTON	90	105	15	SEPULVEDA	2	3	1
GARDEN GROVE	44	44	0	SHERMAN OAKS	35	34	-1
GARDENA	51	60	9	SIERRA MADRE	7	8	1
GLENDALE	139	169	30	SIGNAL HILL	13	18	5
GLENDORA	28	30	2	SILVERADO	14	16	2
GORMAN	12	12	0	SOUTH EL MONTE	9	12	3
GRANADA HILLS	12	16	4	SOUTH GATE	23	30	7
Grand Terrace	5	5	0	SOUTH PASADENA	4	6	2
GREEN VALLEY	1	1	0	STANTON	11	14	3
Green Valley La.	4	4	0	STEVENSON RANCH	2	3	1
Hacienda Heigh.	12	12	0	STUDIO CITY	18	10	-8
HARBOR CITY	8	11	3	SUGARLOAF	1	1	0
Hawaiian Gard.	4	4	0	SUN CITY	11	10	-1
HAWTHORNE	35	38	3	SUN VALLEY	28	33	5
HEMET	56	71	15	SUNLAND	4	4	0
Hermosa Beach	8	9	1	SYLMAR	49	59	10
HESPERIA	1	1	0	TARZANA	14	18	4
HIDDEN HILLS	2	2	0	TEMECULA	87	109	22
HIGHLAND	24	24	0	TEMESCAL VALLEY	1	1	0
HOLLYWOOD	29	30	1	TEMPLE CITY	6	8	2
HOMELAND	3	5	2	TERMINAL ISLAND	5	7	2
Huntington Bea.	128	163	35	THERMAL	17	19	2
Huntington Park	17	20	3	THOUSAND OAKS	0	2	2
IDYLLWILD	9	9	0	THOUSAND PALMS	8	8	0
INDIAN WELLS	14	15	1	TOLUCA LAKE	1	1	0
INDIO	65	67	2	TOPANGA	2	2	0
INGLEWOOD	44	54	10	TORRANCE	161	174	13
IRVINE	445	489	44	TRABUCO CANYON	17	18	1
IRWINDALE	28	38	10	TUJUNGA	6	9	3
JOSHUA TREE	0	1	1	TUSTIN	40	46	6
JURUPA	1	1	0	TWIN PEAKS	4	6	2
JURUPA VALLEY	5	8	3	UNIVERSAL CITY	42	54	12
LA CANADA	9	7	-2	UPLAND	28	31	3
LA CANADA FLIE	20	28	8	VAL VERDE	1	1	0
LA CRESCENTA	10	10	0	VALENCIA	60	68	8

Estimated Population of Backup Generators, BAAQMD and SCAQMD

LA HABRA	21	23	2	VALLEY VILLAGE	2	2	0
LA MIRADA	23	27	4	VAN NUYS	69	85	16
LA PALMA	13	14	1	VENICE	7	8	1
LA PUENTE	11	14	3	VENTURA	0	1	1
LA QUINTA	38	45	7	VERNON	30	37	7
LA VERNE	19	24	5	VIEW PARK	0	1	1
LADERA RANCH	5	6	1	VILLA PARK	1	1	0
LAGUNA BEACH	40	44	4	WALNUT	22	28	6
LAGUNA HILLS	30	36	6	WALNUT PARK	1	1	0
LAGUNA NIGUL	39	40	1	WATTS	1	1	0
Laguna Woods	8	10	2	WEST COVINA	40	44	4
Lake Arrowhead	31	32	1	WEST HILLS	12	10	-2
LAKE ELSINORE	52	58	6	WEST HOLLYWOOD	41	41	0
LAKE FOREST	28	28	0	WEST LOS ANGELES	5	4	-1
LAKE HUGHES	2	5	3	WESTCHESTER	3	3	0
Lake View Terr.	3	3	0	WESTLAKE VILLAGE	27	27	0
LAKEVIEW	1	1	0	WESTMINSTER	27	34	7
LAKEWOOD	26	33	7	WHITE WATER	1	0	-1
LANCASTER	0	3	3	WHITTIER	64	73	9
LAWNDALE	6	6	0	WILDOMAR	17	16	-1
LEBEC	3	1	-2	WILMINGTON	56	73	17
LOMA LINDA	33	34	1	WINCHESTER	15	16	1
LOMITA	5	6	1	WOODLAND HILLS	70	67	-3
LONG BEACH	316	396	80	WRIGHTWOOD	0	2	2
LOS ALAMITOS	24	30	6	YORBA LINDA	31	37	6
LOS ANGELES	2,100	2,463	363	YUCAIPA	25	27	2

Estimated Population of Backup Generators, BAAQMD and SCAQMD