INDEPENDENT ENERGY PRODUCERS

Electricity Sector Contribution to Air Pollution in California

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Scott Murtishaw, Policy Director

Key Findings

- In California, the electricity sector accounts for less than 2% of the statewide criteria pollutants most responsible for damaging public health: fine particulate matter, nitrogen oxides, and reactive organic gases.
- Because renewable bioenergy (e.g., landfill gas and agricultural waste) accounts for some electric sector emissions, entirely eliminating all fossil-fired generation in the state would only reduce nitrogen oxide and particulate matter emissions by about 1%.
- The electricity sector's share of these pollutants is similar in the state's most polluted air basins, the South Coast and San Joaquin Valley, and in disadvantaged community census tracts.
- Recent studies have found that reducing, or even eliminating, gas-fired generation would yield minimal public health benefit.
- As renewable energy increasingly displaces gas-fired generation, the electricity sector's greenhouse gas and criteria pollution emissions will continue to decline even though state agency modeling indicates most existing gas-fired capacity will be retained through 2045.
- Until cost-effective ultralong-duration storage or firm zero-carbon resources can be deployed at scale, retaining most of the state's existing gas-fired capacity will play an essential role in facilitating electrification of transportation and other end uses by ensuring grid reliability at least cost.
- Because other fossil fuel end uses emit far more criteria pollution than power plants, excessive focus on retiring gas-fired capacity can undermine both decarbonization and criteria pollution reduction goals in other sectors.

Introduction

Air pollution is a serious public health problem in California, causing thousands of premature deaths each year and exacerbating asthma and other health conditions. Fine particulate matter (particles with a diameter of 2.5 microns or less, referred to as PM 2.5) and ground-level ozone, which is created when sunlight interacts with nitrogen oxides (NOx) and reactive organic gases (ROGs), account for most of the health impact from air pollution. Under the federal Clean Air Act, air basins are considered to be either in

attainment or non-attainment of federal air quality standards. California contains the only two air basins in the United States considered to be in serious non-attainment of the PM 2.5 standard, the San Joaquin Valley and South Coast. Two other air regions, Imperial County and Plumas County, are designated as moderate non-attainment areas.[1] California also has the country's only extreme (San Joaquin Valley and South Coast), severe (West Mojave, Riverside County, and San Diego County), and serious (Eastern Kern County, Morongo Band of Mission Indians, Sacramento Metro, Ventura County, and Western Nevada County) non-attainment areas for ozone.[2] The US EPA designates several other California areas as marginal non-attainment areas.

California policy makers are rightly concerned about the state's air quality and have aggressively enacted policies to mitigate harmful concentrations of PM 2.5 and ozone. Examples of such policies include emissions controls on stationary and mobile sources, port electrification, transportation electrification, restricting the burning of crop waste, prohibiting natural gas hookups in new construction, and reducing the use of fossil fuels for electricity generation.

In this report, the Independent Energy Producers Association (IEP) reviews data from the Air Resources Board (ARB) that puts PM 2.5, NOx, and ROG emissions from thermal generation facilities using natural gas, biogas, or biomass in the context of other sources of these pollutants. We present the data at the statewide level and for the San Joaquin Valley and South Coast air basins due to their non-attainment status for both PM 2.5 and ozone. In addition to the source-based estimates of NOx and PM 2.5, we discuss findings from a study that used a state-of-the-art air quality model to assess the contribution of gas-fired power plants to ozone and PM 2.5 concentrations in disadvantaged communities (DAC) downwind of the plants. Unlike the ARB data, the air quality model accounts for sources' total contributions to PM 2.5, including the indirect emissions of PM 2.5 that form when NOx molecules interact with other chemicals in the atmosphere. We then review the findings of two recent analyses of the potential health impact of reducing emissions from the electricity sector compared to other fossil fuel end uses. We conclude by discussing the critical role of gas-fired generation facilities in maintaining grid reliability as the grid decarbonizes.

Electricity Sector Share of PM 2.5, NOx, and ROG Emissions

For the analysis of direct emissions, we use data from ARB's California Emissions Projection Analysis Model (CEPAM) 2019 v1.03.[3] Note that the CEPAM data report total emissions from cogeneration units, including the emissions associated with producing useful thermal output for industrial processes. These emissions are more appropriately

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[1] US EPA, 2022. Green Book: PM 2.5 (2012) Designated Area/State Information. https://www3.epa.gov/airquality/greenbook/kbtc.html

[2] US EPA, 2022. Green Book: 8-Hour Ozone (2015) Designated Area/State Information. https://www3.epa.gov/airquality/greenbook/jbtc.html

[3] ARB. CEPAM2019v1.03 – Standard Emission Tool. https://ww2.arb.ca.gov/applications/cepam2019v103-standard-emission-tool (See also https://ww2.arb.ca.gov/applications/emissions-user-defined-query for a query tool that returns data on all criteria pollutants but that does not include non-anthropogenic sources.)

allocated to the industrial sector, consistent with ARB's treatment of cogeneration emissions in the greenhouse gas (GHG) inventory.[4] Aside from using consistent sectoral accounting for its own sake, process heat-related emissions should be excluded from the electricity sector totals because they cannot be mitigated by policies designed to substitute renewable or zero-carbon electricity for fossil-fired electricity. The industrial cogeneration hosts require fuel combustion for process heat. If the cogeneration facilities were retired, the hosts would need to replace them with industrial boilers. For these reasons, we reallocate the emissions associated with useful thermal output to the industrial sector in the tables in Figure 1.

Table 1 presents the data CEPAM estimates for 2020. The data are shown both with and without non-anthropogenic emissions, which includes emissions from wildfires and naturally occurring biogenic and geogenic sources, to show the electricity's sector's emissions relative to total emissions and the subset of anthropogenic emissions that are more directly subject to the influence of California policy. Table 1 reveals two interesting aspects regarding total NOx, ROG, and PM 2.5 emissions in California. First, the electricity sector accounts for a tiny share of all three pollutants, especially ROGs, at the statewide level. Second, while NOx emissions are primarily from anthropogenic sources, this is not true of the other two pollutants. Non-anthropogenic sources account for a large majority, nearly 78%, of the emissions of ROGs, and wildfires account for 60% of PM 2.5 emissions in a typical recent year.[5]

Table 1. Annual Average Statewide Emissions of Criteria Pollutants in 2020, Tons per Day [a]

Source	NOx	ROG	PM 2.5
Electric Utilities [b]	16	2	5
Cogeneration	12	2	2
Cogeneration, Adjusted [c]	7	1	1
Electricity Sector [d]	23	3	5
All Anthropogenic	1,339	1,524	371
Total, Excl Wildfires	1,365	6,326	371
Total	1,411	6,828	940

[a] These data include emissions from ocean-going vessels within 100 nautical miles of California's shoreline, consistent with statewide multipollutant inventories at https://ww2.arb.ca.gov/applications/statewide-emissions.
[b] In ARB's nomenclature, "electric utilities" refers to all power plants, whether utility-owned or independent, that only produce electricity, as opposed to the cogeneration facilities that produce electricity and useful thermal output for industrial processes.
[c] Total cogeneration emissions are multiplied by an adjustment factor of 0.58 (provided by ARB staff) to represent only the emissions associated with electricity generation.
[d] This is the sum of emissions from "electric utilities" and "cogeneration, adjusted," which do not sum to the total for PM 2.5 due to rounding.

[4] ARB, 2021. California Greenhouse Gas Emissions for 2000 to 2019: Trends of Emissions and Other Indicators, pp. 12, 18, and 19. https://ww2.arb.ca.gov/sites/default/files/classic/cc/inventory/2000_2019_ghg_inventory_trends_20220401.pdf

[5] Although not shown in Table 1, it is noteworthy that the combustion of wood in residential stoves and fireplaces accounts for nearly eight times as much direct PM 2.5 as the electricity sector.

Figure 1 provides more information on the contributions of other sectors to the emissions of NOx and PM 2.5 at the statewide level and for the South Coast and San Joaquin Valley air basins. The electricity sector, shown at the bottom of each bar in graph, is barely visible. For PM 2.5, the largest contributors are natural sources (primarily wildfires) and residential and miscellaneous sources, of which residential wood combustion, commercial charbroiling and cooking, and dust account for the greatest share. On-road vehicles and other mobile sources (e.g, construction equipment, ships, trains, and airplanes) are by far the largest sources of NOx in California.

Figure 1. Sources of NOx and PM 2.5 Emissions, 2020

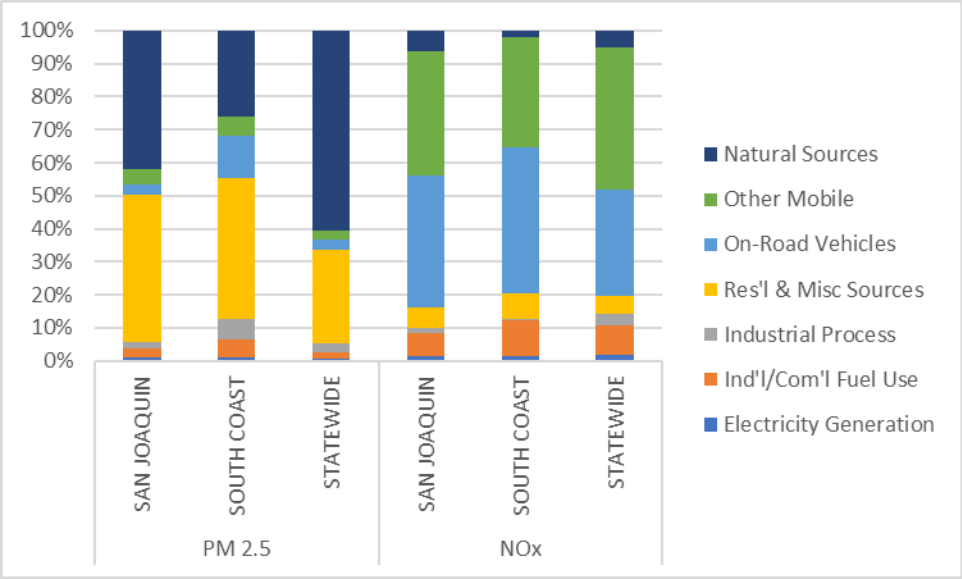


Table 2 shows the electricity sector percentage contribution to direct PM 2.5 and ozone precursor emissions for all pollutants. Even when limited to anthropogenic sources, the electricity sector accounts for less than 2% of each pollutant at any geographic level. The lower half of the table limits emissions to only fossil fuel sources. We include this disaggregation because electricity from biomass and biogas facilities is considered renewable under California's Renewable Portfolio Standard (RPS) and ARB does not attribute GHG emissions to these sources in the GHG inventory. Thus, RPS, Cap and Trade, and other GHG mitigation policies designed to drive down the use of fossil fuels will not affect emissions from bioenergy-based facilities. The percentages in the "Fossil Only" portion of the table reveal the upper limit of the air quality benefit of policies designed to reduce, or eliminate, generation of electricity from fossil fuels.

Table 2. Electricity Sector Share of Criteria Pollution Emissions in 2020

Pollutant	Total Emissions			Anthropogenic Emissions		
	Statewide	South Coast	San Joaquin	Statewide	South Coast	San Joaquin
Electricity Sector, All Sources						
NOx	1.6%	1.5%	1.5%	1.7%	1.5%	1.6%
ROG	0.0%	0.1%	0.0%	0.2%	0.1%	0.1%
PM 2.5	0.6%	0.9%	1.0%	1.5%	1.2%	1.8%
Electricity Sector, Fossil Only						
NOx	1.2%	1.3%	0.9%	1.2%	1.3%	1.0%
ROG	0.0%	0.1%	0.0%	0.2%	0.1%	0.1%
PM 2.5	0.5%	0.8%	0.9%	1.2%	1.1%	1.6%

Unlike the ARB data, which only account for direct emissions of PM 2.5 and ozone precursors, a study conducted by the Ramboll Corporation used a state-of-the-art pollution photochemical grid model to estimate the contributions of gas-fired power plants to PM 2.5, including direct and indirect emissions, and ozone concentrations in California's DAC census tracts.[6, 7] This study found that all gas-fired power plants produced emissions below the US EPA's significant impact levels (SILs), generally by a wide margin. The SIL for ozone is a maximum daily 8-hour average (MDA8) of 1 part per billion (ppb), and the report presents both an annual average of highest 8-hour daily concentration for each day of year as well as the single highest 8-hour average. The report finds that no power plant had an annual average MDA8 value greater than 0.09 ppb, and in fact, only one plant, the Feather River Energy Center, ever exceeded the SIL for even a single day.[8] For PM 2.5, the SIL is an average of 1.2 microgram/m^3 over a 24-hour period. According to the report, no gas-fired power plant ever exceeded the SIL (the highest contribution over a single day was the Russell City Energy Center with a high of 0.98 microgram/m^3). On an annual basis, the plant with the highest daily average rate contributed 0.05 microgram/m^3.[9] Like the data on direct emissions, these findings demonstrate that gas-fired power plants are simply not significant sources of criteria pollution whether at the statewide, air basin, or DAC level.

[6] Ramboll Corporation, 2019. Modeling Ozone and Particulate Air Quality Impacts from California Gas-Fired Power Generation, in Reply Testimony of Christopher A. Emery on Behalf of Calpine Corporation, January 19, 2021. https://docs.cpuc.ca.gov/PublishedDocs/SupDoc/R2011003/3345/360563861.pdf

[7] The Bay Area Air Quality Management District provided the dataset Ramboll Corporation relied on for the study. While the dataset covers most of the state, it unfortunately does not include Imperial, Kings, San Diego, and Orange Counties and includes only portions of Ventura, Los Angeles, and San Bernadino Counties. See Ramboll Corporation, 2019, Figure 3-1, p. 10.

[8] Ramboll Corporation, 2019, pp. 18-19.

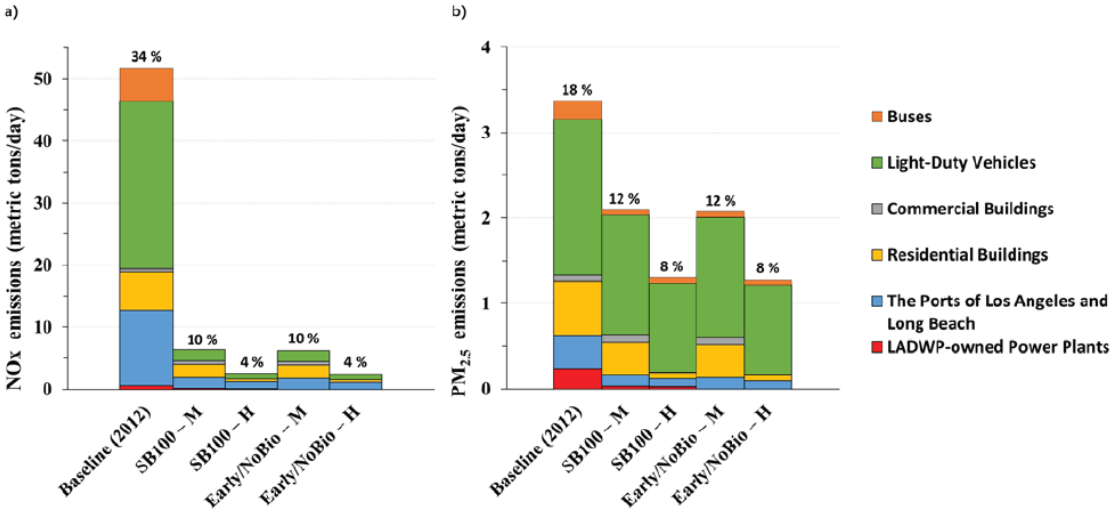
[9] Ramboll Corporation, 2019, pp. 22-23.

Reducing Gas-Fired Generation Provides a Negligible Public Health Benefit

Given the small share of criteria pollutant emissions attributable to electricity generation, it can reasonably be assumed that reducing GHG emissions from the electricity sector will provide a small public health benefit compared to GHG mitigation in other sectors. Below, we summarize the findings of two studies on the air quality impact of electricity generation and the potential benefit of reducing fossil fuel combustion for electricity generation and other end uses. These studies confirm the intuitive conclusion, based on the sector's small contribution to criteria pollution, that reducing the use of fossil fuels for electricity generation will contribute very little to improving air quality.

The first study we review was prepared for the Los Angeles Department of Water and Power (LADWP).[10] The study, referred to hereafter as the LA100 Report, analyzes resource portfolio options for various 100% clean energy scenarios. Figure 2 below, taken from the report, shows the 2012 baseline NOx and PM 2.5 emissions in Los Angeles from six source types and the reductions in those emissions by 2045 under four different scenarios. Note that the report only covers emissions subject to the influence of LADWP and the City of Los Angeles and consequently only includes emissions from power plants owned by LADWP. However, given the small share of all electricity sector emissions to the South Coast air basin totals, the inclusion of plants from the Southern California Edison territory located in the basin would not noticeably change the findings.

Figure 2. NOx and PM 2.5 Emissions in the LA100 Report



Contribution of LA100-influenced sectors to annual average emissions in Los Angeles in 2045 compared to the 2012 Baseline

The percent labels above each column represent the fraction of emissions that are from LA100-influenced sectors out of the total emissions from all sources in the city. The power sector emissions shown represent LADWP-owned power plants located in the South Coast Air Basin.

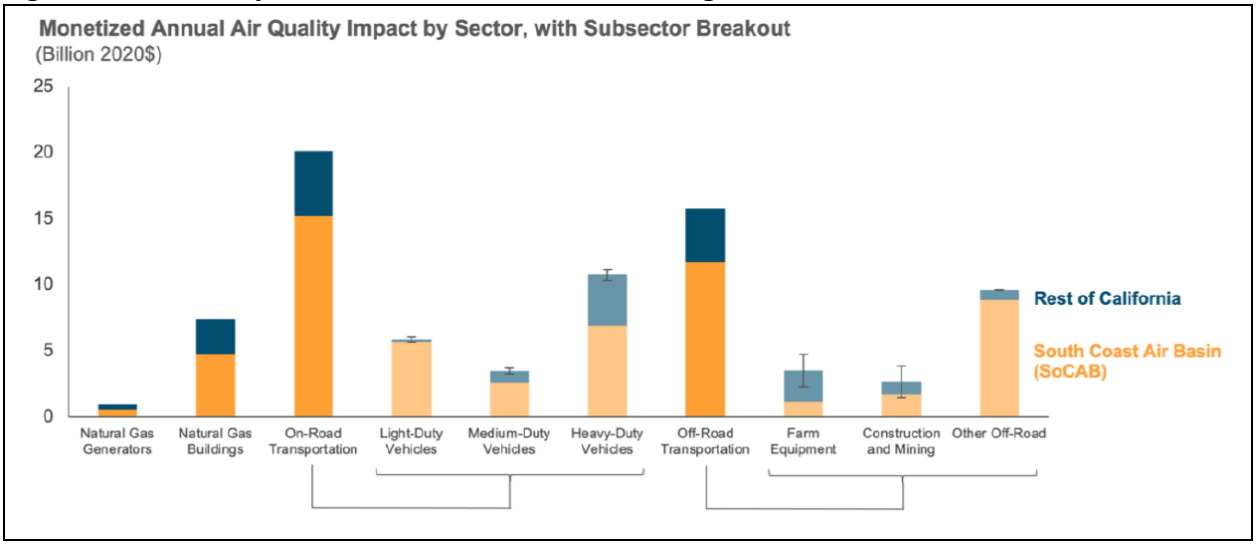
Source: Cochrane et al. 2021, p. 47. The scenarios denoted with an "H" indicate high load scenarios in which more end uses have been electrified compared to the moderate load growth scenarios denoted with an "M."

[10] Cochrane, Jaquelin, et al., 2021. "Executive Summary." In *The Los Angeles 100% Renewable Energy Study*, edited by Jaquelin Cochran and Paul Denholm. Golden, CO. National Renewable Energy Laboratory. NREL/TP-6A20-79444-ES. https://www.nrel.gov/docs/fy21osti/79444-ES.pdf.

Figure 2 shows that the vast majority of emission reductions related to LADWP operations can be achieved by electrifying transportation, ports, and (to a lesser extent) residential uses of natural gas rather than changing the sources of electricity production. The authors note that "changes to LADWP power plants as a result of LA100 scenarios result in very little change in health effects, i.e., these plants are not large contributors to regional air pollution and related health effects."[11]

The second study was conducted for the California Public Utilities Commission (CPUC) to inform resource valuations in the Integrated Resources Planning and Integration of Distributed Energy Resources proceedings.[12] This study begins by eliminating **all** emissions from four different economic sectors relative to ARB's 2035 CEPAM projections. The authors then model the air quality impact from removing these emission sources and quantify the benefit from avoided mortality and morbidity, both statewide and in the South Coast air basin. Consistent with the LA100 Report, Mantegna et al. find that health benefits from eliminating electricity sector NOx and PM 2.5 emissions pale in comparison to the potential benefits from electrifying other end uses, about $1 billion out of a total of $44.5 billion.[13] Figure 3 summarizes the results from that report.

Figure 3. Air Quality Benefits in 2035 from Eliminating NOx and PM 2.5 Emissions



Source: Mantegna et al. 2021, p. 7.

[11] Cochrane et al., 2021, p. 49. Interestingly, the LA100 Report finds that reductions in NOx will slightly **increase** summertime ground-level ozone over the time frame of the study due to the ratio of NOx and ROG in LA's air (see pp. 47-49).

[12] Mantegna, Gabe, Aaron Burdick, Snuller Price, Arne Olsen, Michael MacKinnon, and Scott Samuelsen, 2021. Quantifying the Air Quality Impacts of Decarbonization and Distributed Energy Programs in California. https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/2019-2020-irp-events-and-materials/quantifying-air-quality-impacts.pdf

[13] Mantegna et al., 2021, p. 34.

Comparing the data on tons per day of criteria pollutants emitted by fuel and source type compared to the MMT per year of GHGs emitted by the same fuels and source types provides additional insights into the air quality benefit of reducing GHGs from gas-fired generation relative to other GHG sources. The ratios of PM 2.5 or NOx emissions to GHG emissions will differ by fuel because some fuels are inherently dirtier than others and by source type because many large point sources have pollution control equipment that smaller stationary sources and mobile sources lack. Table 3 presents the total emission data from ARB's GHG inventory[14] and ARB's CEPAM criteria pollution emission tool[15] and the ratios of the criteria pollutants to GHGs. The data are from 2019 because that is the most recent year available from ARB's GHG inventory.

Table 3. Statewide Criteria Pollution (tons/day) and GHG Emissions ($MMTCO_2e$), 2019

	PM 2.5	*NOx*	*GHG*	*PM 2.5/GHG*	*NOx/GHG*
NG Electricity	3.4	10.8	33.6	0.10	0.32
NG Residential	4.9	49.4	25.3	0.19	1.95
NG Other	10.2	75.8	51.2	0.20	1.48
Gasoline	8.9	196.6	125.9	0.07	1.56
Diesel/Distillate	19.6	882.3	36.9	0.53	23.91
Jet Fuel	8.0	52.2	4.2	1.90	12.43

Table 3 shows that reducing the use of other types of fossil fuels, and the use of natural gas in other economic sectors, provides much greater co-pollution benefits compared to reducing the use of natural gas for electricity generation, with the sole exception of PM 2.5 emissions associated with gasoline. Compared to reducing a metric ton of GHG from gas-fired generators, reducing a metric ton of GHG associated with other fuels and end uses results in 2x to 18x more benefit in PM 2.5 reduction and 5x to 74x more benefit in NOx reduction. These ratios reinforce the importance of keeping electricity reliable and affordable to facilitate reductions of both GHGs and criteria pollutants in other sectors.

Retention of Current Gas-Fired Capacity Facilitates Decarbonization of Other Sectors

While the electricity sector accounts for a negligible share of California's criteria pollutant emissions, it plays essential role in reducing greenhouse gas and criteria pollution emissions from other sectors. California homes and businesses will only electrify their transportation and building end uses if their electricity is both affordable and reliable. Senate Bill (SB) 100 (De León, Chapter 312, Statutes of 2018) established a target of 100% zero-carbon electricity to serve all retail sales of electricity in California by 2045. As required by SB 100, the California Energy Commission (CEC), CPUC, and ARB issued a joint

[14] ARB, 2022. Current California GHG Emission Inventory Data: Economic Sector Categorization. https://ww3.arb.ca.gov/cc/inventory/data/tables/ghg_inventory_by_sector_all_00-19.xlsx (Note that GHG emissions are limited to in-state resources for consistency with the criteria pollution data.)

[15] ARB, 2022. CEPAM2019v1.03 – Standard Emission Tool. https://ww2.arb.ca.gov/applications/cepam2019v103-standard-emission-tool

report (SB 100 Report) in March 2021 presenting the joint agencies' analysis of multiple scenarios for reaching the 2045 goal.[16] Note that the study authors interpret SB 100 as excluding on-site generation for self-supply and electricity generated to cover transmission and distribution line losses, which allows for some continued use of gas-fired capacity.[17] The report concludes that no new gas-fired capacity is needed, but the least-cost portfolio for achieving the SB 100 target retains nearly 30 gigawatts (GW) of existing gas-fired capacity.[18] A "no combustion" scenario that eliminates all thermal resources, including bioenergy generation, would necessitate an additional 61 GW of renewable and storage capacity and would raise the total electricity revenue requirement by 12% in 2045.[19]

The SB 100 Report notes that advances in firm zero-carbon generation and long-duration energy storage technologies could reduce the level of economic retention of gas-fired capacity.[20] Until such technologies are ready to be deployed at scale, efforts to force the retirement of gas-fired capacity could prove to be counter-productive to the state's GHG and air quality goals by increasing the cost of electricity or jeopardizing the reliability of the grid. Either outcome will discourage the substitution of electricity for fossil fuels in other sectors of the economy.

Conclusion

The electricity sector emits a trivial share of PM 2.5, NOx, and ROG emissions in California. However, load-serving entities in the state must provide an affordable and reliable supply of electricity to promote electrification of the end uses responsible for most anthropogenic criteria pollutants. The retention of the state's existing gas-fired capacity is expected to play a key role in ensuring reliability at least cost for the foreseeable future, even as the total level of generation from these plants continues to decline. When viewed in the holistic context of all economic sectors, it is evident that excessive focus on retiring gas-fired capacity can undermine achievement of the state's overall criteria pollution and GHG reduction goals.

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[16] CEC, CPUC, and ARB, 2021. 2021 SB 100 Joint Agency Report. CEC-200-2021-001. https://efiling.energy.ca.gov/EFiling/GetFile.aspx?tn=237167&DocumentContentId=70349

[17] SB 100 Report, pp. 59-61.

[18] SB 100 Report, p. 78.

[19] SB 100 Report, p. 13.

[20] SB 100 Report, p. 103.