

Chapter 3

Base Year and Future Emissions



An inventory of regional emissions from all stationary, area and mobile sources is a requirement for the State Implementation Plan. Base year emissions are projected into the future using approved growth factors for each source category. These emissions assist in projecting the level of reductions needed to attain standards in the future.

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Introduction

This chapter summarizes criteria pollutant emissions that occurred in the Basin during the 2012 base year as well as projected emissions for the years 2019, 2022, 2023, 2025, and 2031. A more detailed description of emissions and methodologies is presented in Appendix III. The 2012 base year emissions inventory reflects actual and estimated emissions subject to adopted regulations with current compliance dates as of 2012, whereas future baseline emissions inventories are based on economic projections and adopted regulations with both current and future compliance dates. A list of District and CARB rules and regulations that are part of the base year and future year baseline emissions inventories is presented in Appendix III. The District continues to implement rules that are incorporated in the 2016 AQMP future baseline emissions inventories.

The emissions inventory is divided into two major source classifications: stationary and mobile sources. The 2012 base year point source emissions are based principally on reported data from facilities using the District's Annual Emissions Reporting Program. The area source emissions are estimated jointly by CARB and the District using established inventory methods. The on-road emissions are calculated using CARB's EMFAC 2014 model and the travel activity data provided by the Southern California Association of Governments (SCAG) from their adopted 2016 Regional Transportation Plan / Sustainable Communities Strategy (RTP/SCS). CARB provides emission inventories for off-road equipment which includes construction and mining equipment, industrial and commercial equipment, lawn and garden equipment, agricultural equipment, ocean-going vessels, commercial harbor craft, locomotives, cargo handling equipment, pleasure craft, and recreational vehicles. Aircraft emissions are based on an updated analysis by the District, developed in conjunction with the airports in the region. The future emission forecasts are primarily based on demographic and economic growth projections provided by SCAG. In addition, emission reductions resulting from District regulations amended or adopted by December 2015 and CARB regulations adopted by November 2015 are included in the future baseline projections.

This chapter summarizes the major components of developing the base year and future baseline inventories. More detailed information, such as CARB's and the District's emission reductions resulting from adopted rules and regulations since the 2012 AQMP, growth factors, and demographic trends, are presented in Appendix III. In addition, the top source categories contributing to the 2012, 2019, 2022, 2023, 2025, and 2031 emission inventories are identified in this chapter. An understanding of the highest emitting source categories leads to the identification of potentially more effective control strategies for improving air quality.

Emission Inventories

Two inventories are prepared for the 2016 AQMP for the purpose of regulatory and SIP performance tracking, including transportation conformity¹: an annual average inventory and a summer planning inventory. Baseline emissions data presented in this chapter are based on average annual daily

¹ Transportation conformity is required under CAA Section 176(c) to ensure that federally supported highway and transit project activities "conform" to the purpose of the SIP. More details are provided in Chapter 4.

emissions (i.e., total annual emissions divided by 365 days) and seasonally adjusted summer planning inventory emissions. The 2016 AQMP uses annual average day emissions to estimate the cost-effectiveness of PM_{2.5} control measures and to perform PM_{2.5} modeling and analysis. The summer planning inventory emissions are developed to capture the emission levels during the high ozone season and are used to perform ozone modeling and analysis, estimate the cost-effectiveness of ozone control measures, and to report emission reduction progress as required by the federal and California Clean Air Acts.

Detailed information regarding the emissions inventory development for the base year and future years, the emissions by major source category in the base year and future baseline emission inventories are presented in Appendix III. Attachments A and B to Appendix III list the annual average and summer planning emissions by major source category for 2012, 2019, 2021, 2022, 2023, 2025, and 2031. Attachment C to Appendix III has the top VOC and NO_x point source categories that emitted greater than or equal to 10 tons per year in 2012. Attachment D to Appendix III contains the on-road emissions by vehicle class and pollutant. Attachment E to Appendix III shows emissions associated with the combustion of diesel fuel for various source categories.

Stationary Sources

Stationary sources can be divided into two major subcategories: point and area sources. Point sources are permitted facilities with one or more emission sources at an identified location (e.g., power plants, refineries). These facilities generally have annual emissions of 4 tons or more of either Volatile Organic Compounds (VOC), Nitrogen Oxide (NO_x), Sulfur Oxide (SO_x), or total Particulate Matter (PM), or annual emissions of over 100 tons of Carbon Monoxide (CO). Facilities are required to report their criteria pollutant emissions pursuant to Rule 301 and selected air toxics to the District on an annual basis, subject to audit, if any of these thresholds are exceeded. The 2012 annual reported emissions are used to update the stationary source inventory.

Area sources consist of many small emission sources (e.g., residential water heaters, architectural coatings, consumer products and permitted sources that are smaller than the above thresholds) which are distributed across the region and are not required to individually report their emissions. There are about 400 area source categories for which emission estimates are jointly developed by CARB and the District. The emissions from these sources are estimated using activity information and emission factors. Activity data are usually obtained from survey data or scientific reports (e.g., Energy Information Administration (EIA) reports for fuel consumption other than natural gas fuel, Southern California Gas Company for natural gas consumption, paint suppliers under Rule 314 and District databases). The emission factors are based on rule compliance factors, source tests, manufacturer's product or technical specification data, default factors (mostly from AP-42, U.S. EPA's published emission factor compilation), or weighted emission factors derived from the point source facilities' annual emissions reports. Additionally, the emissions over a given area may be calculated using socioeconomic data.

Appendix III has more detail regarding emissions from specific source categories such as architectural coatings, dairy cattle, oil and gas production operations, gasoline dispensing facilities, and green waste composting. Since the 2012 AQMP was finalized, new area source inventory updates include:

- Architectural Coatings Category: Over 60 area sources in this category were updated based on information provided as part of SCAQMD Rule 314 – “Fees for Architectural Coatings” annual reports.
- Oil and Gas Production Category: The emission estimation methodology for this area source category was revised to incorporate U.S. EPA’s oil and gas production inventory model modified with California-specific emission factors and technologies.
- Gasoline Dispensing Facilities Category: The emission estimation methodology for this area source category was revised to include CARB staff’s updated emission factors and activity data.
- Dairy Cattle: Ammonia and VOC emissions from dairy farms were revised based on the animal head count data reported to the Santa Ana Regional Water Quality Control Board.
- LPG Combustion Categories: The emissions from this category were revised based on the LPG consumption estimation for the Basin. The fraction of California LPG use in the Basin was estimated based on GHG data reported to the CARB. The statewide total LPG consumption was retrieved from State Energy Data (2013).
- Commercial and Industrial Natural Gas Combustion Categories: 2012 actual natural gas consumption data were used, instead of the projection from the 2012 AQMP.
- Composting Waste Disposal: Ammonia and VOC emissions expected from compostable mulch were added in this category.
- REgional CLean Air Incentives Market (RECLAIM) NOx emissions: The future baseline was revised to include the 12 tons per day of RECLAIM Trading Credits (RTCs) reduction by December 2022 that was approved in December 2015.

Mobile Sources

Mobile sources consist of two subcategories: on-road sources and off-road sources. On-road vehicle emissions are calculated with CARB’s EMFAC 2014 model and the travel activity data provided by SCAG from their adopted 2016 RTP/SCS. Spatial distribution data from Caltrans’ Direct Travel Impact Model (DTIM4) are used to place the emissions at the proper time and place. Off-road emissions are calculated using CARB’s category specific inventory models.

On-Road

CARB’s EMFAC 2014 model has undergone extensive revisions from the previous version (EMFAC 2011) to make it more user-friendly, flexible, and to allow incorporation of larger amounts of data demanded by the current regulatory and planning processes. In addition to the model structural changes, other changes include:

- Revision of heavy-duty diesel (HD Diesel) truck emission rates: The emission factors for heavy heavy-duty diesel trucks were also updated using new test data on newer trucks (Model Year 2007 and newer) that more accurately represent the effectiveness of the control equipment used to meet the more stringent 2007 and 2010 emission standards.
- Incorporation of natural gas vehicles for select vehicle classes: Emission factors for natural gas powered solid waste collection vehicles and urban buses are now included in EMFAC 2014 as these classes of vehicles have sufficient penetration of natural gas engines to warrant separate treatment.

- Accounting for federal and California regulations and standards adopted post-2010: The adopted regulations and standards include the State’s Advanced Clean Car Program, the April 2014 amendment to the Truck and Bus Regulation, the Tractor-Trailer Greenhouse Gas Regulation and the federal HD Greenhouse Gas Regulation.
- Socio-econometric modeling of population and VMT: EMFAC 2014 incorporates the use of socioeconomic regression model forecasting methods to predict new vehicle sales and Vehicle Miles Traveled (VMT) growth trends. This allows the use of State and national economic indicators, fuel prices, and regional human population and vehicle ownership characteristics as parameters to more accurately predict vehicle sales and VMT trends.

More detailed information on the changes incorporated in EMFAC 2014 can be found at <http://www.arb.ca.gov/msei/categories.htm>.

Figure 3-1 compares the on-road emissions estimated using EMFAC 2011 in the 2012 AQMP and EMFAC 2014 used in the 2016 AQMP, respectively for milestone years 2012, 2023, and 2031. It should be noted that the comparison for 2012 reflects changes in methodologies, whereas the comparison for 2023 and 2031 also includes adopted rules and updated growth projections since the release of EMFAC 2011, which was the basis of the 2012 AQMP on-road emissions.

For 2012, EMFAC 2014’s newer methodologies show higher emissions of NO_x and VOCs. For the future years 2023 and 2031, in general, the emissions are lower in EMFAC 2014 as compared to EMFAC 2011. The lower emissions can be attributed to additional rules and regulations, more stringent standards, and updates to the heavy-duty emission factors.

Also evident in Figure 3-1 is the change in the rate of emission reductions. The rate of change in the emissions in the early years (2012 to 2023) is significantly larger than that shown further in the later years (2023–2031). This is due to the implementation of the rules and regulations, most of which will be fully implemented by 2023 (e.g., CARB’s Truck and Bus rule requires all trucks to meet the 2010 standards by 2023). The effect of the rules and regulations are significant, showing reductions of about 70 percent NO_x emissions and close to 60 percent VOC emissions between 2012 and 2023, even with increases in fleet population. More modest reductions are predicted from continued fleet turnover, but fleet growth is beginning to outpace the emissions benefits of fleet turnover in the later years. Further emission reductions will require fleets to adopt the use of even cleaner equipment than the current standards require.

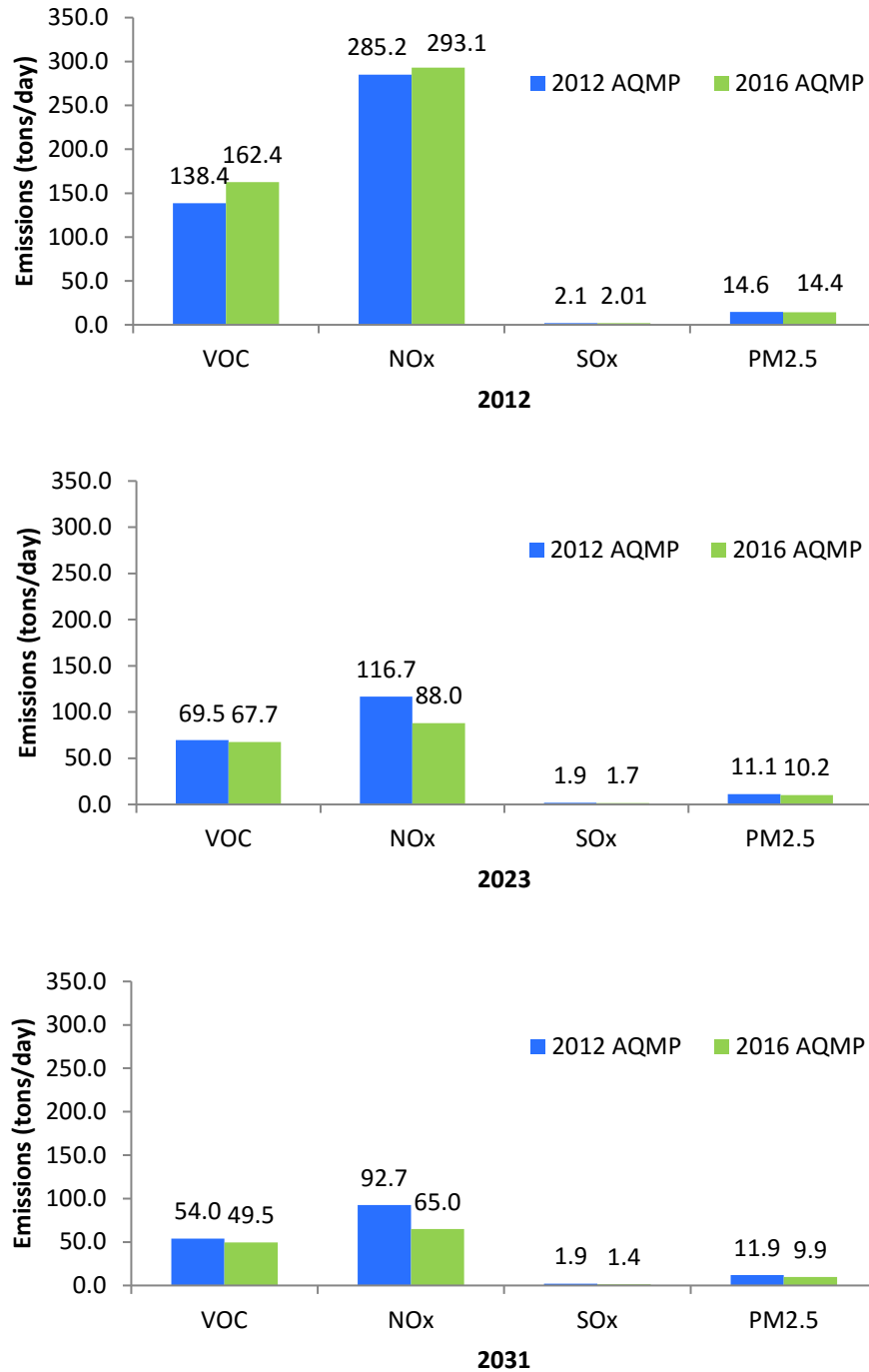


FIGURE 3-1

COMPARISON OF ON-ROAD EMISSIONS ESTIMATED USING EMFAC 2011 IN THE 2012 AQMP AND EMFAC 2014 IN THE 2016 AQMP. VOC AND NOx EMISSIONS REPRESENT SUMMER PLANNING AND SOx & PM2.5 ARE ANNUAL AVERAGE INVENTORY.

Off-Road

Emissions from off-road vehicle categories are primarily based on estimated activity levels and emission factors. Separate emission estimation models have been developed for the many categories of off-road equipment. More information on these models can be found at the following link: <http://www.arb.ca.gov/msei/categories.htm>. Several of these models have been updated since the release of the 2012 AQMP. The major updates include:

- **Locomotives:** The emissions model methodology for the freight locomotive category was completely revised. In addition, activity was updated using data from the Surface Transportation Board and Federal Highway Administration's Freight Analysis Framework. Population information was derived from the Association of American Railroads' population data.
- **Ocean Going Vessels:** New lower growth projections were developed and incorporated into the model using more recent information from the Federal Highway Administration's Freight Analysis Framework model and other forecasts performed for the San Pedro Bay Ports. NOx control factor calculations were updated to more appropriately represent the engine Tier levels.
- **Commercial Harbor Craft:** The vessel turnover rate methodology was improved to better reflect the observed age distribution. A more representative reduced turnover rate is used, which improves consistency with other off-road emissions model methodologies.
- **Pleasure Craft and Off-Highway Recreational Vehicles:** New survey information and DMV data were used to update the population and activity, and new emissions testing data were used to update the emission factors in newly developed models for these two categories.
- **Cargo Handling Equipment:** The model was updated to use growth factors consistent with those developed for ocean going vessels.
- **Farm Equipment:** The inventory was completely revised resulting in a new inventory based on updated equipment population, equipment age distribution, activity, load factors, and turnover practices.
- **Aircraft:** The aircraft emissions inventory is updated for the 2012 base year based on the 2012 aircraft activity data and latest calculation methodologies. A total of 43 airports were identified as having aircraft operations within the District boundaries including commercial air carrier, air taxi, general aviation, and military aircraft operations. The sources of activity data included airport operators and Federal Aviation Administration's (FAA) databases. The emissions calculation methodology was based on the application of FAA's Emissions and Dispersion Modeling System (EDMS) model for commercial airports with detailed aircraft activity data (by aircraft make and model). For other airports and aircraft types (e.g., general aviation, air taxi, military), the total number of aircraft operations was used in conjunction with the U.S. EPA's latest average emission factors by major aircraft type (e.g., general aviation, air taxi, military). For commercial air carrier operations, SCAG's 2040 aircraft operations forecasts from the SCAG's 2016 Regional Transportation Plan (RTP) was used.

The revised 2016 AQMP incorporated the 2040 emissions forecast (based on SCAG's latest forecasts) with interim years interpolated between 2012 and 2040.

Figure 3-2 shows a comparison between the off-road baseline emissions in the 2012 AQMP and the 2016 AQMP for the milestone years 2012, 2023, and 2031. Overall, the updates to the off-road categories result in lower emissions than those used in the 2012 AQMP. It should be noted that the comparison for 2012 reflects changes in methodology, but the comparison for the rest of the years also includes adopted rules and updated growth projections since the release of off-road inventory in the 2012 AQMP. Similar to what is shown for the on-road category, the rate of reductions in emissions of NO_x and VOC is significantly larger in early years (2012 to 2023) compared to the rate seen in the later years (2023 to 2031). This is the result of the rules and regulations adopted at the State and federal levels for most of the off-road categories. As most will be fully implemented by 2023, only modest reductions will be achieved as a result of continued fleet turnover beyond 2023. Without additional rules or programs for further reductions, growth in emissions from increases in vehicle population outweighs the emissions benefits associated with fleet turnover to newer equipment. As projected for the on-road fleet, further emission reductions will require off-road fleets to use even cleaner equipment than current standards require.

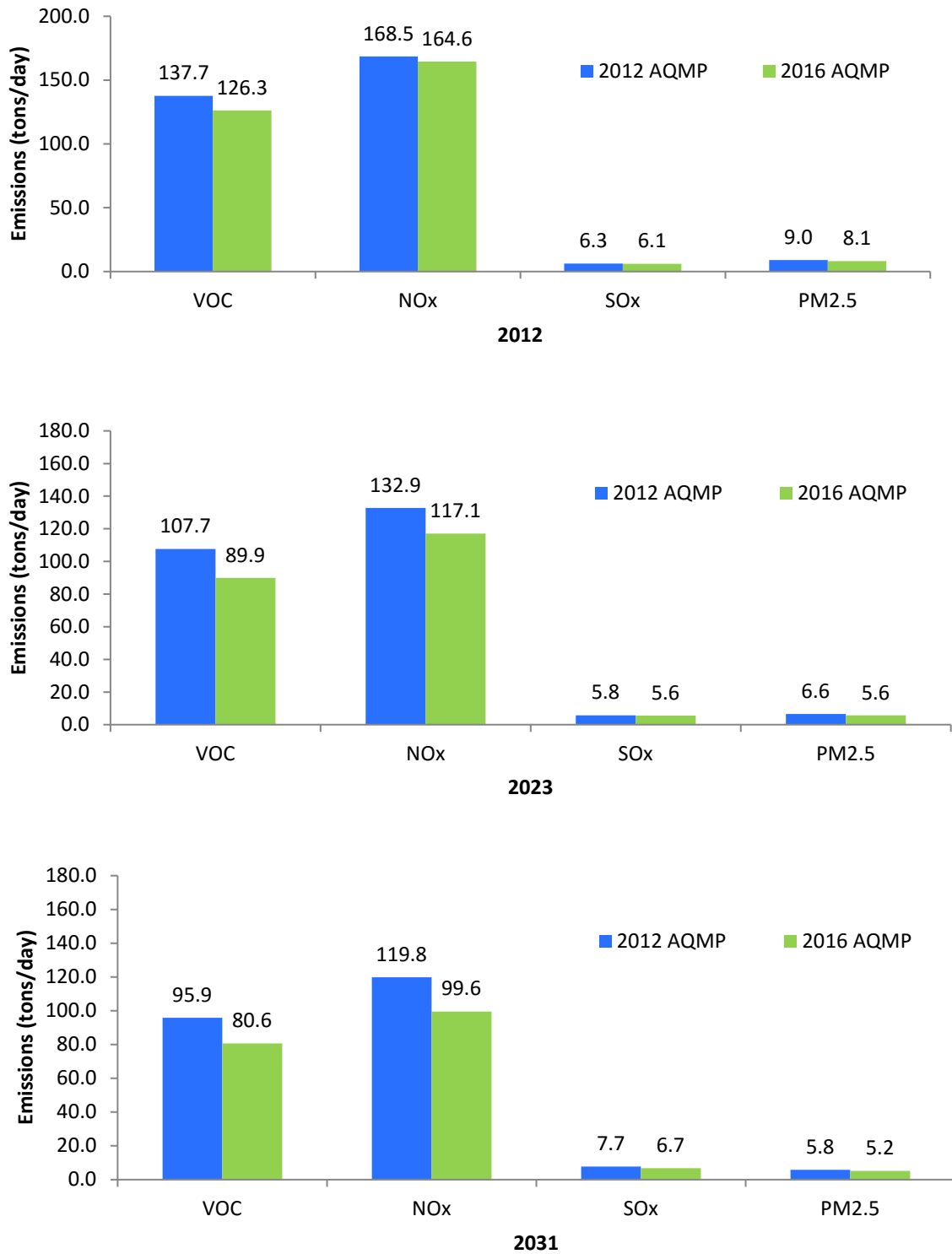


FIGURE 3-2

COMPARISON OF OFF-ROAD EMISSIONS BETWEEN 2012 AQMP AND 2016 AQMP.
 VOC & NOx – SUMMER PLANNING; SOx & PM2.5 – ANNUAL AVERAGE INVENTORY

Uncertainties in the Emissions Inventory

An effective AQMP relies on a complete and accurate emissions inventory. Over the years, significant improvements have been made to quantify emission sources for which control measures are developed. Increased use of continuous monitoring and source testing has contributed to the improvement in point source inventories. Technical assistance to facilities and auditing of reported emissions by the District have also improved the accuracy of the emissions inventory. Area source inventories that rely on average emission factors and regional activities have inherent uncertainty. Industry-specific surveys and source-specific studies during rule development have provided much-needed refinement to these emissions estimates. Mobile source inventories are also continuously updated and improved. As described earlier, many improvements are included in the on-road mobile source model EMFAC 2014, which estimates emissions from trucks, automobiles, and buses. Improvements and updates are included in the off-road models for locomotives, ocean going vessels, commercial harbor craft, pleasure craft and off-highway recreational vehicles, cargo handling equipment, and farm equipment. Overall, the 2016 AQMP inventory is based on the most current data and methodologies, resulting in the most accurate inventory available.

Relative to future growth, there are many challenges inherent in making accurate projections, such as where vehicle trips will occur, the distribution between various modes of transportation (such as trucks and trains), as well as estimates for population growth and the number and type of jobs. Forecasts are made with the best information available; nevertheless, there is uncertainty in emissions projections. AQMP updates are generally developed every three to four years, thereby allowing for frequent updates and improvements to the inventories.

Gridded Emissions

For air quality modeling purposes, the domain extends to Southern Kern County in the north, the Arizona border to the east, northern Mexico to the south and more than 100 miles offshore to the west. The modeling area is divided into a grid system comprised of 4 km by 4 km grid cells. Both stationary and mobile source emissions are allocated to individual grid cells within this system. In general, the modeling emissions data features daily emissions. Variations in temperature, hours of operation, speed of motor vehicles, or other factors are considered in developing gridded motor vehicle emissions. The “gridded” emissions data used for both PM_{2.5} and ozone modeling applications differ from the annual average day or planning inventory emission data in two respects: (1) the modeling region covers larger geographic areas than the Basin; and (2) emissions represent day-specific instead of average or seasonal conditions. Emission inventories are generated for both the PM_{2.5} and ozone modeling applications. For PM_{2.5}, the annual average day is used, which represents the characteristic of emissions that contribute to year-round particulate impacts. The summer planning inventory focuses on the warmer months (May through October) when evaporative VOC emissions and more sunlight, play an important role in ozone formation.

Base Year Emissions

2012 Emission Inventory

Table 3-1A compares the summer planning emissions between the 2012 base year in the 2016 AQMP and the projected 2012 emissions in the Final 2012 AQMP by major source category for VOC and NO_x. Table 3-1B compares the annual average emissions between the 2012 base year in the 2016 AQMP and the projected 2012 emissions in the Final 2012 AQMP for SO_x and PM_{2.5}. It should be noted that the comparison for 2012 reflects updates in methodology, differences between growth projections and actual data, and adopted rules since the release of the 2012 AQMP. Specifically, the growth projection employed in the 2012 AQMP did not fully capture the impact of the economic recession which occurred between 2008 and 2010.

Overall, there is a minor net decrease in VOC emissions in the 2016 AQMP inventory as compared to the 2012 AQMP projections. Estimates of stationary source VOC emissions have decreased by approximately 12 percent, but mobile VOC source emissions have increased by 5 percent. NO_x emissions remain unchanged between the 2016 AQMP inventory and the 2012 projection. As in the VOC category, stationary source NO_x emissions have been revised downward and mobile source emissions have been revised slightly upward. Of note in the stationary source categories are the emission changes associated with the architectural coatings, RECLAIM categories, natural gas and LPG combustion sources, and farming operations. Architectural coatings emissions were updated for the 2016 AQMP using information provided as part of SCAQMD Rule 314 – “Fees for Architectural Coatings” annual reports, resulting in the lower emission estimate. The RECLAIM emissions cap was used to project the NO_x emissions in the 2012 AQMP inventory, while in 2012, the actual emissions were lower than the cap by 7 tons per day (TPD). Use of additional actual reported information in lieu of projected emissions (used in the 2012 AQMP to estimate the 2012 emissions) explain the majority of the remaining emission differences. Refer to Appendix III for details.

For the mobile source category, the updates described earlier to the on-road emissions model EMFAC 2014 resulted in the 17 percent and 3 percent increase in VOC and NO_x emissions, respectively. Updates to several of the off-road category emission estimates resulted in the 8 percent decrease in VOC emissions and a modest 2 percent decrease in NO_x emissions. Updates were completed for locomotives, ocean going vessels, cargo handling equipment, commercial harbor craft, farming equipment, pleasure craft, and off-highway recreational vehicles.

Estimates of SO_x emissions are 23 percent lower in the 2016 AQMP emissions inventory than 2012 projections. This is largely due to the difference in the use of actual reported information in lieu of projected emissions in the RECLAIM sources. Estimates of direct PM_{2.5} from stationary and mobile sources are modestly lower in the 2016 AQMP leading to a decrease of 7 percent. This revised estimation is largely due to changes in the emissions estimates from miscellaneous stationary processes and decreases in off-road vehicle emissions.

Table 3-2 shows the 2012 annual average and summer planning emissions inventory by major source category. Stationary sources are subdivided into point (e.g., chemical manufacturing, petroleum production, and electric utilities) and area sources (e.g., architectural coatings, residential water heaters,

consumer products, and permitted sources smaller than the emission reporting threshold – generally 4 tpy). Mobile sources consist of on-road (e.g., passenger cars and heavy-duty trucks) and off-road sources (e.g., trains and ships). Entrained road dust is also included.

Figure 3-3 characterizes relative contributions by stationary and mobile source categories. On- and off-road sources continue to be major contributors for each of the five pollutants. Overall, total mobile source emissions account for almost 60 percent of the VOC and 90 percent of the NO_x emissions for these two ozone-forming pollutants and 95 percent of the CO emissions. The on-road mobile category alone contributes over 30 percent of the VOC and 56 percent of the NO_x emissions. For directly emitted PM_{2.5}, mobile sources represent 34 percent of the emissions with another 13 percent due to vehicle-related entrained road dust. Stationary sources emit the majority of the SO_x emissions with the point source category contributing 50 percent of the SO_x emissions in the Basin. Area sources play a major role in VOC emissions, emitting about 3.5 times more than point sources. Area sources, including sources such as commercial cooking, are the predominant source of directly emitted PM_{2.5} emissions (42 percent).

Figure 3-4 shows the fraction of the 2012 inventory by responsible agency for VOC, NO_x, SO_x, and directly emitted PM_{2.5}. U.S. EPA and CARB have primary authority to regulate emissions from mobile sources. U.S. EPA's authority applies to aircraft, locomotives, ocean going vessels, and some categories of on- and off-road mobile equipment. CARB has authority over the remainder of the mobile sources, and consumer products. SCAQMD has authority over most area sources and all point sources. As can be seen in Figure 3-4, most of the NO_x and VOC emissions in the District are from sources that fall under the primary jurisdiction of U.S. EPA and CARB. For example, almost 90 percent of the NO_x and over 75 percent of the VOC emissions are from sources primarily under CARB and U.S. EPA control. Conversely, 56 percent of the SO_x emissions and 66 percent of the directly emitted PM_{2.5} emissions are from sources under SCAQMD control. NO_x and VOC are important precursors to ozone and PM_{2.5} formation, and SO_x along with directly emitted PM_{2.5}, contribute to the region's PM_{2.5} nonattainment challenges. This illustrates that actions at the local, State, and federal level are needed to ensure the region attains the federal ambient air quality standards.

TABLE 3-1A

Comparison of VOC and NO_x Emissions By Major Source Category of
2012 Base Year in 2016 AQMP and Projected 2012 in Final 2012 AQMP
Summer Planning Inventory (tpd¹)

SOURCE CATEGORY	2012 AQMP	2016 AQMP	% Change	2012 AQMP	2016 AQMP	% Change
	VOC			NO _x		
STATIONARY SOURCES						
Fuel Combustion	12.9	11.4	-12%	29.4	27.9	-5%
Waste Disposal	12.1	14.1	17%	1.5	2.3	50%
Cleaning and Surface Coatings	41.7	35.6	-15%	0	0	0%
Petroleum Production and Marketing	40.2	29.2	-27%	0	0	0%
Industrial Processes	13.8	10.8	-21%	0	0	0%
Solvent Evaporation:						
Consumer Products	86.6	86.5	0%	0	0	0%
Architectural Coatings	21.5	13.3	-38%	0	0	0%
Others	2.0	2.4	17%	0	0	0%
Misc. Processes	9.7	7.8	-20%	15.5	14.5	-6%
RECLAIM SOURCES	0	0	0%	27.2	19.6	-28%
Total Stationary Sources	240	211	-12%	74	65	-13%
MOBILE SOURCES						
On-Road Vehicles	138.4	162.4	17%	285.2	293.1	3%
Off-Road Vehicles	137.7	126.3	-8%	168.5	164.6	-2%
Total Mobile Sources	276	289	5%	454	458	1%
TOTAL	516	500	-3%	528	522	-1%

¹ Values may not sum due to rounding errors

TABLE 3-1B
 Comparison of SOx and PM2.5 Emissions By Major Source Category of
 2012 Base Year in 2016 AQMP and Projected 2012 in 2012 AQMP
 Annual Average (tpd¹)

SOURCE CATEGORY	2012 AQMP	2016 AQMP	% Change	2012 AQMP	2016 AQMP	% Change
	SOx			PM2.5		
STATIONARY SOURCES						
Fuel Combustion	1.9	1.9	-1%	5.6	5.6	1%
Waste Disposal	0.4	0.5	20%	0.2	0.2	-13%
Cleaning and Surface Coatings	0	0	0%	1.5	1.4	-5%
Petroleum Production and Marketing	0.6	0.4	-26%	1.6	1.5	-6%
Industrial Processes	0.02	0.1	400%	6.7	6.4	-6%
Solvent Evaporation:						
Consumer Products	0	0	0%	0	0	0%
Architectural Coatings	0	0	0%	0	0	0%
Others	0	0	0%	0	0	0%
Misc. Processes	1.0	0.5	-47%	32.5	28.8	-11%
RECLAIM SOURCES	11.8	6.9	-42%	0	0	0%
Total Stationary Sources	16	10	-34%	48	44	-9%
MOBILE SOURCES						
On-Road Vehicles	2.1	2.0	-2%	14.6	14.4	-1%
Off-Road Vehicles	6.3	6.1	-2%	9.0	8.1	-10%
Total Mobile Sources	8	8	-2%	24	23	-5%
TOTAL	24	18	-23%	72	66	-7%

¹Values may not sum due to rounding errors

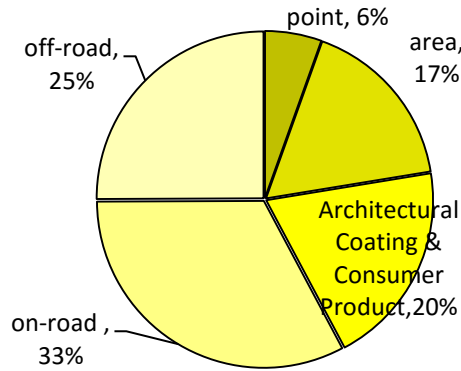
TABLE 3-2

Summary of Emissions By Major Source Category: 2012 Base Year
Average Annual Day and Summer Planning (tpd¹)

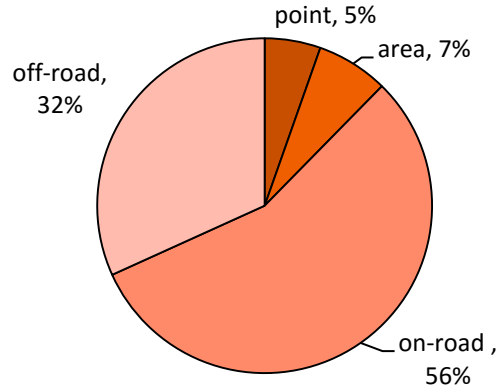
SOURCE CATEGORY	Annual Average						Summer Planning	
	VOC	NOx	CO	SOx	PM2.5	NH3	VOC	NOx
STATIONARY SOURCES								
Fuel Combustion	11	28	49	2	6	9	11	28
Waste Disposal	13	2	1	0	0	5	14	2
Cleaning and Surface Coatings	34	0	0	0	1	0	36	0
Petroleum Production and Marketing	29	0	5	0	2	0	29	0
Industrial Processes	10	0	0	0	6	9	11	0
Solvent Evaporation:								
Consumer Products	87	0	0	0	0	0	87	0
Architectural Coatings	13	0	0	0	0	0	13	0
Others	2	0	0	0	0	1	2	0
Misc. Processes	13	21	54	1	29	38	8	15
RECLAIM SOURCES	0	19	0	7	0	0	0	20
Total Stationary Sources	212	70	109	10	44	63	211	65
MOBILE SOURCES								
On-Road Vehicles	158	317	1328	2	14	18	162	293
Off-Road Vehicles	100	153	686	6	8	0	126	165
Total Mobile Sources	258	470	2014	8	23	18	289	458
TOTAL	470	540	2123	18	66	81	500	522

¹ Values may not sum due to rounding errors

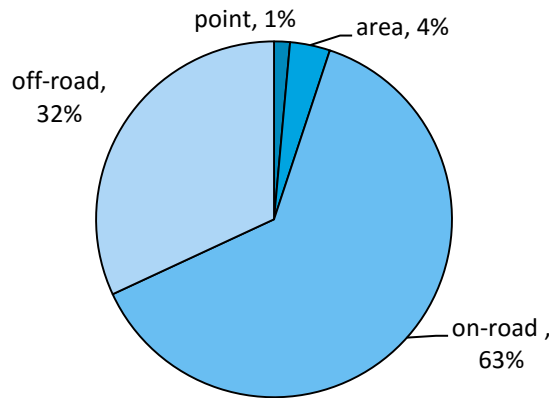
² Includes entrained road dust



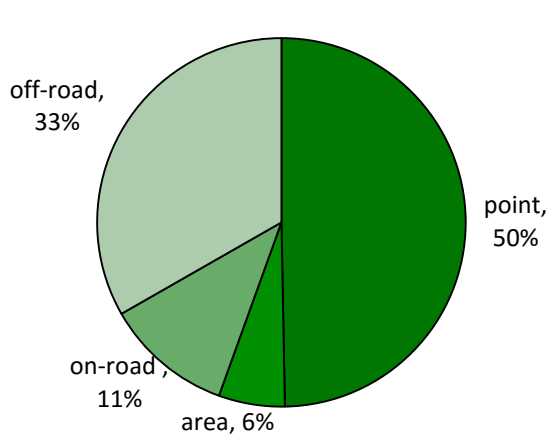
VOC Emissions: 500 tons/day



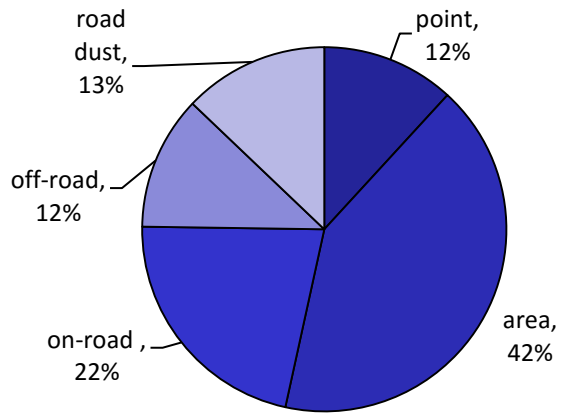
NOx Emissions: 522 tons/day



CO Emissions: 2123 tons/day



SOx Emissions: 18 tons/day



Directly Emitted PM2.5 Emissions: 66 tons/day

FIGURE 3-3

RELATIVE CONTRIBUTION BY SOURCE CATEGORY TO 2012 EMISSION INVENTORY

(VOC & NOx – SUMMER PLANNING; CO, SOx, & PM2.5 – ANNUAL AVERAGE INVENTORY VALUES ARE ROUNDED TO NEAREST INTEGER AND MAY NOT SUM DUE TO ROUNDING)

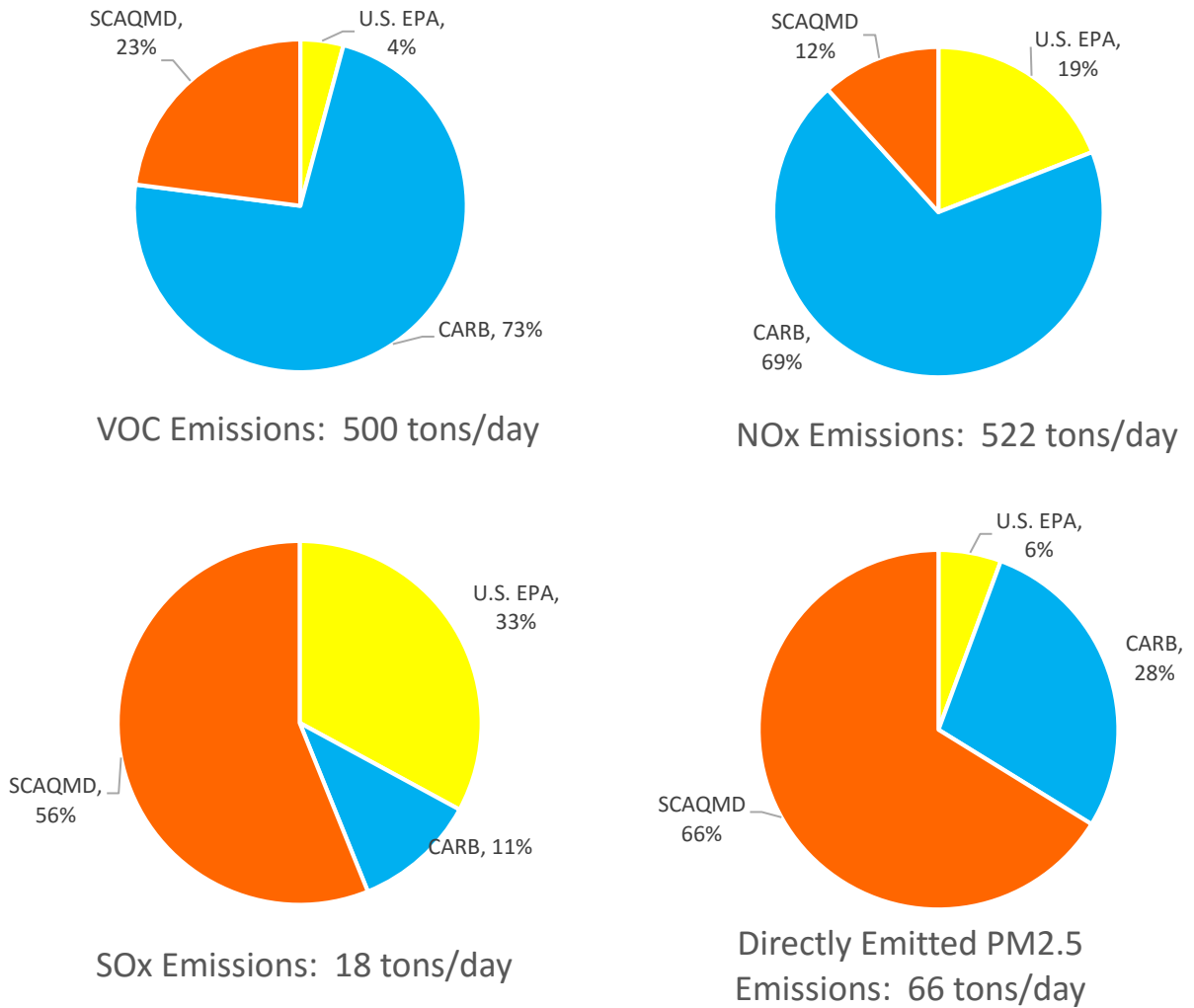


FIGURE 3-4

2012 EMISSION INVENTORY AGENCY PRIMARY RESPONSIBILITY

(VOC & NOx – SUMMER PLANNING; SOx, & PM2.5 – ANNUAL AVERAGE INVENTORY. VALUES ARE ROUNDED TO NEAREST INTEGER AND MAY NOT SUM DUE TO ROUNDING)

Future Emissions

Inventory Development

Inventories were developed for 2012, 2019, 2022, 2023, 2025, and 2031. Year 2012 is the base-year for the attainment demonstrations. Years 2023 and 2031 are the attainment years for the federal 8-hour ozone standards of 80 ppb (revoked) and 75 ppb, respectively. The 2022 inventory was developed to show attainment for the revoked 1-hour ozone standard (120 ppb). The 2019 and 2025 inventories were used to demonstrate attainment for the federal 24-hour and annual PM_{2.5} standards, respectively.

Future-year stationary source emissions are divided into RECLAIM and non-RECLAIM emissions. Future NO_x and SO_x emissions from RECLAIM sources are estimated based on their allocations as specified by District Rule 2002 –Allocations for NO_x and SO_x. The forecasts for non-RECLAIM emissions were derived using: (1) emissions from the 2012 base year, (2) expected controls after implementation of District rules adopted by December 2015 and CARB rules adopted as of November 2015, and (3) activity growth in various source categories between the base and future years.

Demographic growth forecasts for various socioeconomic categories (e.g., population, housing, employment by industry), developed by SCAG for their 2016 RTP/SCS, were used. Industry growth factors for 2012, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2025, 2026, 2031, and 2037 are also provided by SCAG, and interim years are calculated by linear interpolation. Table 3-3 summarizes key socioeconomic parameters used in the 2016 AQMP for emissions inventory development.

In this chapter, the inventories for 2019, 2022, 2023, 2025, and 2031, the 8-hour ozone, 1-hour ozone, along with the annual and 24-hour PM_{2.5} attainment target years are discussed.

TABLE 3-3
Baseline Demographic Forecasts in the 2016 AQMP and the Final 2012 AQMP

CATEGORY	2012	2023	2023 % GROWTH FROM 2012	2031	2031 % GROWTH FROM 2012
Population (Millions)	15.9	17.1	7%	17.9	12%
Housing Units (Millions)	5.1	5.7	10%	6.0	16%
Total Employment (Millions)	6.7	7.8	16%	8.2	23%
Daily VMT (Millions)	380	407	7%	409	8%

Current forecasts indicate that this region will experience a population growth of 7 percent between 2012 and 2023, with a 7 percent increase in vehicle miles traveled (VMT) and a population growth of 12 percent by the year 2031 with an 8 percent increase in VMT.

As compared to the projections in the 2012 AQMP, the current 2023 projections in the 2016 AQMP predict a population of about 200,000 fewer people (2.8 percent less), 100,000 more total employment (1.2 percent more), and 11 million miles more in the daily VMT forecast (2.7 percent more).

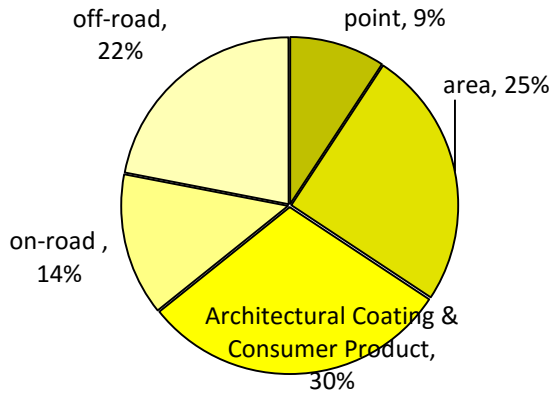
Summary of Future Baseline Emissions

To illustrate trends in the future baseline emissions inventories, emissions data by source categories (point, area, on-road mobile and off-road mobile sources) and by pollutant are presented in Tables 3-4A through 3-4E for the years 2019, 2022, 2023, 2025, and 2031. Baseline inventories are projected future emissions that reflect already adopted rules and regulations, but not additional controls proposed in the 2016 AQMP. This is in contrast to the 2012 base year emission inventory, which captures the actual 2012 emissions and is used as a basis for the projection of future inventories. Tables 3-4 provide annual average, as well as summer planning inventories. Emissions inventories for 2021, the “moderate” annual PM2.5 attainment deadline and milestone years for the Reasonable Further Progress (RTP) analysis (2024, 2027, 2028, 2029 and 2030) can be found in Appendix III.

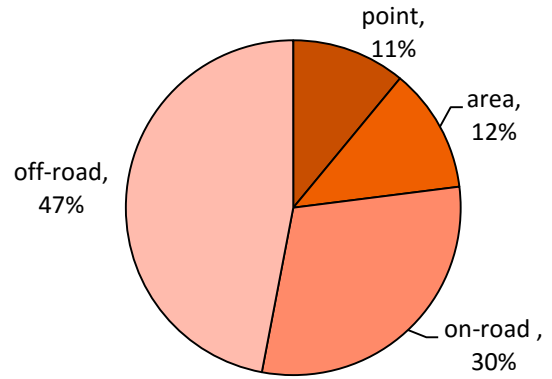
Without any additional control measures, VOC and NOx emissions are expected to decrease due to existing regulations, such as controls for on- and off-road equipment, new vehicle standards, and the RECLAIM program. However, consistent with what was shown earlier with the mobile source categories, the emissions of SOx and PM2.5 show increases after 2022, when most of the rules and regulations will be fully implemented. Increases in emissions due to increase in population and activity outpace the emission reductions from introducing newer and cleaner equipment and vehicles. Figure 3-5 illustrates the relative contribution to the 2031 inventory by source category. A comparison of Figures 3-3 and 3-

5 indicates that the on-road mobile category continues to be a major contributor to CO and NOx emissions. However, because of the implementation of most of the mobile source rules and regulations by 2023, 2031 on-road mobile sources account for much less of the VOC, NOx, and CO emissions as compared to 2012: about 14 percent of total VOC emissions compared to 33 percent in 2012; about 30 percent of total NOx emissions compared to 56 percent in 2012; and about 26 percent of total CO emissions compared to 63 percent in 2012. For directly emitted PM2.5, mobile sources will represent 23 percent of the emissions with another 14 percent due to vehicle-related entrained road dust, a reduction from the mobile source contribution in the base-year. It is projected that stationary sources will emit the majority of the SOx emissions with the point source category, contributing 55 percent of the SOx emissions in the Basin. In 2031, area sources will play even a larger role in VOC emissions, emitting more than point sources and mobile sources combined. Area sources will become the major contributor to VOC emissions from 37 percent in 2012 to 55 percent in 2031 and are projected to remain as the predominant source of directly emitted PM2.5 emissions (49 percent). See Figures 3-7 through 3-30 for the highest-ranking source categories for 2012, 2019, 2022, 2023, 2025, and 2031.

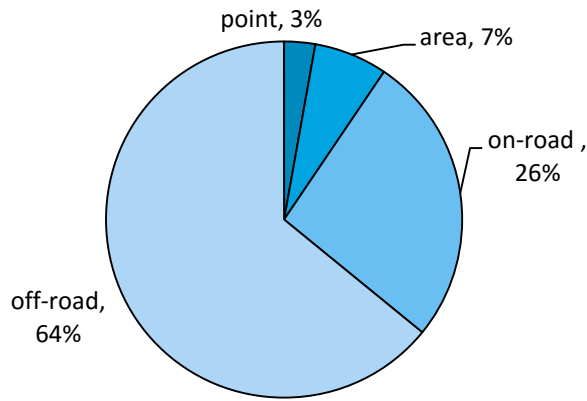
Figure 3-6 shows the fraction of the 2031 inventory by responsible agency for VOC, NOx, SOx, and directly emitted PM2.5. In 2031, a larger fraction of the NOx and VOC emissions will fall under the SCAQMD control. However, the majority of VOC and NOx emissions will remain primarily under CARB and EPA jurisdiction. The fraction of SOx emissions that fall under SCAQMD control will remain largely unchanged from the 2012 base-year inventory. However, the increasing contribution of area and point sources towards direct PM2.5 emissions in 2031 will result in a larger fraction of emissions falling under SCAQMD control.



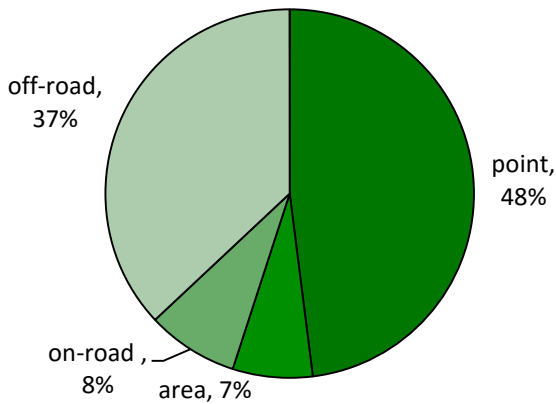
VOC Emissions: 362 tons/day



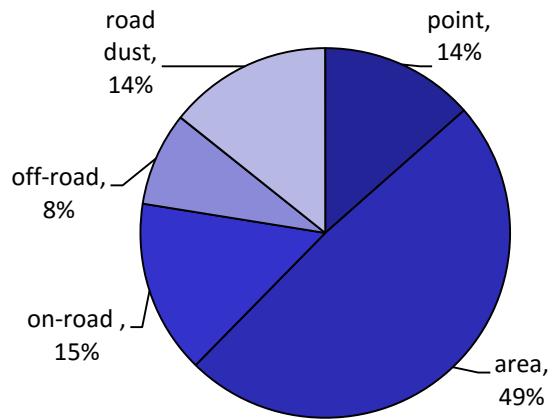
NOx Emissions: 214 tons/day



CO Emissions: 1118 tons/day



SOx Emissions: 18 tons/day



Directly Emitted PM2.5 Emissions: 65 tons/day

FIGURE 3-5

RELATIVE CONTRIBUTION BY SOURCE CATEGORY TO 2031 EMISSION INVENTORY

(VOC & NOx – SUMMER PLANNING; CO, SOx, & PM2.5 – ANNUAL AVERAGE INVENTORY - VALUES ARE ROUNDED TO NEAREST INTEGER AND MAY NOT SUM DUE TO ROUNDING)

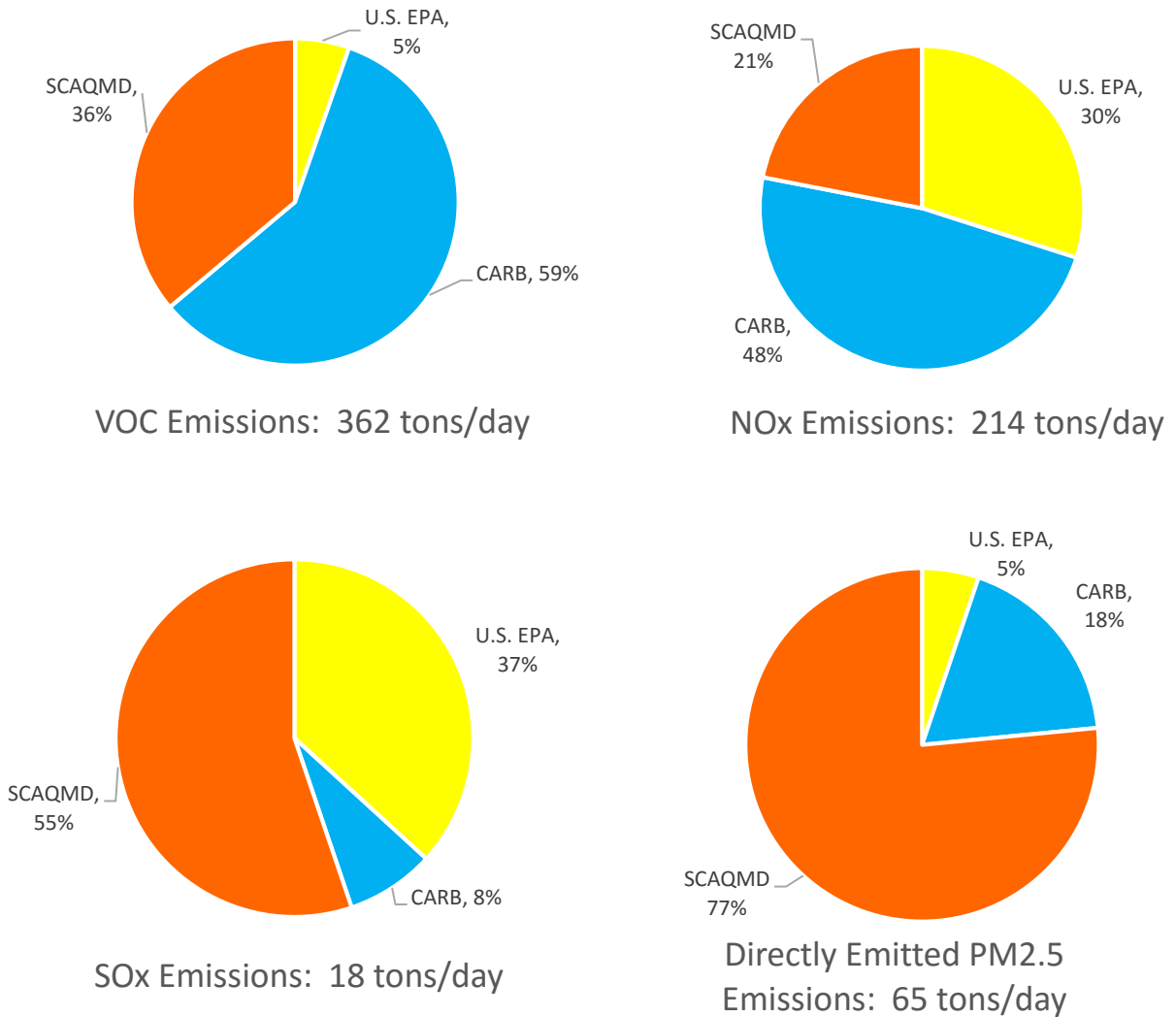


FIGURE 3-6

2031 EMISSION INVENTORY AGENCY RESPONSIBILITY

(VOC & NOx – SUMMER PLANNING; SOx & PM2.5 – ANNUAL AVERAGE INVENTORY. VALUES ARE ROUNDED TO NEAREST INTEGER AND MAY NOT SUM DUE TO ROUNDING)

TABLE 3-4A

Summary of Emissions By Major Source Category: 2019 Baseline (24-hr PM_{2.5} attainment year)
Average Annual Day and Summer Planning (tpd¹)

SOURCE CATEGORY	ANNUAL AVERAGE						SUMMER PLANNING	
	VOC	NO _x	CO	SO _x	PM _{2.5}	NH ₃	VOC	NO _x
STATIONARY SOURCES								
Fuel Combustion	11	23	48	2	6	9	11	23
Waste Disposal	14	2	1	1	0	6	16	2
Cleaning and Surface Coatings	42	0	0	0	2	0	43	0
Petroleum Production and Marketing	21	0	5	0	2	0	21	0
Industrial Processes	12	0	1	0	7	9	13	0
Solvent Evaporation:								
Consumer Products	88	0	0	0	0	0	88	0
Architectural Coatings	12	0	0	0	0	0	12	0
Others	2	0	0	0	0	1	3	0
Misc. Processes ²	13	14	56	1	31	35	7	10
RECLAIM Sources ³	0	23	0	6	0	0	0	23
Total Stationary Sources	214	62	111	10	47	60	213	59
MOBILE SOURCES								
On-Road Vehicles	82	167	639	2	11	14	86	155
Off-Road Vehicles	79	124	697	5	6	0	98	133
Total Mobile Sources	161	291	1336	7	17	14	184	289
TOTAL	376	353	1447	17	64	74	398	347

¹ Values are rounded to nearest integer and may not sum due to rounding

² Includes entrained road dust

³ Includes 2015 RECLAIM NO_x shaves

TABLE 3-4B

Summary of Emissions By Major Source Category: 2022 Baseline (1-hr ozone attainment year)
Average Annual Day and Summer Planning (tpd¹)

SOURCE CATEGORY	Annual Average						Summer Planning	
	VOC	NOx	CO	SOx	PM2.5	NH3	VOC	NOx
STATIONARY SOURCES								
Fuel Combustion	11	22	49	2	6	9	11	22
Waste Disposal	15	2	1	1	0	6	17	3
Cleaning and Surface Coatings	45	0	0	0	2	0	47	0
Petroleum Production and Marketing	20	0	5	0	2	0	20	0
Industrial Processes	12	0	1	0	7	9	13	0
Solvent Evaporation:								
Consumer Products	90	0	0	0	0	0	90	0
Architectural Coatings	12	0	0	0	0	0	12	0
Others	2	0	0	0	0	1	3	0
Misc. Processes ²	13	13	56	1	31	35	7	10
RECLAIM Sources ³	0	15	0	6	0	0	0	15
Total Stationary Sources	220	53	112	10	48	60	220	50
MOBILE SOURCES								
On-Road Vehicles	68	125	498	2	10	13	71	117
Off-Road Vehicles	74	113	715	5	6	0	92	120
Total Mobile Sources	142	238	1213	7	16	13	163	237
TOTAL	362	290	1325	17	64	73	383	287

¹ Values are rounded to nearest integer and may not sum due to rounding

² Includes entrained road dust

³ Includes 2015 RECLAIM NOx shaves

TABLE 3-4C

Summary of Emissions By Major Source Category: 2023 Baseline (1997 8-hr ozone attainment year)
Average Annual Day and Summer Planning (tpd¹)

SOURCE CATEGORY	Annual Average						Summer Planning	
	VOC	NO _x	CO	SO _x	PM _{2.5}	NH ₃	VOC	NO _x
STATIONARY SOURCES								
Fuel Combustion	11	22	49	2	6	9	11	22
Waste Disposal	15	2	1	1	0	6	17	3
Cleaning and Surface Coatings	46	0	0	0	2	0	47	0
Petroleum Production and Marketing	20	0	5	0	2	0	20	0
Industrial Processes	13	0	1	0	8	9	14	0
Solvent Evaporation:								
Consumer Products	90	0	0	0	0	0	90	0
Architectural Coatings	12	0	0	0	0	0	12	0
Others	2	0	0	0	0	1	3	0
Misc. Processes ²	13	13	56	1	32	35	7	10
RECLAIM Sources ³	0	15	0	6	0	0	0	15
Total Stationary Sources	222	52	112	10	48	60	220	50
MOBILE SOURCES								
On-Road Vehicles	65	94	465	2	10	13	68	88
Off-Road Vehicles	73	110	721	6	6	0	90	117
Total Mobile Sources	137	204	1186	7	16	13	158	205
TOTAL	359	257	1298	17	64	72	379	255

¹ Values are rounded to nearest integer and may not sum due to rounding

² Includes entrained road dust

³ Includes 2015 RECLAIM NO_x shaves

TABLE 3-4D

Summary of Emissions By Major Source Category: 2025 Baseline (annual PM2.5 attainment year)
Average Annual Day and Summer Planning (tpd¹)

SOURCE CATEGORY	Annual Average						Summer Planning	
	VOC	NOx	CO	SOx	PM2.5	NH3	VOC	NOx
STATIONARY SOURCES								
Fuel Combustion	11	22	50	2	6	9	11	22
Waste Disposal	16	2	1	1	0	6	18	3
Cleaning and Surface Coatings	47	0	0	0	2	0	49	0
Petroleum Production and Marketing	19	0	5	0	2	0	20	0
Industrial Processes	13	0	1	0	8	9	14	0
Solvent Evaporation:								
Consumer Products	91	0	0	0	0	0	91	0
Architectural Coatings	12	0	0	0	0	0	12	0
Others	3	0	0	0	0	1	3	0
Misc. Processes ²	13	13	56	1	32	35	7	9
RECLAIM Sources ³	0	15	0	6	0	0	0	15
Total Stationary Sources	224	52	112	10	49	60	223	49
MOBILE SOURCES								
On-Road Vehicles	58	85	403	2	10	12	61	79
Off-Road Vehicles	71	104	731	6	5	0	87	110
Total Mobile Sources	129	189	1134	7	15	12	148	190
TOTAL	353	241	1247	17	64	72	372	239

¹ Values are rounded to nearest integer and may not sum due to rounding

² Includes entrained road dust

³ Includes 2015 RECLAIM NOx shaves

TABLE 3-4E

Summary of Emissions By Major Source Category: 2031 Baseline (2008 8-hr ozone attainment year)
Average Annual Day and Summer Planning (tpd¹)

SOURCE CATEGORY	Annual Average						Summer Planning	
	VOC	NOx	CO	SOx	PM2.5	NH3	VOC	NOx
STATIONARY SOURCES								
Fuel Combustion	11	22	51	2	6	9	11	22
Waste Disposal	16	2	1	1	0	6	19	3
Cleaning and Surface Coatings	50	0	0	0	2	1	52	0
Petroleum Production and Marketing	18	0	5	0	2	0	18	0
Industrial Processes	13	0	1	0	8	9	14	0
Solvent Evaporation:								
Consumer Products	94	0	0	0	0	0	94	0
Architectural Coatings	13	0	0	0	0	0	13	0
Others	3	0	0	0	0	1	3	0
Misc. Processes ²	13	11	56	1	33	36	7	9
RECLAIM Sources ³	0	15	0	6	0	0	0	15
Total Stationary Sources	231	51	113	10	50	61	231	50
MOBILE SOURCES								
On-Road Vehicles	47	69	309	1	10	12	49	65
Off-Road Vehicles	66	94	766	7	5	0	81	100
Total Mobile Sources	114	163	1074	8	15	12	130	165
TOTAL	345	214	1188	18	65	73	362	214

¹ Values may not sum due to rounding

² Includes entrained road dust

³ Includes 2015 RECLAIM NOx shaves

Impact of Growth

The 2016 AQMP forecasts the 2031 emissions inventories “with growth” through a detailed consultation process with SCAG. The region is projected to see a 12 percent growth in population, 16 percent growth in housing units, 23 percent growth in employment, and 8 percent growth in vehicle miles traveled between 2012 and 2031. To illustrate the impact of demographic growth on emissions, year 2031 no-growth emissions were estimated by removing the growth factors from the 2031 baseline emissions. Table 3-5 presents the comparison of the projected 2031 emissions with and without growth. In this analysis, the benefit of potential applications of BACT under District’s Regulation XIII – New Source Review (NSR) is not included. The growth impacts to year 2031 for VOC, NO_x, CO, SO_x and PM_{2.5} are 48, 35, 251, 2, and 8 tons per day, respectively.

While economic growth for the region is desirable, it presents a challenge to our air quality improvement efforts since the projected growth could offset the impressive progress made in reducing VOC, NO_x, and PM_{2.5} emissions through adopted regulations. Meeting the U.S. EPA’s current and more-stringent future air quality standards will require the continuation of emission reduction efforts from all levels of government.

TABLE 3-5

Growth Impact to 2031 Emissions¹ in Tons per Day

WITH GROWTH	VOC	NOx	CO	SOx	PM2.5
Point	30	21	34	9	9
Area	201	29	80	1	32
Road Dust	0	0	0	0	9
On-Road	47	69	309	1	10
Off-Road	66	94	766	7	5
Total	345	214	1188	18	65
NO GROWTH	VOC	NOx	CO	SOx	PM2.5
Point	24	20	31	8	8
Area	178	32	78	1	28
Road Dust	0	0	0	0	8
On-Road	46	51	299	1	9
Off-Road	49	76	519	5	4
Total	297	179	927	16	57
IMPACT OF GROWTH	VOC	NOx	CO	SOx	PM2.5
Point	6	1	3	0	1
Area	23	-3	2	0	4
Road Dust	0	0	0	0	1
On-Road	1	18	10	0	1
Off-Road	18	19	237	2	1
Total	48	35	251	2	8

¹Annual Average Inventory

Top Ten Source Categories (2012, 2019, 2022, 2023, 2025, and 2031)

The rankings of the top ten source contributors to the emissions inventories for specific years for VOC, NOx, SOx and PM2.5 are listed and briefly discussed in this section. The summer planning inventories for VOC and NOx, along with the annual average inventories for SOx and PM2.5 for 2012, 2019, 2022, 2023, 2025, and 2031 are shown in Figures 3-7 to 3-30.

Figures 3-7 to 3-12 provide the top ten categories for each of the six inventory years for VOCs. Two of top four categories are on-road mobile sources in the 2012 inventory, but none of the on-road categories are found in the top four categories for 2023, 2025 or 2031. This demonstrates the effect of more-stringent on-road standards in the future. Consumer products, and off-road equipment remain as high-emitting categories over time. The coatings and related processes category becomes much more significant in future years. The top 10 categories account for 78 percent of the total VOC inventory in 2012 and continue to account for over 72 percent through 2031.

NOTE: Figures 3-7, and 3-14 through 3-30 have been updated from the Draft Plan to reflect the latest emission inventory values (e.g., aircraft NOx and SOx, paved road dust PM2.5).

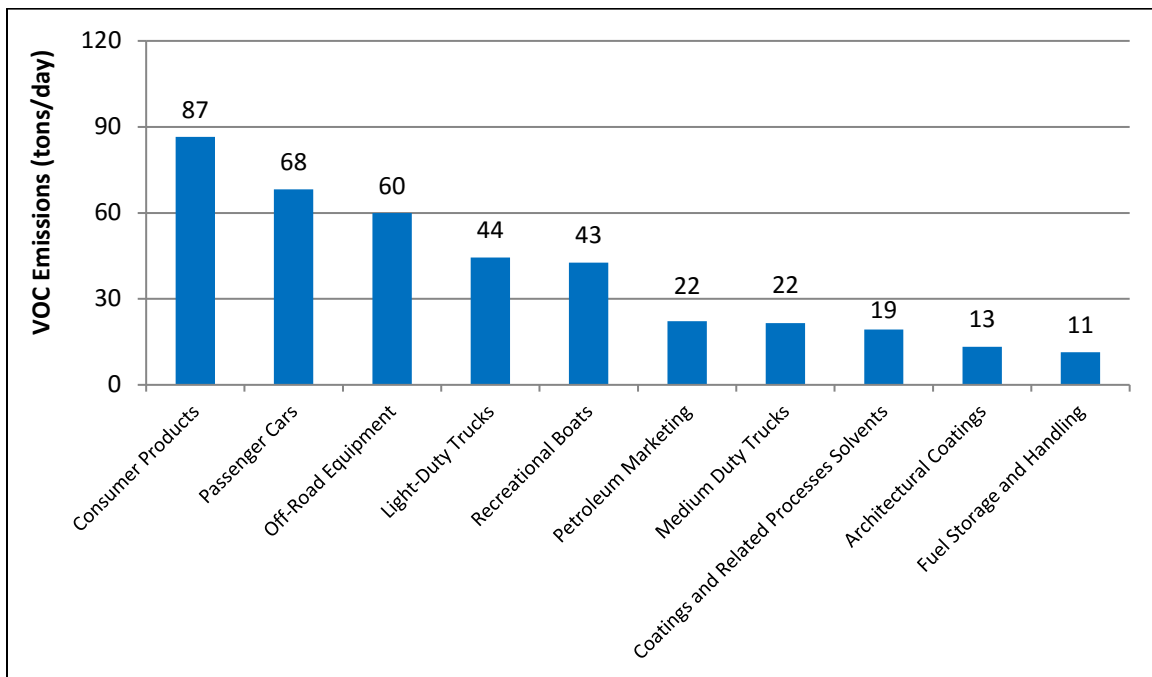


FIGURE 3-7

TOP TEN EMITTER CATEGORIES FOR VOC IN 2012 (SUMMER PLANNING)

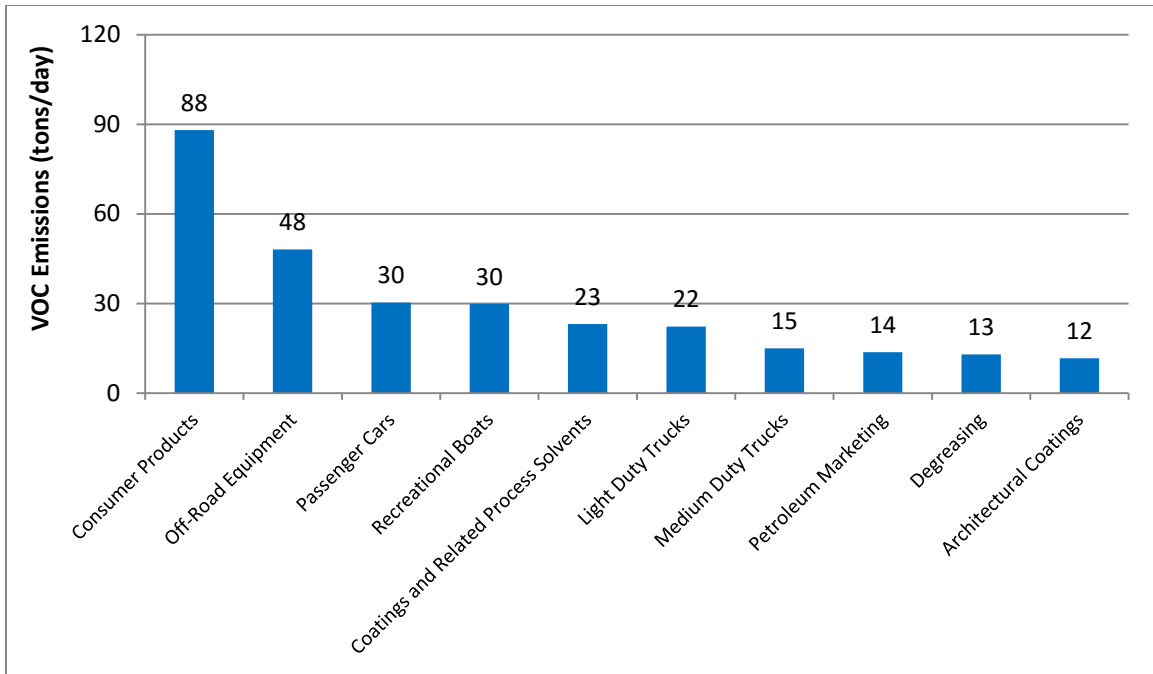


FIGURE 3-8

TOP TEN EMITTER CATEGORIES FOR VOC IN 2019 (SUMMER PLANNING)

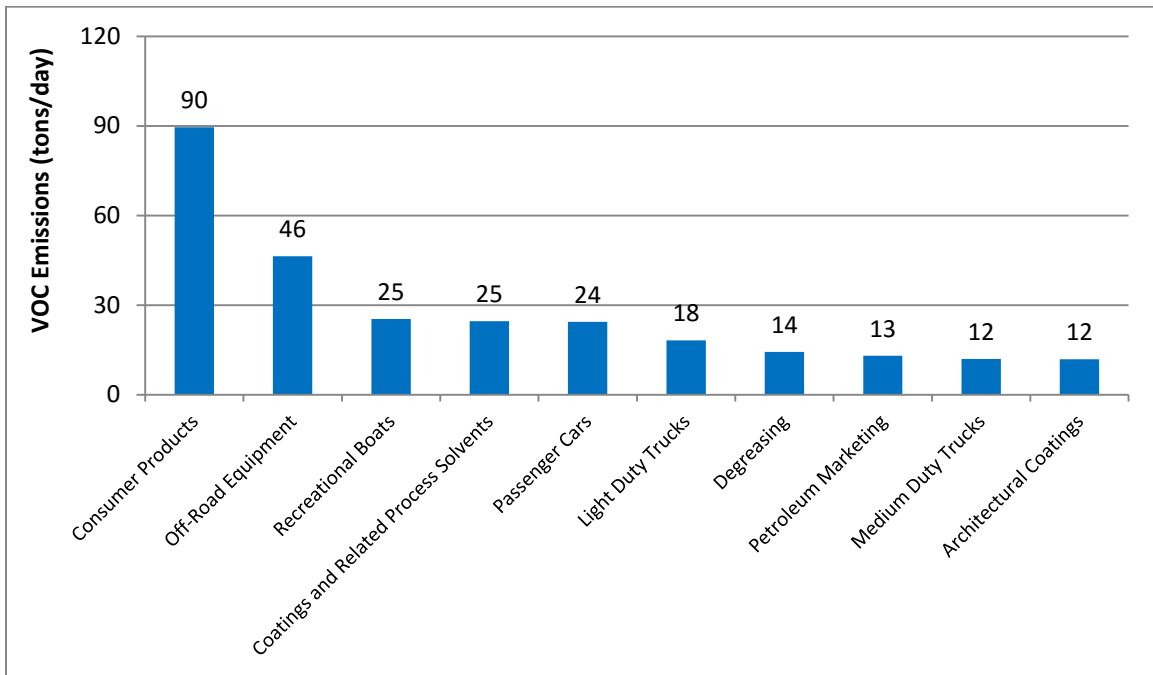


FIGURE 3-9

TOP TEN EMITTER CATEGORIES FOR VOC IN 2022 (SUMMER PLANNING)

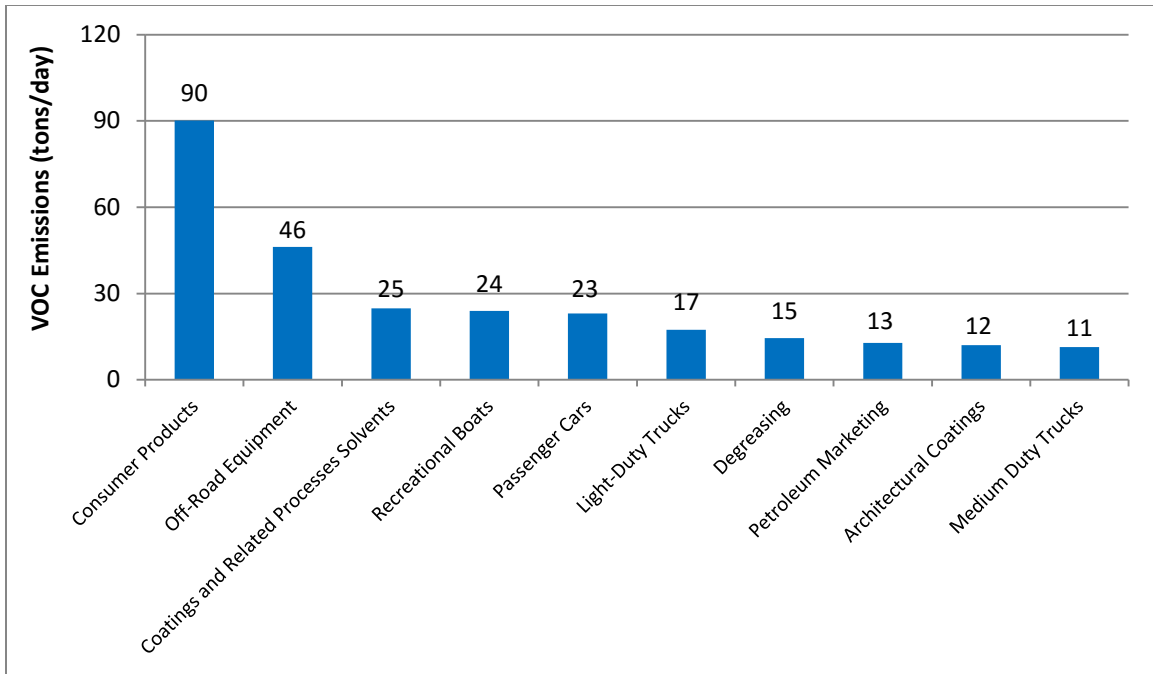


FIGURE 3-10

TOP TEN EMITTER CATEGORIES FOR VOC IN 2023 (SUMMER PLANNING)

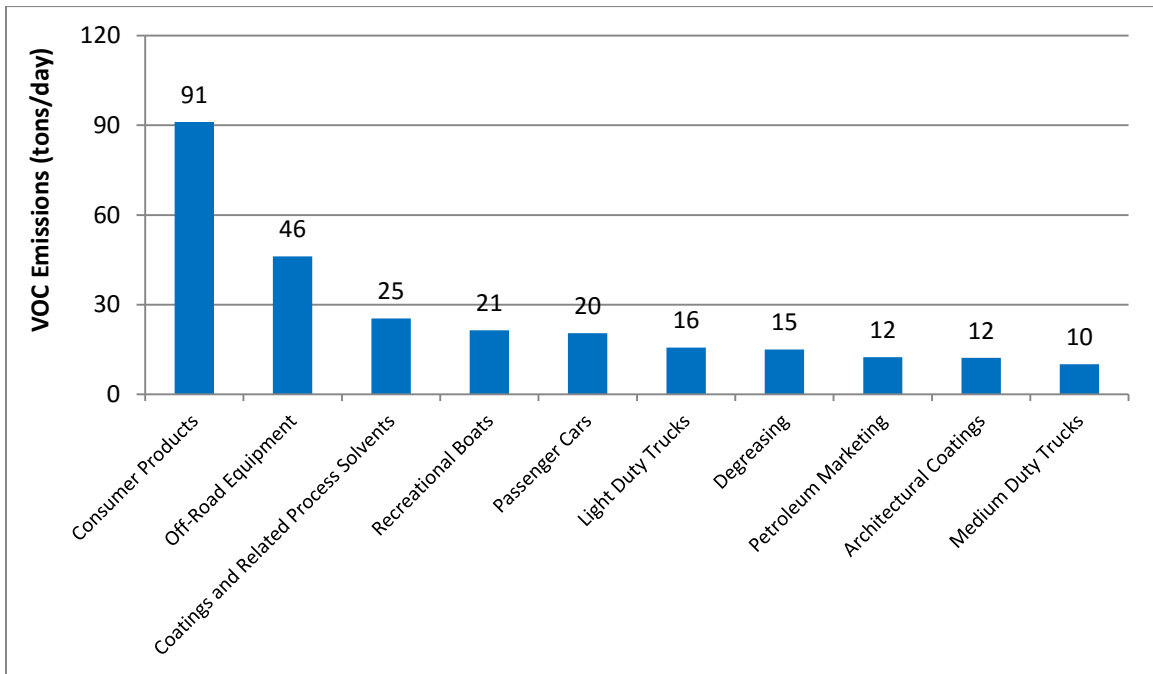


FIGURE 3-11

TOP TEN EMITTER CATEGORIES FOR VOC IN 2025 (SUMMER PLANNING)

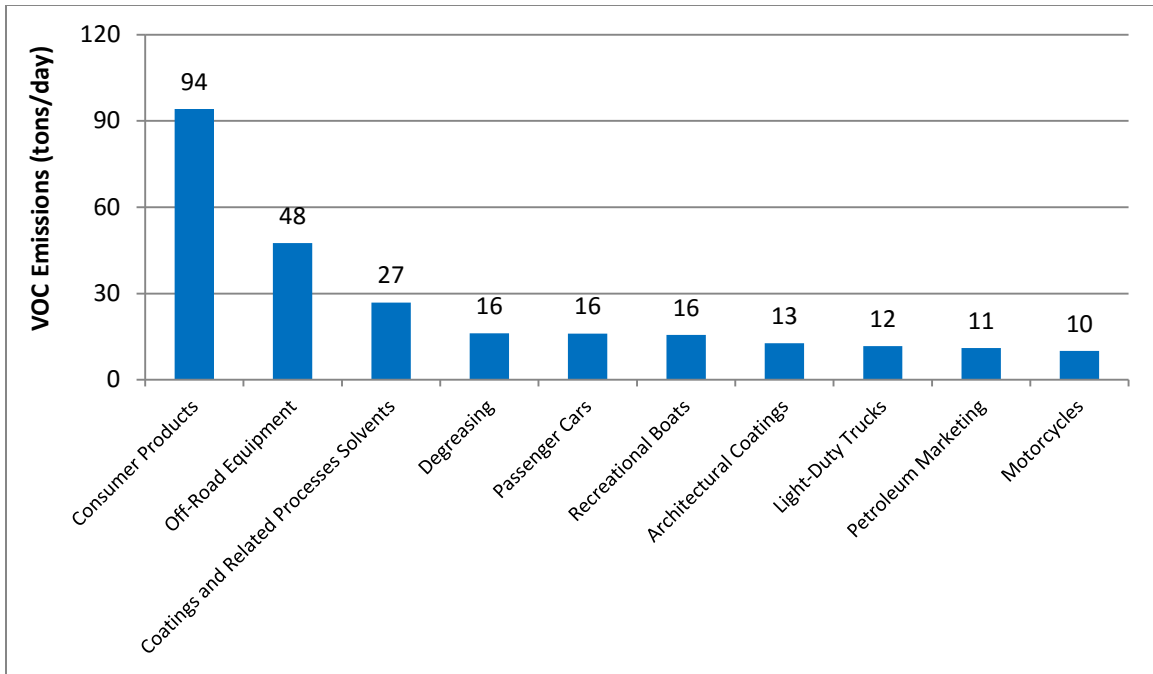


FIGURE 3-12

TOP TEN EMITTER CATEGORIES FOR VOC IN 2031 (SUMMER PLANNING)

Figures 3-13 to 3-18 show the top ten categories for NOx emissions for specific years. Mobile source categories remain the predominant contributor to NOx emissions. Heavy-duty diesel trucks, off-road equipment, and ships and commercial boats are the top three emitters on the list for all six years. NOx RECLAIM and residential fuel combustion are the only non-mobile categories which make it to the top ten list in 2012, but as the mobile source categories clean up due to the implementation of regulations, the number of non-mobile sources appearing in the top 10 categories increases with time, with four non-mobile categories in 2025 and 2031. The top ten categories account for 85 percent of the total NOx inventory in 2012, 84 percent in 2019, 83 percent in 2022, 82 percent in 2023, 83 percent in 2025 and 86 percent in 2031.

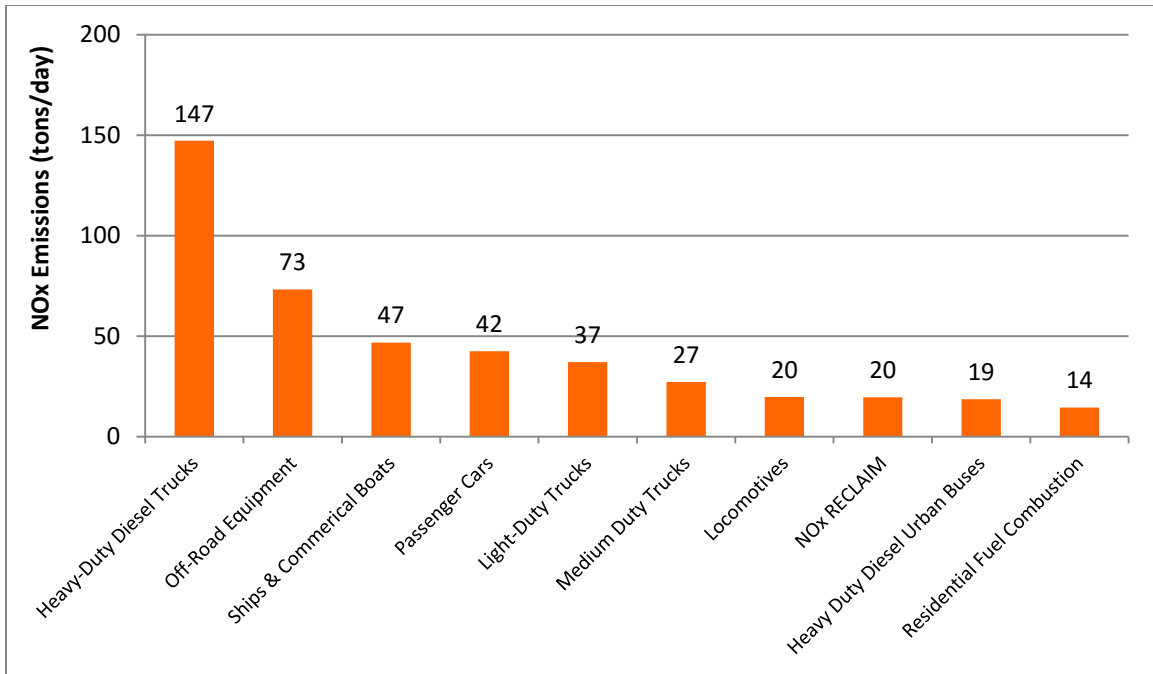


FIGURE 3-13

TOP TEN EMITTER CATEGORIES FOR NOX IN 2012 (SUMMER PLANNING)

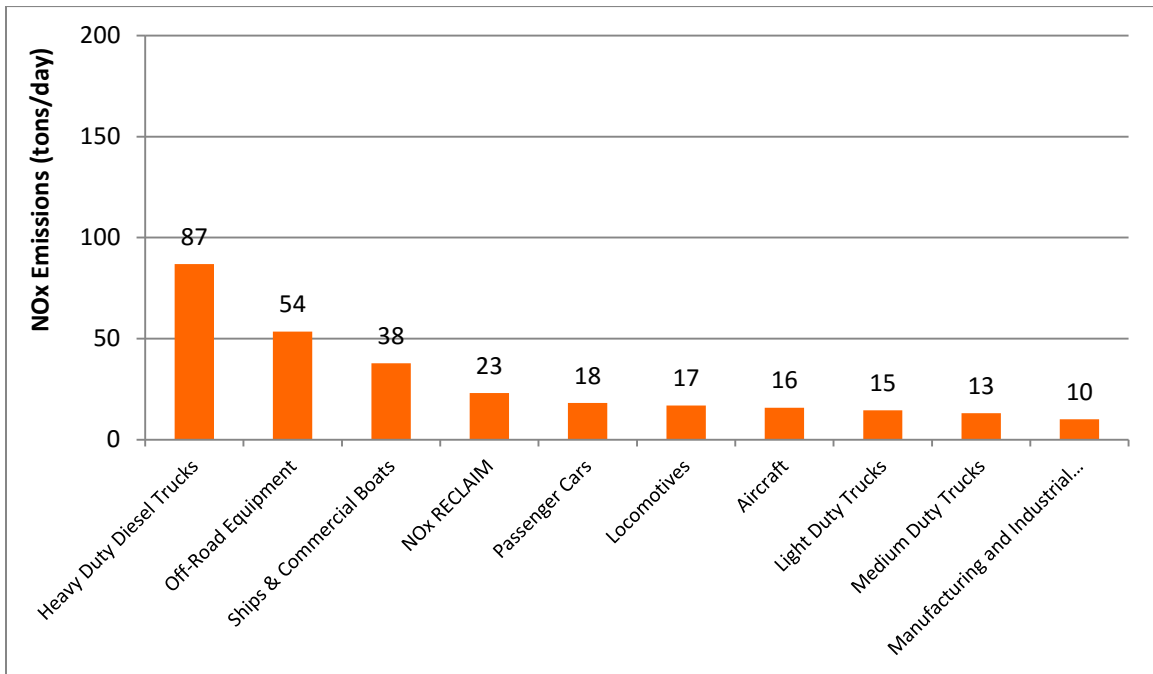


FIGURE 3-14

TOP TEN EMITTER CATEGORIES FOR NOX IN 2019 (SUMMER PLANNING)

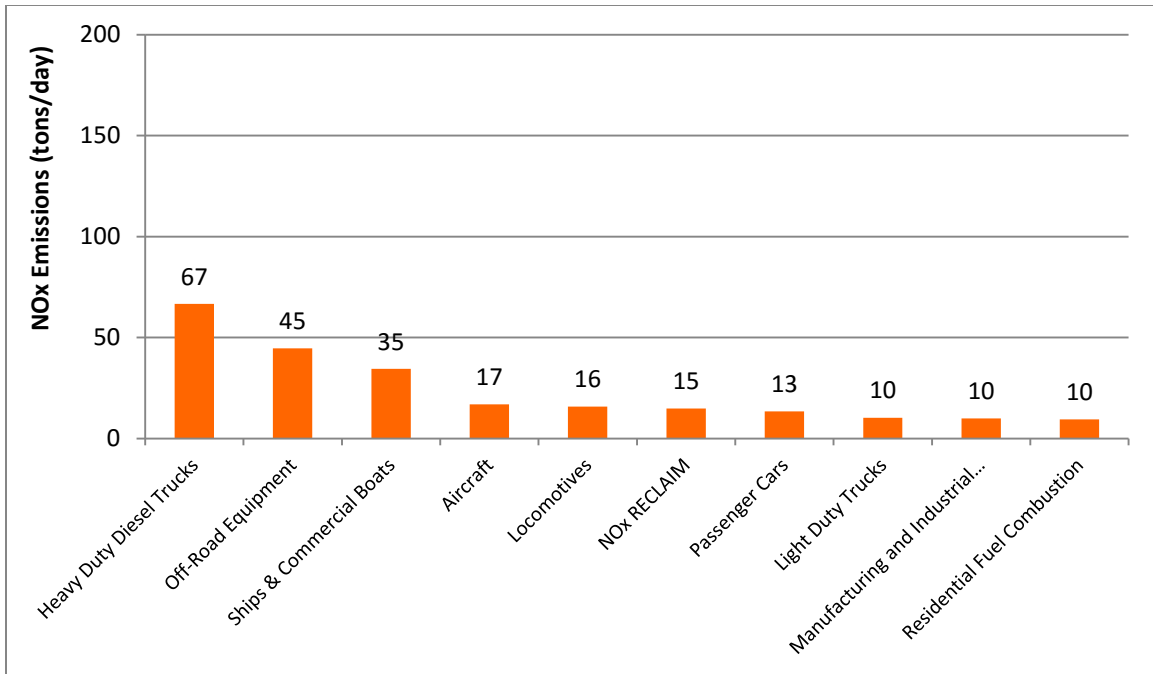


FIGURE 3-15

TOP TEN EMITTER CATEGORIES FOR NOx IN 2022 (SUMMER PLANNING)

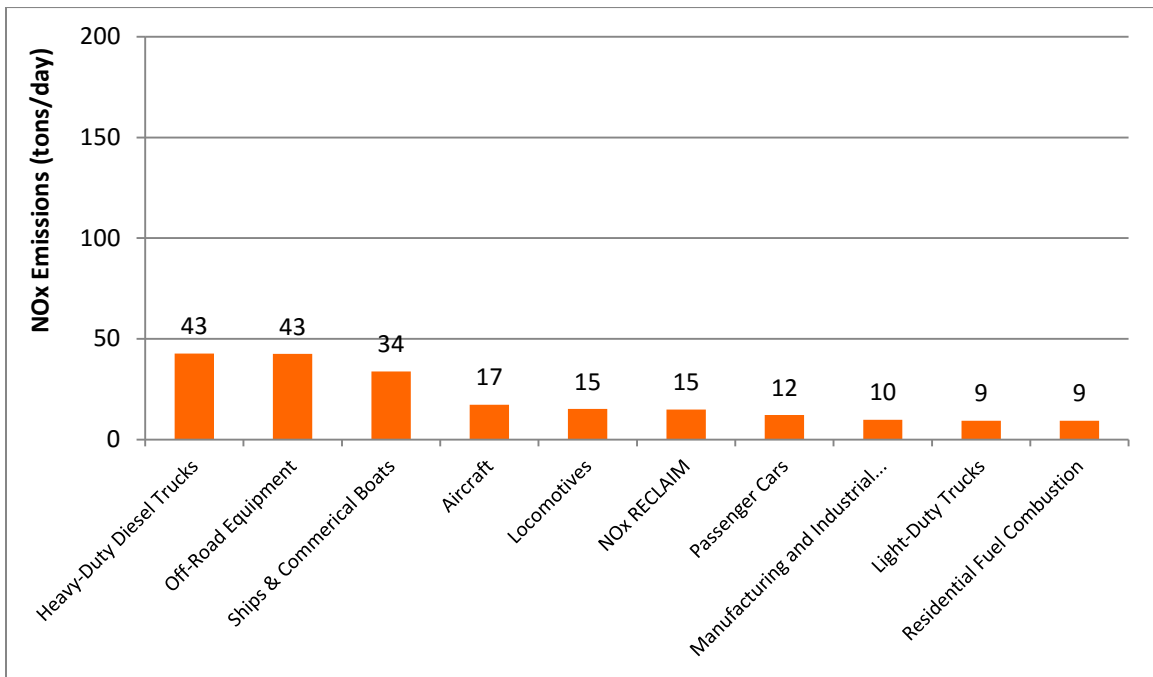


FIGURE 3-16

TOP TEN EMITTER CATEGORIES FOR NOx IN 2023 (SUMMER PLANNING)

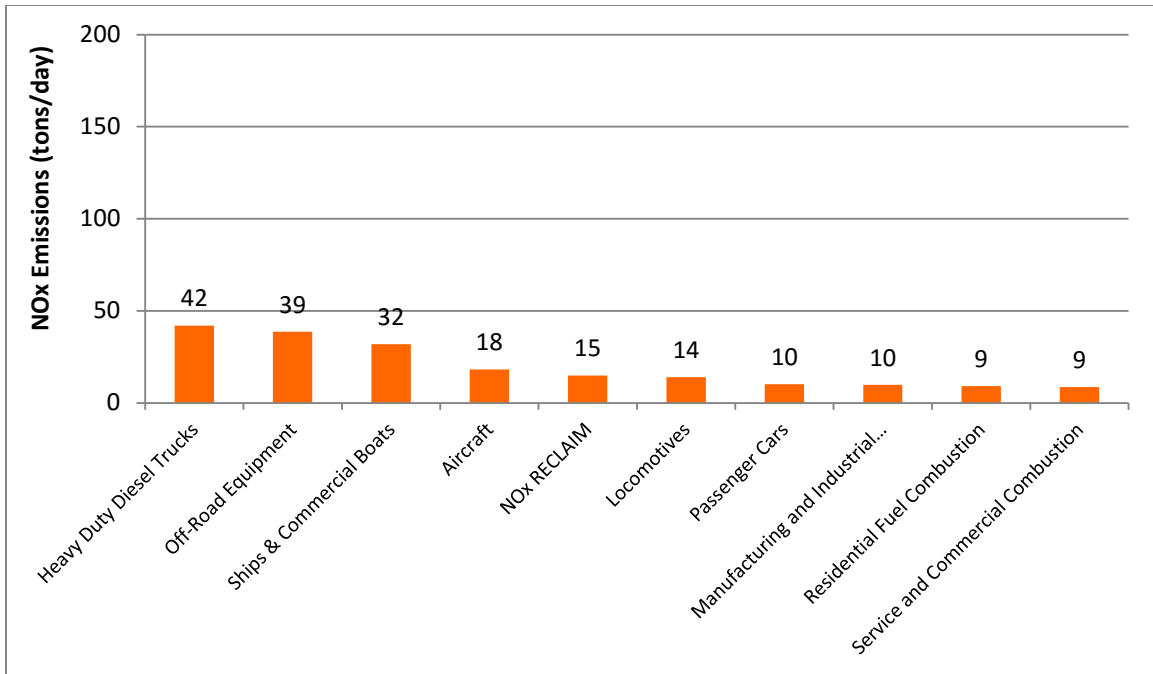


FIGURE 3-17

TOP TEN EMITTER CATEGORIES FOR NOX IN 2025 (SUMMER PLANNING)

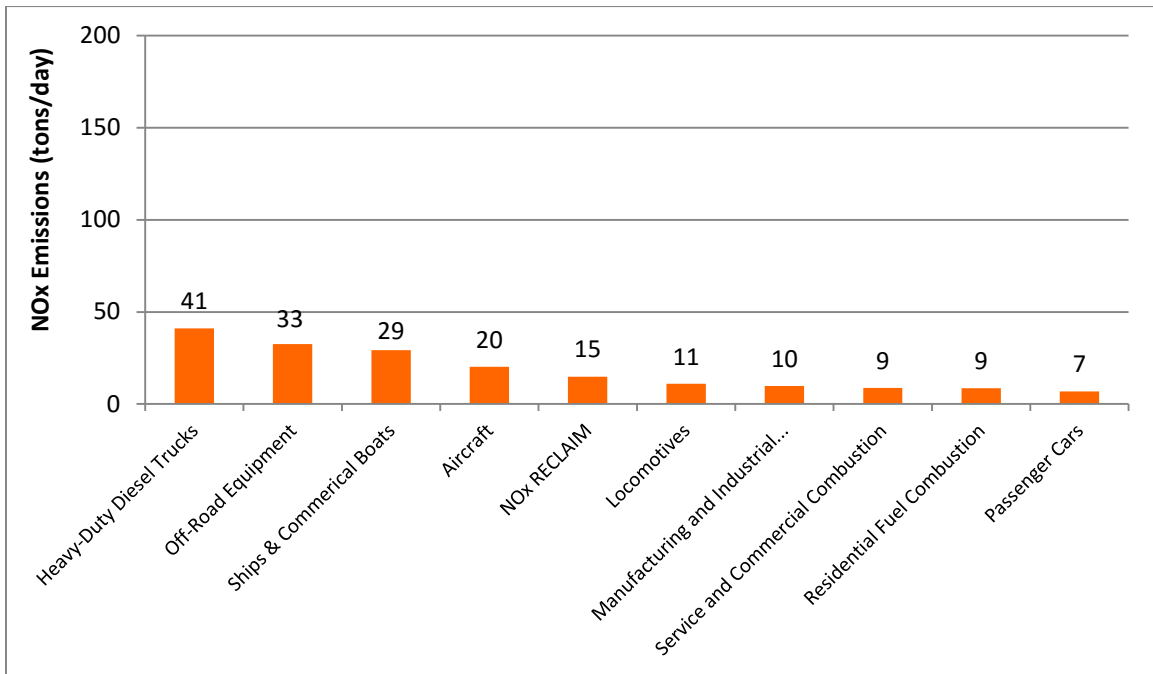


FIGURE 3-18

TOP TEN EMITTER CATEGORIES FOR NOX IN 2031 (SUMMER PLANNING)

Figures 3-19 to 3-23 show the top source categories for SOx emissions in the years 2012, 2019, 2022, 2023, 2025 and 2031. The emission levels of SOx are relatively low. Therefore, only the categories that emit more than 0.5 tons per day of SOx are ranked and listed. The top five high emitting source categories remain the same in all years. SOx RECLAIM and Ships & Commercial Boats are the most significant contributors. The top categories represent 81 percent, 79 percent, 79 percent, 79 percent, 80 percent and 81 percent of the total SOx inventory in 2012, 2019, 2022, 2023, 2025, and 2031, respectively.

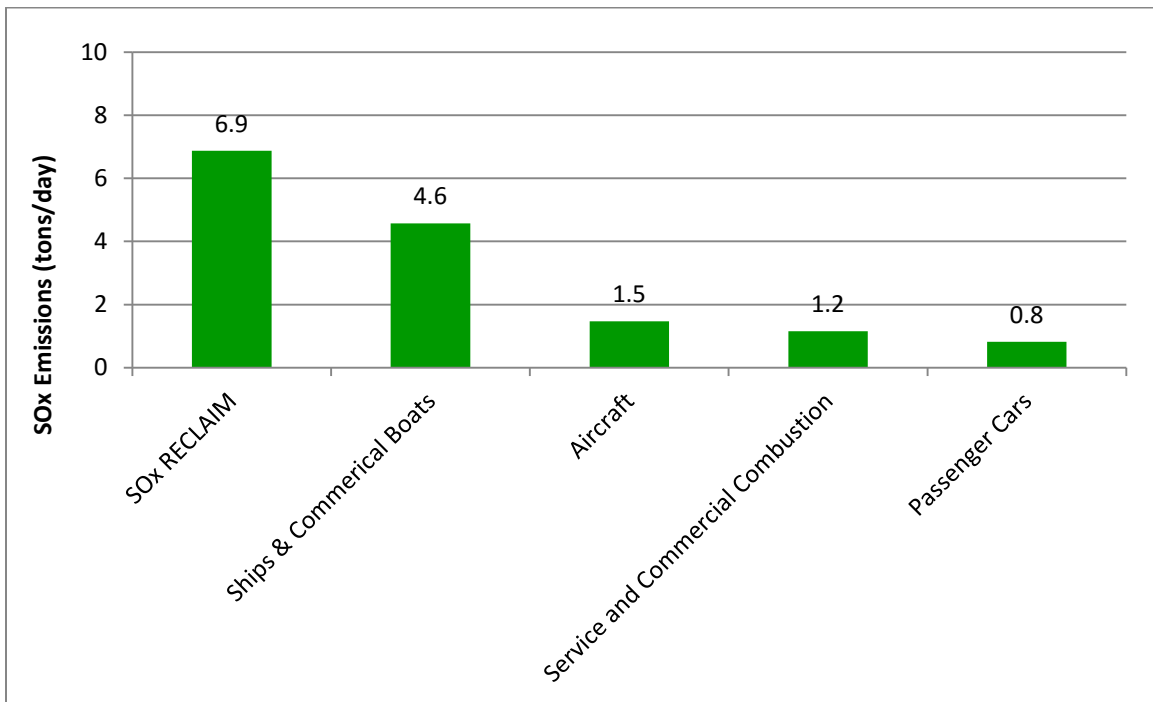


FIGURE 3-19

TOP EMITTER CATEGORIES FOR SOx 0.5 TPD AND OVER IN 2012 (ANNUAL AVERAGE)

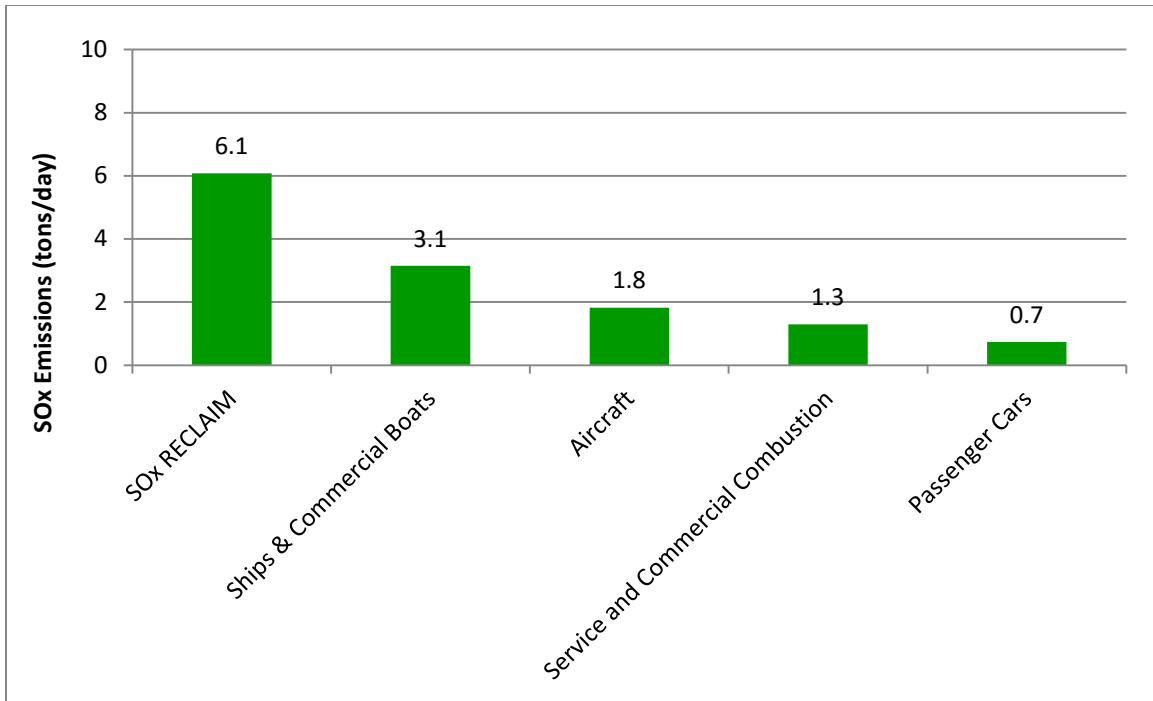


FIGURE 3-20

TOP EMITTER CATEGORIES FOR SOX 0.5 TPD AND OVER IN 2019 (ANNUAL AVERAGE)

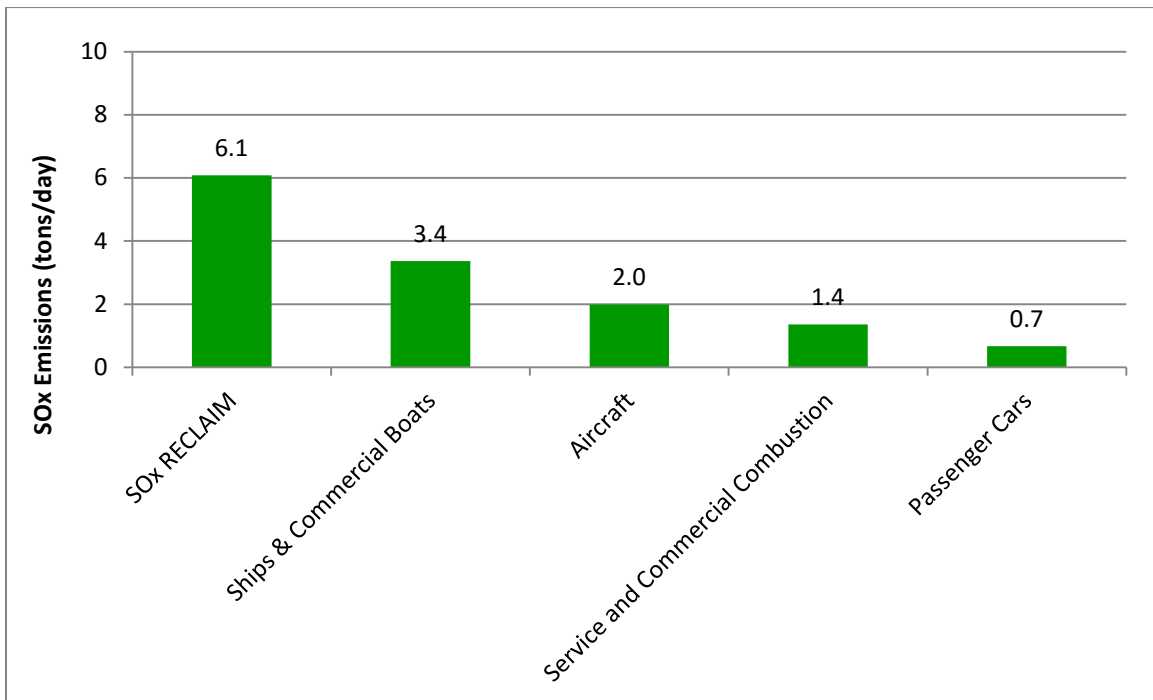


FIGURE 3-21

TOP EMITTER CATEGORIES FOR SOX 0.5 TPD AND OVER IN 2022 (ANNUAL AVERAGE)

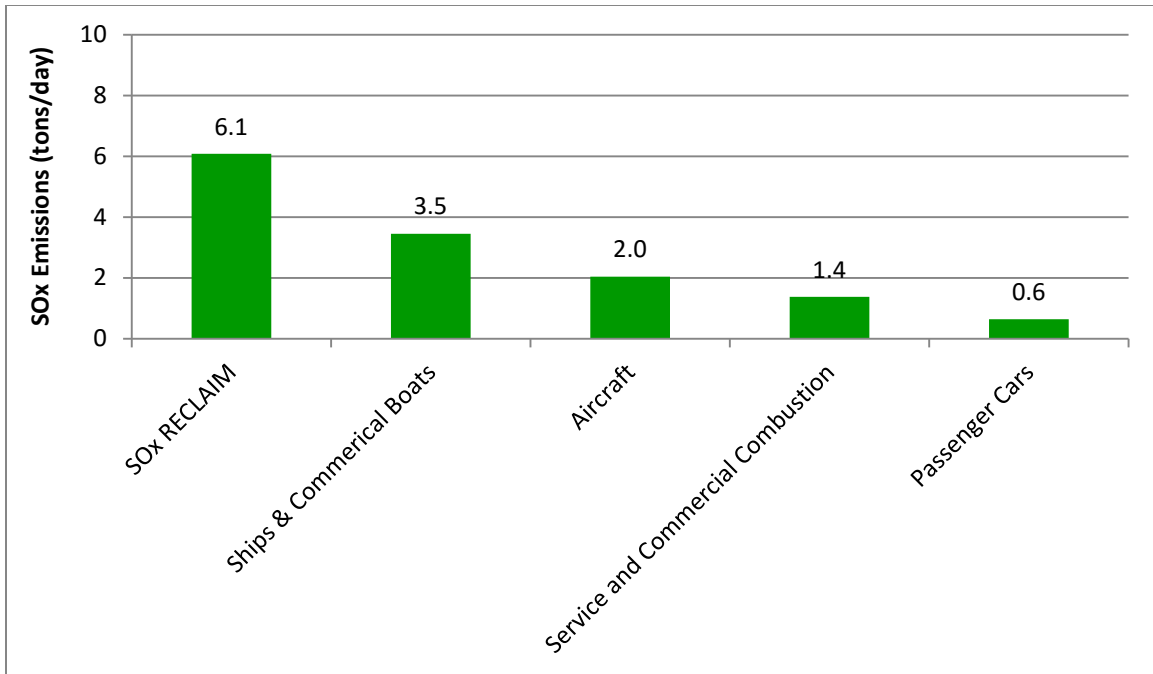


FIGURE 3-22

TOP EMITTER CATEGORIES FOR SOX 0.5 TPD AND OVER IN 2023 (ANNUAL AVERAGE)

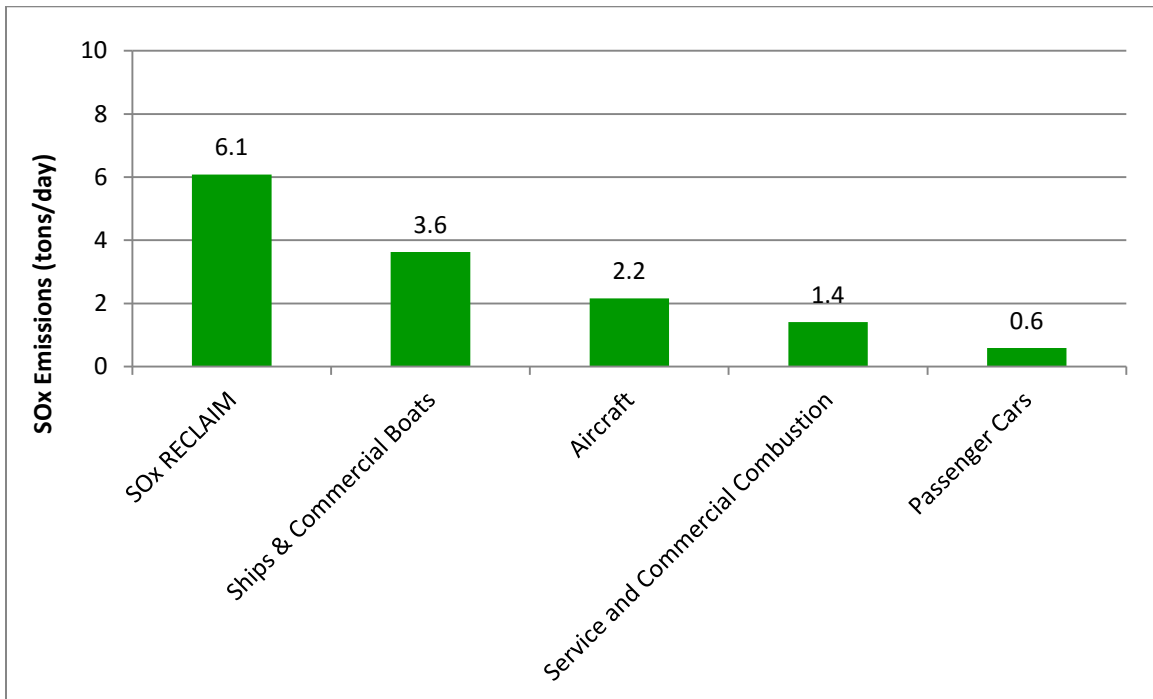


FIGURE 3-23

TOP EMITTER CATEGORIES FOR SOX 0.5 TPD AND OVER IN 2025 (ANNUAL AVERAGE)

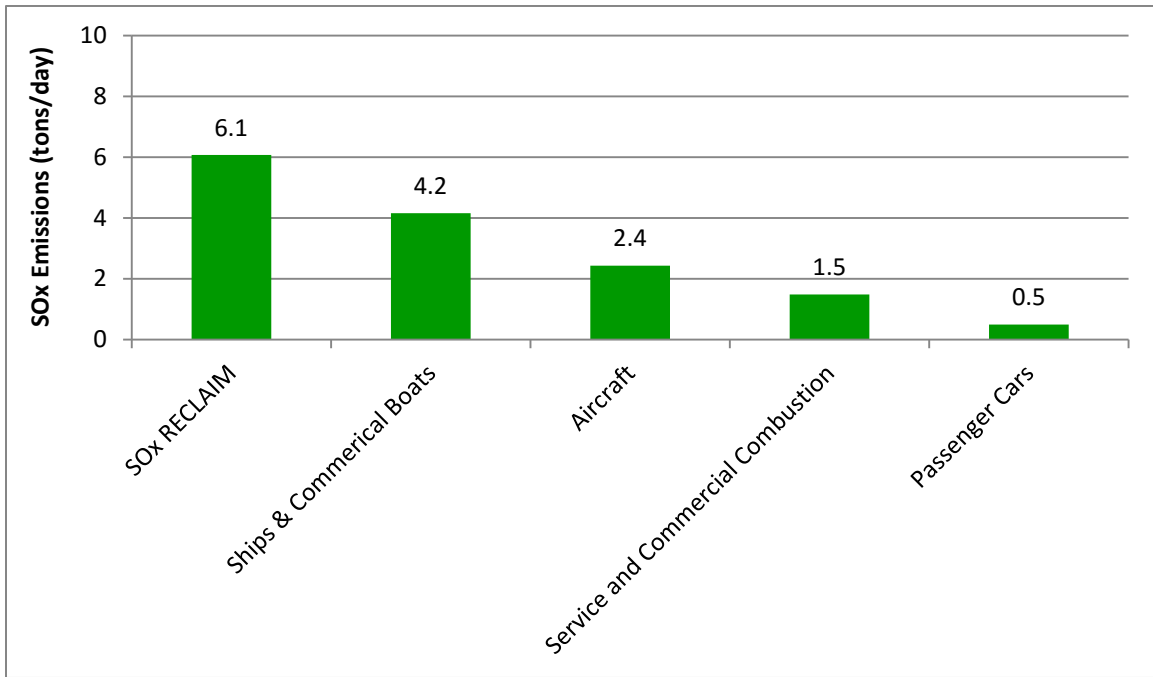


FIGURE 3-24

TOP EMITTER CATEGORIES FOR SOX 0.5 TPD AND OVER IN 2031 (ANNUAL AVERAGE)

Figures 3-25 to 3-30 show the top ten source categories in specific years for directly emitted PM_{2.5}. Commercial cooking, paved road dust, and residential fuel combustion are the top three highest emitting categories for all six years. The top ten categories represent 72 percent of the total directly emitted PM_{2.5} inventory in 2012 and 2019, and 73 percent in 2023 through 2031.

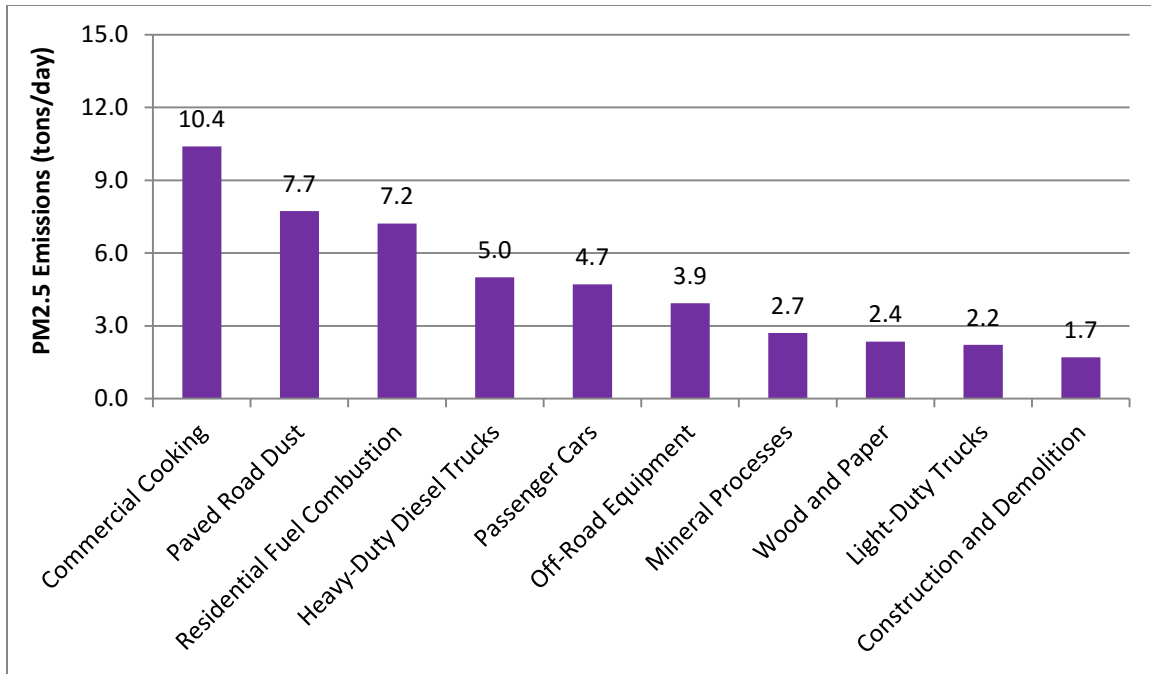


FIGURE 3-25

TOP TEN EMITTER CATEGORIES FOR DIRECTLY EMITTED PM2.5 IN 2012 (ANNUAL AVERAGE)

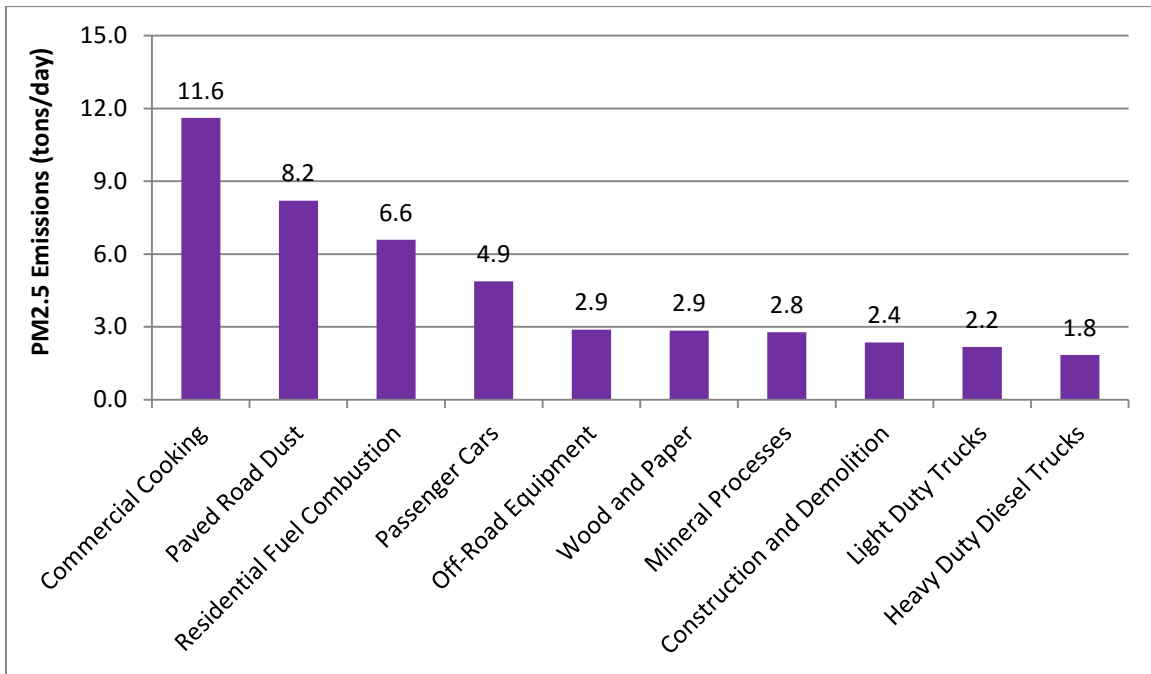


FIGURE 3-26

TOP TEN EMITTER CATEGORIES FOR DIRECTLY EMITTED PM2.5 IN 2019 (ANNUAL AVERAGE)

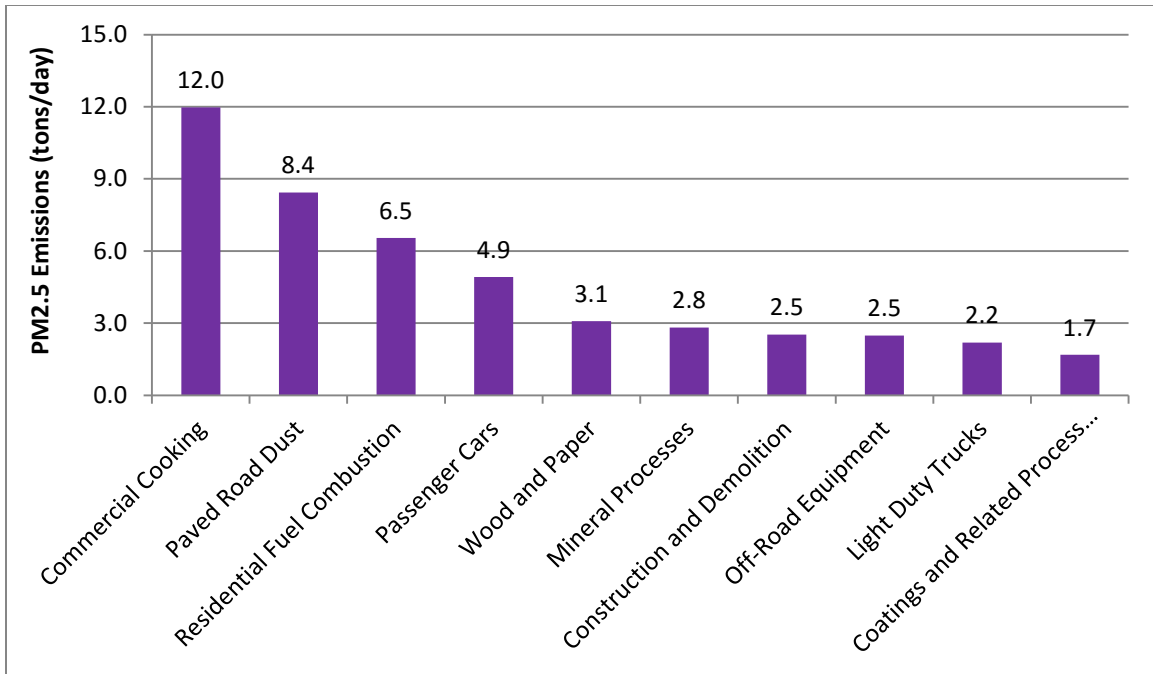


FIGURE 3-27

TOP TEN EMITTER CATEGORIES FOR DIRECTLY EMITTED PM2.5 IN 2022 (ANNUAL AVERAGE)

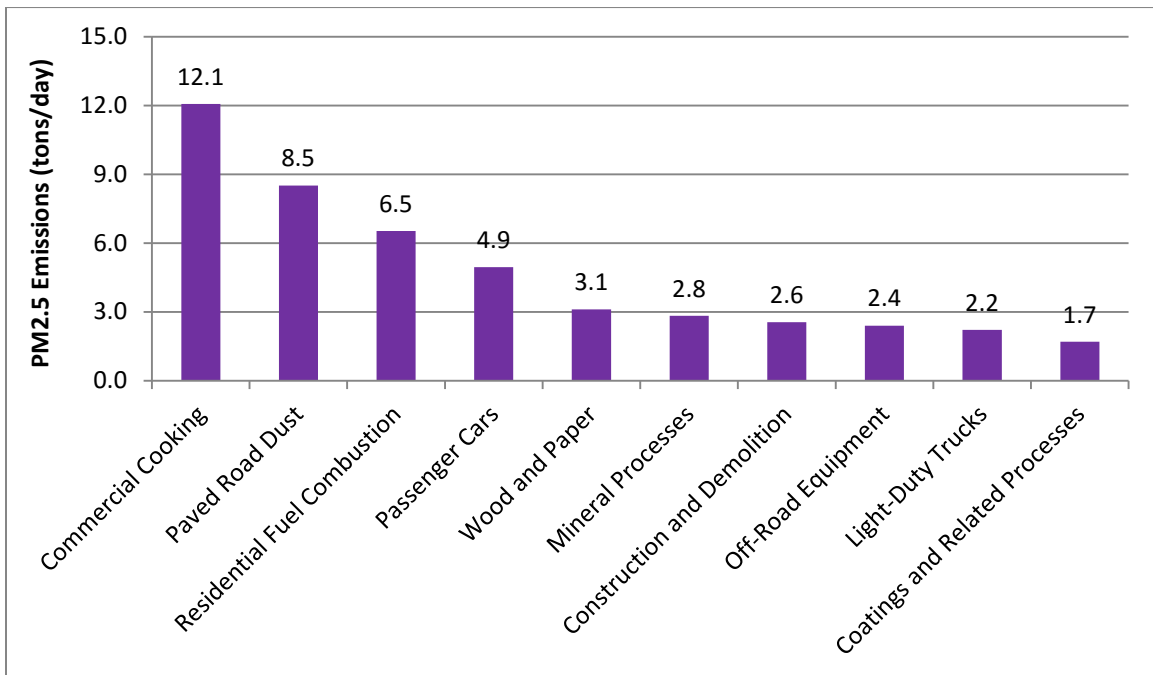


FIGURE 3-28

TOP TEN EMITTER CATEGORIES FOR DIRECTLY EMITTED PM2.5 IN 2023 (ANNUAL AVERAGE)

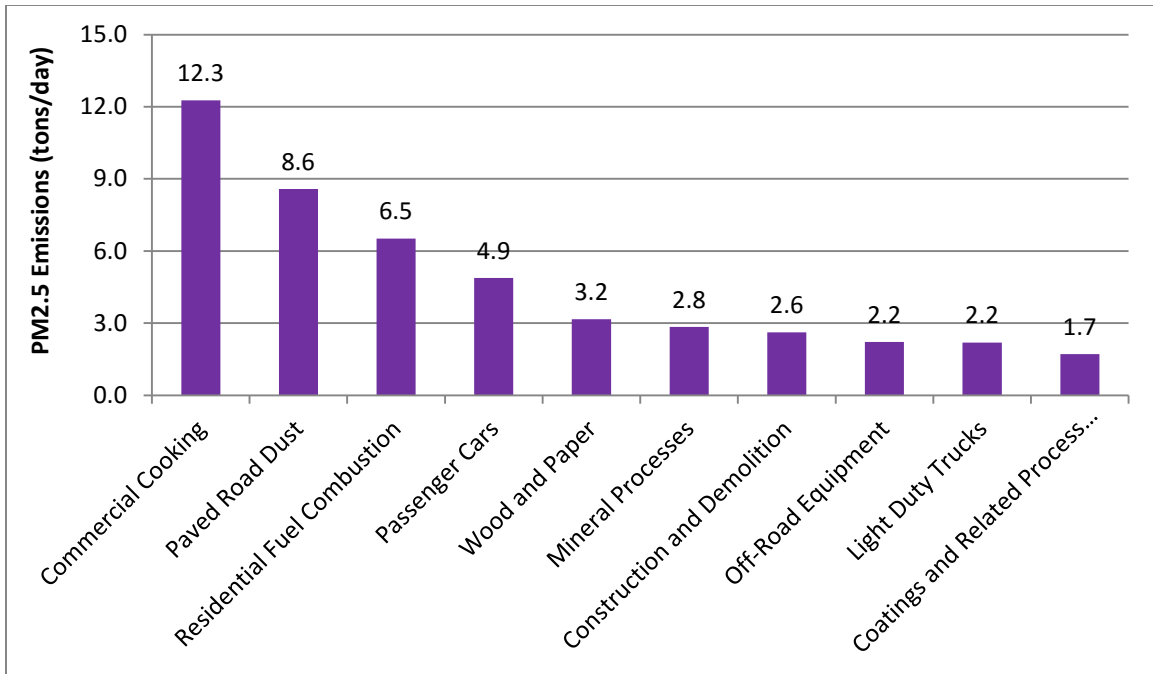


FIGURE 3-29

TOP TEN EMITTER CATEGORIES FOR DIRECTLY EMITTED PM2.5 IN 2025 (ANNUAL AVERAGE)

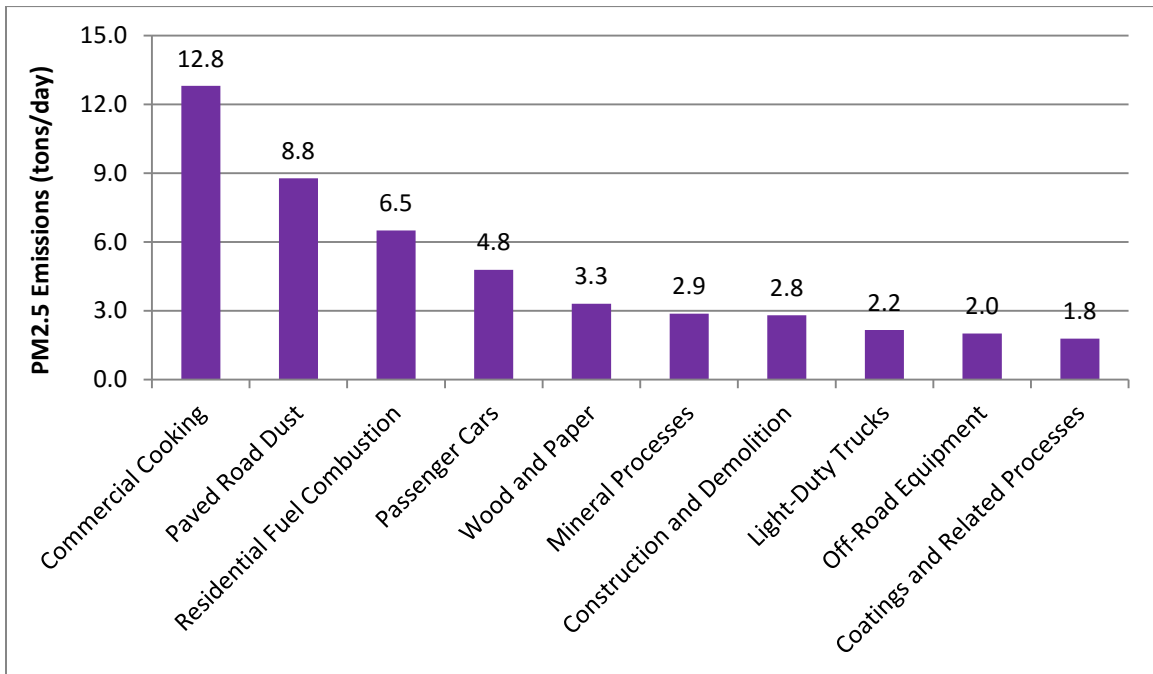


FIGURE 3-30

TOP TEN EMITTER CATEGORIES FOR DIRECTLY EMITTED PM2.5 IN 2031 (ANNUAL AVERAGE)