SOUTH COAST
AIR QUALITY
MANAGEMENT DISTRICT

Passenger Transportation

2016 AQMP WHITE PAPER

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South Coast Air Quality Management District

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Table of Contents

APPENDIX A – CURRENT EMISSIONS CONTROL PROGRAMS

APPENDIX B – POTENTIAL EMISSION REDUCTION TECHNOLOGIES AND EFFICIENCY MEASURES

INTRODUCTION

Purpose and Objective

Despite the significant progress made in reducing emissions that has resulted in substantial improvements in air quality, additional emission reductions will be necessary to attain state and federal ambient air quality standards for ozone and fine particulate matter in the South Coast Air Basin. This white paper is intended to assist the public, stakeholders, and the SCAQMD in understanding key facts and policy issues related to the development of the 2016 South Coast Air Quality Management Plan (AQMP). The paper includes information regarding criteria pollutant emissions that are associated with the passenger transportation sector, which includes (for the purposes of this paper) passenger cars, passenger vans, light-duty trucks, and sport utility vehicles; transit and school buses; passenger locomotives; aircraft; and marine vessels such as cruise ships and ferries.

To illuminate policy choices relevant to the AQMP, the paper describes a number of potential scenarios for reducing emissions from the passenger transportation sector to support attainment of state and federal ozone and particulate matter standards. The emission reduction scenarios highlight emission source categories where emission reductions could potentially be achieved more readily compared to other emission source categories in this sector. In addition, if some emissions source categories are able to go beyond the overall emission reduction target needed for attainment of the air quality standard, the additional reductions would help compensate for other emissions source categories where reductions are more challenging to achieve. The scenarios do not reflect any control strategies or suggest any control approach. As such, this paper does not propose specific rules or other control measures, but provides information to assist in crafting control measures as part of the 2016 AQMP development process. This paper does discuss the potential for achieving additional emission reductions through: greater deployment of cleaner vehicles that have emission levels below the emission standards established in existing state and federal regulations, advanced emission control technologies, use of alternative and renewable fuels, electric power, and the use of operational efficiency measures such as intelligent transportation systems, mode choice, and active transportation.

In a separate effort, the SCAQMD staff has been working with the California Air Resources Board (CARB) and the Southern California Association of Governments (SCAG) to prepare updated emissions inventories for the attainment demonstration of the federal ozone and fine particulate air quality standards. However, the new emission inventories were not available to perform the analyses described above. Therefore, in order to develop this white paper to help illuminate policy choices in the development of the 2016 AQMP, the emission inventories from the 2012 AQMP are used to perform the analyses described above. The initial observations and recommendations in this white paper are relevant regardless if a newer set of emissions inventories are used since the analyses examine the relative differences between the various emissions reduction scenarios since it is not the intent of this white paper to propose specific emissions control levels to meet federal air quality standards. That objective is part of the overall development of the 2016 AQMP.

Document Outline

This white paper provides background information on the base year and future year volatile organic compounds (VOC) and oxides of nitrogen (NOx) emissions inventories associated with the various passenger transportation emissions source categories. The following sections present brief descriptions of the current regional passenger system, associated air quality impacts, emission reduction progress, attainment challenges, and connections to climate change programs. Emission reduction scenario analyses were conducted to examine the range of emission reductions needed for each source category to help meet the ozone air quality standards by 2023 and 2032. The results of the scenario analysis are presented with an initial assessment of the issues and questions raised from the analysis. In addition, operational efficiencies and alternative mobility choices are discussed. Finally, recommendations are provided to help frame the discussions in the development of the 2016 AQMP.

A discussion of current regulatory programs and other planning efforts is provided in Appendix A. Information on potential emission reduction technologies and efficiency measures is discussed in Appendix B.

BACKGROUND

The South Coast Air Quality Management District (SCAQMD or District) consists of an area of approximately 10,743 square miles consisting of the South Coast Air Basin, and the Riverside County portions of the Salton Sea Air Basin (SSAB) known as the Coachella Valley Planning Area. The South Coast Air Basin, which is a subregion of the District's jurisdiction, is bounded by the Pacific Ocean to the west and the San Gabriel, San Bernardino, and San Jacinto mountains to the north and east. It includes all of Orange County and the non-desert portions of Los Angeles, Riverside, and San Bernardino Counties. The region is inhabited by more than 16 million people, representing about half of California's population. In addition, the SCAQMD region is projected to grow to approximately 18 million people by 2030, and this growth is expected to occur primarily in Riverside and San Bernardino Counties. This situation is expected to lead to a greater imbalance of jobs and housing in the region, increasing transportation mobility and air quality challenges because of increased travel demand requirements. [1]

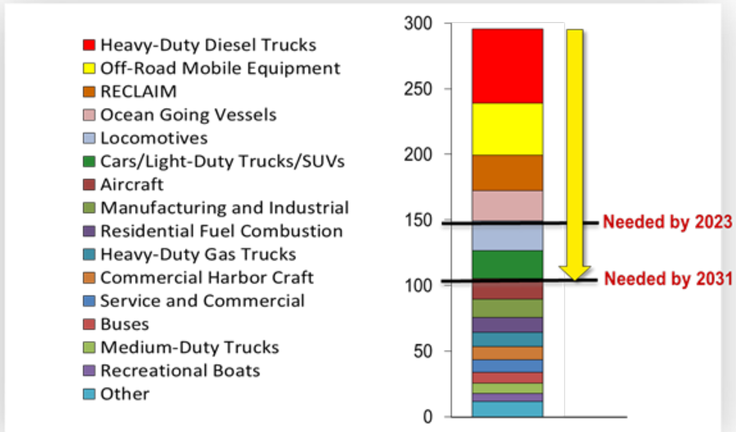
The SCAQMD region includes approximately 21,000 miles of highways and arterials, 450 miles of passenger rail, and six commercial airports. It is estimated that about 90 percent of trips in the SCAQMD make use of the highway and arterial system, utilizing various transportation modes including automobile, public transit, and active transportation (e.g., bicycling on arterial streets).[2]

Attainment Challenge

Meeting national ambient air quality standards for ozone and fine particulate matter will require additional NOx emission reductions in the South Coast Air Basin. Meeting state standards will be even more challenging. Preliminary ozone air quality analysis currently underway in the development of the 2016 AQMP indicates that NOx emissions will need to be reduced by approximately 50% in 2023 and 65% in 2031 (beyond projected 2023 baseline emissions). Note that the percentages will likely change slightly as the emission inventories are updated with more recent economic and demographic forecast information from the Southern California Association of Governments (SCAG) as part of the development of the 2016 AQMP. Figure 1 shows graphically the overall NOx emission reductions needed to attain the 8-hour ozone air quality standards in 2023 and 2031 and the major NOx emission sources contributing to the ozone air quality problem. This is especially challenging given that among the largest contributors to NOx emissions are mobile sources that are primarily regulated by the state and/or federal governments. Since many mobile sources have already achieved over a 90% reduction in NOx emissions, attainment of the ozone standards will require wide-scale deployment of not only new vehicles meeting the tightest tailpipe emissions standards, but also commercialization and deployment of technologies that achieve zero or near-zero emissions.

[1] 2012-2035 Regional Transportation Plan, Southern California Association of Governments, April 2012

[2] *Ibid.*



(Source: Preliminary Draft 2023 Baseline NOx Emissions Inventory, July 2015)

FIGURE 1

Needed NOx Emission Reductions to Achieve
Federal 8-Hour Ozone Ambient Air Quality Standards

Climate Challenge

The SCAQMD Governing Board (Board) has recognized the nexus between technologies that minimize climate impacts and technologies that reduce criteria pollutant emissions, since many of the same technologies simultaneously address both of these challenges. As such, the SCAQMD Governing Board has developed policies and guiding principles which include the coordinated development of criteria air pollutant strategies that have co-benefits in reducing greenhouse gas emissions, to make the most efficient use of limited resources and the time needed to deploy the necessary cleaner technologies. In September 2011, the Board adopted the SCAQMD Air Quality-Related Energy Policy. This policy was developed to integrate air quality, energy issues, and climate change in a coordinated manner. Various policies and actions were identified as part of this effort, some of which would specifically target passenger transportation emission sources. These include policies to promote zero- and near-zero emission technologies to the fullest extent feasible. Action items include studies to identify measures that reduce emissions from the passenger transportation sector, including incentivizing the early introduction of zero- and near-zero emission vehicles and identification of potential new funding mechanisms to support widespread penetration of such technologies within the transportation sector.

Clearly, aggressive and coordinated technology development and deployment efforts are needed in the transportation sector over the next 10 to 20 years to meet ozone ambient air quality standards in 2023 and 2032, as well as greenhouse gas reduction goals between 2020 and 2050. To this end, in 2012, the SCAQMD, California Air Resources Board (CARB), and San Joaquin Valley Unified Air Pollution Control District jointly prepared a document titled: "Vision for Clean Air: A Framework for Air Quality and Climate Planning." This document evaluated various technology scenarios in the transportation sector that provide direction on future control strategies to concurrently achieve criteria pollutant standards and climate change goals. Major conclusions from that effort are that significant changes in transportation technologies are needed to more widely deploy hybrid and electric vehicles as well as increased renewable sources of energy for electricity production.

PASSENGER TRANSPORTATION EMISSIONS SOURCE CATEGORIES

Tables 1 and 2 provide a list of passenger transportation emissions source categories for the discussion purposes of this white paper. The on-road emissions source categories shown in Table 1 include light-duty vehicles up to 5,750 lbs GVWR (gross vehicle weight rating), medium-duty vehicles (5,751 to 8,500 lbs GVWR), and heavy-duty vehicles with gross vehicle weight ratings greater than 8,500 lbs. Examples of light-duty vehicles include passenger cars, light-duty trucks, sport utility vehicles, and minivans. Medium-duty vehicles include heavier pickup trucks and passenger and cargo vans. Heavy-duty vehicles include passenger shuttles, transit buses, school buses, and motor homes. In addition to the vehicles listed above, motorcycles are included in the passenger transportation sector. To provide greater insight into the emissions contributions of each source category, the emissions are further disaggregated by weight category. For example, light-duty trucks are separated into two categories: LDT1 (up to 3,750 lbs GVWR) and LDT2 (3,751 to 5,750 lbs GVWR).

TABLE 1

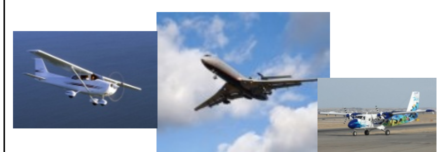
On-Road Transportation Categories

Description/ Weight Class (lbs)	
Passenger Car/Light Duty Automobile (LDA)	
Light-Duty Trucks 1 (LDT-1) (Up to 3,750)	
Light-Duty Trucks 2 (LDT-2) (3,751 – 5,750)	
Medium-Duty Vehicles (MDV) (5,751 – 8,500)	
Motorcycles (MCY)	
School Buses (SBUS)	
Urban Buses (UBUS)	
Other Buses (OBUS)	
Motor Homes (MH)	

Table 2 shows the various off-road emissions source categories that are part of the passenger transportation sector. These categories include passenger rail, passenger and excursion ferries, cruise ships, and commercial and general aviation aircraft.

TABLE 2

Off-Road Transportation Categories

Description	
Ocean-Going Vessels (Cruise Ships)	
Commercial Harbor Craft (Ferries and Excursion Vessels)	
Commuter Rail (Passenger Locomotives)	
Aircraft (Commercial and General Aviation)	

Air Quality Impacts of Passenger Transportation Sources

The adoption and implementation of control strategies specific to the passenger transportation sector have resulted in significant emissions reductions. However, additional emission reductions are needed in order to achieve federal ambient air quality standards for ozone and fine particulate matter. A discussion of the current regulatory programs and other planning efforts in the passenger transportation sector is provided in Appendix A.

NOTE: For the purposes of this white paper, the emissions inventories provided in this section and the subsequent sections are from the 2012 AQMP. The 2016 AQMP will contain updated emission inventories for use in demonstrating attainment of the federal ozone and fine particulate air quality standards.

Figures 2 and 3 show the VOC and NOx emissions in tons/day from the passenger transportation sector and their contribution to the total emissions for 2014, 2023, and 2032. For 2014, passenger transportation sources contribute approximately 23 and 28% of the South Coast Air Basin's VOC and NOx emissions inventory. The percent contribution from passenger transportation sources to total VOC and NOx emissions in 2032 are 11 and 21%, respectively.

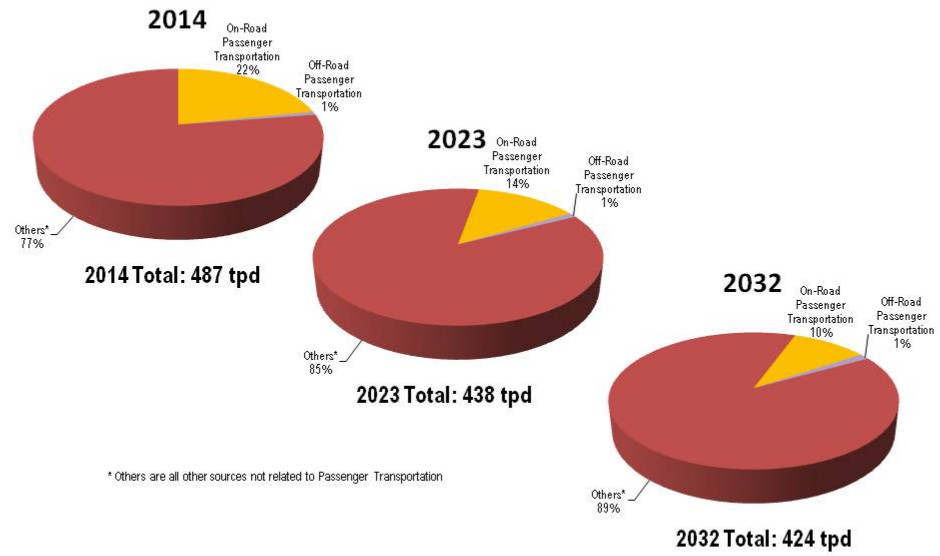


FIGURE 2

Passenger Transportation Sector VOC Emissions Contribution to the Total VOC Emissions for 2014, 2023, and 2032 (Source: 2012 AQMP)

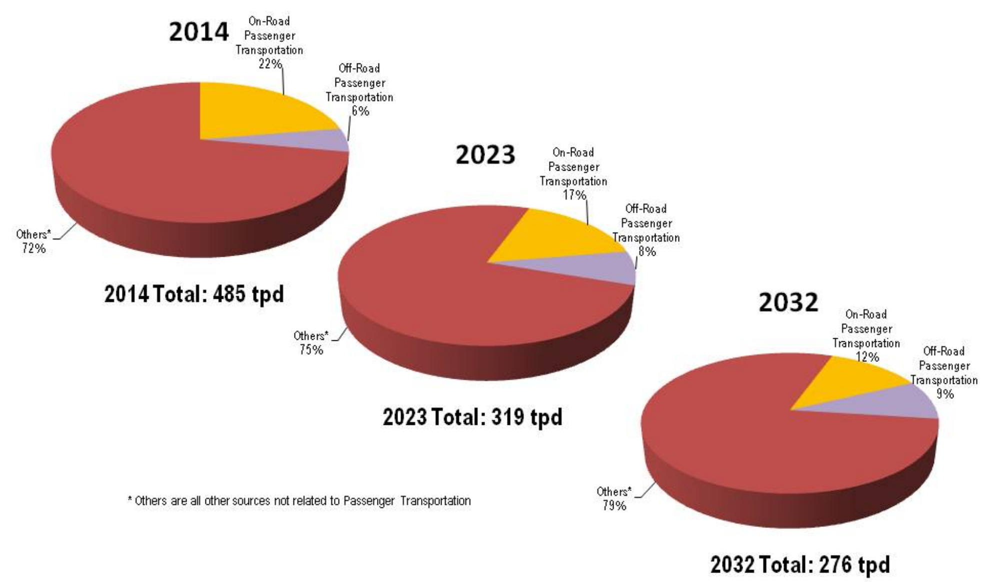


FIGURE 3

Passenger Transportation Sector NOx Emissions Contribution to the Total NOx Emissions for 2014, 2023, and 2032 (Source: 2012 AQMP)

Tables 3, 4, and 5 provide VOC and NOx emissions for the various emissions source categories in the passenger transportation sector for calendar years 2014, 2023, and 2032, respectively. In addition, the vehicle population and vehicle miles travelled are provided.

TABLE 3

VOC and NOx Emissions from On-Road Mobile Sources in the Passenger Transportation Sector for Calendar Year 2014 (Source: 2012 AQMP)

Source Category	Population	VMT (miles/day)	VOC (tons/day)	NOx (tons/day)
Light Duty Passenger	5,728,985	202,036,463	44.63	31.00
Light Duty Trucks-1 (up to 3750 lb.)	670,990	23,667,541	13.61	9.02
Light Duty Trucks-2 (3751 to 5750 lb.)	1,873,658	70,389,181	19.24	20.33
Medium Duty Trucks (5751-8500 lb.)	1,545,179	54,982,815	19.71	23.84
Heavy Duty Diesel Urban Buses	7,114	762,389	0.5	12.67
Heavy Duty Gas Urban Buses	1,787	191,845	0.32	0.67
School Buses - Gas	1,510	54,279	0.08	0.12
School Buses - Diesel	4,643	172,951	0.04	2.15
Other Buses - Gas	7,024	290,381	0.36	0.86
Other Buses - Diesel	5,499	435,008	0.13	4.21
Motor Homes	70,444	782,786	0.19	1.47
Motorcycles	222,597	1,627,281	7.29	2.06
Total	**10,139,428**	**355,392,919**	**106.10**	**108.40**

TABLE 4

VOC and NOx Emissions from On-Road Mobile Sources in the Passenger Transportation Sector for Calendar Year 2023 (Source: 2012 AQMP)

Source Category	Population	VMT (miles/day)	VOC (tons/day)	NOx (tons/day)
Light Duty Passenger	6,045,577	202,227,892	18.24	12.34
Light Duty Trucks-1 (up to 3750 lb.)	716,203	24,037,227	7.83	4.33
Light Duty Trucks-2 (3751 to 5750 lb.)	2,036,593	73,251,629	10.91	7.66
Medium Duty Trucks (5751-8500 lb.)	1,703,888	56,678,252	14.93	11.92
Heavy Duty Diesel Urban Buses	7,613	815,970	0.43	10.43
Heavy Duty Gas Urban Buses	1,958	210,257	0.3	0.61
School Buses - Gas	1,683	60,450	0.04	0.07
School Buses - Diesel	4,770	170,017	0.04	1.73
Other Buses - Gas	7,417	277,729	0.28	0.5
Other Buses - Diesel	6,444	528,964	0.1	0.94
Motor Homes	83,646	948,629	0.07	0.97
Motorcycles	239,153	1,734,034	6.58	2.03
Total	**10,854,946**	**360,941,049**	**59.75**	**53.53**

TABLE 5

VOC and NOx Emissions from On-Road Mobile Sources in the Passenger Transportation Sector for Calendar Year 2032 (Source: 2012 AQMP)

Source Category	Population	VMT (miles/day)	VOC (tons/day)	NOx (tons/day)
Light Duty Passenger	6,198,902	208,469,240	8.88	6.83
Light Duty Trucks-1 (up to 3750 lb.)	774,282	26,511,038	4.69	1.91
Light Duty Trucks-2 (3751 to 5750 lb.)	2,220,575	80,214,386	8.51	4.48
Medium Duty Trucks (5751-8500 lb.)	1,881,310	62,155,336	12.43	6.82
Heavy Duty Diesel Urban Buses	8,234	882,829	0.35	7.85
Heavy Duty Gas Urban Buses	2,159	231,860	0.13	0.54
School Buses - Gas	1,890	67,874	0.02	0.05
School Buses - Diesel	4,808	165,524	0.05	1.07
Other Buses - Gas	7,924	297,772	0.26	0.37
Other Buses - Diesel	7,365	618,352	0.12	1.15
Motor Homes	113,494	1,308,532	0.05	0.92
Motorcycles	242,094	1,732,796	6.85	2.07
Total	**11,463,038**	**382,655,538**	**42.34**	**34.06**

Tables 6 through 8 show the VOC and NOx emissions associated with the off-road emissions source categories in the passenger transportation sector for 2014, 2023, and 2032, respectively.

TABLE 6

VOC and NOx Emissions from Off-Road Mobile Sources in the Passenger Transportation Sector for Calendar Year 2014 (Source: 2012 AQMP)

Source Category	VOC (tons/day)	NOx (tons/day)
Ocean-Going Vessels (Cruise Ships)	0.22	5.91
Passenger Locomotives	0.21	4.46
Harbor Craft (Ferries and Excursion Vessels)	0.42	4.09
Aircraft (Excluding Air Cargo Transport)	3.05	12.13
Total	**3.90**	**26.59**

TABLE 7

VOC and NOx Emissions from Off-Road Mobile Sources in the Passenger Transportation Sector for Calendar Year 2023 (Source: 2012 AQMP)

Source Category	VOC (tons/day)	NOx (tons/day)
Ocean-Going Vessels (Cruise Ships)	0.24	3.54
Passenger Locomotives	0.26	4.46
Harbor Craft (Ferries and Excursion Vessels)	0.43	3.32
Aircraft (Excluding Air Cargo Transport)	3.93	13.59
Total	**4.86**	**24.92**

TABLE 8

VOC and NOx Emissions from Off-Road Mobile Sources in the Passenger Transportation Sector for Calendar Year 2032 (Source: 2012 AQMP)

Source Category	VOC (tons/day)	NOx (tons/day)
Ocean-Going Vessels (Cruise Ships)	0.38	2.15
Passenger Locomotives	0.27	4.92
Harbor Craft (Ferries and Excursion Vessels)	0.43	3.30
Aircraft (Excluding Air Cargo Transport)	4.62	14.74
Total	**5.70**	**25.11**

Emissions Reduction Progress to Date

The following sections describe the historic emission trends from the on-road and off-road passenger transportation sources.

On-Road Passenger Transportation Emission Sources

As shown in Figure 4, on-road passenger transportation source emissions of VOC, NOx, and PM have experienced reductions ranging from 84 percent to 88 percent from 1990 levels. These reductions have primarily relied upon development and commercialization of technologies that control emissions from internal combustion engines.

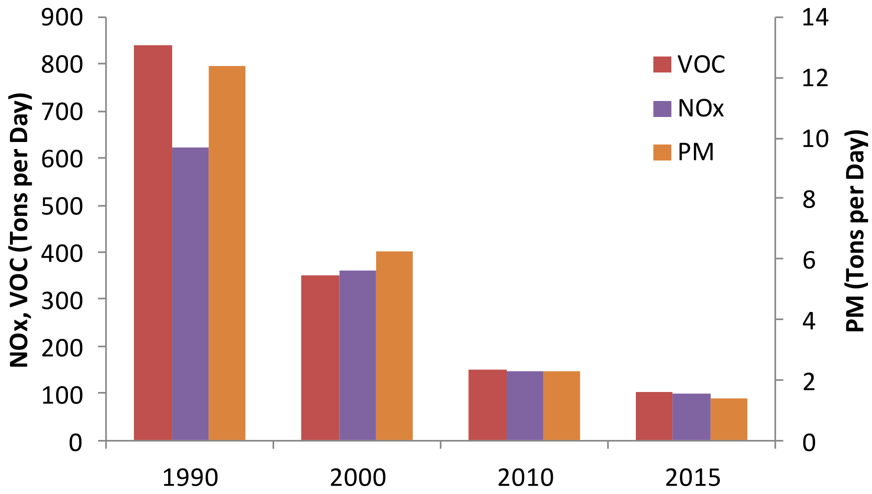


FIGURE 4

On-Road Passenger Transportation Sources
(Source: EMFAC2011 with Vehicle Miles Traveled Information from the 2012 AQMP)

NOx and VOC emissions from on-road passenger transportation emission sources provided in Tables 3, 4, and 5 are shown graphically in Figures 5 and 6 for 2014, 2023, and 2032 calendar years to illustrate the projected trend in emissions due to the impact of regulatory programs for specific sources of emissions in the passenger transportation sector. Regulatory programs include a combination of command and control programs, such as more stringent emission standards applicable to original equipment manufacturers and in-use compliance programs applicable to vehicle/fleet owners, as well as monetary incentive programs that promote the market penetration of lower-emitting vehicles. These emission reductions have occurred despite the general increase in the population of passenger transportation emission sources over time, as illustrated in Figure 7.

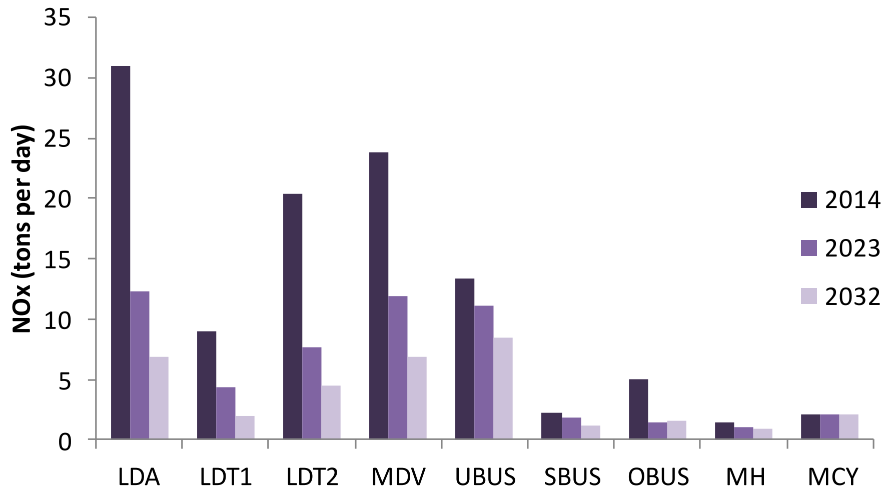


FIGURE 5

NOx Emissions for Specific On-Road Passenger Transportation Sources

(Source: 2012 AQMP)

(LDA – Light Duty Automobile; LDT1 and LDT2 –Light-Duty Trucks;
MDV – Medium-Duty vehicles; UBUS – Urban Buses; SBUS – School Buses:
OBUS – Other Buses; MH – Motorhomes; MCY – Motorcycles)

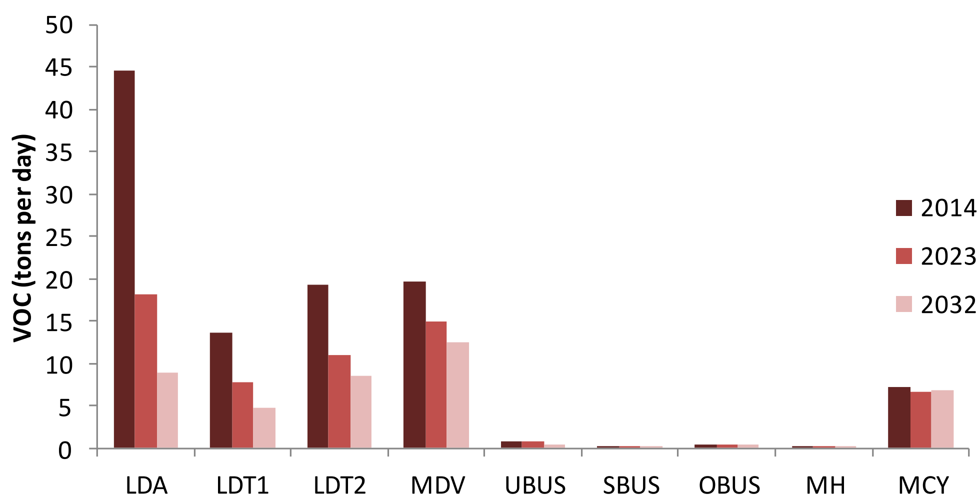


FIGURE 6

VOC Emissions for Specific On-Road Passenger Transportation Sources

(Source: 2012 AQMP)

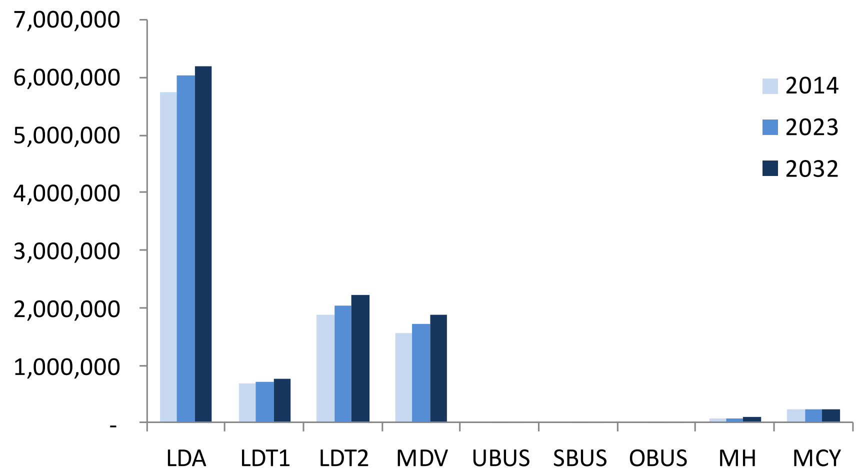


FIGURE 7

Populations for Specific On-Road Passenger Transportation Sources
(Source: 2012 AQMP)

Off-Road Passenger Transportation Emission Sources

NOx and VOC emissions from off-road passenger transportation sources provided in Tables 6, 7, and 8 are shown graphically in Figures 8 and 9 for 2014, 2023, and 2032 calendar years to illustrate the trend in emissions and the impact of regulatory programs on emissions for specific sources of emissions in the passenger transportation sector. Aircraft and commuter rail emissions of NOx increase over time due to greater activity and no additional regulations. Cruise ship and ferry/excursion vessel NOx emission decrease over time due to state regulations.

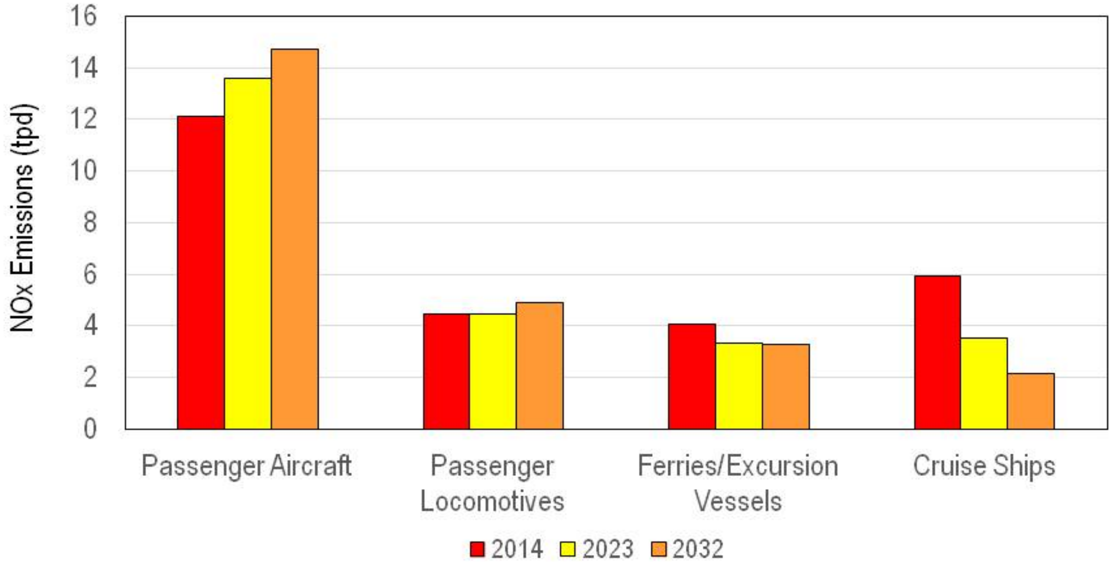


FIGURE 8

NOx Emissions for Specific Off-Road Passenger Transportation Sources

(Source: 2012 AQMP)

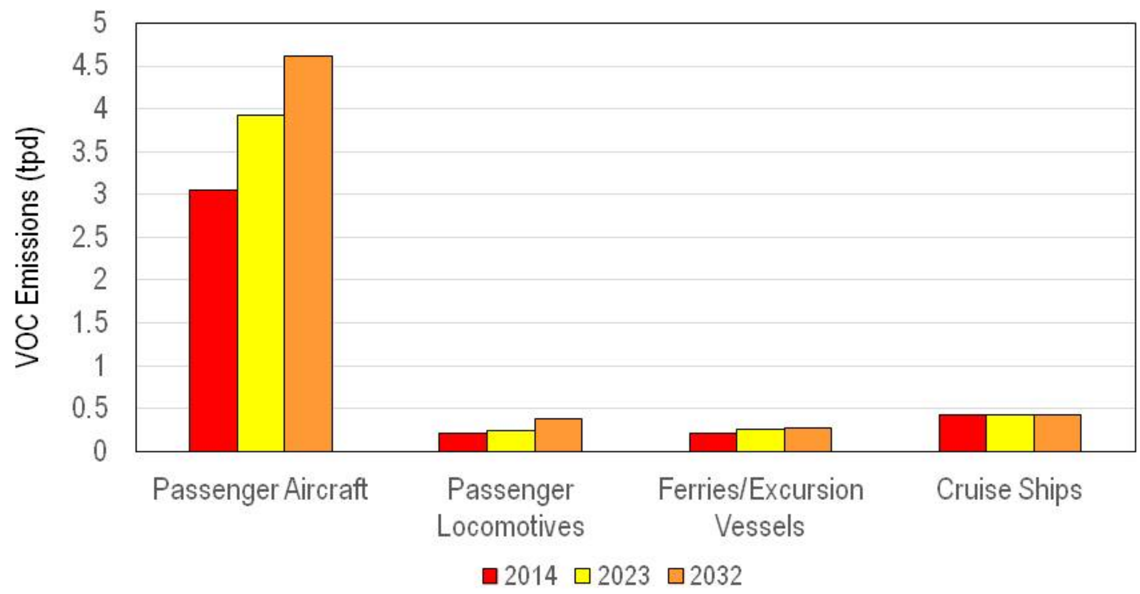


FIGURE 9

VOC Emissions for Specific Off-Road Passenger Transportation Sources

(Source: 2012 AQMP)

NOx EMISSION REDUCTION SCENARIOS

Various NOx emission reduction scenarios were developed to assess the amount of NOx emission reductions and levels of technology deployment that may be necessary across the passenger transportation emission source categories to achieve regional NOx carrying capacities in attainment deadline years. In addition, these scenarios serve to provide insight into the various emission tradeoffs associated with different technology penetration rates. The emission scenarios are intended to help provide perspective on the challenging task to achieve necessary emission reductions in compressed timeframes to meet air quality attainment goals. The scenarios do not represent any specific strategies to meet the emission reductions associated with the various scenarios. As such, the scenarios do not take into consideration potential need for new advanced technologies, socioeconomic impacts, or the regulatory agency authority to regulate each of the emission source categories in this sector. Specific strategies will be developed as part of the 2016 AQMP development process.

As noted in the beginning of this white paper, the emissions inventories used for the emissions reduction scenarios are from the 2012 AQMP. The 2012 AQMP calls for 65 and 75 percent reduction in NOx emissions to attain the federal 8-hr ozone air quality standards in 2023 and 2032, respectively. However, preliminary analysis as part of the development of the 2016 AQMP indicates that the needed NOx emission reductions are approximately 50 and 65 percent for 2023 and 2031, respectively. The initial observations and recommendations would not change due to differences in the emissions inventories since the analysis are based on relative changes among the various emissions source categories.

The scenarios were developed using the latest approved CARB emissions inventory model, EMFAC2011, as provided in the Final 2012 AQMP. These scenarios and underlying assumptions are described below.

For the two attainment years 2023 and 2032, six scenarios were developed and analyzed. The six scenarios are:

- <u>Equal Share Reduction in NOx</u>
  Under this scenario, all of the transportation source category baseline emissions are reduced by 65% for 2023 and 75% for 2032 (from the 2023 baseline emissions).
- <u>100 Percent Existing Standards</u>
  Under this scenario, all vehicle NOx emissions are assumed to be at the greatest level of control based on current exhaust emissions standards.

- 90 Percent Cleaner Combustion Technologies
  Transit and school bus NOx emissions are assumed to achieve additional 90 percent or cleaner emission levels beyond existing emission standards. Passenger locomotives and marine vessels are assumed to achieve some additional level of NOx reductions beyond Tier 4.
- Varying Penetration of Zero-Emission Technologies (Three Scenarios)
  Three scenarios were developed analyzing the potential to have 25%, 50%, and 75% penetration of zero-emission technologies.

Tables 9 and 10 provide the results of the emissions analysis for each scenario for 2023 and 2032, respectively.

TABLE 9

Remaining NOx Emissions (tons/day) in 2023

(Baseline and Equal Share Emissions from the 2012 AQMP)

(a) On-Road Passenger Transportation Vehicles

Source	Baseline	Equal Share	100% Existing Standards	90% Cleaner	ATP1 - 25% Zero / 75% Near-Zero	ATP2 - 50% Zero / 50% Near-Zero	ATP3 - 75% Zero / 25% Near-Zero
LDA	12.34	4.32	5.17	5.17	3.88	2.58	1.29
LDT1	4.33	1.52	0.98	0.98	0.73	0.49	0.24
LDT2	7.66	2.68	2.86	2.86	2.15	1.43	0.72
MDV	11.92	4.17	2.82	2.82	2.11	1.41	0.70
UBUS-DSL	10.43	3.65	0.50	0.05	0.04	0.02	0.01
UBUS-GAS	0.61	0.21	0.08	0.01	0.01	0.00	0.00
SBUS-GAS	0.07	0.02	0.01	0.00	0.00	0.00	0.00
SBUS-DSL	1.73	0.61	0.28	0.03	0.02	0.01	0.01
OBUS-GAS	0.5	0.18	0.18	0.02	0.01	0.01	0.00
OBUS-DSL	0.94	0.33	0.94	0.09	0.07	0.05	0.02
MH	0.97	0.34	0.53	0.05	0.04	0.03	0.01
MCY	2.03	0.71	2.03	2.03	2.03	2.03	2.03
Total	**53.53**	**18.74**	**16.36**	**14.10**	**11.09**	**8.07**	**5.05**

(b) Off-Road Passenger Transportation

Source	**Baseline**	**Equal Share**	**Existing Standard**	**90% Cleaner**	**ATP 1 - 25% Zero/ 75% Near-Zero**	**ATP 2 - 50% Zero/ 50% Near-Zero**	**ATP 3 - 75% Zero/ 25% Near-Zero**
Ocean-Going Vessels	3.54	1.24	1.32	0.99	0.99	0.99	0.99
Passenger Locomotives	4.46	1.56	1.07	0.11	0.08	0.06	0.03
Harbor Craft	3.32	1.16	0.88	0.57	0.57	0.57	0.57
Aircraft	13.59	4.76	3.40	3.40	3.40	3.40	3.40
Total	**24.92**	**8.72**	**6.67**	**5.07**	**5.04**	**5.01**	**4.98**

(c) Total On-Road and Off-Road Passenger Transportation

All Sources	**Baseline**	**Equal Share**	**Existing Standard**	**90% Cleaner**	**ATP 1 - 25% Zero/ 75% Near-Zero**	**ATP 2 - 50% Zero/ 50% Near-Zero**	**ATP 3 - 75% Zero/ 25% Near-Zero**
Total	**78.45**	**27.46**	**23.03**	**19.17**	**16.13**	**13.08**	**10.03**

TABLE 10

Remaining NOx Emissions (tons/day) in 2032

(Baseline and Equal Share Emissions from the 2012 AQMP)

(a) On-Road Passenger Transportation Vehicles

Source	Baseline	Equal Share	100% Existing Standards	90% Cleaner	ATP1 - 25% Zero / 75% Near-Zero	ATP2 - 50% Zero / 50% Near-Zero	ATP3 - 75% Zero / 25% Near-Zero
LDA	6.83	3.07	5.33	5.33	4.00	2.66	1.33
LDT1	1.91	1.09	1.08	1.08	0.81	0.54	0.27
LDT2	4.48	1.93	3.13	3.13	2.35	1.57	0.78
MDV	6.82	3.00	3.09	3.09	2.32	1.54	0.77
UBUS-DSL	7.85	2.59	0.54	0.05	0.04	0.03	0.01
UBUS-GAS	0.54	0.15	0.10	0.01	0.01	0.01	0.00
SBUS-GAS	0.05	0.02	0.01	0.00	0.00	0.00	0.00
SBUS-DSL	1.07	0.43	0.30	0.03	0.02	0.02	0.01
OBUS-GAS	0.37	0.12	0.22	0.02	0.02	0.01	0.01
OBUS-DSL	1.15	0.23	1.15	0.11	0.09	0.06	0.03
MH	0.92	0.92	0.75	0.08	0.06	0.04	0.02
MCY	2.07	0.52	2.07	2.07	2.07	2.07	2.07
Total	**34.06**	**14.07**	**17.77**	**15.00**	**11.77**	**8.54**	**5.30**

(b) Off-Road Passenger Transportation

Source	Baseline	Equal Share	Existing Standard	90% Cleaner	ATP 1 - 25% Zero/ 75% Near-Zero	ATP 2 - 50% Zero/ 50% Near-Zero	ATP 3 - 75% Zero/ 25% Near-Zero
Ocean-Going Vessels	1.79	0.50	1.76	1.36	1.36	1.36	1.36
Passenger Locomotives	4.91	1.38	2.12	0.21	0.16	0.11	0.05
Harbor Craft	3.30	0.76	0.92	0.6	0.60	0.60	0.60
Aircraft	15.06	3.46	7.53	7.53	7.53	7.53	7.53
Total	**25.06**	**6.10**	**12.32**	**10.00**	**9.95**	**9.90**	**9.85**

(c) Total On-Road and Off-Road Passenger Transportation

All Sources	Baseline	Equal Share	Existing Standard	90% Cleaner	ATP 1 - 25% Zero/ 75% Near-Zero	ATP 2 - 50% Zero/ 50% Near-Zero	ATP 3 - 75% Zero/ 25% Near-Zero
Total	**59.12**	**20.17**	**30.09**	**25.00**	**21.72**	**18.44**	**15.15**

Equal Share Reduction in NOx Scenario

For the 2023 attainment year, an overall 65% NOx reduction for all source categories in the South Coast Air Basin was determined to be needed for attainment of the 80 ppb federal 8-hour ozone air quality standard. This is reflected in a straight 65% reduction across all passenger transportation source categories, resulting in an overall decrease of NOx emissions from 53.53 tons/day to 18.74 tons/day for on-road passenger transportation vehicles, and NOx emissions decrease from 24.92 to 8.72 tons/day for off-road sources [Tables 9(a) and 9(b)]. The total remaining NOx emissions combining on-road and off-road emissions are 27.46 tons/day [Table 9(c)].

For the 2032 attainment year, an overall 75% NOx reduction in all source categories based on 2023 baseline emission inventories was determined to be needed for attainment of the 75 ppb Federal 8-hour ozone standard. This is reflected in a straight 75% reduction across all passenger transportation sources as applied to 2023 baseline emission inventories, with remaining inventories applied to the 2032 attainment year. This calculation was performed in this manner to provide the incremental emission reductions by source category in "2023 currency" necessary to meet the more stringent Federal 8-hour ozone air quality standard in 2032. Reflecting all passenger transportation emission sources, the on-road NOx emissions are reduced from 34.0 tons/day to 14.1 tons/day in 2032 [Table 10(a)]. Off-road NOx emissions are reduced from 25.06 tons/day to 6.1 tons/day [Table 10(b)]. The total remaining NOx emissions combining on-road and off-road emissions are 20.17 tons/day [Table 10(c)].

100 Percent Existing Standards Scenario

This scenario assumes full implementation of existing adopted emission standards and complete fleet turnover to vehicles that meet these emission standards. For vehicles weighing up to 14,000 lbs. GVWR, the applicable emission standards are based on full implementation of CARB's Accelerated Clean Car Program in 2023 and 2032 (i.e., the vehicle emission standard component of this program (LEV III regulation) is fully phased–in by 2023). The in-use fleet average emission level for NOx was developed for the 2025 to 2032 calendar year timeframe, reflecting an in-use vehicle fleet that meets the most stringent LEV III emission standards while incorporating emissions deterioration.

A similar methodology was utilized for passenger transportation vehicle sources with gross vehicle weight ratings greater than 14,000 lbs. It was assumed that all vehicles meet the 2010 model year on-road heavy-duty engine exhaust emissions standard of 0.2 g/bhp-hr for NOx. To incorporate emission deterioration, for the 2023 and 2032 calendar year scenarios, EMFAC2011 was used to calculate in-use fleet average NOx emissions for the 2010 to 2023 calendar year timeframe and 2010 to 2032 calendar year timeframe, respectively. Reflecting all passenger transportation emission sources (on-road and off-road sources), the NOx inventory was reduced from 78.45 tons/day to 23.03 tons/day in 2023, and 59.12 tons/day to 30.09 tons/day in 2032 [Table 9(c) and 10(c)].

90 Percent Cleaner Combustion Technologies Scenario

For this scenario, light- and medium-duty vehicles (up to 14,000 lbs GVWR) are assumed to meet the cleanest combustion levels provided in the Advanced Clean Car Program (LEV III element). For vehicles weighing more than 14,000 lbs. GVWR, the 90% cleaner combustion technology reflects the entire on-road fleet meeting a 0.02 g/bhp-hr NOx emissions standard. For off-road passenger transportation sources, locomotives are assumed to reach a 90% cleaner level, NOx emissions from ocean-going vessels would be further reduced through reduction of emissions from auxiliary engines and boilers while at-berth, and ferry vessels emissions would be further reduced through deployment of cleaner engines and hybrid systems. The resulting remaining emissions shown in Tables 9(c) and 10(c), are 19.17 tons/day (from 78.45 tons/day) in 2023 and 25.0 tons/day (from 59.12 tons/day) in 2032.

Varying Penetration of Zero-Emission Technologies Scenarios

The varying penetration scenarios assume various in-use penetrations of zero emission technologies to achieve emission reductions beyond the 90% cleaner combustion scenario. Three specific in-use fleet penetration scenarios were evaluated corresponding to 25% ZEV/75% near-ZEV, 50% ZEV/50% near-ZEV, and 75% ZEV/25% near-ZEV. Note that “near-ZEV” corresponds to the vehicle technologies incorporated into the 90% cleaner combustion scenario. As expected, these scenarios result in the largest emission reductions for all scenarios evaluated, reducing the remaining NOx inventory in 2023 to 16.13 tons/day, 13.08 tons/day, and 10.03 tons/day, respectively, from a baseline inventory of 78.45 tons/day. In 2032, the remaining NOx inventories are reduced to 21.72 tons/ day, 18.44 tons/day, and 15.15 tons/day, respectively, from a baseline inventory of 59.12 tons/day.

INITIAL OBSERVATIONS

Emission Reduction Scenarios

The emission reduction scenario analysis provides insights into the development of control strategies needed to attain the federal 8-hour ozone air quality standards in 2023 and 2032. Some of the initial observations are provided below.

- The analysis conducted for this white paper focuses on specific emissions source categories related to the passenger transportation sector. As such, any analysis performed does not imply that the federal ozone air quality standards will be attained without further reductions from all emission source categories that contribute to the ozone air quality problem. That analysis will be conducted as part of the development of the 2016 AQMP. However, the scenarios analyzed as part of this white paper provide information on areas to focus on for the development of the 2016 AQMP.

- There is a general recognition that not all emission sources will be able to achieve an "equal share" reduction in NOx emissions for a variety of reasons, including, but not limited to, availability of cleaner technologies, cost-effectiveness, sheer number of vehicles or equipment, and the timeframe for turning over older vehicles to meet air quality standards.

- If all vehicles and equipment were turned over to meet the lowest emissions standards established in current international (IMO, ICAO), U.S. EPA, and CARB exhaust emission standards, the passenger transportation sector would not achieve the 75 percent "equal share" NOx emissions reductions needed to attain the federal ozone air quality standard in 2032.

- If all vehicle and equipment were turned over to meet the lowest emissions standards established in current exhaust emission standards, the passenger transportation sector would potentially achieve the 65 percent "equal share" NOx emissions reduction needed to attain the federal ozone air quality standard in 2023. However, given the significant number of vehicles and equipment in this sector, the likelihood of complete turnover will be challenging.

- Additional NOx reductions are needed from federal sources (i.e., locomotives, marine vessels, and aircraft).

- Accelerated deployment of commercially available zero-emission vehicles in the passenger transportation sector will be needed to help meet the "equal share" reduction levels in 2023 and 2032.

- If the passenger transportation sector does not achieve the needed NOx reductions, other emission sources must achieve greater NOx reductions to make up the difference. Conversely, if emission sources other than the passenger transportation sector do not achieve needed NOx reductions, there will be a need for the passenger transportation sector to achieve greater levels of NOx reductions to make up the difference.

- While significant emission reductions have occurred in this sector, new exhaust emission standards need to be established as early as possible. For the light- and medium-duty vehicle sectors, new criteria pollutant tailpipe emissions standards are needed beginning in 2025 and beyond to increase deployment of zero- and near-zero emission vehicles. In addition, new heavy-duty exhaust emissions standards must be established as early as possible. Given the low pollutant levels of such standards, innovative approaches will be needed in setting them and in maximizing the deployment of zero- and near-zero emission vehicles.

- Given the sheer number of registered vehicles in the South Coast Air Basin and their NOx contribution to the total emissions in this sector, the most effective set of strategies will consist of a combination of accelerated advanced technology deployment, incentive programs to accelerate older vehicle retirement, alternative mobility options, infrastructure enhancements, and transformative urban forms.

- Operational efficiency enhancements can be made relative to congestion relief, greater use of intelligent transportation systems, and connected vehicle technologies (i.e., equipped for wireless communication).

- There is a nexus with the goods movement sector. On certain freeways and arterial roads, heavy-duty truck traffic is shared with passenger cars and transit buses during the morning and evening commute hours. In addition, commuter rail operate on rail tracks shared with freight rail. The reader is referred to the Goods Movement White Paper for more information on the freight rail sector.

Advanced Technologies

The following are observations on the availability of zero- and near-zero emission technologies for the transportation sector. For some sectors (e.g., aircraft), if zero- or near-zero technologies are not feasible, cleaner combustion technologies are needed. In addition, advancing cleaner fuels and renewable fuels will help reduce criteria pollutant and greenhouse gas emissions. A discussion of existing emission control technologies and advanced technologies is provided in Appendix B.

- There is an increasing number of commercially-available battery-electric and plug-in hybrid electric light-duty vehicle models and increasing numbers of models sold each year. Current sales of zero-emission and plug-in hybrid electric vehicles have exceeded projections provided in CARB's Advanced Clean Car Program.

- Battery storage capacity is expected to increase significantly over the next few years and is expected to interest more consumers in acquiring a zero-emission or plug-in hybrid electric vehicle.

- There is a need to expand zero-emission technologies into categories of larger vehicles.

- Zero-emission buses are commercially available either in dedicated battery electric configurations or fuel cell configurations.

- The region's passenger rail locomotives are being replaced with Tier 4 locomotives. In the longer term, cleaner locomotives will need to be developed and demonstrated in the passenger transportation sector. Metrolink, the region's primary commuter rail service, has committed to testing cleaner locomotive technologies, such as alternative fuels, hybrid system, and wayside/external power, that provide emission benefits beyond current Tier 4 emission standards.

- Hybridization will have a significant role in reducing emissions from cruise ships and ferries.

- The FAA CLEEN Program plays an important role in developing lower NOx emitting aircraft engines with an objective to have new aircraft engines 60% cleaner in NOx emissions.

Efficiency Measures and Active Transportation

While greater penetration of zero- and near-zero emission technologies are needed to attain air quality standards, operational efficiencies in the roadway network and implementation of SB 375 sustainable community strategies will play an important role to help meet air quality standards. Some initial observations are:

- Intelligent transportation systems (ITS) and connected vehicles can potentially provide additional environmental benefits not only in congestion relief and fuel savings, but also in reduced criteria pollutant and greenhouse gas emissions.

- Operational efficiencies in goods movement will help reduce road congestion and reduce emissions.

- Implementation of SB 375 (including increased transit and commuter rail ridership) and active transportation programs will help reduce emissions and congestion.

RECOMMENDATIONS

The emission reduction scenario analysis for the passenger transportation sector shows a need for greater penetration of zero- and near-zero emission technologies in order to attain air quality standards. Given the large number of passenger cars registered in the South Coast Air Basin, existing programs such as older vehicle scrapping and incentives for zero-emission and alternative fueled vehicles are integral in the overall effort to reduce emissions from this sector. There is also a need to continue development of cleaner combustion engine technologies for federal transportation sources. The following are some key recommendations to consider during the development of the 2016 AQMP.

Technology-Related and Vehicle Deployment Recommendations

As mentioned earlier, the numbers of on-road zero-emission and plug-in hybrid electric vehicles offered commercially are growing every year. However, the sale percentage of advanced technology vehicles is relatively small compared to annual sales of conventionally-fueled vehicles, and the vehicle choices are generally smaller sized vehicles. Implementing the following recommendations would help accelerate deployment of cleaner vehicles.

- Current programs to accelerate early retirement of light- and medium-duty vehicles are important given the significant number of older vehicles operating in the South Coast Air Basin. Accelerated vehicle retirement combined with incentives to purchase cleaner, fuel efficient vehicles and advanced technology vehicles can help accelerate penetration of advanced technology vehicles for the foreseeable future.

- Increased public funding assistance to accelerate replacement of existing vehicles will be beneficial for all categories of emissions in the passenger transportation sector.

- New mechanisms must be developed to significantly increase deployment of zero- and near-zero emission technology vehicles and expand refueling infrastructure. Such mechanisms may take the form of regulations or monetary and non-monetary incentives.

- Establish a new NOx emissions standard for urban buses and school buses that is 90 percent cleaner than the current bus exhaust emissions standard. As part of this effort, develop new certification test procedures for urban buses that take into account integration of hybrid systems that provide for zero-emission miles operation.

- Given the limited financial resources of public transit agencies and public school districts, seek additional funding opportunities for near-zero and zero-emission bus deployment.

- Seek funding opportunities to assist Metrolink in demonstrating alternative fuel and hybrid locomotives that are potentially significantly cleaner than the current Tier 4 locomotive NOx emissions standards.

- As deployment of near-zero and zero-emission technologies occur, additional public funding assistance will help in training technicians who are not familiar with the new technologies to maintain and operate advanced-model buses and vehicles.

- Encourage greater deployment of "emissions capture systems" at marine ports and at passenger rail maintenance facilities to reduce emissions from cruise ships and ferries while at berth and passenger rail locomotives during maintenance.

- Support the FAA CLEEN Program in the development of cleaner, more fuel efficient aircraft engine.

- Renewable fuels may potentially provide criteria pollutant emission reduction benefits along with greenhouse gas emissions benefits. The use of renewable fuels should be supported, such as renewable gasoline, renewable diesel, renewable natural gas, and other biofuels, to help reduce fine particulate emissions and to some extent NOx emissions. [Note: The reader is referred to the Energy Outlook White Paper for further discussions of renewable fuels and infrastructure development.]

Vehicle Miles Traveled (VMT) and Operational Efficiency Recommendations

Meeting SB 375 targets and improving operational efficiency in existing transportation infrastructure can have potential criteria pollutant co-benefits. The following recommendations can potentially help to further reduce criteria pollutant emissions and greenhouse gas emissions.

- Work with SCAG and the county transportation commissions to aggressively pursue and effectively implement SB 375 to reduce vehicle miles travelled (VMT).

- Work with the county transportation commissions to promote alternative forms of transportation to the single occupant vehicle. Such alternative forms include greater utilization of public transit and commuter rail, and active transportation.

- Encourage municipalities to consider "last mile" (e.g., distance from nearest public transportation node to the passenger's home or workplace) travel options in future land use planning efforts.

- Support studies to assess intelligent transportation systems' (ITS) potential to reduce congestion and criteria pollutant emissions.

- Support efforts to deploy ITS in key congestion areas and best practices in transit, commuter rail, and aviation to help further reduce emissions and reduce congestion.

- Urge Caltrans and the county transportation commission to incentivize zero- and near-zero trucks on proposed dedicated truck lanes as part of freeway expansion projects that can help reduce commuter traffic congestion where appropriate. However, there is a general recognition that an expanded freeway may eventually become congested due to economic and population growth.

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APPENDIX A

CURRENT EMISSION CONTROL PROGRAMS

CURRENT EMISSION CONTROL PROGRAMS

Current regulatory programs and other planning efforts affecting the passenger transportation sector are provided in this appendix.

PASSENGER TRANSPORTATION SECTOR

Commute Vehicles – Automobile, Light-Duty Trucks, SUVs, Passenger Vans

Commute vehicles are a subset of the on-road vehicle emission inventory, which is developed from activity data and emission rate data. For these categories of vehicles, activity data includes vehicle miles travelled and number of trips, and are generally estimated from vehicle owner surveys and vehicle count data. Emission rates are primarily based on actual measurements of tailpipe emissions (exhaust emissions) during engine operation and measurements of fuel that escapes from the vehicle's fuel system (evaporative emissions) both during engine operation and non-operation. Exhaust emissions result from incomplete fuel combustion and combustion byproducts, and consist of hydrocarbons, oxides of nitrogen, and particulate matter. Evaporative emissions consist solely of hydrocarbon emissions. The control of exhaust and evaporative emissions for a particular vehicle fundamentally depends on the technology used by the vehicle manufacturer to meet the applicable exhaust and evaporative emission standards, which are adopted and implemented by CARB, as well as control programs targeting the maintenance and repair of in-use vehicle emission control systems, implemented by CARB and the Bureau of Automotive Repair (BAR).

The specific processes generating exhaust emissions occur during running, idling, and starting conditions. Evaporative emission processes include diurnal, resting, hot soak, and running-loss. Diurnal and resting emissions result from heating and vaporization of the vehicle's fuel as the ambient temperature rises or declines during the day. Hot soak emissions are generated from residual engine heat vaporizing vehicle fuel subsequent to engine shut-down. Finally, running losses are generated by engine heat vaporizing vehicle fuel during engine operation. It should be noted that fuel evaporative emissions can also occur from vehicle refueling, where liquid fuel displaces vapor in the fuel tank during the refueling process.

SCAQMD Rule 2202 – On-Road Motor Vehicle Mitigation Options directly impacts mobile source emissions generated from employee commutes. Rule 2202 applies to employer worksites[3] with 250 or more employees, affecting home-to-work commute trips occurring between 6:00 AM and 10:00 AM from Monday through Friday. Rule 2202 provides a methodology to quantify commute emissions, an emission reduction target by employer depending on a number of factors such as employer location and number of commute vehicles, as well as a menu of options that can be implemented by employers to generate emission reductions for rule compliance. Rule 2202 was adopted in December 1995, with the first full year of implementation in 1996, replacing earlier trip reduction rules.

In Calendar Year 2013, Rule 2202 affected around 1,400 worksites, encompassing approximately 685,000 employees and 440,000 vehicles. During this calendar year, Rule 2202 targeted emission reductions were 1.68 tons/day VOC, 1.68 tons/day NOx, and 16.54 tons/day CO. Actual emission reductions exceeded these targets: 2.09 tons/day VOC, 1.70 tons/day NOx, and 17.41 tons/day CO.

Work-Related/Non-Goods Movement – Automobile, Light-Duty Trucks, and Cargo Vans

A small subset of the overall population of automobiles, light-duty trucks and vans are considered work related vehicles that carry workers from their residents to a jobsite and are considered as part of the passenger transportation sector. During the 1998 Low-Emission Vehicle (LEV) II rulemaking, CARB determined that work related vehicles up to 8,500 lbs. GVWR should be controlled to passenger car emission standards since available evidence indicated that these vehicles are primarily used for passenger transportation purposes, not as work vehicles. Cargo vans clearly are work vehicles; and models can weigh above or below 8,500 lbs. GVWR. It should be noted that the 8,500 lbs. to 10,000 lbs. GVWR category corresponds to the CARB Light-Heavy-Duty I category, and is included within the scope of the Goods Movement White Paper. In terms of how emissions are generated from these vehicles and controlled through regulation, see the preceding discussion on commute vehicles.

3 In Rule 2202, worksite means "a structure, building, portion of a building, or grouping of buildings that are in actual physical contact or are separated solely by a private or public roadway or other private or public right-of-way, and that are occupied by the same employer. Employers may opt to treat more than one structure, building or grouping of buildings as a single worksite, even if they do not have the above characteristics, if they are located within a 2 mile radius and are in the same Performance Zone. "

Transit System (Buses/Shuttles)

Transit system and shuttle bus vehicle emissions are regulated by a combination of rules, including the CARB heavy-duty vehicle emission standard regulations, Fleet Rule for Transit Agencies, and Truck and Bus Rule. In addition, transit agency emissions are regulated by SCAQMD Rule 1192 – Clean On-Road Transit Buses. CARB's emission standard regulation applies to engine manufacturers, while the remaining CARB and SCAQMD rules apply to vehicle fleets. In general, the CARB fleet rules require faster turnover to cleaner vehicles than would otherwise occur in the absence of the rules, or installation of retrofit emission control hardware. The SCAQMD rule requires the purchase of clean-fueled vehicles (e.g., CNG, LNG, electric) when a fleet decides on its own to either replace or add a vehicle to its fleet. Finally, CARB has adopted a zero-emission bus purchase requirement. CARB staff is conducting a technical assessment and is planning amendments to the transit fleet rule in an effort to further reduce criteria pollutant and greenhouse gas emissions, as well as promote zero-emission technologies in this sector.

Student Transportation

School buses come in a variety of sizes and configurations, powered by gasoline, diesel, CNG, propane, or electricity, and are generally assigned to one of four types: A, B, C, or D. Type A is considered a medium-duty vehicle with a weight rating of more than 10,000 lbs GVWR (Type A-I) or less than 10,000 lbs GVWR (Type A-II). Type A school buses are capable of transporting 10 to 24 passengers. The Type B school bus model is considered a step-van configuration, weighing more than 10,000 lbs. GVWR, with similar passenger capacities as Type A school buses. Type C school buses are considered heavy-duty vehicles weighing more than 14,000 lbs GVWR, with a front-mounted engine, capable of transporting between 42 and 72 passengers. Finally, the Type D school bus model is considered a "transit style bus" with a flat frontal area, and engine located either at the front or rear of the bus. These school buses can accommodate up to 90 passengers.

School buses are covered by a various regulations that impact engine and vehicle manufacturers as well as fleet owners. Specifically, CARB's Low-Emission Vehicle Regulation applies to school bus engines/vehicles weighing 14,000 lbs GVWR or less, and heavier school buses are covered by CARB's on-road heavy-duty engine emission standards. In addition, CARB's Truck and Bus Regulation affects school bus fleet owners, requiring them to install particulate filters on diesel-powered school buses weighing more than 14,000 lbs GVWR in accordance with a phase-in schedule. In addition, school bus fleets can obtain Truck and Bus Regulation compliance credit through the use of alternative-fuel vehicles (CNG, LNG, or electric).

Locally, SCAQMD's Rule 1195 affects school bus fleet operators by requiring the purchase of alternative-fuel school buses when a fleet owner decides on its own to replace or add to its vehicle fleet. To-date, a large number of the school buses operated by public school districts have been replaced with natural gas-powered buses. There have been various incentive programs to promote the use of low-emissions technology for the school bus sector – the largest program is the Lower Emission School Bus Incentive Program. Using state, federal and local matching funds, a total of 1,021 pre-1987 diesel school buses have been retired and replaced with 935 new CNG-powered school buses and 86 low-emitting diesel buses in the South Coast Air Basin. In addition, this incentive program has funded the installation of particulate filters in 3,425 school buses (1994 model-year and newer).

Passenger Locomotives

The four-county region of the Basin is serviced by a network of intercity (Amtrak) and commuter (Metrolink) heavy rail networks. Emissions are produced by diesel-electric locomotives. Diesel-electric locomotives have a large diesel engine (main traction engine) for generating electric power which in turn drives electric motors in each axle. Passenger locomotives also have auxiliary engines that provide power for lighting, utility power, heat and air conditioning the passenger cars. Passenger locomotives are forecast to contribute approximately 4.5 tons per day or 1.5% of NOx emissions in the South Coast Air Basin in 2023. In 2015, U.S. EPA Tier 4 standards take effect for new locomotive engines which are 90% lower in NOx and PM emissions than pre-control engines. Due to the long life of locomotives (>30 years), however, it will take many years to fully benefit from Tier 4 engines. In addition, Tier 4 locomotive NOx standards are substantially less stringent than Tier 4 off-road NOx standards, providing an opportunity to further strengthen locomotive emission standards in the future and to introduce alternative near-zero or zero-emission technology.

Commercial Aircraft

Commercial aircraft emission inventories combine passenger aircraft and dedicated cargo aircraft. CARB estimates that 87% of commercial aircraft emissions are attributable to passenger transport by commercial airlines. In addition, general aviation aircraft, primarily piston engine powered, contribute about 2% (0.3 tons per day) of aircraft emissions. Based on the South Coast Air Basin aircraft NOx emission forecast for 2023, 13.6 tons per day or 4% of NOx emissions in 2023 are attributed to aircraft emissions. Aircraft engine emissions are regulated by U.S. EPA, which harmonized emission standards in 2005 with the International Civil Aviation Organization's Committee on Aviation Environmental Protection (ICAO-CAEP). Aircraft have a long service life (typically, greater than 30 years) although there is an economic incentive to retire older aircraft due to better fuel efficiency from new aircraft. The most stringent currently adopted standard took effect in 2014 and provided approximately 50% cleaner NOx emissions than engines manufactured before 2005.

Commercial Harbor Craft

Approximately 65 ferries and excursion vessels transport passengers within the District. They are forecast to emit 3.3 tons per day NOx in 2023. These vessels generally have multiple propulsion and auxiliary engines with total power between several hundred and several thousand horsepower. Essentially all of these vessels are currently diesel powered. Activities include scheduled trips to Catalina Island, whale watching, dinner cruises, and sightseeing trips. These harbor craft are subject to new engine regulations that now require Tier 3 standards for engines less than 800 hp and Tier 4 standards, the most stringent currently adopted, for engines greater than 800 hp. In addition, excursion vessels and ferries are subject to the CARB Commercial Harbor Craft regulation which specifies turnover of older marine engines for new engines on a schedule that essentially will leave all regulated harbor craft with Tier 2 or cleaner engines by 2023.

Ocean-Going Vessels

Ocean-going vessels transporting passengers, i.e., cruise ships, which primarily run on diesel fuel, contribute a significant portion of NO_x, PM, greenhouse gas, and toxic emissions particularly in coastal regions in and around shipping ports. These emissions contribute to on-shore air quality problems representing approximately 3.5 tons per day total NOx emissions in the South Coast Air Basin for 2023. NOx emissions produced by main propulsion and auxiliary engines when the vessels are transiting within the South Coast Air Basin and the auxiliary engines when the vessels are anchored or docked at a port in the South Coast Air Basin are included in the emission inventory. CARB has introduced low sulfur fuel standards which reduced PM and SOx emissions but not NOx emissions. Lower NOx emission propulsion and auxiliary engines are being introduced in compliance with the International Maritime Organization (IMO) standards but due to the long useful life of ocean-going vessels, these standards will have limited beneficial effect by 2023. Additional retrofit control technologies are being explored by the San Pedro Bay Ports Technology Advancement Program (TAP) Advisory Group, which is comprised of CARB, U.S. EPA, SCAQMD, and the ports of Los Angeles and Long Beach. The ports are also exploring the use of dock-side or barge-mounted capture and treatment systems for auxiliary engine emissions which represent a significant fraction of the marine vessel NOx emissions, particularly near the ports.

OTHER PLANNING EFFORTS AFFECTING THE PASSENGER TRANSPORTATION SECTOR

SB 375 Sustainable Communities and Climate Protection Act of 2008

The Sustainable Communities and Climate Protection Act of 2008 supports California's climate action goals to reduce greenhouse gas (GHG) emissions through coordinated transportation and land use planning with the goal of more sustainable communities.

Under the Sustainable Communities Act, CARB sets regional targets for GHG emissions reductions from passenger vehicle use. In 2010, CARB established these targets for 2020 and 2035 for each region covered by one of the State's metropolitan planning organizations (MPO), and CARB will periodically review and update the targets as needed.

Each MPO must prepare a Sustainable Communities Strategies (SCS) as an integral part of its Regional Transportation Plans (RTP). The SCS contains land use, housing, and transportation strategies that, if implemented, would allow the region to meet its GHG emission reduction targets. Once adopted by the MPO, the RTP/SCS guides the transportation policies and investments for the region. CARB must review the adopted SCS to confirm and accept the MPO's determination that the SCS, if implemented, would meet the regional GHG targets. If the combination of measures in the SCS does not meet the regional targets, the MPO must prepare a separate "alternative planning strategy" (APS) to meet the targets.

SCAG Regional Transportation Plan

The Southern California Association of Governments (SCAG) prepares the RTP, with the primary goal of increasing mobility in the region. An additional goal includes increasing the region's sustainability and reduction in greenhouse gas emissions, officially incorporated into the RTP as the SCS. The most recent RTP/SCS is the 2012 – 2035 RTP/SCS, and was adopted by SCAG on April 12, 2012. (http://www.scagrtp.net).

The 2012 RTP/SCS includes elements that would reduce emissions from transportation sources, improve public health, and help the region meet national ambient air quality standards. Specifically, the 2012 RTP incorporates widespread utilization of zero- and near-zero emission transportation technologies in the 2023 to 2035 timeframe and various mechanisms to incrementally achieve this objective. This approach is intended to generate numerous co-benefits, including energy security, cost certainty, increased public support for infrastructure, GHG reduction, and economic development.

Federal Surface Transportation Reauthorization

Every five years the federal government usually adopts legislation broadly categorized as "federal surface transportation legislation" that authorizes and funds transportation related infrastructure, impacting the federal highway system, transit system, and related local infrastructure projects. The latest federal surface transportation legislation enacted by Congress is the "Moving Ahead for Progress in the 21st Century," known as MAP-21. It was adopted in 2012 with expiration at the end of 2014. The short expiration date resulted from lack of funding primarily due to shortfalls in vehicle fuel taxes ($/gallon), imposed at the pump, that were established approximately 20 years ago and never increased over time to offset the effects of lower gasoline consumption from increased fuel economy. At the end of 2014, MAP-21 was extended to May 2015 as a temporary measure, and federal surface transportation legislation targeting up to a six-year time frame is currently being developed.

As a result of the authorization and funding components, surface transportation legislation establishes policy on the priority of highway and related infrastructure projects that are federally supported. This legislation provides a mechanism by which the federal government can participate in the funding of critical infrastructure projects, that support the widespread deployment of near-zero and zero-emission vehicle technologies in the SCAQMD region. As identified previously, the deployment of these technologies is critical for ambient air quality standard attainment as reflected in the 2012 AQMP.

Caltrans California Transportation Plan 2040

The California Transportation Plan (CTP) provides a long-range policy framework to meet California's future mobility needs and reduce greenhouse gas emissions. The CTP defines goals, performance-based policies, and strategies to achieve our collective vision for California's future statewide, integrated, multimodal transportation system. The plan envisions a sustainable system that improves mobility and enhances the quality of life. While the plan focuses on sustainable transportation, the plan identifies key mobility and technology strategies that can potentially lead to criteria pollutant emission reduction benefits. A draft CTP (CTP 204) was released in March 2015 for public comments. (http://www.dot.ca.gov/ hq/tpp/californiatransportationplan2040/)

APPENDIX B

POTENTIAL EMISSION REDUCTION TECHNOLOGIES AND EFFICIENCY MEASURES

POTENTIAL EMISSION REDUCTION TECHNOLOGIES AND EFFICIENCY MEASURES

Provided in this Appendix are discussions on emission control technologies that have led to criteria pollutant emission reductions in the passenger transportation sector historically and potential technologies to further reduce emissions including greater deployment of zero-emission and near-zero emission advanced technologies. In addition, operational efficiency measures will have an important role in reducing not only congestion, but also criteria pollutant and greenhouse gas emissions.

PASSENGER TRANSPORTATION SECTOR

Light- and Medium-Duty Vehicles

In January 2012, CARB adopted the Low-Emission Vehicle (LEV) III Program, commonly called the Advanced Clean Car (ACC) Regulation. This regulation incorporates a coordinated approach to meet criteria pollutant and climate air quality goals. Incorporated into this regulatory package are more stringent low-emission vehicle standards for vehicles weighing up to 14,000 lbs. GVWR, with a major objective to reduce the fleet average emissions of passenger cars, light-duty trucks, and medium-duty passenger vehicles to super ultra-low emissions levels by 2025. This program element will yield significant emission benefits for the transportation vehicle sector, and will lead to advanced gasoline and diesel technologies applied to almost all vehicle product lines for this sector, resulting in an overall 75% reduction from current average emission levels. It should be noted that this control program will also reduce GHG emissions by 34% in 2025 for this vehicle sector.

Another component of the ACC Program is the Zero-Emission Regulation. This regulation will require manufacturers to commercialize increasing numbers of plug-in hybrid electric vehicles and zero-emission vehicles for the 2018 to 2025 timeframe. CARB projects that by 2025, approximately 15% of new vehicles sales will consist of a mix of fuel cell vehicles, battery-electric vehicles, and plug-in hybrid vehicles. The Zero-Emission Regulation in combination with the LEV III Regulation puts California on a trajectory to generate the needed GHG reductions from this sector to contribute to the overall state attainment of an 80% reduction in GHG emissions from 1990 levels by 2050.

As part of the ACC Program, CARB developed market penetration forecasts of zero- and near-zero vehicle technologies. Figure B-1 illustrates one scenario depicting new vehicle sales statewide for zero- and new-zero technologies through 2025. In addition, Figure B-2 shows one possible zero- and near-zero vehicle penetration scenario through 2050 for GHG target attainment, which builds upon the 2025 new vehicle sales forecast shown in Figure B-1.

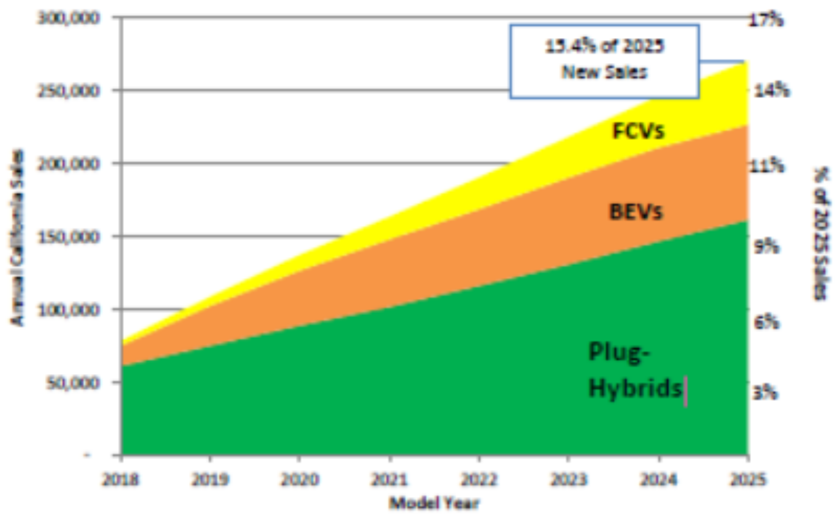
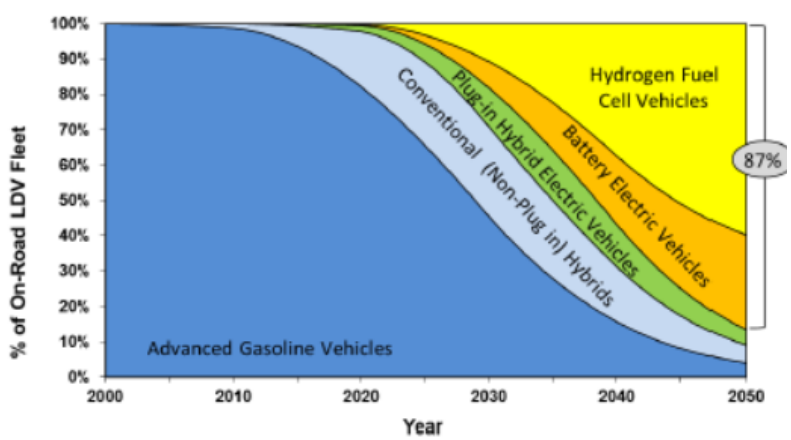


FIGURE B-1

Expected ZEV Regulation Compliance for 2018 to 2025 Model Years[4]



[4] Advanced Clean Cars Summary, California Air Resources Board, January 2012

FIGURE B-2

On-Road Passenger Car Scenario to Meet 2050 Goal

The final component of the ACC Program is the Clean Fuels Outlet Regulation. An amendment to this regulation was proposed as part of the ACC Program, which would have required construction and operation of alternative fuel outlets for a particular fuel, triggered when specific numbers of alternative fuel vehicles are commercially deployed. The Clean Fuels Outlet requirements have been placed on hold to allow for funding opportunities to expand the network of hydrogen refueling stations throughout California.

Current on-road vehicles powered by spark ignition engines (e.g., gasoline and natural gas engine) use a portfolio of on-board emission reduction technologies to meet emission standard requirements. To reduce exhaust emissions from internal combustion engines, three-way catalytic converters, on-board computer hardware, and sensors measuring engine operational parameters and inputting this information into the on-board computer hardware are used to simultaneously reduce tailpipe hydrocarbon, NOx, and carbon monoxide emissions. In addition, exhaust gas recirculation (EGR) valve and other engine-based technologies such as improved combustion-chamber and ignition system design are used to further reduce exhaust emissions.

To comply with CARB low-emission vehicle requirements, including the Advanced Clean Cars Program requirements, vehicle manufacturers have significantly improved these technologies resulting in exhaust emission reductions greater than 95% compared to uncontrolled levels (MECA, 2013). Examples of these improvements include dual oxygen sensors, adaptive fuel control systems, sequential multi-point fuel injections, close-coupled catalysts, increased catalyst loading in catalytic converters, electrically-heated catalysts, and full electronic EGR.

As mentioned previously, another major source of vehicle pollution is fuel evaporative emissions (gasoline vehicles). These emissions are addressed by on-board carbon canisters that adsorb evaporative emissions and subsequently release these emissions into the engine for combustion. Examples of improvements needed to meet the latest evaporative emission standards include low permeation polymer fuel tanks, multilayer co-extruded hoses, low permeation seals and gaskets, and high working capacity activated carbon canisters. These improvements have substantially reduced evaporative emissions from gasoline vehicles.

With regard to compression ignition engines (diesel engines), current exhaust aftertreatment control technologies include urea-based selective catalytic reduction (SCR) systems, catalyzed diesel particulate filters, diesel oxidation catalysts, ammonia slip catalysts, as well as engine based technologies such as cooled EGR, variable geometry turbochargers, and high pressure injection (CARB, 2014). Depending on system design SCR systems can reduce NOx emissions greater than 95% (MECA, 2014). These systems can also reduce hydrocarbon and PM emissions by up to 80% and 20 to 30%, respectively. Catalyzed diesel particulate filters can additionally reduce PM emissions more than 90% (MECA, 2014).

Alternative-Fuel Vehicles, Biofuels, Hybrid, and Dedicated Zero-Emission Technologies

Alternative fuel vehicles and biofuels in the light- and medium-duty vehicle sector (up to 14,000 lbs. GVWR), follow CARB low-emission vehicle regulations, meeting the same corresponding emission standards as conventional fuels including gasoline and diesel. Because these emission standards are so stringent, requiring advanced engine-based emission control and exhaust aftertreatment technologies, emission reduction potential for both categories of fuels are similar. It should be noted that hybrid-electric, battery electric, and fuel cell vehicles will generate additional emission reductions depending on percent of operation in all-electric or zero-emission mode.

Fuel cell technology can be utilized in all types of vehicle models; however, according to vehicle manufacturer input received by CARB, fuel cell vehicles will most likely be used in mid-sized sedans and larger sized vehicles such as trucks and sport utility vehicles. Battery electric vehicles will most likely be used in small vehicle platforms, in urban locations where fewer batteries need to be used. Plug-in hybrid vehicles will most likely be used as a bridge from conventional hybrid electric vehicles to battery electric and fuel cell vehicles. Plug-in hybrid vehicles have the advantage of adequate vehicle range for all applications; however, there is currently a tradeoff between longer all-electric range and associated costs. CARB indicated that in order for plug-in hybrid vehicles to achieve needed GHG reductions, advanced low carbon biofuels need to be used to meet the 2050 goal. It is uncertain whether biofuel fuel use in plug-in hybrid applications will be utilized in significant quantities in the long term without additional incentives given that conventional gasoline fuel remains the dominant choice to power these vehicles when not operating in all-electric mode.

Transit and School Buses

The same general principles that apply to lighter vehicles also apply to heavy-duty passenger shuttles, transit buses, and school buses (14,000lbs. GVWR and greater), regarding the need to implement advanced engine based and exhaust aftertreatment technologies to meet emission standards for both alternative- and conventional-fuel vehicles. Similarly, the potential for additional emission reductions also exists for operation in zero-emissions mode for dedicated and hybrid technologies. However, there is the potential for significant additional NOx emission reductions for both diesel and natural gas heavy-duty engines.

Research is underway to further reduce NOx levels of current diesel and natural gas-powered heavy-duty vehicles to near-zero levels, specifically targeting a 90% NOx reduction from the current level of 0.2 g/bhp-hr. This research is being conducted separately by CARB under a contract with Southwest Research Institute. Under funding from the SCAQMD, California Energy Commission, and Southern California Gas Company, several natural gas engine manufacturers are developing the next generation natural gas engines to meet a 0.02 g/bhp-hr exhaust emissions level in the next several years. CARB research efforts focus on the development of emission control technologies that could be used to further reduce NOx emissions from diesel and natural gas engines. The ultimate goal of the work being conducted under sponsorship from the SCAQMD, CEC, and Southern California Gas Company is to have commercialized natural gas engine products as early as possible. Further improvements in engine and aftertreatment control technologies will be investigated as part of these research projects. It may be possible to extrapolate the results of this research for application with other fuels of interest (e.g., renewable diesel, biofuels, and renewable natural gas) to further address criteria pollutant and GHG emission reduction goals.

Battery electric and hybrid-electric technologies can also play an important role in generating needed emission reductions in heavy-duty passenger transportation applications (includes urban buses, school buses, other buses, and motor homes). Similar limitations associated with the use of these technologies in light- and medium-duty passenger transportation applications are also applicable for heavy-duty vehicle applications.

Passenger Locomotives

The most stringent locomotive standard is Tier 4 and takes effect in 2015. This standard is expected to be met through engine modifications and without aftertreatment technologies. These engine modifications include high rate cooled EGR, two stage turbochargers, and improved fuel injection systems. These technologies were previously adopted in automotive and truck diesel engines. Also due to the long service life of locomotives, modification of in-use engines should also be considered. These in-use engine modifications may include addition of dual fuel systems, engine overhaul kits (injectors, fuel pumps, cylinder heads, turbochargers, manifolds, etc.) or reprogrammed engine management computers that reduce emissions. Modified in-use engines are unlikely to meet Tier 4 standards and the emission reduction from these modifications will vary depending on the technology utilized and the original engine design.

Further emission reductions beyond Tier 4 could be achieved using aftertreatment technologies such as oxidation or three-way catalysts, diesel particulate filters, and selective catalytic reduction (SCR) systems incorporated into Tier 4 engines. These technologies may also be retrofitted to in-use engines where technically feasible. Diesel oxidation catalysts do not reduce NOx but can reduce hydrocarbons by 50% and particulates by 20-25%. Three-way catalysts for stoichiometric spark ignition natural gas engines can reduce hydrocarbon, carbon monoxide, and NOx by 90% but are not effective on particulates or for NOx reductions in lean burn gas or diesel engines. Diesel particulate filters do not reduce NOx, but can reduce particulate emissions by more than 90% by mass and, depending on design, may also reduce hydrocarbons. SCR systems can reduce NOx by 90% using a reductant such as urea, commercially available as Diesel Exhaust Fluid, and in some cases, can provide moderate reductions in particulate emissions. Aftertreatment systems do not reduce CO2 emissions.

Alternative power sources include electric hybrid, fuel cell, battery-electric with tender car, and catenary electric systems. Hybrid systems provide emission reductions of criteria and GHG emissions of 20-30% when used in applications with opportunities for energy recovery such as commuter service with multiple stops and/or hilly terrain. Alternative power sources have been commercialized for on-road vehicles, but have not been extensively adopted for passenger locomotives in the region; due in part, that the local commuter rail agencies, Metrolink and Amtrak, share their operations on freight rail tracks owned by the Class I railroads.

Alternative fuels include dedicated natural gas, dual fuel systems (diesel ignition with natural gas), propane, biodiesel, and hydrogen. The use of these fuels has the potential to further reduce NOx emissions with appropriate engine development similar to their on-road counterparts. The use of alternative fuels also reduces particulate and CO2 emissions compared to diesel or gasoline. For passenger locomotives, the most likely alternative fuel will be natural gas, either liquefied or compressed due to the lower fuel cost.

There are opportunities for combining technologies to gain greater emission reductions. For example, natural gas-hybrids with high-efficiency aftertreatment systems combine low carbon emissions of natural gas engines, energy savings of hybrids, and low NOx emissions from advanced aftertreatment.

Efficiency measures include improved route scheduling, addition of double tracks and sidings to reduce congestion at traffic choke points, and steps to reduce accidents and equipment downtime.

Ocean-Going Vessels (OGVs)

OGVs produce emissions from main (propulsion) engines as well as auxiliary engines (electrical generators). Passenger-carrying OGVs are cruise ships. Cruise ships have particularly large auxiliary engines to provide shipboard power while docked and at sea. New vessels built beginning in 2016 must have engines capable of meeting Marine Category 3 Tier 3 standards when operating in Emission Control Areas (ECAs) established by the International Maritime Organization (IMO). These areas include waters off the United States and Canada. Technologies required to meet these standards include engine modifications/improvements such as common rail injection, electronic engine monitoring/control, slide valve injectors, advanced injector orifice design, turbocharging, and cooled EGR. The controls individually, do not necessarily achieve Tier 3 standards, but enable use of aftertreatment seawater scrubber or SCR technology, which will. Tier 3 standards vary by engine horsepower and design but typically reduce NOx by approximately 80% compared to a fleet average of Tier 1.

Liquified natural gas (LNG) is being considered as a fuel for ocean-going vessels to reduce both fuel cost and emissions. LNG-powered vessels are currently deployed in several regions around the world. Some of the LNG-powered vessels are meeting Tier 3 NOx emissions levels. However, LNG-powered cruise vessels have not been deployed. Combined with aftertreatment, LNG-powered engines have the potential to achieve NOx levels lower than Tier 3 diesel engines. In addition to LNG fuel, emulsified fuels have been considered as an alternative or supplement to EGR for NOx reduction.

Cruise ships are also subject to the CARB At-Berth regulation to reduce fleet emissions from auxiliary engines when docked. This regulation is generally satisfied by using shore power instead of ship-board power although alternative capture and treatment systems can be used if shown to provide equivalent reductions to shore power. At-berth auxiliary emissions from cruise ships using shore power or capture and treatment systems are reduced about 90%. Capture and treatment systems can also be applied to boiler emissions which are not regulated by the At-Berth Regulation.

IMO standards require 30% improvement in vessel fuel efficiency by 2025 as a means of reducing GHG from ocean-going vessels. Reductions in fuel consumption will also lead to proportional reductions in NOx emissions. Several alternative technologies can contribute to that goal: fuel cells, wind power, hull coatings, hull design, propeller optimization, and engine heat recovery. Vessel trip optimization and vessel speed reduction also contribute to reduced fuel consumption and emissions.

Commercial Harbor Craft

Commercial harbor craft used in passenger transport include ferries and excursion vessels. The boats operate primarily in or from the Ports of Los Angeles and Long Beach. Commercial harbor craft have a long useful life and turnover to newer engines or vessels is slow. Most commercial harbor craft have engines less than 800 horsepower, for which the most stringent standard is Tier 3 (5.4 g/bhp-hr NOx) for Category 1 and 2 marine engines. Engines greater than 800 horsepower, used mainly on ferries, are subject to the Tier 4 standard (1.3 g/bhp-hr NOx) for Category 1 and 2 marine engines, which may need SCR and possibly diesel particulate filters. Marine emission standards are not as stringent as off-road standards of the same tier. As such, additional emission reductions could be obtained by introducing lower emission standards to force new engine designs or use of SCR aftertreatment. Promising alternative technologies include fuel cells and hybrid-diesel or hybrid-natural gas engines. Hybrid vessels have been shown to reduce overall emissions approximately 30%. Fuel cells and battery systems can be used for auxiliary power which would reduce emissions.

Improvements in vessel efficiency will also lead to proportional reductions in NOx emissions. Several alternative technologies can contribute to that goal: hull coatings, hull design, and propeller optimization.

Commercial Aircraft

Lower NOx emissions and fuel consumption will be obtained through improved jet engine combustor, turbine, and air frame designs. The improvements are driven by international and U.S. EPA emission standards for aircraft engines. Research supporting these improvements is guided by the Federal Aviation Administration (FAA) Continuous Lower Energy, Emissions, and Noise (CLEEN) Program. In efforts to reduce fuel consumption, many airports provide landside electrical power to run the auxiliary power units (APUs) on aircraft. In addition, several airlines are testing biofuels to reduce particulate, GHG emissions, and potentially, NOx emissions. Fuel cell technologies are also being investigated for auxiliary power as are wing and airframe designs to improve flight efficiency.

TRANSPORTATION SYSTEM EFFICIENCY MEASURES

While improvements in existing control technologies and increased deployment of near-zero and zero-emission vehicles will lead to reduced emissions, improvements and enhancements to the transportation system in terms of reduced roadway congestion can result in reduced idling emissions and vehicle miles traveled when considering alternative mode choices (i.e., ridesharing, public transit, commuter rail, and active transportation).

The state of technology for providing real-time information is continuing to grow and become available to commuters and regional traffic managers. Intelligent transportation systems (ITS) cover a broad range of information communications and control technologies that improve the safety, efficiency, and performance of the surface transportation system. ITS technologies provide the traveling public with accurate, real-time information, allowing them to make more informed and efficient travel decisions.[5] Such technologies will enhance current traffic control and management systems, incident management systems, and advance traveler information systems, which potentially can result in reducing emissions. In addition, greater use of sophisticated technologies such GPS (global positioning systems), wireless connected vehicles, and intelligent transportation systems can potentially lead to additional criteria pollutant reductions.

Land use decisions by local governments and SCAG can have a beneficial impact on the transportation system through coordinated planning with the county transportation commissions and SCAG. For more information, see SCAG's 2012 – 2035 RTP/SCS.

[5] Caltrans (2015). Draft California Transportation Plan 2040. March 2015. (http://www.dot.ca.gov/hq/tpp/californiatransportationplan2040/)

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