ARB Staff Assessment of the Impact of the Economy on California Trucking Activity and Emissions 2006-2014

California Air Resources Board
December 2009

Summary

At its December 2008 meeting, the California Air Resources Board (ARB or Board) adopted the Statewide Truck and Bus Rule (Rule). At that Hearing, the Board directed ARB staff to report back in December 2009 on the impact of the current recession on heavy duty diesel truck activity and emissions in California. This document describes the data sources and approach taken to evaluate near term statewide impacts of the recession on trucking activity and emissions as well as the results of a sensitivity analysis assessing the implications of two different growth scenarios for statewide truck and bus emissions through 2014. With the exception of drayage trucks, there was insufficient information available to accurately characterize how the recession is impacting truck emissions either regionally or by type of trucking vocation.

In conducting this assessment, staff analyzed a wide variety of data sources including diesel fuel sales, roadway sensor information, shipping container throughput, trucking industry tonnage reports, truck sales trends, and truck registration data. Based on the data reviewed diesel fuel use, truck traffic, and a number of other statewide surrogates of truck activity in California decreased by approximately 20 percent between 2007 and 2009. The lower emissions associated with this reduced activity has been partially offset by the overall age of the California-registered truck fleet increasing by approximately one year between 2006 and 2009 due to a 60 percent reduction in new truck registrations in California over that time period. Combined, the reduced truck activity and older average fleet age results in calendar year 2009 emissions being 20 percent lower than was estimated in the Rule staff report.

Looking forward, there is no single metric or forecast that is a direct indicator for projecting future emissions from trucks and buses in California. As a result, staff reviewed a large number of economic and fuel consumption forecasts for California and the nation. These included forecasts from national agencies such as the Congressional Budget Office and the Energy Information Administration; California state agencies including the Department of Finance, Legislative Analyst's Office, and California Energy Commission; leading California universities including the UCLA Anderson School and the University of the Pacific; and independent consultants such as Beacon Economics.

These forecasts provided a range of different rates of economic recovery. To encompass the variability in these forecasts staff conducted a sensitivity analysis of potential future emissions trends. The upper and lower bounds of this

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sensitivity analysis were defined by two growth rates and informed by the economic, fuel, and other forecasts reviewed. Staff defined a faster growth scenario where California truck activity and sales begin to grow in 2010 and return to the long term trend in eight years, and a slower growth scenario in which California truck activity and sales are flat from 2009 to 2011 and then grow at historically average rates through 2014. The eight year recovery period assumed in the faster growth scenario is consistent with the length of time required for the U.S. economy to recover from the Great Depression. It is also supported by the Congressional Budget Office forecast coupled with an assumption that California's economic recovery will lag the nation by two years. The rate of growth assumed in the slower growth scenario is generally consistent with most of the California-specific employment forecasts reviewed.

Results show that in the near term (2010 and 2011), in both scenarios evaluated, lower truck activity will reduce diesel particulate matter ($PM_{2.5}$) and oxide of nitrogen (NOx) emissions to a greater degree than was expected in the 2008 Rule staff report. However, beginning in 2012 and continuing through 2014, the Rule is required to achieve needed emissions reductions for both growth scenarios considered. Under a faster growth scenario, the Rule in its entirety Is needed to meet State Implementation Plan (SIP) obligations for NOx and $PM_{2.5}$. Under a slower growth scenario, the Rule provides slightly more emissions reductions than were expected in the Rule staff report. This analysis shows that assumptions about the rate of economic recovery and related growth in truck activity and sales determines whether the Rule provides any NOx emissions reductions above and beyond what was expected in the Rule staff report.

Introduction

In December 2008 the California Air Resources Board (ARB) adopted the Statewide Truck and Bus Rule (Rule). At that hearing, the Board directed ARB staff to report back to the Board in December 2009 on the impact of the current recession on heavy duty diesel vehicle activity and emissions in California. This document describes the data sources and approach taken to evaluate near term impacts of the recession as well as the results of a sensitivity analysis assessing the implications of different economic scenarios for California truck emissions through 2014.

In developing the Rule in 2008, ARB staff updated assumptions about the population of trucks operating in California, the annual miles traveled by different trucking vocations, their average age, and sales. A complete description of these sources and how they were used to estimate emissions for the Rule is provided in Appendix G of the Rule staff report. This assessment uses the same emissions estimation methods as were used for the staff report but incorporates more current truck activity, population, and age data from a variety of sources.

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Assessing Current Truck Activity

Staff evaluated a variety of different data sources to assess the current impact of the recession on trucking activity.

- On-Road Diesel Fuel Sales – the California State Board of Equalization (BOE) collects and makes publically available California-specific on-road diesel fuel sales estimates on a monthly basis. There is a 4 month lag in the release of the BOE fuel sales data such that the most recent fuel sales data used in this analysis was August 2009; data were evaluated back to 2000. Fuel sales vary seasonally; the magnitude of the calculated reduction in fuel sales can vary depending upon the time period selected for analysis.

- Highway Performance Monitoring System (PeMS) – Thousands of roadway sensors are embedded on freeways and state highways throughout California. This system was developed by the California Department of Transportation (Caltrans) to assist traffic management efforts and summary reports are published through Caltrans and UC Berkeley. Truck volume data are estimated on an hourly basis at each site, allowing trends in truck activity to be developed, but this is complicated by the fact that sensors are added, removed, and repaired every year.

  PeMS data are most useful when high quality data are available for several consecutive years at the same site or set of sites. Staff reviewed data for eight PeMS stations as shown in Table 1 that were selected based on their location on major truck thoroughfares and their data quality over the period 2004 - 2009. Staff also evaluated California and regional summary data provided by UC Berkeley through their PeMS web site. These data are available in near-real time; the most recent PeMS data used in this analysis were from October 2009.

Table 1. Selected PeMS Locations

Location	Freeway	Station No.	County
Norwalk	I5 Northbound	715915	Los Angeles
Oakland	I580 Westbound	400549	Alameda
Ontario	I10 Eastbound	801269	San Bernardino
Los Angeles	SR101	764781	Los Angeles
San Joaquin Valley and French Camp Road	SR99 Northbound	1004910	San Joaquin
Irvine	I405 Northbound	1201333	Orange
East of Pleasant Valley	I80 Westbound	401877	Solano
San Jose	I880 Southbound	400514	Santa Clara

- Weigh-in Motion (WIM) Stations – More than one hundred weigh-in motion sensors are embedded on freeways and state highways in California. These sensors provide very detailed and accurate information on truck volumes,

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weights, axle configuration, and speeds throughout the State. Staff obtained multi-year historical data from Caltrans for nine selected sites and analyzed the results. These sites were chosen based on their location and data completeness between 2004 and 2009. Selected locations are shown in Table 2. The WIM data require significant processing such that the most recent data used in this analysis were from March 2009.

Table 2. Selected WIM Stations

Location	Freeway	Station No.	County
Fresno	SR-99 SB	10	Fresno
Antelope	I80 (East of Sacramento)	3	Sacramento
Hayward	I880 NB	18	Alameda
Fontana	I15 NB	70	San Bernardino
Balboa	I15 NB	88	San Diego
Chico	SR-99 SB	107	Butte
Ports of LA / Long Beach	I710 Near I405 Interchange	116	Los Angeles
Carbona	580 WB in San Joaquin County	113	San Joaquin
Willows	I5 NB	108	Glenn

- Port Container Throughput – The Ports of Los Angeles, Long Beach, and Oakland publish historical and current port-specific container throughput statistics in a monthly database. The most recent container throughput data analyzed for this assessment was from October 2009; data were evaluated back to 1995.

- American Trucking Association (ATA) Truck Tonnage Index – Each month the ATA asks its national membership the amount of tonnage each carrier hauled, including all types of freight. These data are summarized, normalized to the 2000 calendar year, and published. The index represents the relative activity of ATA members, and is not specific to California. The most recent ATA truck tonnage data analyzed for this assessment was from September 2009; data were analyzed back to 2005.

- Bureau of Transportation Statistics (BTS) Transportation Services Index – The TSI is a seasonally adjusted, weighted measure of the movement of freight which is published monthly. The index is national and not specific to California. The most recent BTS transportation services data analyzed for this assessment was from September 2009; data were evaluated back to 1990.

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A complete listing of each source and the estimated decrease in activity relative to calendar year 2007 is provided in Table 3.

Table 3. Estimated Decrease in Current Activity Relative to 2007

Data Source	Region	Change 2007-2009	Latest Data Used
California Fuel Sales	Statewide	-13% to -18%	August 2009
California PeMS Counts	Statewide	-4% or more	October 2009
California WIM Counts	Statewide	-10% or more	March 2009
Port of LA / Long Beach Container Traffic	Los Angeles	-26%	October 2009
Port of Oakland Container Traffic	Bay Area	-17%	October 2009
ATA Tonnage Index	Nationwide	-10%	September 2009
BTS Transportation Services Index	Nationwide	-14%	September 2009

Results show that truck activity in California is down between 4% and 26% since 2007, depending on the data source. Staff believes statewide fuel sales is the most appropriate measure of the impact of the recession on non-drayage trucks, which is consistent with national trends. Preliminary analysis of PeMS and WIM data show significant variability in truck activity reductions depending upon the location and staff are continuing to assess regional differences.

Staff believes there are significant differences in the impact of the recession on different types of trucking operations. For example, as shown in Table 1, container movements through California's ports and associated drayage truck activity have been impacted more significantly than trucking operations in general. Also, according to the California Department of Finance, construction employment has decreased significantly more than transportation employment as a whole. However, with the exception of drayage trucks, staff was not able to identify trucking activity-specific statistics for individual trucking sectors in California.

Assessing Current Truck Age in California

In developing the emissions analysis documented in the Rule staff report, staff evaluated the impact that trucking sales have on the age distribution of vehicles, and found that national sales statistics are correlated with truck age distributions in California. This is important because newly manufactured trucks are cleaner than older trucks. This correlation was used as an input to the emissions analysis, so that historical and future forecasted truck sales have an impact on the modeled age distribution of vehicles in each calendar year. When more vehicles are sold nationally, more appear in California fleets; and when fewer vehicles are sold nationally, fewer appear in California fleets. To validate this assumption, staff analyzed trends in national new truck sales reported by WardsAuto and changes in the fraction of new truck registrations reported by the California Department of Motor Vehicles (DMV).

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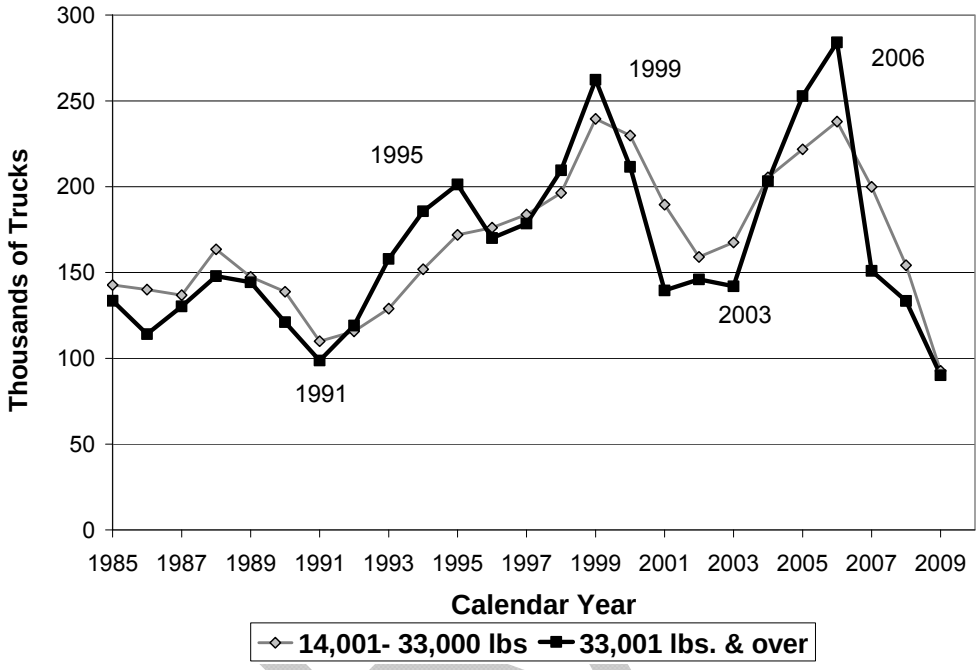
WardsAuto is a company that monitors and publishes national truck sales data that are available through a subscription service. Figure 1 shows historical new truck sales, and indicates that current sales volumes are at their lowest level in 25 years. The table also shows significant year to year variability and sensitivity to economic conditions.

Figure 1. National Heavy Duty Diesel New Truck Sales 1985-2009



Because national truck sales are so low, staff expects that the average age of vehicles operating in California is getting older. Staff assumes the relationship between vehicle sales and registered truck population applies to all trucks regardless of registered location, body type, or vocation. This assumption has been confirmed for California registered trucks by analysis of California DMV registration data, as described below.

Every six months ARB staff obtains a snapshot copy of the DMV registration database. The database contains roughly 50 million records that staff process to count the number of cars and trucks by weight class, technology, age, and other factors. Staff processed the database to count California-registered non-drayage heavy-heavy duty diesel trucks by model year. Drayage trucks were removed in order to focus this analysis on vehicle sales caused by normal business vehicle replacement decisions, and not by replacement decisions driven by compliance requirements. Staff identified roughly 3000 new vehicle registrations in 2009 that were also registered in the ARB drayage truck registry. These new vehicle registrations in the drayage fleet were higher than normal new vehicle

registration rates for drayage trucks, suggesting that these additional registrations were completed to comply with Drayage Truck Rule requirements effective January 2010, and were not caused by natural turnover. The emissions reductions generated by compliance with the Drayage Truck Rule are attributed to that Rule and not to the Statewide Truck and Bus Rule.

Table 4 shows that between 2005 and 2007, approximately 6% of all registered in-state non-drayage heavy-heavy duty diesel trucks were new model year vehicles. The associated 10% increase in truck population over that same time period suggests that in those years the number of new trucks entering the California fleet exceeded the number of trucks being retired. However, starting in 2008, new truck registrations dropped dramatically, consistent with the decline in national truck sales, such that less than 3% in-state non-drayage trucks registered in 2009 were new model year vehicles. This drop in new vehicle registrations resulted in the truck population leveling off and the average fleet age increasing by almost a year as fewer new vehicles were purchased and existing vehicles stayed on the road longer.

Table 4. Estimated DMV Registration Database Heavy-Heavy Duty Registered Non-Drayage Truck Population in California: 2005-2009

Year	Percent of New Vehicles in Fleet	Population (thousands) (non-drayage)	Average Age
2005	6.4%	181	9.1
2006	6.8%	198	9.1
2007	6.1%	199	9.2
2008	3.4%	198	9.6
2009	2.7%	197	9.9

Table 5 compares the reduction in national new truck sales (as measured through national sales data) to the reduction in the number of new non-drayage registered vehicles as measured through the California DMV database. Results show comparable reductions between 2005 and 2009 in new truck sales on a nationwide basis and registration of new model year non-drayage trucks in California.

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Table 5. Trend in National New Truck Sales and New Registered Non-Drayage Trucks in California: 2006-2009

	% Change Relative to 2005	
Year	National[1]	California[2]
2006	+12%	+6%
2007	-40%	-5%
2008	-46%	-47%
2009	-64%	-58%*

[1] WardsAuto national sales database
[2] Analysis of California DMV new truck registration data
* Excludes drayage trucks

The Emissions Analysis

The Rule emissions analysis reflects annual average long term growth and did not evaluate emissions under the cyclical conditions of periodic economic expansion and contraction. However, the Rule emissions analysis has two important inputs that can be used to reflect the economic cycle: activity growth rates, and sales forecasts.

During a recession the economy contracts due to less economic activity. In the trucking sector this translates into fewer overall miles driven and fewer average miles driven per truck. Some trucking firms may operate fewer vehicles during a recession than during stable economic periods. The net effect is that during a recession (assuming no changes in average vehicle age), fewer miles are driven, and emissions are reduced as a result.

During stable economic periods trucking firms will operate their vehicles and as mileage accumulates, vehicles will eventually reach the end of their economic or useful life. When this occurs firms will replace older trucks with new or newer used vehicles. This turnover of vehicles is a standard practice in the industry during stable economic periods and varies by type of business. However, during a recession this turnover is affected in two ways. First, because fewer miles are being driven per truck per year, older vehicles will last longer than they otherwise would have, reducing the demand for new or newer used vehicles. Second, because businesses are more financially stressed during a recession they are less likely or able to purchase new or newer used vehicles. The combined impact of these two factors is that over time the fleet gets older. Because older vehicles have fewer and less effective emissions controls than newer vehicles, fleet average emission rates will increase over time.

During this recession, the decreased demand for newer vehicles has resulted in lower vehicle sales. As shown in Figure 1 and Table 5, 2008 and 2009 model year sales and registrations have been very low relative to historical values. In

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the absence of regulatory requirements, 2008 and 2009 model year vehicles will enter the California fleet both now and in the future in numbers significantly lower than previously assumed. Because 2007 standard engines are 70% cleaner for NOx and 85% cleaner for $PM_{2.5}$ than engines manufactured prior to 2007, fleet average emission rates will be higher both now and in the future relative to what was anticipated in the Rule inventory.

Revised 2009 calendar year emissions estimates were developed using the most recent diesel fuel sales, truck activity, and truck sales data available. A listing of the fuel sales and activity data sources used are shown in Table 3 and the truck sales estimates used are provided in Tables 4 and 5. Figures 2 and 3 show that these revised $PM_{2.5}$ and NOx emissions estimates for calendar year 2009 are approximately 20% lower than the estimates provided in the Rule staff report.

Figure 2. 2009 $PM_{2.5}$ Emissions: 2008 Staff Report vs. Revised Estimate

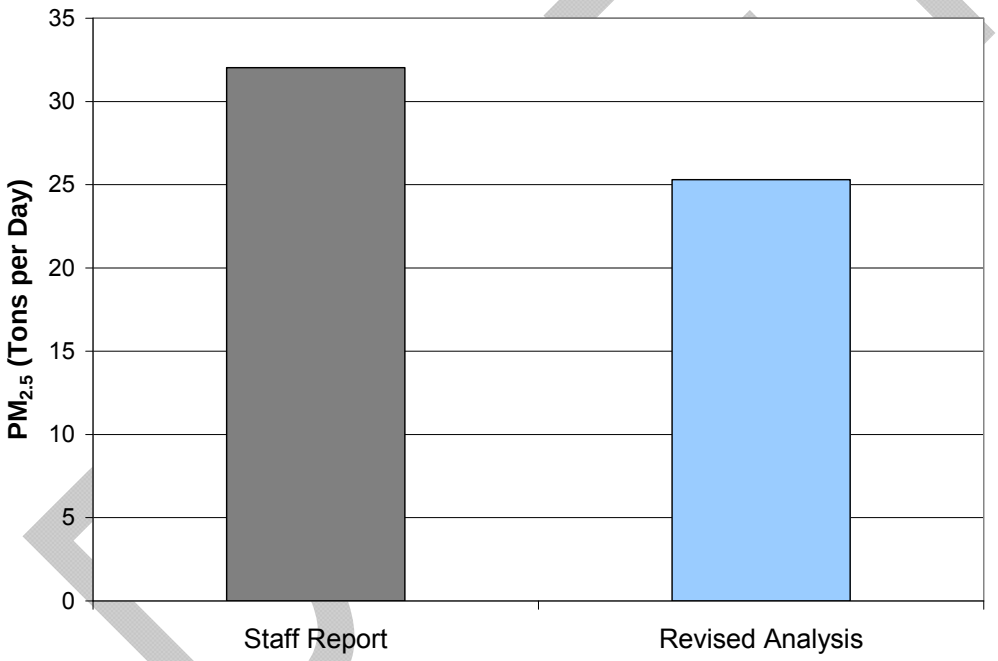
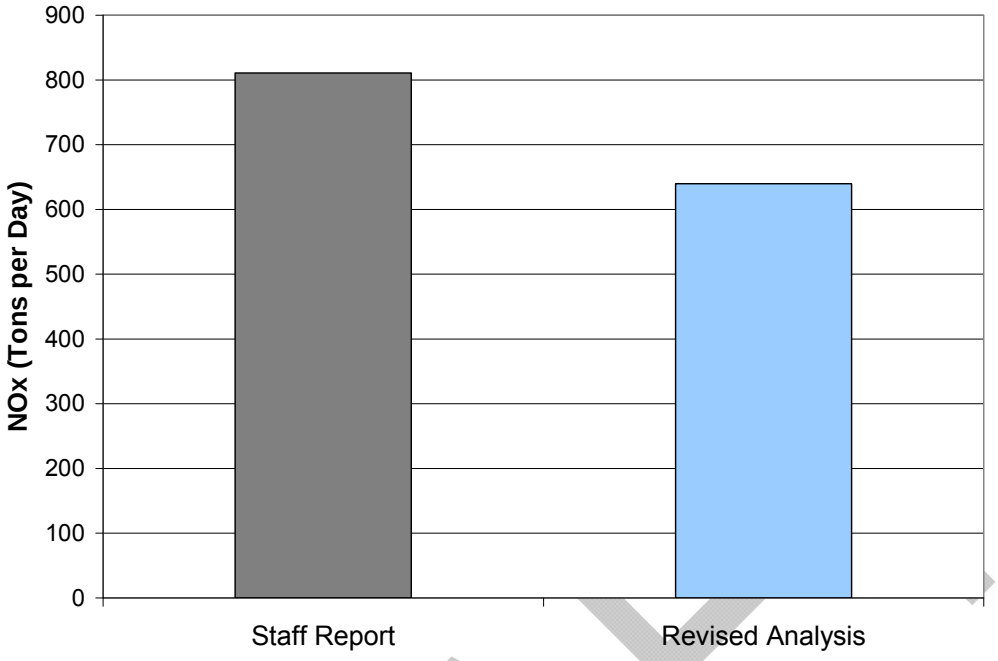


Figure 3. 2009 NOx Emissions: 2008 Staff Report vs. Revised Estimate



The Statewide Truck and Bus Rule phases-in compliance requirements for NOx and $PM_{2.5}$ over a thirteen year period starting in 2011. The first round of requirements take effect over three years beginning in 2011, and requires nearly all vehicles to be equipped with a diesel particulate filter by 2014. These relatively near-term requirements are focused on reducing near-source risk in the vicinity of ports, heavily traveled roadways, and environmental justice communities; and on providing emissions reductions in 2014 to meet SIP targets.

The second round of requirements in the Rule focuses on reducing NOx emissions to meet both particulate matter and ozone air quality standards. Requirements are phased in between 2012 and 2023 and are designed to meet two objectives. The first objective is to meet regional SIP targets in the South Coast, San Joaquin, and other regions of the state. The second is to ensure that by 2023 all trucks operating in California will be equipped with the lowest NOx and $PM_{2.5}$ emissions control technology available.

Because the Rule is designed to phase-in compliance over time, understanding how the recession will impact future year emissions is important. The Rule emissions analysis documented in the staff report assumed long-term annual average growth in activity and an estimate of future new vehicle sales. In order to assess the impact of the recession, staff evaluated economic and fuel consumption projections from a wide variety of sources in order to estimate how activity and new vehicle sales will change during and after the recession.

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Forecasts Used
Staff evaluated a number of economic, fuel, and other forecasts at the local, state, and national level including:

Economic Forecasts

- UCLA Anderson School
  Since March 2006 the UCLA Anderson Forecast has provided quarterly economic forecasts for California and the U.S. The most recent forecast, published in September 2009, provides forecasts for employment, gross domestic product (GDP) and housing permits out to 2011. Previous publications (e.g. 2007 and 2008) have provided extended forecasts out to 2020, but the 2009 forecast did not do so.

- University of the Pacific
  The California and Metro Forecast is a quarterly forecast of the economies of California and 11 metropolitan areas in northern California (Modesto, Merced, Napa, Fresno, Oakland, Sacramento, San Francisco, San Jose, Stockton-Lodi, and Vallejo-Fairfield). Published in September of this year the report provides forecasts for gross state product, employment, housing permits, and population out to 2014.

- Beacon Economics
  Beaconomics is a quarterly economic forecast for the U.S. and California. Published in September of this year the report provides forecasts for personal income, employment, housing permits, and imports/exports out to 2013.

- California Department of Finance
  The forecasts were prepared by the Economic Research Unit of the California Department of Finance in April 2009. The reports provide annual and quarterly economic forecasts employment, income, and housing permits for California and the U.S. out to 2011.

- California Legislative Analyst's Office
  The LAO's "2010-11 Budget: California's Fiscal Outlook" published in November 2009 provides economic projections on California's budget as well as California and U.S. employment, GDP and housing permits out to 2015.

- United States Congressional Budget Office
  In the CBO's "The Budget and Economic Outlook: An Update" published in August 2009 they provide a forecast of U.S. real and potential gross domestic

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product out to 2019. The projections suggest that real GDP will converge with potential GDP no later than 2015.

Fuel Consumption and Other Forecasts

- California Energy Commission
  CEC staff for the *2009 Integrated Energy Policy Report*, developed long-term forecasts of transportation fuel demand. The Fuel Demand Forecast provides diesel fuel consumption for four primary areas: truck and rail freight goods movement, residential and commercial light-duty vehicle transportation, urban and intercity public transit, and off-road vehicles. The report was published in August 2009 and forecasts fuel demand out to 2030.

- United States Energy Information Administration
  The Annual Energy Outlook 2009 published in March 2009 provides projections of US energy supply, demand, and prices through 2030. The projections are based on results from the Energy Information Administration's National Energy Modeling System. The reference case was updated in April 2009 to reflect the American Recovery and Reinvestment Act adopted in February 2009. The Annual Energy Outlook forecasts national fuel use, truck sales and truck vehicle miles traveled through 2030 but does not include any information specific to California.

Table 6 compares each of the forecasts in terms of the information provided, when the forecast is last published, and when the next release is anticipated.

Projecting heavy duty truck emissions into the future requires developing growth rates that represent California-specific estimated vehicle activity (vehicle miles traveled or VMT) and new vehicle sales in each future year. These growth rates can then be input to the emissions analysis to calculate future year emissions.

Staff evaluated each forecast, and found that none provided California-specific growth estimates for truck VMT or truck sales in future years. Staff then evaluated each forecast to compare information provided across forecasts. Both the Annual Energy Outlook (AEO) from the United States Energy Information Administration and the Integrated Energy Policy Report from the California Energy Commission provided future year fuel consumption forecasts. The AEO also provided truck VMT and truck sales forecasts, but these were nationwide projections and did not provide any estimates for California specifically.

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Table 6. Comparison of Economic and Fuel Consumption Forecasts

Economic Forecasts

Region	Data Source	Information Provided	Forecast to	Date Last Published	Future Release Date
California	UCLA Anderson School	CA non-farm employment by sector; California and national GDP; housing permits.	2011	September 2009	December 2009
	Univ. of the Pacific	CA non-farm employment by sector; California GDP; housing starts. Forecasts statewide and regional.	2014	September 2009	December 2009
	Beacon Economics	CA non-farm employment by sector; California and national GDP; housing permits; and imports/exports.	2013	September 2009	December 2009
	CA Dept of Finance	CA non-farm employment by sector; California and national GDP; housing permits.	2011	April 2009	2010
	CA Office of the Legislative Analyst	CA non-farm employment by sector; California and national GDP; housing permits.	2015	November 2009	2010
United States	Congressional Budget Office (CBO)	National Real GDP	2019	August 2009	Early 2010

Fuel Consumption Forecasts

Region	Data Source	Information Provided	Forecast to	Date Last Published	Future Release Date
California	CEC Fuel Demand Forecast	CA diesel fuel demand	2030	August 2009	August 2010
United States	Energy Information Administration (EIA)	National truck VMT and new truck sales	2030	April 2009	2011

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Most California-specific economic forecasts evaluated by staff provided a statewide assessment of projected economic measures such as gross state domestic product and employment. Those economic measures are not direct indicators of trucking activity or vehicle sales but are useful for assessing the potential timing and rate of a future economic recovery. Most of the available California forecasts focused on the near-term (the next three to five years) and did not forecast longer term trends. Finally, each economic forecast projected different recovery rates for economic indicators such as gross domestic product and employment.

Bounding Potential Emissions Forecast Scenarios

As part of this assessment, staff developed a bounding exercise to bracket the range of potential economic recovery conditions and their impact on heavy duty vehicle emissions in California. Based on the range of economic and other forecasts discussed previously, staff developed a faster growth scenario and a slower growth scenario for the years 2010 through 2014. These faster and slower growth scenarios bracket the range of available forecasts that were reviewed. Both scenarios provide emissions projections for several broad trucking categories: non-drayage heavy-heavy duty trucks and buses (>33,000 lbs gross vehicle weight rating); non-drayage medium-heavy duty trucks and buses (14,000-33,000 lbs gross vehicle weight rating), drayage trucks at the Port of Los Angeles and Long Beach, and drayage trucks at the Port of Oakland.

The faster growth scenario assumes that by 2017 trucking activity and vehicle sales in California will return to levels anticipated in the Rule staff report. The return to anticipated activity and vehicle sales levels by 2017 is based on historic recovery rates from previous recessions and also accounts for the idea that California is likely to recover more slowly from this recession than the country as a whole. Specifically, the Congressional Budget Office historical national gross domestic product data indicates that no national recession or depression since 1929, including the Great Depression, has taken more than eight years to recover back to previously anticipated growth levels. In addition, the Congressional Budget Office forecast suggests that real gross domestic product at a nationwide level will converge with potential gross domestic product trends no later than 2015. Coupling this national forecast with the assumption that California's recovery will lag the nation by several years yields the 2017 recovery date assumed for the faster growth scenario.

For this analysis, the vehicle activity recovery rate was assumed to be linear between current 2009 levels and anticipated 2017 levels, which results in a recovery rate of approximately 6.3% per year in heavy heavy-duty diesel truck activity. Because vehicle sales are much more sensitive to changes in economic conditions than is truck activity, the growth in heavy heavy-duty diesel vehicle

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sales was assumed to be 36% per year for 2010 and 2011, and 4.8% per year from 2012 to 2017.

The slower growth scenario is based on the assumption that trucking activity and new vehicle sales will not return to previously anticipated levels in the foreseeable future. Staff assumed that truck activity will remain flat in 2010 at 2009 levels, and then grow at annual average growth rates reflected in long term trends and published in the staff report (which as documented in the staff report is 2.6% per year for heavy heavy-duty diesel trucks). This scenario is generally consistent with the economic outlook defined by the California Legislative Analyst's Office (November 2009), national trends in the AEO, and recovery rates in most California-specific employment forecasts. Vehicle sales are assumed to be flat in 2010 and 2011, with 11% per year growth occurring between 2011 and 2017.

Method for Forecasting Emissions

Staff developed a scaling approach for estimating the impacts of projected reduced activity and projected reduced vehicle sales on emissions for each calendar year between 2010 and 2014. The scaling approach starts with the emissions estimated by the Rule analysis, and ratios those emissions to reflect the change in activity, sales, and the reductions resulting from the Rule. The scaling approach is conducted in a Microsoft Access database. The following equation was used to calculate emissions for NOx and $PM_{2.5}$ without the application of reductions generated by the Rule:

$$\sum E_{sypc} = E_{bypc} \times A_{syc} \times S_{syc} \qquad (1)$$

where

E_{sypc} = Emissions after rule is applied for scenario "s," year "y," pollutant "p," and category "c"

E_{bypc} = Baseline emissions from rule inventory analysis for year "y" and pollutant "p," and category "c"

A_{syc} = Activity ratio reduction factor for scenario "s," year "y," and category "c"

S_{syc} = Sales ratio reduction factor for scenario "s," year "y," and category "c"

The following equation was used to calculate emissions for NOx and $PM_{2.5}$ (prior to 2014) after the Rule is applied:

$$\sum E_{sypc} = E_{bypc} \times A_{syc} \times S_{syc} \times R_{ypc} \qquad (2)$$

where,

R_{ypc} = Rule ratio reduction factor for scenario year "y," pollutant "p," and category "c"

A similar scaling equation was used for calculating $PM_{2.5}$ emissions after application of the Rule in 2014 except that the sales reduction ratio is not used

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because after the implementation of the Rule for $PM_{2.5}$ in 2014, all vehicles are required to be equipped with a diesel particulate filter. As a result, the increase in age does not materially affect remaining emissions after the Rule is applied.

The equation for PM2.5 emissions in 2014 is as follows:

$$\sum E_{sypc} = E_{bypc} \times A_{syc} \times R_{ypc} \qquad (3)$$

In these equations, the activity ratio reduction is calculated as the projected activity level (vehicle miles traveled) divided by the anticipated activity level in the Rule inventory analysis (vehicle miles traveled) in each calendar year for each scenario.

The rule reduction factor is calculated as the ratio of the Rule emissions analysis with the rule applied in each calendar year divided by the Rule emissions analysis baseline inventory without the rule applied. This ratio is calculated for each calendar year, pollutant and inventory category in the Rule inventory, and is applied independent of economic scenario. The fact that the ratio is applied independent of economic scenario is a simplification because the model year distribution of vehicles will vary from the baseline in each economic scenario due to different forecasts of vehicle sales and their impact on projected age distributions in each category and fleet size group.

The sales reduction ratio is calculated using a two step process that adjusts the fraction of a model year in an age distribution by the ratio of projected sales under a bounding scenario to annual average projected sales. This ratio reflects the fact that a recession reduces the originally estimated new vehicle sales and vehicle turnover, and as a result the vehicle fleet becomes older. In the Rule inventory analysis vehicle turnover is a function of national new vehicle sales, the methodology for which is described on pages 46-53 of Appendix G of the Staff Report for the Statewide Truck and Bus Rule. In the methodology, the fraction of each model year in the inventory category age distribution is a function of an average age distribution and a sales forecast, as shown in equation 4. This fraction for each model year and calendar year is normalized to one, as shown in equation 5.

$$F_{MY,CY,c} = A_{MY,CY,c} \times (S_s / S_a) \qquad (4)$$

where,

$F_{MY, CY, c}$ = Fraction of a given model year in a calendar year and inventory category.

$A_{MY, CY, c}$ = Average fraction of a given model year in a calendar year and inventory category, calculated using 2000-2005 historical DMV data.

S_s = Projected sales in a forecast scenario "s."

S_a = Projected average annual sales, calculated with by regression line through historical truck sales 1985-2009 and projected into the future.

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$$Fc_c = (F_{MY,CY,c} \times 100) / \sum F_{MY,CY,c} \quad (5)$$

where,

Fc_c = Corrected fraction of a given model year in a calendar year and inventory category.

Using this methodology, the fraction of a model year in a calendar year and inventory category can be adjusted using different sales forecast scenarios. To assess the impact of this assumption, the VMT-weighed average emission rate can be compared across economic scenarios. As an example, Table 7 compares the heavy-heavy duty diesel California registered in-state tractor fleet average $PM_{2.5}$ and NOx emission rate for the 2008 Rule emissions analysis published in the staff report, the faster growth scenario, and the slower growth scenario in calendar year 2014. The table shows that the expected fleet average emission rate in 2014 is significantly higher than assumed in the staff report due to sharply lower truck sales. Depending upon the rate of truck activity growth, fleet average emission rates in 2014 will be 6% to 16% higher for NOx and 8% to 21% higher for PM2.5 than was assumed in the 2008 Rule analysis.

Table 7. Heavy-Heavy Duty Diesel Tractor VMT Weighted Emission Rates (grams per mile) in 2014 by Growth Scenario.

Scenario	$PM_{2.5}$	*Percent*	NOx	*Percent*
2008 Rule Emissions Analysis	0.49	*100%*	10.2	*100%*
Faster Growth Scenario	0.52	*108%*	10.8	*106%*
Slower Growth Scenario	0.58	*121%*	11.9	*117%*

Results

Figure 4 compares estimated $PM_{2.5}$ emissions resulting from implementation of the Rule as described in the 2008 staff report to what would happen under the two growth scenarios assumed. Because the Rule is phased-in over a number of years, most of the Rule reductions are expected to occur between 2012 and 2014. The figure shows in 2011 the recession provides more emissions reductions than the Rule was projected to provide in the Rule staff report. After 2011 the Rule is projected to provide more emissions reductions than the recession alone would provide. After 2012 the Rule provides significantly more emissions reductions than under either the faster or the slower growth scenarios.

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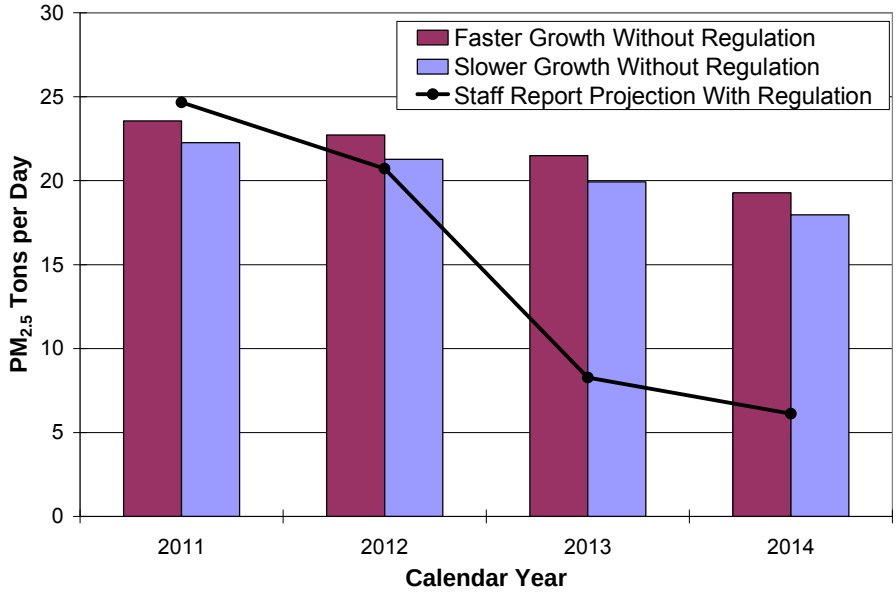
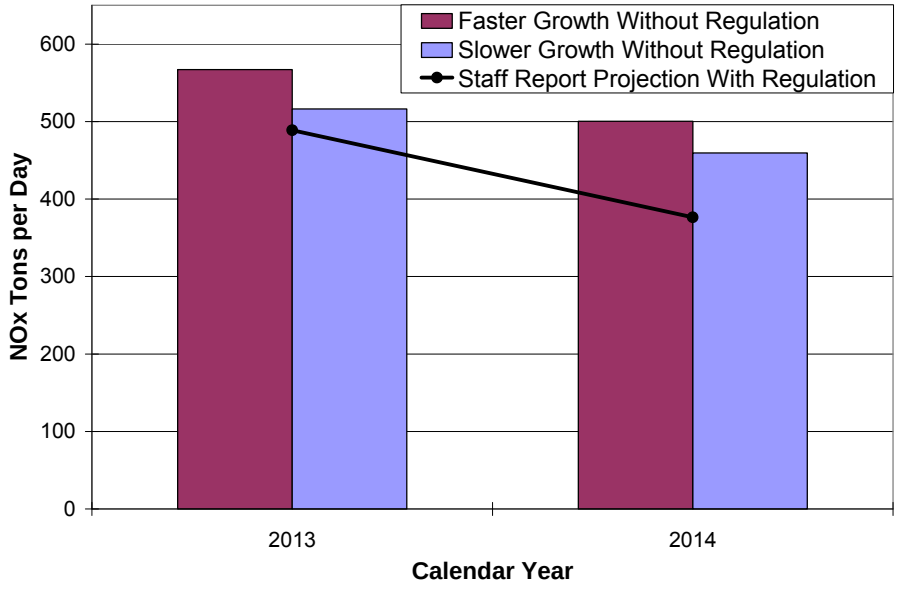
Figure 4. Statewide $PM_{2.5}$ Emissions 2011-2014



Due to the phase-in of requirements in the Rule, NOx emissions reductions are not expected until 2013. Figure 5 compares NOx emissions reductions projected to be achieved by the Rule in the 2008 staff report to the faster and slower growth scenarios. Results show that in 2013 and 2014 the Rule is anticipated to provide more emissions reductions than would be achieved by the recession alone.

Figure 5. Statewide NOx Emissions 2011-2014



The Statewide Truck and Bus Rule was designed to provide sufficient NOx and $PM_{2.5}$ emissions reductions to meet SIP targets in the South Coast region in 2014. The next step in the analysis was to estimate calendar year 2014 emissions under the faster and slower growth scenarios and compare the results to the SIP target. Figure 6 compares 2014 $PM_{2.5}$ emissions in the faster and slower growth scenarios after the Rule is applied to anticipated emissions levels in the staff report and SIP target. Results suggest that in the faster growth scenario, the Rule is not projected to provide significantly more $PM_{2.5}$ emissions reductions than anticipated in the staff report. In the slower growth scenario, emissions are slightly lower than anticipated in the staff report.

Figure 6. Projected 2014 Statewide $PM_{2.5}$ Emissions (tons per day)

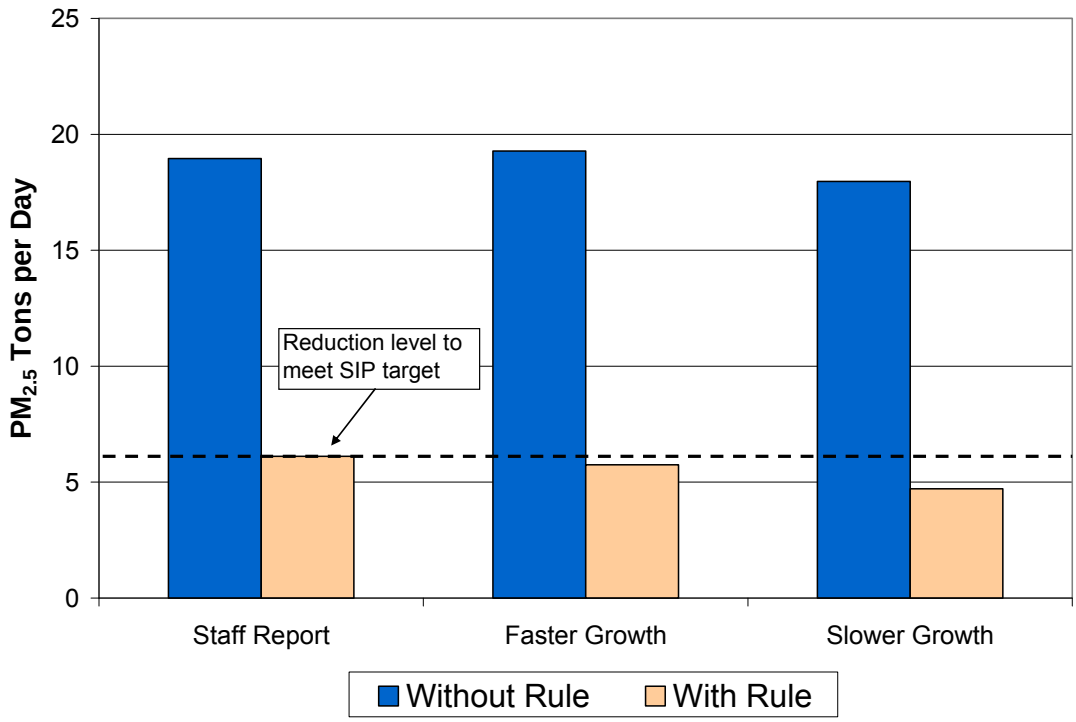
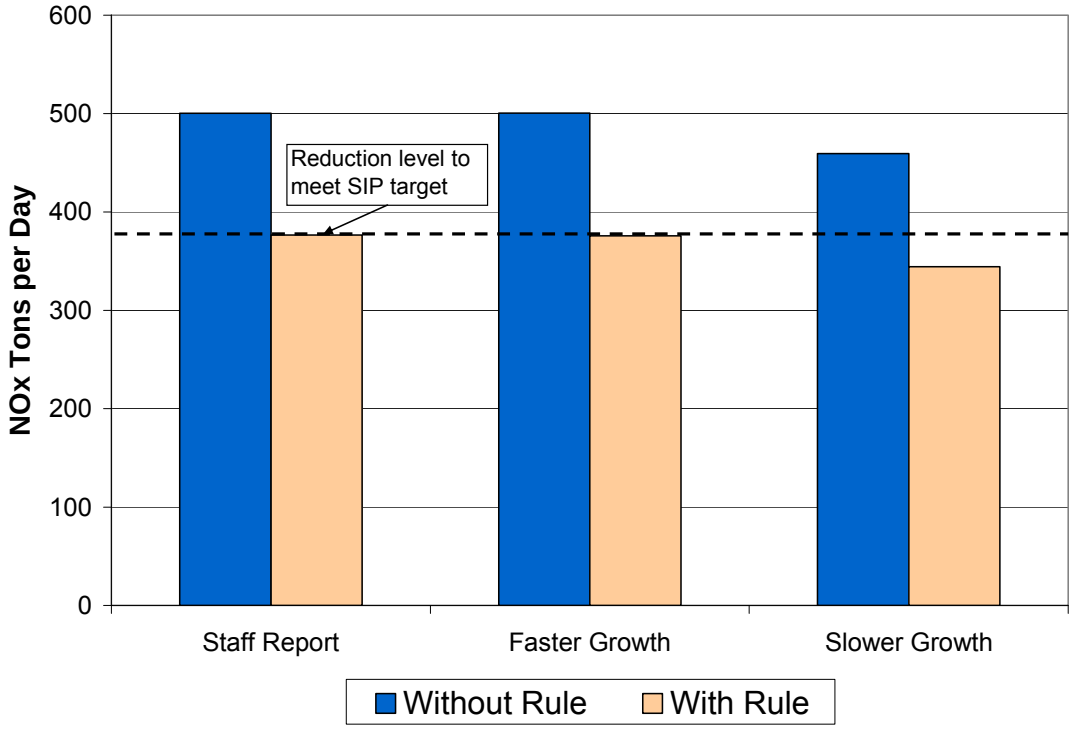


Figure 7 compares 2014 NOx emissions in the faster and slower growth scenarios after the Rule is applied to anticipated emissions levels in the staff report. Under the faster growth scenario the drop in truck activity that reduces emissions is offset by the increased emissions caused by decreased vehicle sales and fleet turnover. Under the slower growth scenario the impact of the drop in activity due to the recession reduces emissions more than the impact of reduced sales increases emissions. After the Rule is applied to the slower growth scenario, the Rule might provide slightly more emissions reductions than were anticipated in the Rule staff report. This analysis shows that assumptions about the rate of economic recovery and related growth in truck activity and sales determines whether the Rule provides any NOx emissions reductions above and beyond what was expected in the Rule staff report.

Figure 7. Projected 2014 Statewide NOx Emissions (tons per day)



Conclusions

The economy has had a significant impact on emissions from trucks and buses in California. Staff estimates emissions in 2009 have been reduced by more than 20% relative to estimates published in the 2008 staff report. Projected future emissions are dependent upon how California truck activity and truck sales recovers from the recession over the next five years. Staff developed two scenarios that were designed to bound the range of economic and fuel forecasts that were reviewed. Results suggest the recession will reduce emissions in 2011 more than was anticipated by the Rule in the staff report because the Rule is phased-in and relatively few reductions were anticipated in 2011. After 2012 the Rule is expected to generate much lower emissions than would be generated by the recession alone. In 2014, the analysis demonstrates the Rule is necessary to achieve the SIP target, and the extent to which the economy recovers will dictate whether or not the Rule will generate any emissions reductions above and beyond what was expected in the staff report.

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