Estimating the Construction Industry Compliance Costs for CARB's Off-Road Diesel Vehicle Rule

Prepared by

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On behalf of

the Construction Industry Air Quality Coalition

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Executive Summary

M.Cubed was retained by the Construction Industry Air Quality Coalition (CIAQC) to assist in estimating the potential economic impacts on the construction industry from regulations proposed by the Air Resources Board to control emissions from off-road diesel vehicles used for construction activities. The underlying analytical tool of this study is an Excel spreadsheet model of fleet evolution from 2008 thru 2020 and associated incremental costs accrued to the construction industry as it complies with the proposed ARB rule.

In 2005 the construction industry accounted for approximately 5 percent of gross state product. The construction industry employed approximately 835,000 Californians in 2004, representing $36 billion in payroll. Fifty-five percent of California construction firms have fewer than five employees, with 74 percent employing less than ten individuals. Less than one percent of the state's construction firms have more than 250 employees. Similarly, 97 percent of all California construction firms generate less than $10 million in annual sales. Finally, several forecasts call for a decline in construction spending in the near term, and Department of Finance data shows a significant downturn.

The construction industry also provides a larger "bang for the buck" than most other economic sectors. For every dollar spent on construction, total output, including "multiplier impacts," increases by $2.40. Construction produces 21.5 jobs throughout the economy for each million dollars added output the industry; or conversely, 21.5 jobs are lost along with each million dollars of reduced output.

On several key parameters, ARB Staff's modeling relies on unrepresentative data or unsupported assumptions. Where the ARB Staff has chosen assumptions upon which the information is quite uncertain, those choices have biased the estimated costs downward:

(1) The ARB has estimated the number and composition of mobile equipment in the off-road inventory from national surveys that do not reflect state-level compositions.

(2) The ARB Staff does not have an accurate count of firms falling into different fleet class sizes, i.e., small, medium and large despite this data being available from other state agencies. In addition, the ARB Staff analysis relies on an unrepresentative model fleet and appears to assume that public and private fleets have similar compositions and purchasing patterns.

(3) The ARB models presume an annual normal retirement rate of 4.45% while the U.S. EPA uses 3% which is a value more consistent with industry experience. It is also not apparent how the ARB model accounts for the necessary introduction of new equipment to meet the higher standards.

(4) The ARB Staff estimates for new equipments are 35% to 40% lower than quotes provided to industry firms.

(5) The proportion of the equipment fleet that can be repowered to meet Tier 2 and 3 emission standards, much less achieving Tier 4 level is unknown. *Answering this question is the single most important aspect of more accurately estimating potential costs.* The ARB Staff appears to be assuming

all equipment above 250 HP can be repowered while industry experiences shows much less than a quarter can meet this criteria.

(6) No analysis has been conducted on how repowering engines might affect equipment life.

(7) Current industry experience shows the costs of retrofits to control PM to be 50% higher than the estimates used by the ARB Staff in its analysis.

The Construction Industry Cost Model (CICM) uses a statewide basis for estimating costs rather than building up from individual fleets as the ARB Staff model does. However, the general economic principles used are similar.

The CICM was first run using the proposed regulations and the ARB Staff's data assumptions. The total net present value cost of the current regulatory proposal is $6.0 billion over the 2009 to 2020 period, an amount twice the $3.0 to $3.4 billion for 2009 to 2030 reported in the Staff's report. The annual cost over the 2009 to 2020 period is $699 million or about $276 per horsepower.

A series of scenarios were run representing changes in the ARB Staff assumptions. These scenarios indicated how sensitive the cost results are to underlying assumptions about parameters for which we have little or no information. Using 60% higher new equipment prices, a 75% lower proportion of the fleet that can be repowered and a 50% lower normal retirement rate—within documented industry experience and consistent with U.S. EPA analyses—the total net present value cost rises to $13.5 billion and the annual cost to $1.58 billion. This is equivalent to $623 per horsepower. This is an increase of 125% over the Staff estimate.

Two sensitivities were run to determine how changing the regulation might affect costs. In the first case, the turnover cap was reduced to 6% and the retrofit cap to 10%. This reduced costs by 16% to 39%. In the second, the compliance period was extended five years with the same introduction schedule and turnover and retrofit caps. This reduced the costs by 8% to 11%. Nevertheless, the fleet composition differed only slightly from the ARB Staff proposal in 2020.

We can assess whether the construction industry can pass through additional regulatory costs based on currently available economic studies. One set of estimates was developed as part of the basis for the Dynamic Revenue Analysis Model (DRAM) used by the Department of Finance to estimate how fiscal changes affect projected state revenues. Based on these estimates, construction firms would bear 54 percent of the added costs. The US EPA provided estimates in its Regulatory Impact Analysis for its off-road regulations in 2003 and construction firms bear 49 percent of the regulatory costs.

Construction firms are likely to have absorb a substantial portion of those costs through reduced profits and/or reduced employment—likely at least half. The projected statewide employment loss is 10,900 to 34,000 jobs using a set of reasonable and conservative assumptions about compliance cost estimates. This represents 1.3% to 4.1% of the state's construction employment.

In addition, these regulatory costs are likely to increase costs for the projects constructed through the bond measures authorized November 2006 by about $2.1 billion. This represents 5% of the authorized bond amounts.

Introduction

M.Cubed was retained by the Construction Industry Air Quality Coalition (CIAQC) to assist in estimating the potential economic impacts on the construction industry from regulations proposed by the California Air Resources Board to control emissions from off-road diesel vehicles used for construction activities.

As a first step of this analysis, this report summarizes the industry's financial status and economic importance, including the distribution of key economic characteristics across the industry. In addition, we have developed an estimate of the distribution of fleet size and total horsepower linked to a measure of firm size, in this case the number of employees. This estimate is derived from a survey of firms that showed a high correlation between fleet size, number of employees and annual gross revenues.

This report then provides initial findings from our estimate of the range of potential compliance costs to comply with the proposed In-Use Off-Road Diesel Vehicle regulation. The underlying analytical tool of this study is the Construction Industry Cost Model (CICM), an Excel spreadsheet model of fleet evolution from 2008 thru 2020 and associated incremental costs accrued to the construction industry as it complies with the proposed ARB rule. We focus on this period because this is the one in which the proposed regulation has its most significant impact. If the analysis is extended to 2030 to match the latest ARB Staff analysis, the total cost would increase commensurately and significantly, although the annualized costs may decrease.

On several key parameters, ARB's modeling relies on unrepresentative data or unsupported assumptions:

(1) The number and composition of mobile equipment in the off-road inventory;

(2) The split of the equipment inventory among different fleet class sizes, i.e., small, medium and large;

(3) The difference in the composition of public versus private fleets;

(4) The current retirement and turnover rate of existing and future equipment, thus affecting the assumed expected remaining life of each equipment type;

(5) How many new vehicles must be introduced into the fleet to achieve the proposed standards, versus the assumed reliance on used vehicle purchases by the ARB Staff;

(6) The new and resale value of off-road equipment;

(7) The proportion of the equipment fleet that can be repowered to meet Tier 2 and 3 emission standards, much less achieving Tier 4 levels;

(8) The change in the expected remaining life of equipment after repowering; and

(9) The cost of retrofits for PM emissions.

The model was run across several cases and scenarios to determine the sensitivity of the analytic results to changes in assumptions. The model's premise is that most if not all firms will need to turnover their fleets at the turnover cap rate to comply with the rule.

This is based on preliminary analysis of several private fleets, including newer ones, carried out by CIAQC members. A base case was run using much of the ARB Staff's modeling assumptions.[1] Then scenarios were run changing key assumptions about new equipment costs, proportion that can be repowered and the underlying turnover rate. In addition cases were run with a reduced turnover cap of 6% (versus the Staff's 10% after 2014) and retrofit rate of 10% (instead of 20%), and extending the compliance dates by five years.

Finally, we derived the share of costs to that are likely to be borne by construction firms from the new regulations. Based on two different studies, these firms will absorb about half of these costs, unable to pass them through to customers. A portion will be realized in reduced profits, while the remainder likely will result in lost jobs in the sector.

The Construction Industry's Importance to California and Its Sensitivity to Changing Costs

California's construction industry is responsible for a significant share of the state's economic activity. In 2005 the sector accounted for approximately 5 percent of gross state product.[2] The construction industry employed approximately 835,000 Californians in 2004, representing $36 billion in payroll.

The construction industry also provides a larger "bang for the buck" than most other economic sectors. For example, for every dollar spent on construction, total output, including "multiplier impacts," increases by $2.40. Only the insurance and hotel sectors have higher output multipliers. Likewise, at 76 cents construction's earnings multiplier is higher than all sectors except services; and the sector's job multiplier, 21.5, is greater than any other industry except agriculture and services.[3] In other words, construction produces 21.5 jobs throughout the economy for each million dollars added output the industry; or conversely, 21.5 jobs are lost along with each million dollars of reduced output.

Despite the economic significance of the state's construction sector, it is extremely sensitive to economic cycles, as well as changes in input prices. For example, during the 2000-2001 recession the number of construction firms declined by 2 percent, and total employment dropped by more than 1 percent nationwide.[4] As shown in Figure 1, spending on construction is expected to decline in 2007, followed by modest growth between 2008 and 2011. Of particular interest is that the growth trend is expected to shift downward compared with historic patterns, as shown in the chart.

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[1] CARB Staff, *Staff Report: Initial Statement of Reasons for Proposed Rulemaking*, Mobile Source Control Division, Heavy Duty In-Use Strategies Branch, April 4, 2007.

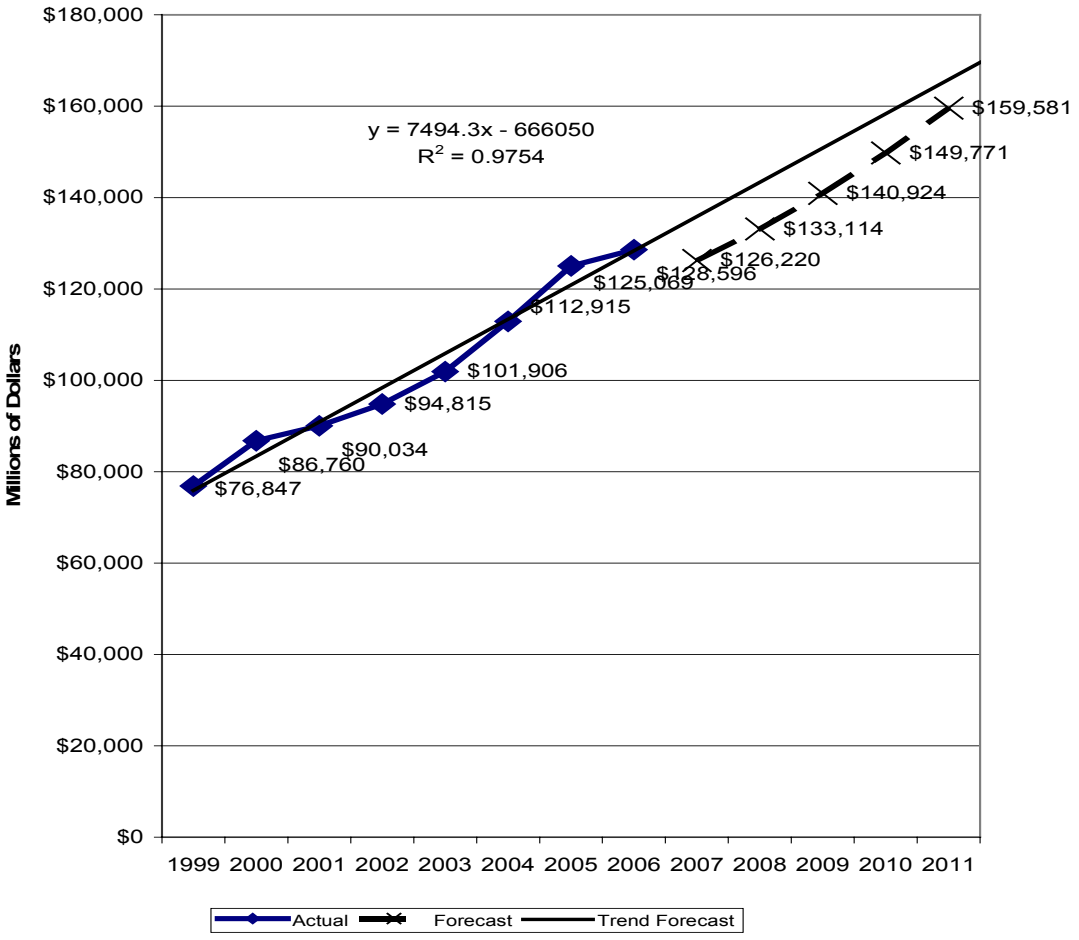
[2] U.S. Department of Commerce, Bureau of Economic Analysis, www.bea/doc.gov.

[3] California Economic Strategy Panel, *Using Multipliers to Measure Economic Impacts*, 2002.

[4] U.S. Census Bureau, *County Business Patterns*, April 10, 2003.

Figure 1

Slower Growth Seen for California's Construction Industry



Construction input prices, including equipment costs, jumped by 30 percent between 1996 and 2003, contributing to rapidly increasing housing prices in the state.[5] For example, the share of first-time buyers in California declined to their second lowest level last year, dropping from 31 percent in 2005 to 27 percent in 2006. Likewise, the share of California buyers who relied on a second mortgage rose from 38 percent in 2005 to 43 percent in 2006, more than tripling since 2001, and the highest percentage since 1982.[6]

The sector's vulnerability is in part due to the fact that it is dominated by small firms. Fifty-five percent of California construction firms have fewer than five

[5] U.S. Census Bureau, op. cit.

[6] California Association of Realtors (2006).

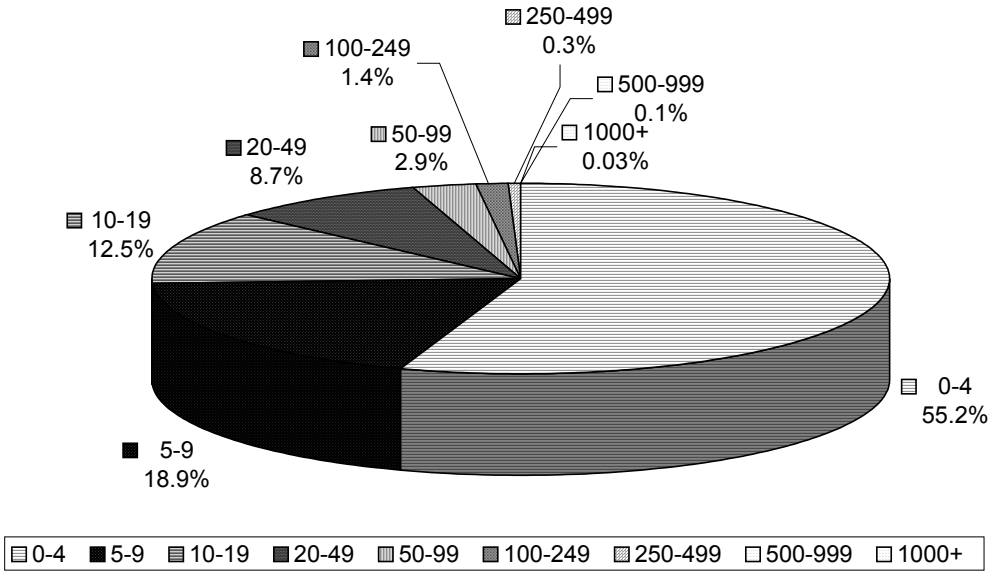
employees; with 74 percent employing less than ten individuals.[7] Less than one percent of the state's construction firms have more than 250 employees. Figure 2 illustrates this firm distribution. Similarly, 97 percent of all California construction firms generate less than $10 million in annual sales.[8]

[7] Employment Development Department, Labor Market Information Division, 2007, http://www.labormarketinfo.edd.ca.gov/cgi/databrowsing/?PageID=67&SubID=138

[8] Ibid.

Figure 2

Number of California Construction Firms by Employee Size (2005)



Similar to the agricultural sector – particularly commodities such as lettuce and other produce -- the construction sector tends to be subjected to extreme fluctuations in profitability. Net profits for an individual firm can bounce from more than 20 percent of revenues in one year to a negative return in the next, depending on economic conditions, the weather, and fuel and other input costs. On average net profits after tax tend to range from between 3 to 5 percent.[9] Fluctuations in profit, combined with generally modest margins, results in most construction firms being extremely dependent on access to short-term capital to operate their business (see below).

Regulations Could Reduce Construction Firms'—Particularly Smaller Businesses'—Access to Necessary Credit

As with agriculture, construction firms are highly dependent on short-term credit (e.g., credit lines) to finance their operations (i.e., working capital). Access to credit is determined by the health of an individual firm's balance sheet; cash flow; existing debt load; and year-to-year profitability. The proposed regulations could adversely impact construction firms' access to credit as a result of several factors, particularly for small businesses, which tend to have a lower margin for error. According to a recent study for the U.S. Small Business Administration, smaller firms bear a higher burden of regulatory

[9] Risk Management Associates, *Annual Statement Studies – Financial Ratio Benchmarks*, 2005-2006.

costs on average than larger ones.[10] In particular, environmental compliance cost for firms with less than 20 employees are more than triple those larger firms.

First, and most obviously, the regulation will increase the cost of the equipment. Alternatively, to the extent the regulations induce firms to simply retire older equipment without replacing it, these firms' capacity to undertake construction assignments will be reduced. As the ARB Staff acknowledges, the proposed regulation increases the cost of purchasing new or used equipment to increase capacity for new contracts. By increasing the industry demand for occasional capacity, the proposed regulation would increase demand for rental equipment. Increased demand for rental equipment will put upward pressures on rental prices. In addition, the proposed regulation imposes higher costs on rental fleets themselves, particularly larger rental fleets that must comply with stricter accelerated emission standards. The proposed regulation's increased costs on rental fleets also will put upward pressure on rental prices. These two factors (increased industry demand and increased supplier costs) combined would act to greatly increase rental prices. Since smaller construction firms tend to rely more on rental fleets, this will effectively increase small fleet costs even though the regulation is supposedly designed to mitigate small fleet impacts.

Under this circumstance unless a firm's contract includes adjustments for price escalations they will either have to "eat" the cost of these prices increases through profit reductions, or attempt to terminate the contract. In either case the firm's underlying economic health would be impaired, weakening their ability to gain access to good credit terms and remain viable in the marketplace.

Second, firms' existing equipment stock is reflected in their financial statements as a notable asset, similar to having equity in a home. This equity can be tapped to borrow against to finance business needs. It is important to note that equipment value for a construction contractor may be a substantial proportion of a firm's total assets. For less equipment-intensive contractors, such as plumbers or electricians, the value of their powered equipment is likely to be a small fraction of their total assets. But for a grading contractor equipment value may represents upwards of three-quarters of their total assets, representing tens of millions of dollars for larger firms. Reductions in the value of this equipment could have substantially negative impacts on a construction firm's ability to remain in business.

To the extent that the regulation reduces equipment value – by forcing it to be scrapped, or by flooding out-of-state markets with used equipment, thereby depressing prices – it will act to decrease the market value of the asset—the value of even fully depreciated equipment that still can be resold at significant prices. Given that some equipment that is used in California has minimal value elsewhere in the country, this hidden value is substantially at risk if state regulations effectively ban its use. For example, large scrappers are typically used in Southern California to move dirt, but are not used in rocky soils that are prevalent in other regions. As a result, while this

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[10] W. Mark Crain, "Impact of Regulatory Costs on Small Firms," *Small Business Research Summary*, Prepared for the Small Business Administration Office of Advocacy by Lafayette College, No. 264, September 2005.

equipment has significant value in California under the status quo, it may be virtually worthless elsewhere in the U.S. Reductions in a firm's equipment value would serve to lessen the firm's net worth, with a concomitant decline in their ability to obtain good borrowing terms, and more importantly, reduce borrowing and bonding capacity for investing in such things as new, cleaner equipment.[11]

Third, firms that elect to replace older equipment with government-sanctioned models will either need to dip into their cash reserves or obtain loans to pay for the new capital. If relying on cash results in a significant decline in available reserves it could lead to increased borrowing costs. In addition, the capacity of construction equipment suppliers to ramp-up production of new model equipment, particularly if the replacement engine technology is not fully conceived and developed, is constrained. If the regulations cause a noticeably longer back-log in equipment delivery this in turn could reduce firms' ability to effectively complete projects, with associated impacts on cash flows as well as risks of profit reductions in cases where contracts include schedule delay-related penalties. For example, since last fall construction firms have had to wait up to four months for equipment delivery.[12]

It is also important to note that many firms, particularly smaller businesses, rely on the used equipment market rather than purchasing new. Yet under the regulation the market for used equipment within would shrink substantially; only newer models will meet the air quality requirements and current owners would retain Tier 2 and 3 models to meet the various standards . As a result, firms accustomed to paying lower prices for second- or third-hand equipment – with associated access to available credit -- reflecting the partially depreciated nature of used equipment, will be forced to noticeably increase their expenditures on a given piece of equipment. This, in turn, will lead to firms going out of business, and result in an overall reduction in the number of businesses operating in the sector, with concomitant increases in firm concentration in the industry. Such adjustments are well-known to reduce competition and to lead to higher market prices. One of the hallmarks of the 2000-2001 statewide electricity crisis was the concentration of generators which lead to well-documented market abuses.[13]

Overall the value of a contractor's equipment is a substantial factor in their ability to conduct business. If this value is adversely impacted, construction firms' ability to remain economically viable could be compromised.

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[11] A more extensive discussion of these impacts was presented by Ralph Potter, CIT Construction, Specialty Finance Affiliate of the CIT Group, New York, at "California Emissions: Where do you stand with the proposed Regulations?" March 27, 2007.

[12] Jim Haughey, "U.S. Equipment Buying Slows, While Exports Increase," *Construction Equipment Market Update*, 2006.

[13] Richard J. McCann, "'The Perfect Mess': How California's Energy Markets Sank" (paper presented at the Western Economics Association International Meeting, Seattle, Washington, June 2002).

Characterizing the State's Construction Fleets Based on CIAQC Survey Responses

Although the broad direction of adverse economic impacts can be described (see above), it is difficult to accurately estimate the regulation's precise potential impact on the construction sector. This is because little data exists on individual firm characteristics, or the linkage between these characteristics, financial health, and equipment fleet size and type. To address this data gap CIAQC collected survey data from its members related to 2005 annual gross revenues, number of employees, and the characteristics of their fleets that would be regulated under the proposal.

Twenty-one firms responded at least in part to the survey. These responses were used to identify statistical relationships between number of employees, firm revenues and equipment fleet characteristics.[14] Regression models for each relationship were estimated; parameter estimates for the mean were used in the subsequent analysis estimating typical firm revenues and fleet characteristics across the industry, along with high and low estimates based on the 95% confidence interval derived from the sample data.

Employment data for the construction industry was collected from the California Employment Development Department (EDD) Labor Market Information website. EDD's data shows the number of construction firms and associated number of employees in the third quarter for 2005 by firm size categories.[15] The estimates of the relationship between number of employees, firm revenues, and equipment fleet characteristics from the survey analysis were then applied to the EDD data to estimate the statewide range of annual revenues, fleet sizes and total horsepower within each firm size category.

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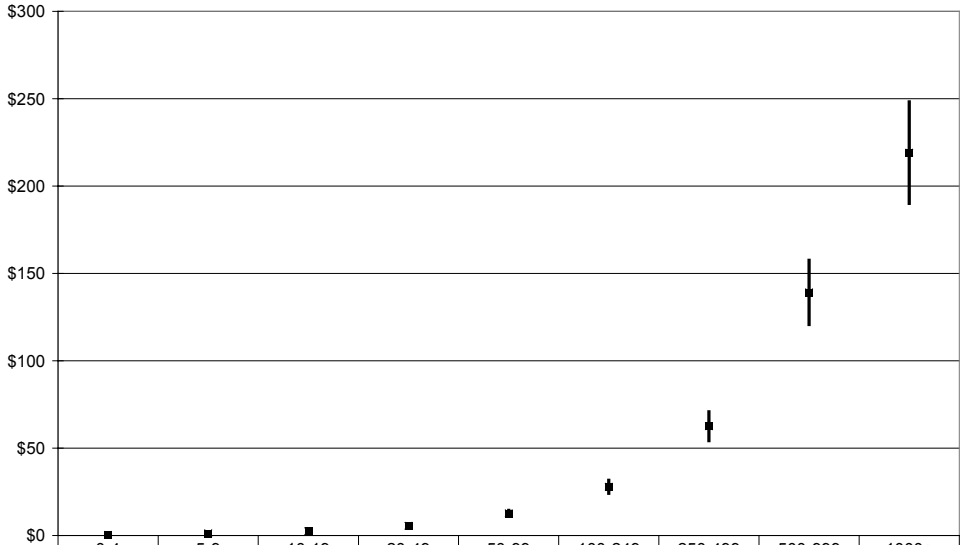
[14] Of particular note were the high correlations between these measures, with the R^2 exceeding 0.96 out of 1.0 in all cases. The correlation coefficient measures how close of a relationship exists between two variables, with a positive correlation showing a positive relationship. An R^2 of 1.0 indicates a perfect relationship between two variables, i.e., they vary in tandem together. The high correlation for the CIAQC survey provided substantial confidence that number of employees was a strong indicator of firm revenues, number of vehicles and total horsepower in the fleet.

[15] We assumed that most firms in the NAICS 236 and 237 categories would possess regulated construction equipment, but that only a portion—21%— of NAICS 238 (special trades) would use such equipment. (U.S. Census, "Sector 23: Construction: Industry Series: Employment Statistics for Establishments by State: 2002", 2007.) US Census data counts 23% of sector 238 employees in these firms. Thus, the estimates presented here represent a smaller segment of the construction industry than the full NAICS 23 sector.

Figure 3 shows the distribution of annual gross revenues across firm size. Firms with less than 100 employees – 98 percent of the industry -- average less than $13 million of gross revenues a year.

Figure 3

California Construction Industry Estimated Firm Average 2005 Gross Revenues by Employee Size (Millions $)

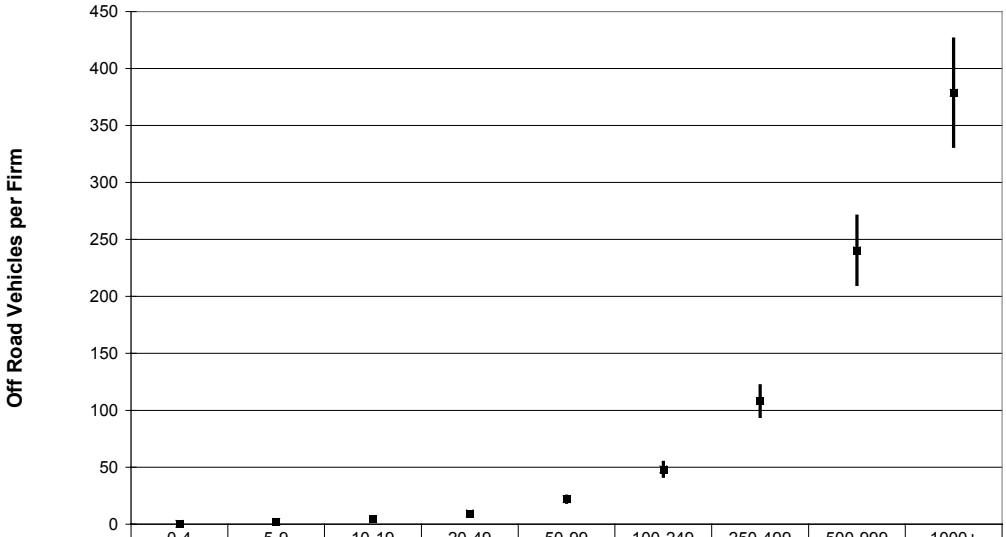


	0-4	5-9	10-19	20-49	50-99	100-249	250-499	500-999	1000+
High Parameter Estimate	$0.32	$1.4	$2.8	$6.3	$14.4	$32	$71	$158	$248
Low Parameter Estimate	$0.25	$1.1	$2.2	$4.8	$11.0	$24	$54	$121	$190
■ Mean Parameter Estimate	$0.29	$1.2	$2.5	$5.6	$12.7	$28	$63	$139	$219

Figure 4 shows the relationship of average fleet size to firm size. Smaller firms tend to have 10 vehicles or less.

Figure 4

California Construction Industry Estimated Firm Average Fleet Size by Firm Employee Size

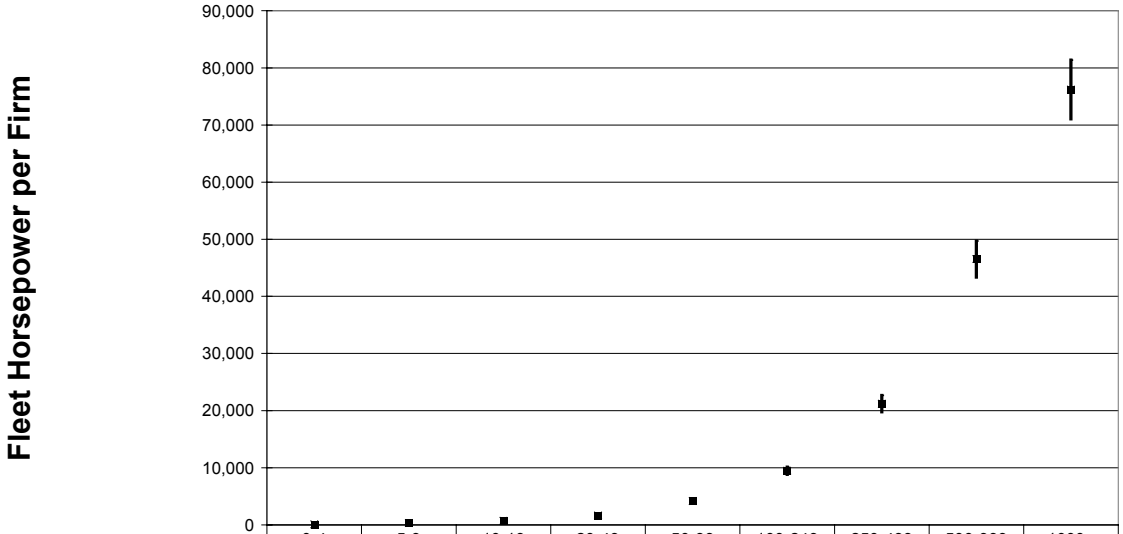


	0-4	5-9	10-19	20-49	50-99	100-249	250-499	500-999	1000+
High Parameter Estimate	0.56	2.4	4.9	10.8	24.7	54	121	270	426
Low Parameter Estimate	0.43	1.9	3.8	8.4	19.2	42	95	211	332
■ Mean Parameter Estimate	0.50	2.1	4.3	9.6	22.0	48	108	241	379

Figure 5 shows the average horsepower in each firm's fleet by size category. Firms with 20 to 49 employees average between 1,057 and 1,772 total HP, indicating that firms this size and larger, up to 100 employees, are likely to be captured in the medium-sized fleet portion of the regulation, which covers fleets between 1,500 HP and 5,000 HP. Companies with more than 100 employees are the likely candidates for the large-fleet regulations.

Figure 5

California Construction Industry Estimated Firm Average Fleet Horsepower by Firm Employee Size

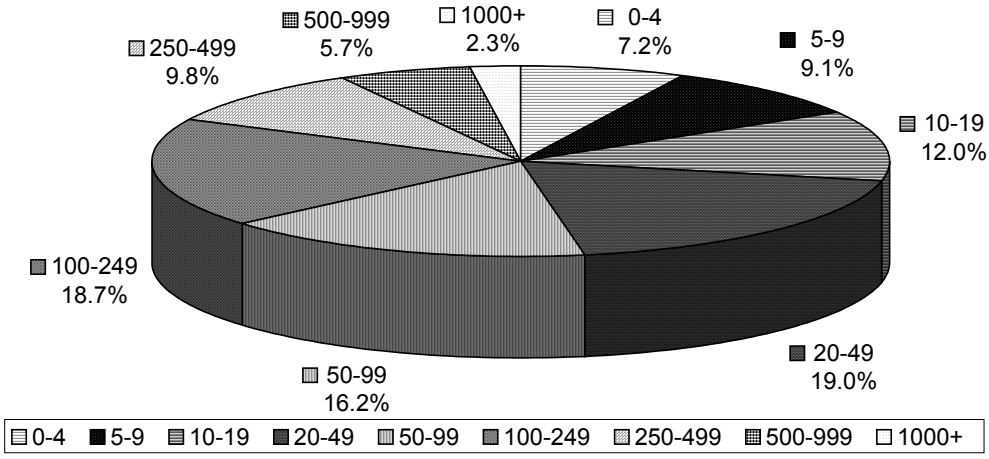


	0-4	5-9	10-19	20-49	50-99	100-249	250-499	500-999	1000+
High Parameter Estimate	89	365	758	1,772	4,455	10,132	22,650	49,673	81,348
Low Parameter Estimate	78	319	663	1,548	3,893	8,853	19,790	43,400	71,076
Mean Parameter Estimate	83	342	710	1,660	4,174	9,492	21,220	46,536	76,212

Figure 6 shows how the total fleet horsepower is distributed among the firm sizes based on the approximation derived from this analysis. Firms with less than 20 employees, which are the most likely to own "small" fleets less than 1,500 HP, control about 28 percent of the horsepower. Firms larger than 100 employees, which are most likely to own "large" fleets of more than 5,000 HP, control about 36 percent of the total statewide horsepower. The firms with 20 to 100 employees control the remaining 36 percent that are likely to fall into the "medium" category.

Figure 6

California Construction Industry Total Fleet Horsepower by Firm Employee Size



This analysis was done with publicly-available EDD data on firm characteristics. A more refined analysis that could better characterize the distribution of fleet characteristics could be done with firm-specific EDD data. As a state agency the ARB could gain access to these data, with firm names obscured, and then be able to more precisely estimate the range of fleet characteristics and resulting regulatory impacts on the industry. The ARB could determine more accurately how many firms will qualify as "small" businesses, the distribution of financial characteristics in the industry, the relationship of employment force to financial characteristics and other important parameters for measuring the distribution of regulatory costs and impacts. In addition, this data can be used in concert with other analyses on other proposed regulations to determine the cumulative impacts of recently enacted and proposed regulations on the industry.

The Analytic Steps for Estimating Compliance Costs

The objective research question is: What is the net present value of the fiscal costs to the construction industry from complying with ARB's proposed in-use off-road diesel vehicle rule? We estimated compliance costs by constructing an Excel spreadsheet model and then simulating several scenarios determined by values chosen for input parameters. The Construction Industry Cost Model (CICM) is described in more detail in the Appendix.

Estimating Fleet Composition Changes

The CICM represents the state fleet as a whole, rather than attempting to aggregate up from a set of "representative" firms' fleets as the ARB Staff did. The CICM differentiates the statewide fleet proportionally based on the firm size representations that M.Cubed estimated from a survey of CIAQC members and extrapolating that to the EDD statistics on firm characteristics.[16] These differentiations are used to introduce different regulatory components over the 2009 to 2020 period.

The CICM then calculates the costs of compliance by assuming one of two actions occur during the year:

- Based on analysis by Justice and Associates about the turnover required to meet the individual fleet targets, Tier 0 and Tier 1 equipment is turned over or retrofitted to comply with phase out targets of 2012 for Tier 0 and 2014 for Tier 1, and Tier 2 and Tier 3 are then turned over or retrofitted to comply with phase out targets of 2020, **OR**
- The total fleet turnover and retrofit rates are constrained to the ARB Staff proposals by fleet size.

These actions reflect the decision tree summarized by the ARB Staff that look first to turning over to comply with the NOx standards, and then retrofitting to comply with PM standards. Equipment less than 10 years old is exempt from the turnover requirement and that less than five years old is exempt from the retrofit requirement. Based on analysis conducted on individual fleets by CIAQC members and Justice and Associates, we assume that no firms can comply with the fleet emission standards and must instead meet the turnover cap. This is an outer bound assumption, but we do not have sufficient information from the ARB Staff to derive a more refined estimate. Nevertheless, the turnover and retrofit rates can be changed to reflect the ARB Staff's assessment of that rate from its own modeling when those detailed results are made available.

Figure 7 shows the projected fleet composition from the model assuming no new regulations are added. Figure 8 shows the fleet composition by engine tier and year derived from the ARB Staff's assumptions for the proposed regulations as implemented

[16] The breakdown is 11% is in small firms', 36% in medium firms', and 53% in large firms' fleets. These values differ from the EDD breakdowns above because the small fleet definition includes not only a limit on total horsepower, but also on total annual revenues based on the definition of "small construction businesses" in the state code. In comparison the ARB Staff estimate appears to be 2.6% for small, 4.6% for medium and 92.7% for large based on the tables in its Technical Supplement.

in CICM. Tier 0 engines decline much more rapidly and along Tiers 1 and 2 are retired at an accelerated rate from 2015 to 2017 compared to the reference case shown in Figure 7.

Figure 7

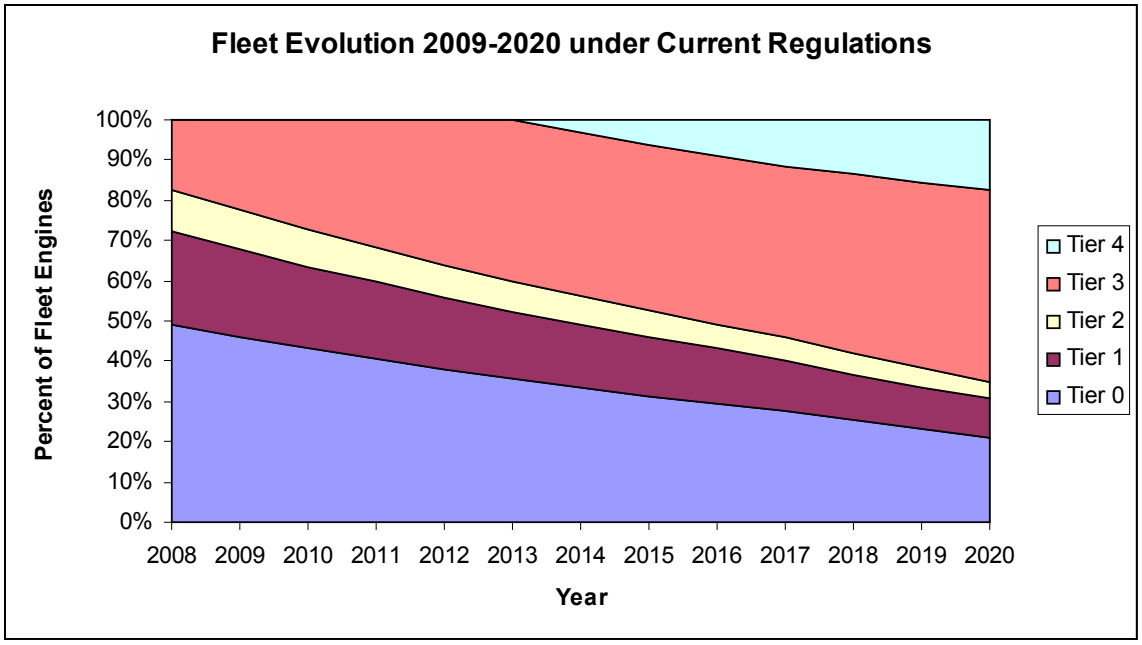
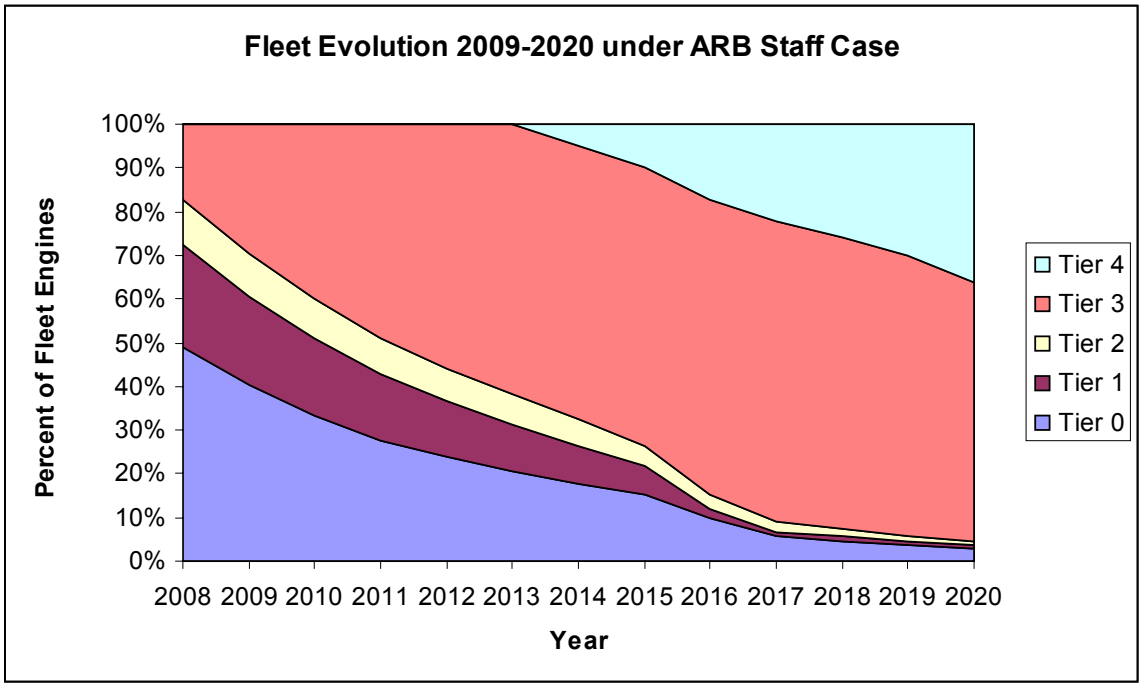


Figure 8



Problems with the ARB Staff Report Methodology

An important issue not discussed adequately in the ARB Staff Report or its Technical Supplement is how the model extrapolates from the individual 22 fleets up to the statewide fleet. At least two salient issues are unanswered:

- The Staff assumes that fleets will continue to buy equipment in the same proportion of new and used as they have in the past. However, to meet the higher emission targets, more *new* equipment of Tier 3 and Tier 4 levels will have to be introduced into the statewide fleet. To achieve this means that individual fleets will have to buy a higher proportion of new equipment than in the past. The Staff Report fails to discuss how this rebalancing of purchasing practices has been accomplished.
- The report appears to draw from a mixed sample of public and private fleets without regard to the relative proportion that each represents of the statewide fleet. Yet, as stated in the TIAX 2003 report, public fleets rely mostly on new vehicle purchases, and thus are much more likely to have newer equipment than private fleets.[17] Because the samples were not weighted for their relative shares of the statewide fleet, this introduces a significant bias toward underestimating the age of the fleets, and thus underestimating potential costs statewide.

Estimating Compliance Costs

Several cost categories are relevant. Not all of these components are directly represented in the model, but are captured implicitly:

- Additional purchase cost of new equipment with emissions controls
    - Capital cost incurred earlier
    - Capital is more expensive with emissions controls
    - Depreciation period starts sooner, thereby accelerating purchase of the second set of new vehicles
- Accelerated repowering with retrofitting
- Additional retrofitting on equipment not repowered or replaced
- Additional O&M costs of the equipment
    - Maintenance of VDECS or other emissions controls
    - Reduced fuel efficiency associated with VDECS
    - VDECS failures and replacements
    - ARB rule compliance reporting

[17] TIAX, *California Public Fleet Heavy Duty Vehicle and Equipment Inventory*, Final Report, Reference 75446/D0105, TIAX Report FR-03-113, Cupertino, California, March 17, 2003, p. 5-7.

It was not analytically tractable to address all of these cost categories explicitly due to complexity, data and time limitations, and/or uncertainties that render quantitative findings unreliable.

The CICM reflects the costs of complying by replacement, repowering and/or retrofitting. The replacement costs are computed as the difference between (1) replacing a machine over three replacement cycles without the regulation and (2) shifting the three replacement cycles forward by the expected remaining life that the machine would have had if it was not retired prematurely due to the regulation. Thus, replacing older machines is less expensive than replacing newer ones.

An important difference with the ARB Staff model reflects that use of a statewide perspective instead of individual fleets. The ARB Staff assumes that an individual fleet owner can recoup some of the replacement costs by selling the older piece of equipment. However, this logic does not hold when applying to the statewide fleet. The accelerated purchase of a new machine leads to a chain of transactions that net to the purchase of a new piece equipment. For example, the sequence would occur as follows for one such regulation-induced purchase:

- Firm A buys a new Tier 3 scraper for $1 million to comply and sells it older Tier 2 scraper for $500,000.
- Firm B buys Firm A's Tier 2 scraper to comply and sells its Tier 1 for $250,000.
- Firm C buys Firm B's Tier 1 scraper to comply and sells its Tier 0 for $50,000.
- Finally, Firm D buys Firm C's Tier 0 scraper and retires its older Tier 0 for a nominal salvage value.

Tracing through this sequence we see the total net cost across all of the fleets is $1,000,000 minus a nominal salvage value. Thus, the replacement cost from a statewide perspective is essentially the full cost of a new machine.

Repowering costs vary by whether the new engine will meet the Tier 2 or 3 standard versus Tier 4. The ARB Staff and Justice and Associates have arrived at roughly similar estimates and differences. However, the estimate of what might be repowered differs substantially. The ARB Staff apparently presumes that all equipment larger than 250 HP can be repowered based on the single template model it provided to CIAQC and its Technical Supplement; however Justice and Associates and CIAQC members have documented a much restricted list of equipment that can be repowered. For the ARB Staff base case presented here, the analysis used 100% repowering as the representative option. If the net replacement cost is less than that for repowering due to the advanced vintage of the equipment cohort, then the replacement cost is used.

How the life of the equipment is affected by repowering has not been addressed, and that aspect is ignored in both the Staff analysis and the CICM. Nevertheless, any adjustment would lead to increased costs since repowering is presumed to extend life the same amount as replacement in both analyses.

The repowering and replacement options are merged to estimate the turnover costs. A weighted average of the least cost option is computed for each piece of equipment and each year of vintage. Repowering is less costly than replacement for most of a machine's life until the point that the replacement cycle costs fall below repowering. The turnover cost equals a weighted average of the minimum cost between repowering and replacement for percentage that can be repowered and the cost of replacement for the remainder. For the ARB Staff base case, the repowered percentage is assumed to be 100%.

Substantial uncertainty exists over retrofit costs and how those may change over time. This analysis uses $63 per horsepower for the ARB Staff base case using the Level 3 controls for 175 to 400 HP engines. However, recent installations have cost closer to $100 per HP. Even so, the total cost estimates are relatively insensitive to changes in the retrofit costs because so many vehicles must turnover to comply with the regulations, thus obviating the need for retrofits.

The analysis uses an increase in operating and maintenance costs of $21 per HP net present value based on the amount report in the ARB Staff's April 4, 2007 report (p. 41).

The total net present value cost of the current regulatory proposal using the ARB Staff assumptions is $5.96 billion over the 2009 to 2020 period, compared to the $3.0 to $3.4 billion for 2009 to 2030 reported in the Staff's report. The annual cost over the 2009 to 2020 period is $699 million. This amounts to $276 per hp for existing equipment.

Modeling Parameter and Data Uncertainties

Several key modeling assumptions and input data require further vetting to increase confidence in modeling results. Using local[18] sensitivity analysis, we may identify several variables with significant influence on results, including:

- Fleet growth rate due to industry growth. We use ARB Staff's suggested growth rate of 1.95% per year, but a deviations from that growth rate could have unknown effects.
- Fleet natural retirement rate. Whereas EPA suggests normal retirement rates of 3% per year, we derived from average annual retirement rate using survivorship rates provided by ARB of 4.45%. The ARB retirement rate does not differ by horsepower despite industry experience that large machines tend to last longer. A scenario was run using an underlying 3% retirement rate.
- New equipment prices. The ARB Staff estimated resale prices from two auction house websites. However, a comparison of the ARB's new machine prices was made with three new equipment price lists compiled by CIAQC members. The firms' reported prices averaged 55% to 65% higher than the ARB Staff estimates. Scenarios were run with new machine prices 60% higher than the Staff estimates.

[18] Changing one parameter value while holding all others constant.

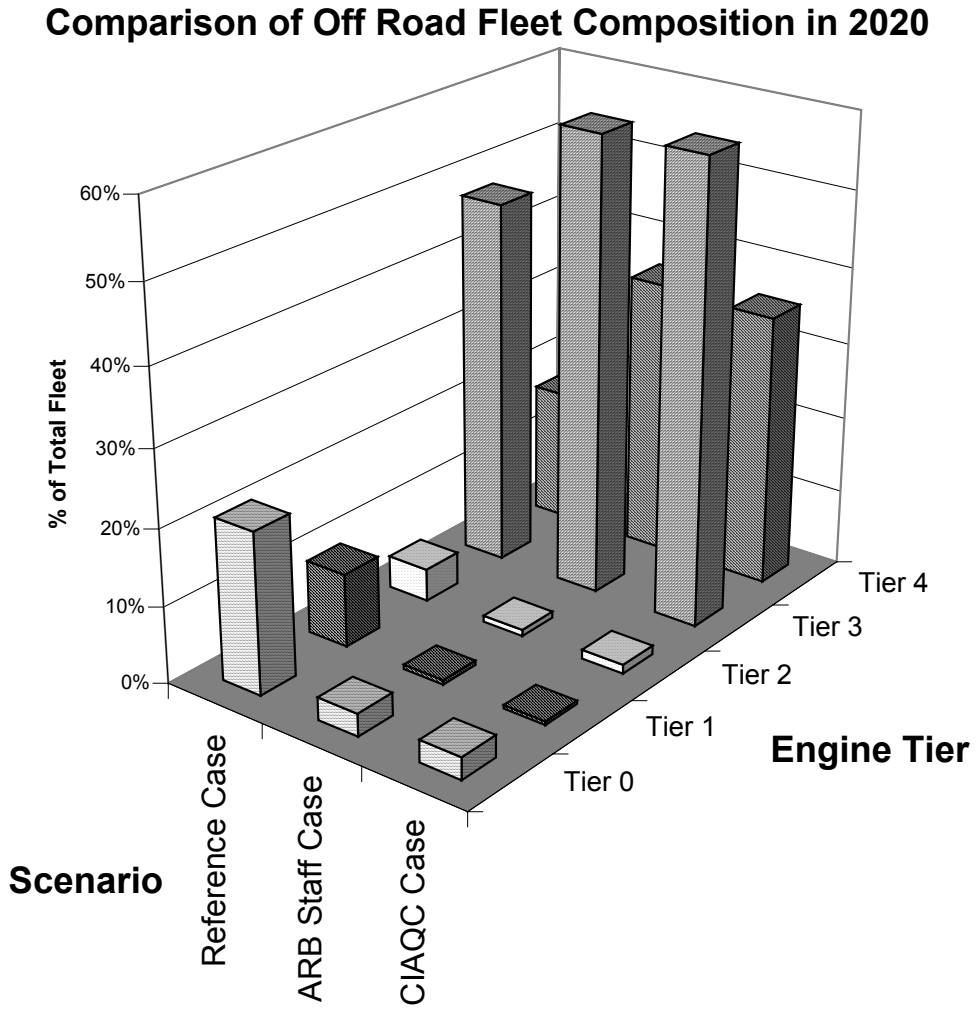
- The proportion of the existing fleet that can be repowered. As discussed above, only a portion of the fleet can be converted. Based on an optimistic assessment, scenarios included an assumption that 25% of the fleet could be repowered. Existing data indicate that the actual rate may be substantially lower.
- The discount rate is always an influential parameter, especially when costs or benefits occur far in the future. We used a real discount rate of 4.5% to reflect the lack of inflation adjustments in CICM model.[19]

Comparing Compliance Cost Estimates

Figure 9 compares the fleet compositions in 2020 for the different scenarios from the CICM. The base case shows the breakdown by tier if the regulation is not adopted. This reflects a 4.45% retirement rate. The ARB Staff Case reflects the same retirement rate with the turnover and retrofit requirements discussed above. The final scenario reflects the results when the retirement rate is dropped to 3% and the proportion repowered is reduced to 25% along with an increase in new equipment prices of 60% to reflect CIAQC data. The latter two cases differ little because the turnover requirements drive the fleet to similar endpoints.

[19] Equals 7% nominal rate used by the ARB Staff minus a 2.5% inflation rate derived from the embedded forecast in 20 year U.S. Treasury bond yield rates. We cannot determine from the ARB Staff Report as to whether the underlying cost assumptions were properly escalated for inflation over the study period.

Figure 9



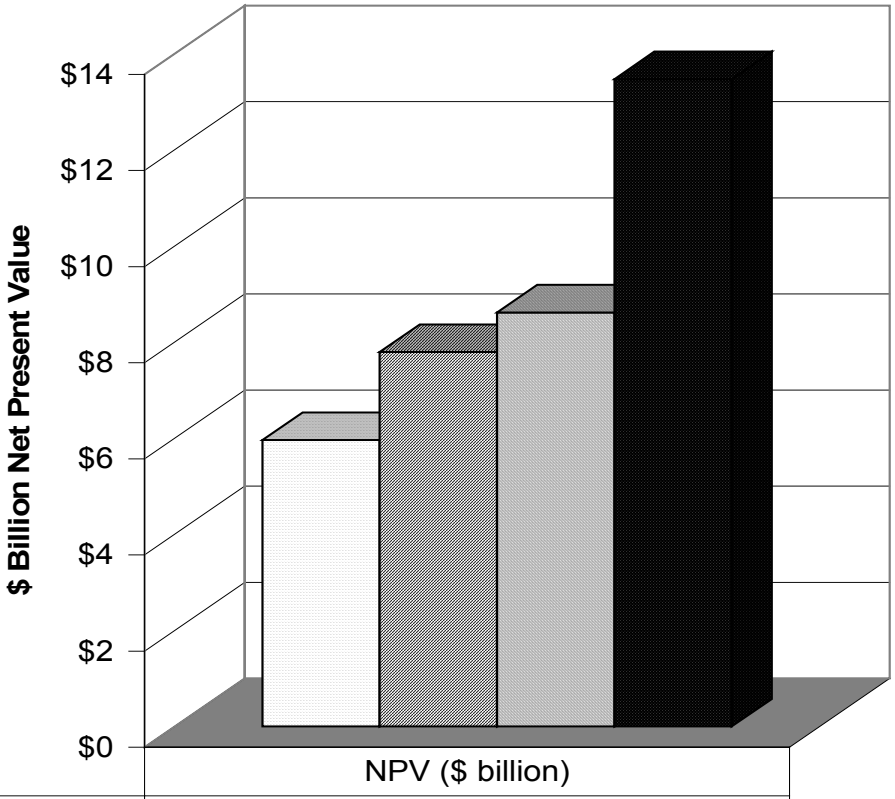
	Reference Case	ARB Staff Case	CIAQC Case
Tier 0	21.1%	3.0%	2.9%
Tier 1	9.6%	0.6%	0.5%
Tier 2	4.3%	0.8%	1.2%
Tier 3	47.7%	59.6%	59.9%
Tier 4	17.3%	36.1%	35.6%

Figure 10 compares the cost impacts for changing key assumptions in CICM. The first scenario shows the ARB Staff case results. The second one adds a lower underlying retirement rate based on U.S. EPA assumptions, but still allows for 100% repowering of the fleet above 250 hp where economic. This increases costs by 31%. The third reduces

the proportion of the fleet that can be repowered to 25% with the lower turnover rate. This increases costs 45% above the ARB Staff estimate. The final scenario increases new equipment purchase costs by 60% to be more consistent with data from three private fleets pricing replacement purchases. This increases the costs 126% over the estimate using Staff assumptions. This last scenario costs $1.58 billion annually.

Figure 10

Net Present Value Cost Impacts for 2009-2020



	NPV ($ billion)
ARB Staff Case	$6.0
wEPA Retirement Rate	$7.8
w/Repower = 25% & EPA Rate	$8.6
CIAQC Case w/EPA Retirement, 25% Repower & 60% Higher Price	$13.5

Part of the annual cost difference compared to the $240 million in the Staff Report is explained by the time period over which the costs are allocated. The ARB Staff assumes the costs can be spread over a 21-year period, beyond the end of the regulation

period, while we are looking at the 11-year period directly addressed by the regulation. In addition, we have not estimated the added costs beyond 2020. Even so, these costs are still subject to substantial uncertainty about other factors previously discussed, as well as uncertainty about future technology availability and costs.

Alternative Scenarios

To test the sensitivity of the costs to changes in the regulatory language, we ran two cases against two scenarios:

(1) the ARB Staff base case; and

(2) the CIAQC case with 65% higher new equipment prices, 25% repowered and 3% retirement rate.

The results of these are summarized in Table 1. In the first sensitivity, the turnover cap is reduced to 6% annually from 8% for 2009 to 2014 and 10% for 2015 to 2020, and the remaining retrofit requirement reduced to 10%. This change reduces costs by 37% to 39%. The second sensitivity extends the compliance period by five years but still has the same turnover cap and retrofit rates introduced on the same time schedule. In this case, the costs are reduced by 9% to 11%.

Table 1
Alternative Policy Sensitivity Cases

	ARB Staff Case	CIAQC Case
6% Turnover Cap / 10% Retrofit	$3.6	$12.1
% Difference	-39%	-16%
5 Year Longer Phase In	$5.3	$12.4
% Difference	-11%	-8%

One key question is how these changes might affect the fleet composition in 2020. Table 2 summarizes that comparison against the ARB Staff base case. The fleet composition appears to differ little by that date despite the differences in the trajectories.

Table 2
Comparison of 2020 Compostion under Alternative Regulations

	Current Regulations	ARB Staff Case	6% Turnover Cap / 10% Retrofit	5 Year Longer Phase In
Tier 0	21.1%	3.0%	12.0%	3.1%
Tier 1	9.6%	0.6%	3.9%	1.8%
Tier 2	4.3%	0.8%	1.0%	2.2%
Tier 3	47.7%	59.6%	54.4%	59.5%
Tier 4	17.3%	36.1%	28.6%	33.5%

Construction Firms Will Be Unlikely to Pass through Substantial Added Costs to Customers Based on State and US EPA Models

Of particular note is how the industry must handle the costs of the increased regulation. If all firms were identical and demand was perfectly inelastic (i.e., customers would not reduce their construction expenditures and could not turn to other competitors), then all regulatory costs could be passed through to customers, and a firm owner and their employees would not have to bear any of the direct regulatory costs. On the other hand, if the demand is highly elastic (i.e., customers are very sensitive to increased costs and will either reduce expenditures or will turn to other competitors), then a firm cannot pass through most of the additional costs, and must instead bear those directly through reduced profits and jobs. This is particularly the case if the industry is heterogeneous (i.e., the firms have widely varying characteristics). The data presented here demonstrates the wide dispersion of firm characteristics in the construction industry. Firm size is widely distributed and the proportion of vehicles in different sized fleets likely are distributed even more so.

We can assess whether the construction industry can pass through additional regulatory costs based on currently available elasticity estimates. The elasticity of demand for housing describes how demand for housing will fall given an increase in the price of housing. The elasticity of supply describes how firms will increase output capacity in response to price increases. These elasticity estimates can provide an indirect measure of how increased construction costs will decrease demand. We can then apply "tax" incidence analysis to determine the shares of the increased regulatory costs that are borne by consumers and suppliers.[20]

Different estimates of the these elasticities are available in the literature. One set of estimates was developed as part of the basis for the Dynamic Revenue Analysis Model (DRAM) used by the Department of Finance to estimate how fiscal changes affect projected state revenues.[21] The estimated housing demand elasticity was -1.8 (i.e., a one percent increase in price will lead to a 1.8% decrease in demand). This is considered by economists to be highly elastic or responsive demand. It strongly implies that construction firms can not pass on a significant proportion of increase costs in the housing marketing. The import supply elasticity, which mirrors that for the domestic industry, was 1.5. Based on these estimates, construction firms would bear 54 percent of the added costs. The US EPA provided estimates in its Regulatory Impact Analysis for its off-road regulations in 2003.[22] The housing demand and supply were less elastic at

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[20] Economists consider increased regulatory-induced costs as a form of an indirect tax. This method distributes the cost burden between consumers and suppliers. (Walter Nicholson, Microeconomic Theory: Basic Principles and Extensions, Fourth ed. (Chicago, Illinois: The Dryden Press, 1989), p. 418-419).

[21] Peter Berck, Peter Hess, and Bruce Smith, "Estimation of Household Demand for Goods and Services in California's Dynamic Revenue Analysis Model," (Department of Agricultural and Resource Economics, University of California at Berkeley, and California Department of Finance, 1997).

[22] The US EPA has considered cost incidence in its regulatory development, e.g., the RIA prepared in 2003 on off-road engines regulations (see http://nsdi.epa.gov/otaq/cleaner-nonroad/, Chapter 10).

-0.96 for demand and 1.0 for supply. In this case, construction firms bear 49 percent of the regulatory costs. In either case, construction firms are likely to have absorb a substantial portion of those costs through reduced profits and/or reduced employment.

Relying on ARB Compliance Costs, Job Impacts Will Be Substantial

The ARB Staff has reported that it projects compliance costs to range from $3.0 to $3.4 billion annually.[23] This can be translated into expected job losses based on the industry's job multiplier of 21.5 jobs per million in revenue. In this case, we have run two scenarios to look at the range of outcomes based on the ability of the industry to pass through some portion of costs to consumer. Even so, being able to pass through higher costs may mean fewer job losses within the construction industry, but to higher statewide losses in other industries.

Based on the ARB Staff's estimates, the projected statewide employment loss is 2,500 to 5,500 jobs. Using a range from the higher cost estimates based on reasonable and conservative adjustments to the ARB Staff's assumptions, the losses range from 10,900 to 34,000 jobs. This is equivalent to 1.3% to 4.1% of the state's construction employment. Of particular note is that these costs will be borne largely by the narrower sector that relies on heavy equipment, which is perhaps 30% of statewide construction activity.

Regulation Would Increase Costs for the State's Recently Enacted Highway, Traffic Reduction, Air Quality and other Public Sector Infrastructure Programs

Last November Californians passed several ballot initiatives that will heavily rely on the state's construction industry to implement, including the following:

- Proposition 1B authorized $19.9 billion be spent on a variety of transportation projects intended to reduce congestion, lower polluting air emissions, and improve transit safety. These funds will be invested in ongoing maintenance and rehabilitation of existing facilities as well as in new infrastructure.
- Proposition 1C authorized $2.85 billion to build affordable housing, with two-thirds of the funds dedicated to new construction.
- Proposition 1D authorized $7.3 billion to construct and modernize primary and higher education facilities.
- Proposition 1E authorized $4.1 billion to rehabilitate the state's existing levee system.
- Proposition 84 authorized $5.4 billion for a variety of water quality, safety, supply, and flood control projects, though only a portion of these funds will be dedicated to infrastructure investments.

[23] ARB Staff, April 4, 2007, p. 39.

Taken together these bonds represent up to $40 billion of construction industry purchases.

Construction equipment price hikes caused by the regulation, as well as the resulting consolidation of the construction industry, would serve to raise the overall costs of public infrastructure projects, thereby lowering the amount of these goods that can be purchased. That is, the regulation would directly result in fewer highways and schools being built, less affordable housing being constructed, and fewer repairs to the state's levee system.

If we assume that most of the $13.5 billion in added costs are concentrated in the heavy and public construction subsectors, and we assume further that the construction authorized by this bond will be completed in the same 2009-2020 time frame, then this added spending will represent 17% of the affected construction in that time period. As a result, the proposed regulation would represent an added cost of about $2.1 billion, thus reducing the effective spending for the bonds by 5%.

Appendix - Construction Industry Cost Model (CICM)

The CICM model is comprised of several interactive worksheets:

- FleetChanges - showing the evolution of the construction fleet through 2020; capable of representing user-selected rates for replacement, retrofit and repower in each of the years. This also shows the parameters used to drive the evolution under different regulatory regimes.
- ELife – showing the expected remaining life of a piece of equipment based on the "survival curves" used in the ARB's 2007OFFROAD emission inventory model.
- Replace – showing the net costs of the accelerated purchase of a new piece of equipment to comply with the proposed regulation.
- Repower – showing the calculation of the costs to repower to Tier 2 or 3 and Tier 4 plus retrofitting, both as done by Justice and Associates and the ARB Staff.
- Retrofit – showing the range of retrofit costs estimated from several sources.
- Cost – showing the expected compliance cost associated with turnover for a specific equipment type at a specific vintage.
- Total Cost – computes the total net present value (NPV) change in costs by multiplying the changes in the construction fleet in FleetChanges by the associated turnover and retrofit costs for the appropriate model and vintage.

Due to the size of the files and number of algorithms, these files will NOT recalculate automatically; recalculation is a manual operation.

There are several "decision rules" embedded in CICM. Two significant rules are that retrofits will only be on equipment less than 150 hp and repowers only for equipment greater than 150 hp.

The fleet is described by equipment type, HP, and age, and assumes Tiers 0, 1 and 2 are converted to Tier 3 and, starting in 2014, to Tier 4 for each year of the study. Conversation rates are specified for replacements, repowers, and retrofits. As well, the user may specify what portion of converted equipment is Tiers 3 or 4. No interim Tiers (e.g., 2+) are included in the analysis, but they might be represented with updated emissions factor calculations.

POLICY ANALYSIS FOR THE PUBLIC AND PRIVATE SECTORS
M.CUBED

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Dr. Richard McCann specializes in environmental and energy resource economics and policy. He has completed numerous project benefit assessments and impact analyses. He also has testified before the Federal Energy Regulatory Commission, California Public Utilities Commission, California Energy Commission, Air Resources Board, State Water Resources Control Board, and other regulatory agencies.

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Dr. McCann has analyzed many different aspects of energy and transportation industry issues for the CEC, petroleum and automotive manufacturing companies and agricultural energy users. He has evaluated California's plan to reduce its petroleum dependence, the costs of replacing the state's diesel truck fleet with alternative fuels, the cost-effectiveness of proposed SCAQMD regulations for diesel-truck fleets and SJVUAPCD regulations for agricultural engines. He also developed the proposal to convert agricultural engines to electricity adopted by the CPUC. He conducted a large-scale study on the costs of meeting greenhouse gas reduction targets for California, and proposed alternative policy approaches for addressing global climate change issues. He has worked with the CEC to estimate the costs for new alternative generating technologies. He coauthored a guide for the CalEPA in evaluating environmental impacts, and provided input on CalEPA's cost-effectiveness guidelines. For the CARB, he assessed the economic costs and impacts of its Statewide Implementation Plan. He assessed the impact of natural gas demand created by SCAQMD Clean Fuels Rule in Southern California on transport and storage capability to determine need for new pipeline, as well as the stationary fuel use in the region.

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