CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

AIR RESOURCES BOARD

ARB STAFF REVIEW OF REPORT ENTITLED "IMPACTS OF ALTERNATIVE ZEV SALES MANDATES ON CALIFORNIA MOTOR VEHICLE EMISSIONS: A COMPREHENSIVE STUDY"

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1. INTRODUCTION

On January 23, 2001, General Motors Corporation (GM) filed extensive written comments in the current Air Resource Board (ARB or Board) rulemaking regarding the California Zero-Emission Vehicle (ZEV) regulations. On January 25, 2001, the ARB conducted a public hearing in the rulemaking, at which the Board approved the staff's proposed amendments with a number of significant modifications.

The primary theme of GM's January 23 comments was the assertion that the ZEV regulations will ultimately increase rather than decrease emissions. GM claims this will happen because assumed increases in the prices of new California cars and light trucks resulting from the ZEV mandate will depress sales of new vehicles, to the extent that emission increases from the greater number of higher-emitting older vehicles on the road due to reduced "fleet turnover" will more than offset the emission decreases attributable to the presence of ZEVs in the new vehicle fleet. To support this position, GM relies on a report dated January 2001 by National Economic Research Associates, Inc. and Sierra Research, Inc. entitled "Impacts of Alternative ZEV Sales Mandates on California Motor Vehicle Emissions: A Comprehensive Study" (the NERA/Sierra Report), included in Volume II of GM's January 23 submittal.

The NERA/Sierra report is based on a series of linked models, with the results from one model feeding into the next. The New Vehicle Market Model projects changes in vehicle purchases based on a set of assumptions about the cost of producing ZEVs, and consumer response to price changes. Output from this model feeds into the Fleet Population Model, which estimates the effect of changes in the new vehicle market on the entire motor vehicle fleet. The VMT Model determines the extent to which ZEVs would replace non-ZEV vehicle miles of travel. The Emissions Model estimates the effect of changing fleet composition on fleetwide emissions.

This document provides the ARB staff analysis of the NERA/Sierra report. To assist staff in this effort, ARB retained the services of economists from the Institute for Economic and Environmental Studies, California State University Fullerton. This staff analysis is based both on the staff review of the NERA/Sierra report and on material supplied by our contractors. ARB staff is seeking comment on the NERA/Sierra report, this ARB staff response, and on the material supplied by our contractors.

2. ARB STAFF REVIEW OF NERA/SIERRA REPORT

The NERA/Sierra report sets forth a linked series of arguments:

- The ZEV program increases cost to manufacturers;
- This increased cost is passed on in the form of increased prices on vehicles sold in California;
- The increased prices result in decreased sales of new vehicles;
- Reduced new vehicle sales result in increased retention of older vehicles;
- Increased retention of older vehicles results in increased emissions.

The NERA/Sierra report also argues that emissions from the existing fleet will increase still further because EVs are likely to be driven fewer miles than conventional vehicles, and this deficit will be made up through increased travel by other vehicles.

While these arguments may appear to be reasonable on their face, the key issue from a policy perspective is the magnitude of any such effects. The NERA/Sierra report uses a series of models to estimate the intermediate and end results. Each link in the chain of arguments is necessarily based on assumptions regarding vehicle cost, consumer behavior, and a variety of other factors. In reviewing the details of the individual calculations, ARB staff has concluded that the NERA/Sierra report significantly overstates the purported effect of the ZEV program on fleet turnover and resulting fleetwide emissions. Major considerations include:

- The cost increases assumed by NERA/Sierra are overstated.
- Manufacturers will not necessarily be able to pass along all increased costs.
- Small price increases can be addressed by a variety of manufacturer marketing practices and will not necessarily reduce sales.
- The NERA/Sierra emission modeling fails to take into account recent changes to the LEV II program.

Using more reasonable ARB staff assumptions rather than the assumptions used in the NERA/Sierra analysis, the NERA/Sierra model projects an average per vehicle increased cost of roughly $25 to $40 rather than the $250 to $400 estimated in the NERA/Sierra report. Staff believes that at these modest levels, such increases would have an insignificant effect on vehicle sales. Even if one accepts the NERA/Sierra premise that any cost increase, no matter how small, will reduce vehicle sales, staff concludes that the ZEV program will result in an emission decrease, rather than the emission increase alleged in the NERA/Sierra report.

The following sections go through each element of the NERA/Sierra analysis in turn, and note issues identified by staff and by our contractors.

2.1 New Vehicle Market Model

The New Vehicle Market Model projects changes in vehicle purchases based on a set of assumptions about the cost of producing ZEVs, and consumer response to price changes. Staff's review of the New Vehicle Market Model is divided into sections, which address the incremental cost of the ZEV program to manufacturers, the effect of that incremental cost on vehicle prices, and the effect of vehicle prices on new vehicle sales.

2.1.1 Incremental Cost of ZEV Program

The first key factor in the NERA/Sierra report is the incremental cost of the ZEV program. That is, how much extra will manufacturers have to spend to build the next-generation vehicles called for under the ZEV regulation?

Under the ARB ZEV program, beginning in 2003 10 percent of the vehicles offered for sale in California by large manufacturers must be ZEVs. Manufacturers have the option to offset 60 percent of this requirement (6 percent of sales) with extremely clean conventional vehicles known as Partial Zero Emission Vehicles, or PZEVs. Manufacturers may also offset 20 percent of the requirement with "Advanced Technology" PZEVs (AT PZEVs) that exhibit other ZEV-like characteristics, such as electric drive. Staff expects that manufacturers will take advantage of these options.

The amount of ZEV credit earned by a vehicle varies according to the characteristics of the vehicle and the year in which the vehicle is introduced. For example, most ZEVs will be worth more than one credit in the early years, and PZEVs typically will earn less than one credit. Thus the actual number of vehicles produced will differ from the strict percentages outlined above.

Estimating the incremental cost of the ZEV program involves two elements—the incremental cost per vehicle to produce various vehicle types, and the number of vehicles that must be produced. The incremental per vehicle costs used in the NERA/Sierra report are nominally based on cost estimates developed by ARB staff and included in the August 2000 Staff Report on the ZEV program. Given how the estimates are used, changes made by NERA/Sierra and recent ARB re-evaluations lead staff to believe that the NERA/Sierra estimates significantly overstate the incremental cost of production, particularly in the longer term. Specifically:

- ARB staff has reduced, from $500 to $200, its estimate of the incremental cost for PZEVs due to a better understanding of the technologies that will be employed.
- The NERA/Sierra report fails to take into the account an efficiency multiplier that will be earned by AT PZEV hybrid electric vehicles, thereby overstating the required number of vehicles.

- The report fails to take into account the value of the fuel savings achieved by hybrid electric vehicles.
- The report assumes that the only factor affecting AT PZEV and ZEV cost over the 2003-2020 timeframe is manufacturing volume—there are no technical improvements in future years.

Table 1 below shows staff's estimate of the model year 2007 cost impact of several of the items noted above. A more complete explanation of each point follows. The potential impact of future ZEV technical improvement is more complex and is discussed separately below.

Table 1
ARB Staff Corrections to NERA/Sierra Incremental Cost Estimates

	Change	Change per Covered Vehicle
Reduce PZEV Incremental Cost	-$117,174,600	-$100
Correct for AT PZEV Efficiency Multiplier	-$18,612,500	-$16
Reduce AT PZEV Incremental Cost	-$49,635,600	-$43
Correct for AT PZEV Fuel Savings	-$56,726,400	-$49
Total	-$242,149,100	-$207

As Table 1 shows, these changes alone reduce the estimated increased cost per "covered vehicle" by $207. (In the terminology used by NERA/Sierra, a "covered vehicle" is a vehicle whose sale triggers a ZEV obligation for the manufacturer, and whose price is increased to cover the cost of the ZEV program. The NERA/Sierra report estimates the number of covered vehicles in 2007 as 1,167,258).

The NERA/Sierra report uses a measure that it calls the "ZEV tax" to quantify the purported impact of the ZEV program on new vehicle prices. The "ZEV tax", in NERA/Sierra terms, is the average price increase per covered vehicle, excluding ZEVs, that can be attributed to the operation of the ZEV regulation.

To put the cost reductions noted above in context, $207 represents about two-thirds of the entire NERA/Sierra estimated per vehicle "ZEV tax" in 2007 (the 2007 "ZEV tax" is $305 in the NERA/Sierra base case). Staff recognizes that the average incremental cost per vehicle and the "ZEV tax" are not identical, but they are closely related. Therefore a significant reduction in the incremental cost of the ZEV program will necessarily lead to a significant reduction in the "ZEV tax".

In Section 3 below, staff systematically substitutes more reasonable assumptions for the base assumptions used in the NERA/Sierra model, and describes the quantitative effect on the NERA/Sierra model results.

The rationale for the staff adjustments noted in Table 1 above is as follows:

2.1.1.1 PZEV Incremental Cost

NERA/Sierra uses an ARB staff estimate of $500 increased cost per vehicle for PZEV production, as compared to the base SULEV, taken from the August 7, 2000 Staff Report for the ZEV Biennial Review. Since that time, based upon additional information acquired by staff, the PZEV incremental cost estimate has been revised from $500 to $200. This revised estimate applies generally, not just in the context of this review, and will be applied where appropriate in future ARB regulatory actions.

The revised cost reflects a reevaluation of the likely technology to be used by PZEVs. The original ARB estimate included $200 for emission control hardware and $300 for the cost of extending the emission warranty to 15 years/150,000 miles relative to SULEVs. With regard to hardware cost, confidential information from several manufacturers indicates that PZEVs soon to be introduced for sale in California will use a simpler and much less costly combined HC adsorber/catalyst rather than a separate adsorber and an attendant switching valve as had been assumed earlier. Further, the new information indicates that additional catalyst volume will not likely be required as was the case in the first PZEV system certified for sale in California. In general the technology will be much less complex than staff originally envisioned. Manufacturers will still face some increased cost to build increased durability into the emission control components (e.g. increased catalyst loading) in order to avoid excessive repair costs during the 150,000 mile emission warranty period. It appears that the changes needed to implement zero evaporative emission control systems relative to near-zero evaporative systems are also much less involved than anticipated earlier. Based on the information acquired by staff, some additional carbon trap capability will be added, along with improved seals and reconfiguration of some components that do not add large cost. The cost of going to a zero evaporative system from the near zero systems is now estimated to be $10 per vehicle. Taking all of these factors into account, staff now estimates that the necessary hardware modifications to meet PZEV requirements will range from $60 to $85 per vehicle.

With regard to warranty cost, the original estimate assumed three repairs per vehicle over the extended warranty period, due in part to the more complex technology involved. Based upon evaluation of recent warranty information provided to ARB, the less complex nature of the underlying technology, and the increased durability of emission control components used by PZEVs, staff now estimates warranty cost of $125-$150 per vehicle.

Thus the revised cost for hardware plus warranty is now estimated to be from $185 to $235 per vehicle. Staff has chosen $200 per vehicle, about the midpoint of this range. This updated estimate reduces the assumed incremental cost of PZEV production by 60 percent. The NERA/Sierra report estimates 2007 PZEV

production of 390,582 vehicles. Reducing the per vehicle cost by $300 reduces the total estimated incremental cost by $117,174,600 (390,582 x $300). Note that because PZEV production levels are much higher than production levels for other vehicle types, any reduction in PZEV cost has a dramatic impact on the assumed incremental cost of production for the entire ZEV program.

Staff also notes that the PZEV extended warranty (15 years or 150,000 miles) has additional value to the customer above and beyond the normal emission warranty. Customers would certainly prefer a vehicle with a 15 year emissions warranty as opposed to the standard 7 year warranty. Although this value, which could allow manufacturers to recover some of the increased cost in the form of increased price, is not quantified in our analysis, qualitatively it would reduce the price increases assumed in the NERA/Sierra analysis.

2.1.1.2 Required Number of AT PZEVs

The NERA/Sierra report assumes, in keeping with ARB staff, that AT PZEVs are likely to be hybrid electric vehicles (HEVs). To estimate the number of such vehicles that manufacturers must build, the NERA/Sierra report assumes a credit value of 0.45 per vehicle, which results in production of 42,899 vehicles. In addition to the base level of credit assumed by NERA/Sierra, however, such vehicles are eligible to earn an "efficiency multiplier". Because HEVs are highly efficient, it is likely that they will earn an efficiency multiplier. The NERA/Sierra report fails to take this multiplier into account. In the long term, taking into account other staff-proposed modifications to the method used to calculate AT PZEV credit, staff assumes that the typical AT PZEV credit score will be 0.544 per vehicle. This has the effect of reducing the required number of AT PZEVs by about 21 percent. Thus the correct number of AT PZEV vehicles required for 2007 is not the 42,899 assumed by NERA/Sierra, but rather 35,454 (42,899 divided by 1.21)—a reduction of 7,445 vehicles. Using NERA/Sierra's assumed 2007 AT PZEV cost of $2,500, the overall cost reduction resulting from this correction is $18,340,000 (7,445 x $2,500).

2.1.1.3 AT PZEV Incremental Cost

The August 7, 2000 Staff Report estimated that the incremental cost to produce an AT PZEV will be $3,282 in the near term and $1,086 in volume production. The NERA/Sierra report uses the staff value for the near term, but for long term volume production it substitutes a value of $2,500. The $2,500 figure is taken from a study prepared by K.G. Duleep that estimates the incremental cost for various types of hybrid electric vehicles. (Cost and Pricing of Hybrid Vehicles, K.G. Duleep, Energy and Environmental Analysis, Inc., December 7, 1999).

Although the K.G. Duleep study does not provide an overall indication of the time frames under consideration, it appears that the estimates are near-term in nature. For example, in discussing the cost of an integrated system, the study

provides two estimates described as “current” and “2004+”. Both estimates assume current production levels. Thus it appears that the latter estimate ($2,300) is expected to be valid for the 2004 time period.

The NERA/Sierra report, by using the $2,500 estimate throughout the 2020 study period, in essence assumes that there will be no technical improvement in future years that will reduce the cost of HEV production. (This same implicit assumption is made with respect to long term ZEV costs, as is discussed in detail below). The ARB staff estimate for volume production levels ($1,086) was also primarily near-term in nature and was not intended to address 2015 or 2020 circumstances. This was done because the time horizon of interest during the ZEV Biennial Review was the near term. Given that the NERA/Sierra report models ZEV program impacts through 2020, however, it is appropriate to build in some allowance for technical improvement. As a proxy for future cost reductions, staff has substituted the staff report estimate of $1,086 for the NERA/Sierra estimate of $2,500. Using the corrected number of AT PZEVs needed for 2007 (35,454), and the difference between the ARB staff estimate and the NERA/Sierra estimate (approximately $1,400), the resulting total savings is $49,635,600 (35,454 x $1,400).

Staff also notes that the long-term incremental cost of a hybrid vehicle assumed by the NERA/Sierra report ($2,500) is higher than some costs reported by the analyst that they cite. For example, Duleep estimates a 2004 incremental cost of $2,300 for a Prius type hybrid at current production levels.

In addition, the NERA/Sierra analysis does not take into account the value of subsidies that may be provided to encourage the purchase of advanced technology vehicles. Legislation under consideration at the federal level would provide incentives for consumer purchase of hybrid electric vehicles. Any such subsidies will reduce the incremental cost faced by the consumer.

2.1.1.4 AT PZEV Fuel Savings

As noted above, staff expects that near term AT PZEVs will be HEVs, and the NERA/Sierra report makes the same assumption. Although such vehicles will carry an increased initial purchase price, because of their fuel efficiency they will recoup a savings over the life of the vehicle in terms of reduced fuel expenditures. This benefit can be substantial. For example, K. G. Duleep in the analysis cited by NERA/Sierra estimates a lifetime fuel savings of $350 for each 10 percent fuel efficiency improvement, using a gasoline price of $1.30 per gallon. In the August 7, 2000 Staff Report, staff assumed that HEVs would show improved fuel economy of 50 percent in 2003 and 57 percent in future volume production. (By way of comparison, the Prius combined fuel economy is roughly 90 percent better than the average vehicle in its USEPA size classification). Using the methodology outlined in the August 7 Staff Report, the net present

value of the fuel savings for HEVs was estimated to be about $1,600 per vehicle using an after-tax gasoline price of $1.75.

Although these fuel savings may not be large enough to entirely offset the increased incremental cost of an AT PZEV in the near term, they do provide a significant benefit. Consumers thus would be expected to be willing to pay a premium for such vehicles. This premium reduces the effective cost increase associated with such vehicles below the level assumed by NERA/Sierra. Using the corrected number of AT PZEVs needed for 2007 (35,454), and the ARB staff estimated fuel savings of $1,600 per vehicle, the resulting total savings is $56,726,400 (35,454 x $1,600).

In addition, as was discussed for PZEVs above, the extended emission warranty has value to AT PZEV purchasers. The NERA/Sierra report does not take into account the attractiveness of increased fuel economy or enhanced emission warranties to vehicle purchasers. In response to an ARB question on this point, a NERA written response stated that "We assume that for the high sales volumes that would be required under the ZEV Mandate, PZEVs and AT PZEVs have the same attractiveness to the average consumer as the average conventional vehicle and therefore would not command a price premium". (July 25, 2001 memo from NERA to General Motors Corporation). Thus the NERA/Sierra estimates ignore the value of the emission warranty or fuel savings. This reduces the relative attractiveness of ZEV program vehicles to consumers and therefore tends to overstate the effect of the PZEV and AT PZEV programs on consumer demand for vehicles.

2.1.1.5 ZEV Incremental Cost

The ARB December 8, 2000 Staff Report used an estimated incremental cost of $17,000 for a model year 2003 full function ZEV. This was a mid-point among several estimates provided in the August 7, 2000 Staff Report, which ranged from $13,000 to $24,000 for near-term full function ZEVs, depending on the type of vehicle and the battery employed. The August 7, 2000 Staff report also provided longer term estimates for ZEV cost in volume production, which ranged from about $1,500 for a City EV up to about $11,000 for a long range two passenger vehicle.

In its base case scenario NERA/Sierra uses a higher incremental cost for 2003 of $45,715 per vehicle ($28,320 for the battery, $14,895 for other components, and $2,500 for the charger). The increase as compared to the ARB Staff Report is based on two factors:

- The NERA/Sierra study assumes that the most cost-effective way for manufacturers to comply with the ARB ZEV regulation is with full function vehicles with a range of 190 miles. These vehicles would have a higher per vehicle cost but according to NERA/Sierra would be more cost effective

overall because fewer of them would need to be produced due to the larger number of credits earned per vehicle.

- The NERA/Sierra study provided an adjustment factor to account for the fact that the number of ZEVs required under the staff proposal (roughly 4,650 in the early years) is less than the number that was assumed in the cost calculations in the August 7 Staff Report (roughly 22,000 per year).

With regard to future costs, the NERA/Sierra study takes the ARB near term estimates and assumes that these cost levels will continue on in perpetuity, except for changes due to increased production volume. Specifically, the NERA/Sierra Report estimates that the incremental cost for a ZEV decreases gradually over time from $45,715 in 2003 to $32,215 in 2020. It is important to note, however, that this cost decrease is related solely to increased production volume, and does not include any allowance for technical improvement over time. In other words, the NERA/Sierra study assumes that the technology used in a ZEV in 2020 will be exactly the same as is used 2003, and will cost exactly the same per vehicle aside from any savings due to increased production volume. Staff believes that this is an extreme assumption that is contrary to the history of ongoing improvements in vehicle technology.

First of all, manufacturers continue to identify technical improvements that increase the performance and reduce the complexity, mass and cost of critical electric vehicle components. Turning only to GM for examples, staff readily identified the following:

- An August 17, 2001 letter from Mr. Ken Stewart (Brand Manager), to EV1 lessees notified drivers of 1997 and 1999 EV1 vehicles that their base mileage allowances have been increased by 12,000 miles. (The base mileage allowance is the number of miles the lessee can drive before incurring an excess mileage charge). According to the letter, “This change reflects the current range capability of our vehicles and is intended to enhance customer satisfaction and the knowledge of our latest battery technology”.

- The Precept concept vehicle achieves 20 percent lower aerodynamic drag than the EV1 (the production world record holder). The Precept also takes advantage of a Generation III electric motor and a second-generation aluminum–intensive body structure. A key component of the power inverter module has been shrunk to one-sixth the size needed on the EV1.

- Confidential material submitted to ARB staff by GM during the 2000 Biennial Review identified ongoing improvements to electric vehicle power electronics and drive units that reduce their cost, mass and parts count. The purpose of providing this information was to persuade staff that electric vehicle technology should be allowed to mature and take advantage of additional cost

reductions before moving to significant production levels. The NERA/Sierra report assumptions are inconsistent with this previous argument.

Second, all major automakers are devoting enormous resources to development of fuel cell technologies. The scale of this investment, estimated at billions of dollars industry-wide, clearly implies that manufacturers believe that there is a business case to be made that future fuel cell technologies can compete directly with the internal combustion engine, let alone be produced at an incremental cost of more than $30,000 in 2020. Significant progress has been made in recent years and additional progress is expected in the future. For example, articles in the November 2000 issue of Automotive World make a number of relevant points:

> Today, a fully dressed four-cylinder costs in the region of $750 to produce. By contrast, one of Ballard's latest Mk900 fuel cells with a similar performance would cost around five times more to produce. But production costs of fuel cells have tumbled in recent years, and no one doubts that further technology breakthroughs will reduce them further. (page 44)
>
> The [Ballard] programme appears to have progressed well. Assertions at the time by Ballard CEO Firoz Rasul that the secret of mass producible fuel cells was already understood were vindicated at the beginning of this year. The company announced the Mk900 fuel cell, replacing the Mk700, in turn replacing two or three stacks with a single integrated unit. Power moved up to 75kW from 50 kW, power density increased by 30 percent to 1.3kW per litre, weight reduced by 30 percent and size by 50 percent. More important was the news of Ballard's new factory to build the Mk900 in much higher volumes. (page 42)
>
> GM's fuel-cell project has made dramatic progress since it was quietly announced in December 1998. …GM is clearly on a roll and GAPC [Global Alternative Propulsion Center] co-director Schubert more confident than ever of delivering the goods. "We have not fixed a time for delivery to customers", he said at the HydroGen1 launch in June, "but we would like to be production–ready by 2004, with a view to delivering cars to customers from 2004 to 2008. We have still not solved the cost issues and we need to find enough customers. Fleets are no problem but for general customers it will be more difficult." "The car is virtually ready," Schubert continued, "but we still have a lot of challenges and we don't have the durability in the system yet. But that is just a question of engineering resources. What the energy side needs to understand is that there is a new product coming." (page 40)
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> [Andrew] Bosco [supervisor of design and development of fuel cells at General Motors Global Alternative Propulsion Center] is bullish about his

team's prospect and keen to start production. "We could already manufacture the stack fitted to HydroGen1 in production volumes," he says, adding, "I would like to see us coming down the cost curve, ironing out some of the small problems then freezing development and going for production." (page 42)

Recent GM press releases provide additional examples of technical progress:

- In a January 11, 2000 press release unveiling a fuel cell version of the Precept concept vehicle, Mr. Larry Burns (GM Vice President in charge of research and development and global portfolios) stated that "At GM, we've accelerated the pace of fuel cell research and development to the point that it feels like we're in the computer industry, where the product arriving at retailers is virtually obsolete before it goes on sale. For example, we're currently developing our 10th generation fuel-cell stack design, with a new design implemented nearly every two months". The press release goes on to note that "General Motors has achieved tremendous improvements in fuel cell technology technical performance. Recent efforts have been concentrated on solving practical problems associated with fuel cell use in everyday automobiles such as below freezing temperatures."

- An August 7, 2001 GM press release states that "The world's leading fuel cell just got better. The power density of General Motors' next-generation fuel cell stack is 25 percent greater than the stack used recently by GM's HydroGen to set 11 endurance records in 100-degree heat in Mesa, Arizona. …Reducing the size and weight of the fuel cell stack while maintaining or improving its power output is important for packaging, design and affordability. Smaller stacks create space for other components and allow their use in smaller vehicles and stationary units. They also require less material, providing an opportunity to further reduce cost."

Given the uncertain nature of technical advancement, it is difficult to predict how developments will unfold over a 10 or 20 year timeframe. Staff's intent in citing the above examples is to demonstrate that the NERA/Sierra assumption of <u>no</u> future improvement or cost reduction in ZEV technology is implausible and unreasonable.

To provide a more reasonable view of long term ZEV costs, staff reviewed recent published studies. The most recent and comprehensive analysis that staff was able to identify was prepared by Arthur D. Little for the California Energy Commission (Projected Automotive Fuel Cell Use in California, Arthur D. Little Inc., October 2001). This report looks as the status of fuel cell technology and projects cost trends and market penetration scenarios. With regard to cost, the A.D. Little study concludes the following:

Using Arthur D. Little's projections of fuel cell system costs and a cost model developed by Arthur D. Little for the Hybrid Electric Vehicle Working Group to calculate hybrid electric vehicle costs, total incremental vehicle prices above current average mid-size vehicle costs ($18,900) are estimated to be about $9,300 higher for a direct hydrogen mid-size FCV, $10,000 for a SR methanol mid-size FCV and around $11,200 higher for a gasoline or ethanol autothermal reformer-based mid-size FCV in the near-term (2010 to 2020). For aggressive hybridization strategies, incremental costs of $9,000 for a direct hydrogen FCV, $9,700 for a SR methanol FCV and $10,400 for an autothermal reformer gasoline or ethanol FCV are calculated.

Further cost reductions are possible as fuel cells become more reliable and warranty issues are less of a concern to automobile manufacturers. Additional savings could occur from larger production volumes through the learning curve phenomena.

Although these incremental cost projections of around $9,300 for a hydrogen fuel cell vehicle are subject to considerable uncertainty, they are markedly lower than the ZEV incremental cost estimates assumed in the NERA/Sierra report ($40,602 in 2010 and $32,215 in 2020). This provides further support for staff's belief that it is reasonable to expect some level of cost reduction due to future ZEV technical advances. The effect of substituting more plausible long term ZEV costs in the NERA/Sierra model is assessed in Section 3 below.

Staff recognizes that there are infrastructure issues associated with the use of hydrogen to power fuel cell vehicles. Considerable work is underway to address such issues. In addition, it is important to note that compliance with the California ZEV regulation does not require that the entire new vehicle fleet be converted to any particular advanced technology, but rather that relatively small numbers of vehicles be placed in service as a technology-forcing measure. Staff estimates that if all manufacturers pursued a hydrogen fuel cell compliance strategy, the number of hydrogen fuel cell vehicles needed to fully comply with the ZEV regulation in 2010 would be about 8,000. Infrastructure for this small number of vehicles could be accommodated in a variety of ways.

2.1.2. Effect of ZEV Program Cost on Price of Vehicles Sold

The prior section reviewed the NERA/Sierra assumptions with regard to the cost that the ZEV program imposes on manufacturers. The next element in the NERA/Sierra report is the effect of manufacturer cost increases on vehicle prices. As was the case in the previous section, staff believes that the NERA/Sierra report overstates the impact of the ZEV program on vehicle prices.

2.1.2.1 Manufacturer Decision to Raise Prices in Competitive Market

The NERA/Sierra report assumes that all manufacturers will spread the increased cost of the ZEV program over California covered vehicles. In the highly competitive vehicle market, however, manufacturers may not be able to pass along any cost increase at all. Unless all manufacturers behave in concert, manufacturers who raise the prices of their vehicles will lose market share to their competitors. Moreover, because "intermediate" manufacturers have the ability to satisfy their entire ZEV obligation using PZEVs, the pricing practices of intermediate manufacturers may establish a price ceiling that major manufacturers will not be able to exceed. Finally, many popular models are now sold as "50 state" vehicles and can legally be purchased in other states and brought in to California (see below). This likewise may limit manufacturers' ability to impose a price increase solely on California sales.

The importance of this issue cannot be overstated. If, due to competitive pressures, manufacturers are unable to pass along increased costs to purchasers of California vehicles only, then the entire NERA/Sierra argument collapses. If prices do not increase, then sales do not decline and fleet turnover is unaffected.

If manufacturers are unable to pass along a cost increase, they must absorb the cost within their own operations. To place in context the manufacturers' ability to do so, staff collected data on manufacturers' annual net income. For the five most recent fiscal years for which data is available (2000-1996 for domestic automakers and 2001-1997 for Japanese automakers), the average annual combined net income for the six large manufacturers subject to the ZEV requirement was about $26 billion. In the December 7, 2000 Staff Report, staff estimated that the incremental cost of the ZEV program for 2006, when the PZEV option is fully phased in, would be about $450 million. This amount represents about 1.7 percent of the annual average net income for the six large automakers over the recent five year period reviewed.

Staff recognizes that automaker net income fluctuates over time, and that current trends are negative relative to the most recent five years. Over the 20 year time period relevant for the NERA/Sierra report, however, such fluctuations will average out. Our point in citing the net income statistics is not to focus on the exact ratio of ZEV program cost to net income, but rather to show that the incremental cost of the California ZEV program is very small relative to the scale of operation of the auto industry.

2.1.2.2 Manufacturer Decision to Raise Prices Only for California Vehicles

The NERA/Sierra report assumes that manufacturers will spread the entire increased cost of the ZEV program over all California covered vehicles, but not over other California vehicles, or over cars sold outside of California. In essence,

manufacturers will recover all of their incremental costs from sales in California, and only from covered models. This point is discussed in detail in the CSU Fullerton report, as follows:

> A key NERA-Sierra assumption here is that GM (and other manufacturers subject to the mandate) will spread the pejoratively labeled "ZEV tax" over all California covered vehicles, but not over cars sold outside of California, or over all California sales of the major manufacturers. In essence, the manufacturers will recover all of their incremental costs from sales in California, and only from covered models. Their fundamental argument is that the two markets (California vs. "rest of US") are completely separate, and since the marginal conditions (marginal revenue – which follows from the product demand – and marginal cost) have not changed in the U.S. outside of California, no profit-maximizing firm would change its price/output decision in the national market as a result of a California regulation. To do so would be to lose potential profits. (This argument is graphically demonstrated in the January, 2001 report, Appendix D). At the same time, NERA-Sierra notes that many manufacturers *do* in fact spread costs over a national market"– There is anecdotal evidence that manufacturers have spread the costs of previous California mandates to car purchasers in the U.S., rather than only to those in California." (January, 2001, Appendix D, p. D-4). NERA-Sierra goes on to state that this behavior demonstrates "the leeway that might arise when costs increases are relatively modest." (p. D-4) This is a disingenuous argument. If spreading modest costs – contrasted with larger costs – of California regulations across national sales does not cause profit to fall more than spreading them solely in California, then this is a matter of degree and a profit-maximizing firm would be consistent in the pattern of cost allocation to vehicle models.
>
> Obvious questions arise: Do manufacturers behave in accordance with the NERA-Sierra economic model or not? Does the profit-maximization model only hold for "large" cost increases? What constitutes a "large" versus a "modest" increase? Do the analysts really intend to maintain that, based on their presentation of cost allocation patterns, when costs increases are "small," firms do not behave as profit-maximizers?
>
> Moreover, NERA-Sierra asserts that the California market is essentially isolated from the rest of the U.S. market, but for many models this is simply not true. Asian and European manufacturers, especially, produce many or most of their compact and subcompact models as "50-state vehicles", which can legally be purchased in another state and imported into California[1]. U.S. manufacturers also produce all or some models as

[1] Manufacturers can choose not to place the California emission label on 50-state cars sold in other states, even though they meet California emission standards. This might be done to

> 50-state vehicles as well (EPA, 2001). These 50-state models include some of the most popular, for example, the Toyota Camry and Corolla, the Mazda 626, and the Honda Civic and Accord. Clearly, sales in California are not fully protected from competition from dealers in neighboring states. Of 375 compact and subcompact models sold in the U.S., 338 are 50-state cars and another 12 models are California standard cars. Only 25 – or seven percent – of all models in this class are manufactured only for sale outside of California (EPA 2001). With more than 90 percent of all models meeting California emissions standards, it is clear that manufacturers and dealers face significant competitive pressure to not significantly raise prices in California. This also implies that the maximum price increase that could be imposed would be the difference between the price of a vehicle delivered at a California dealer and one delivered from out of state.

In summary, although the NERA/Sierra report asserts that its assumed manufacturer behavior is a necessary and inevitable outcome of economic theory, the report itself also specifically acknowledges that in the real world the treatment of California regulatory costs is a choice made by manufacturers.

The flexibility of manufacturers' treatment of California emission control costs is also noted by the Green Car Institute Future EV Pricing report, which notes that:

> Historically, automakers have made allowances for the California market's specific emissions demands by increasing their manufacturer's suggested retail price by an additional $100 (approximate, since the actual charge varied from manufacturer to manufacturer). Recently, that charge was dropped as manufacturers rolled emissions program costs into all vehicles produced nationally. From a marketing standpoint the automakers viewed the separate charge for California emissions programs as negative to their other marketing efforts.
>
> Auto companies routinely make regional variations in their vehicle prices, usually through consumer or dealer incentives. So the possibility of pricing vehicles separately for California to recover program costs for EVs or near-EVs, or other emissions requirements, has historical precedent, as does the pattern of absorbing those costs either statewide in all vehicles sold, or even nationally. (Future EV Pricing, page 24).

Thus both the NERA/Sierra report itself as well as other sources indicate that there is precedent for manufacturers to spread the cost of California emission requirements across national sales. Given this situation, then the key question again becomes the magnitude of the cost increase that must be covered.

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prevent disproportionate sales of a popular model in California. If manufacturers were, however, to widely engage in this behavior it could well be found to be illegal restraint of trade.

As has been shown in previous sections, and is further demonstrated in Section 3 below, using realistic staff assumptions the cost increases anticipated due to the ZEV program are much smaller than those estimated by NERA/Sierra. The "ZEV tax" estimated by the model, using ARB assumptions, is only $36 per vehicle in 2007 and $29 per vehicle in 2012. Thus it is reasonable to anticipate that such cost increases would be handled in the same fashion as previous small cost increases, and would be spread to car purchasers in the entire U.S. rather than confined to California.

This assumption has a dominant effect on the model results. In recent years California new passenger car and truck registrations have been approximately 10 percent of national registrations. Therefore if the cost increases are spread nationally rather than confined to California they are reduced by a factor of 10.

In addition, the NERA/Sierra report assumes that automobile companies compete by setting quantities (as shown in Appendix D). However, the automobile industry is well known as a set of oligopolistic firms where competition occurs along price dimensions. The outcome in the case of an increase in marginal costs for a subset of these firms will vary depending on the assumptions made regarding strategic behavior.

2.1.2.3 Reliance on Data from Marketing of MOA Vehicles

In order to estimate consumer demand for ZEVs as compared to conventional vehicles, the NERA/Sierra model relies upon price and sales data for the years 1996-2000. This is the period during which manufacturers were marketing vehicles in California in fulfillment of their Memoranda of Agreement (MOA) with the ARB. Thus it is important to consider whether experience during the MOA marketing period provides a basis for projecting future consumer behavior.

In its August 7, 2000 Staff Report for the Biennial Review of the ZEV program, staff noted that the marketing of vehicles to date has differed from a normal market in several significant respects:

- Only two manufacturers, GM and Honda, offered their vehicles to retail customers with broad-based marketing efforts. The remaining manufacturers marketed only to fleets, using a marketing approach appropriate for fleet sales.
- Although a variety of vehicle platforms was produced, none of the manufacturers chose to develop a five passenger four door sedan.
- Manufacturers used a variety of approaches to sell, distribute and service the vehicles, but no manufacturer marketed its vehicles at all dealerships.
- Due to the new technology employed, EVs imposed unusual information and training demands on all involved parties – customers, dealership staff, infrastructure providers, and marketing staff.

- Manufacturer pricing strategies were intended to gather information about customer demand, but were not set in a competitive fashion based on prices of otherwise equivalent conventional vehicles.
- Most vehicles were available for lease only rather than for purchase, and some leases included low mileage caps of 10,000 miles per year. (August 7, 2000 Staff Report, page 83).

Staff went on to conclude that:

> In summary, the MOA marketing efforts provide an opportunity to begin to understand the factors involved in advertising, selling and supporting electric vehicles. Lessons have been learned which will be of value in future efforts. The MOA experience does not, however, lead to definitive conclusions about the prospects for 2003. (August 7, 2000 Staff Report, page 84).

Similar observations are made in the Green Car Institute report:

> EV sales under the Memoranda of Understanding (MOA) period have not produced a true market. Automaker goals, where they are apparent form marketing programs, were focused on a relatively quick completion of MOA goals as opposed to building and sustaining a market for EVs. That is evident from the high prices, unusual acquisition barriers placed before potential EV buyers (filling out forms, waiting for approval, waiting for the vehicle) and the limited nature of the vehicles offered to consumers. And, of the six manufacturers offering EVs under the MOA, only two actively marketed to consumers while all six focused heavily on the fleet market. (Future EV Pricing, page 2)

In highlighting these issues, staff is not attempting to criticize the MOA marketing efforts but rather is drawing attention to the distinctions between the MOA experience and a typical new vehicle market. This point is important because the NERA model uses observed demand from the MOA marketing period to estimate consumer demand for ZEVs. Given that the MOA marketing period differed in many respects from a normal new vehicle market, reliance on data from this period will tend to understate consumer demand for ZEVs and thereby reduce the estimated price that consumers are willing to pay. This in turn will increase the cost that must by spread by manufacturers across other vehicle types.

The NERA/Sierra model ran a case (Scenario E) that assumed that consumer demand is 10 times the level estimated during the MOA period. This resulted in a reduction in the "ZEV tax" ranging from 6 to 11 percent over the 2003-2020 period. Staff believes that in light of the extensive testimony received during the Biennial Review regarding consumer difficulties in obtaining ZEVs (e.g. long waiting lists and rigorous pre-lease screening), even the higher assumed level demand could tend to underestimate consumer demand that would exist given

normal vehicle advertising and availability. To be conservative, when assessing the combined effect of revised assumptions on the NERA/Sierra model results in Section 3 below, staff uses the "10 times observed sales" case as assumed by NERA/Sierra.

2.1.2.4 Horizontal Marginal Cost Curve

A final factor that influences the impact of any given cost increase on price is the shape of the marginal cost curve. The CSU Fullerton consultants raised a concern regarding the curve used for the NERA/Sierra report:

> NERA-Sierra represents marginal cost (MC) with a horizontal line (see January 2001 report, Appendix D), as opposed to the accepted upward-sloping curve. The difference is that, with horizontal MC, any cost increase is passed entirely on to the consumer. In contrast, if MC slopes upward, only a portion of the cost increase is passed on—the producer must absorb some of the cost. A horizontal MC curve contributes to upwardly biased estimates of the impact of price increases on new car sales.

2.1.3 Effect of Price Increase on Sales

The next major element in the NERA/Sierra argument is the effect of a price increase on vehicle sales. Staff has noted that the cost of the ZEV program is less than estimated by NERA/Sierra, and that manufacturers may not be able to recover increased cost in the form of higher vehicle prices. Even assuming that those portions of the NERA/Sierra argument are correct, however, staff believes that the projected impact of the price increase on sales is also overstated, for several reasons:

- Small price increases can be addressed by a variety of manufacturer marketing practices and will not necessarily reduce sales.
- The NERA/Sierra report assumptions regarding the price elasticity of demand are problematic.

2.1.3.1 Manufacturer and Dealer Marketing Practices

The NERA/Sierra report assumes a rigid relationship between price and sales, such that any increase in the manufacturers' suggested retail price, no matter how small, results in a sales decrease. In reality, however, automobile pricing is fluid, and manufacturers and dealers have available a variety of methods to encourage sales. Assuming for the sake of argument that manufacturers are able to pass along all of their increased costs (which staff believes is unlikely), the resulting price increases as estimated by the NERA/Sierra model still are quite small. Over the 2003-2020 time period, the "ZEV tax" per vehicle ranges from $277 to $416 in the NERA/Sierra base case and from $26 to $36 using ARB

assumptions (see Section 3 below). At these levels, such price increases can get lost in the "noise" of other marketing techniques.

For example, it is very common for manufacturers to offer cash or financing incentives. ARB staff has reviewed a sample of rebate incentive offers available over the past year, as reported in AutoWeek magazine. Cash rebates (excluding financing incentives) ranged from $100 (one offer) to $5,000. Out of 2,068 rebate offers reviewed, 80 percent were for $1,000 or more, and the weighted average incentive amount was $1,469. Table 2 below shows the distribution of incentive levels.

Table 2
Distribution of Manufacturer Incentives

Incentive Amount	Number of Incentives
Less than $500	2
$500-$749	301
$750-$999	114
$1000-$1249	500
$1250-$1499	40
$1500-$1749	423
$1750-$1999	19
$2000-$2249	364
$2250-$2499	10
$2500-$2749	129
$2750-$2999	1
$3000-$3249	150
$3250-$3499	0
$3500-$3749	11
$3750-$3999	0
$4000-$4999	3
$5,000	1
Total	2068

As the table shows, only two of the 2,068 incentives offered were for less than $500 (one for $100 and one for $400). This implies that manufacturers find it necessary to offer price decreases of $500 or more in order to elicit a meaningful response from customers. By the same token, price increases in the sub-$100 range, as projected in Section 3 below using ARB assumptions, would not be expected to significantly affect sales levels.

In many situations, moreover, customer decisions are driven by the size of the monthly payment rather than the purchase price of the vehicle. From this standpoint, the impact of the ZEV program on monthly payments is trivial. If we accept the NERA/Sierra arguments as submitted, and assume a price increase

of $500 (larger than any value reported in the NERA/Sierra base case), the monthly payment for a $20,000 vehicle on a 48 month loan at 6 percent increases by just $11.74. Using the more reasonable ARB assumptions, and assuming a price increase of $50 (again more than the NERA/Sierra model predicts given ARB assumptions), the increase in monthly payment under the same loan is $1.17. By way of contrast, if the customer extends the term of the loan to 60 rather than 48 months, the customer could fully cover a $500 price increase and still reduce the monthly payment by $73.38.

Low rate financing offers customers another way to increase the value of the car that they can purchase and still stay within a given monthly payment. Finally, customers have the ability to delete an option or otherwise modify their purchase decision to get the price to their target area. Again, given the small amounts under discussion here, very little is needed in order to offset the assumed price increase. For example, the model year 2007 "ZEV tax" using ARB assumptions ($36) is much less than the price of carpeted floor mats for the Chevrolet Malibu ($79). Thus the NERA/Sierra argument, put in simplest terms, requires one to accept that for less than the price of new floor mats, thousands of customers statewide would put off vehicle purchases and instead continue to drive their older vehicles.

2.1.3.2 Other Issues

The CSU Fullerton consultants identified several other problems with the NERA/Sierra report as it relates to the effect of a price increase on vehicle sales:

> Consumer Response to Prices
>
> In the event that some costs are passed on to consumers, the next step is to determine how this would influence prices. Price elasticity of demand is one measure of how consumers will respond to a change in the price of a product. Since quantity purchased has an inverse relationship to price, price elasticity is almost always negative, showing that as prices rise, purchases decline (and vice versa). The question then is how large an effect price changes will have on consumer choices. If price elasticity is less than one, rising prices will lead to a less than proportional decline in purchases, other factors remaining constant. Since the NERA-Sierra conclusions rest heavily on the assumed level of price elasticity, this is a key variable. They assume an aggregate elasticity of –1.0 , referencing Gruenspecht (2000) who constructed this figure from other sources. NERA-Sierra and Gruenspecht both reference McCarthy (1996), who estimates an elasticity of –0.87, based on a 1989 household survey. McCarthy, in contrast to Gruenspecht, who finds a "clustering of estimates in the neighborhood of –1.0", also concludes that "the market demand for new vehicles lies in the unitary price elasticity range, but is income elastic." He then states that "estimated market price elasticities of

demand…fall in the (-1.2, -0.6) range *with the preponderance of estimates lying below unity*." (Emphasis added.) That is, elasticities fall primarily below –1.0. Using an elasticity of less than –1.0 would reduce any level of impacts substantially. NERA assigns elasticities for PCs and LDT1s of –1.2 and LDT2-4s of –1.6, respectively (GM V. II, C-10). Using McCarthy's estimate of –0.87, fleet turnover increases substantially compared to the NERA-Sierra results, with additional sales of 927, 1,101, and 1,573 in 2003, 2007 and 2020, respectively. (As compared to estimated sales in the NERA/Sierra base case—clarification added by ARB staff).

The precise choice of which price elasticity to use is, however, not the only important factor in calculating the impact of price changes on consumer choices. First, the use of one price elasticity to represent consumer behavior over a wide range of models, prices and attributes is not appropriate. (NERA-Sierra appear to recognize this, given that they use different elasticities for the two groups of vehicles, as noted above.) Especially for relatively small changes in price, consumers could well respond by financing a car over a longer period, deciding against one or more optional add-ons, delaying purchase for a limited period (weeks or months), or simply purchasing a vehicle from a manufacturer not required to offer ZEVs for sale, or from an out-of-state dealer or wholesaler.

Another weakness in using price elasticities derived from older studies is that in recent years consumers report a shift in the relative importance of vehicle attributes considered when they determine when and what to purchase. The elasticities chosen by NERA-Sierra depend on studies going back to 1977, with the most recent data drawn from consumer surveys in 1989 (McCarthy 1996). If price has become less important, relative to other vehicle attributes, since 1989, then price elasticities based on the earlier time period will overstate consumer response to price changes. The following table summarizes the shift in the weights consumers place on several factors.

Vehicle Attribute Importance to Consumers[2]

Year	Fuel Economy	Dependability	Low Price	Quality	Safety
1980	42%	31%	14%	4%	9%
1983	13%	38%	30%	11%	9%
1985	8%	41%	29%	12%	10%
1987	4%	44%	31%	8%	14%
1996	7%	35%	10%	19%	29%
1998	4%	36%	5%	20%	33%
2000	11%	33%	11%	22%	24%

[2] Office of Transportation Technologies, http://www.ott.doe.gov/facts/archives/fotw144supp.html

It is apparent that prices have generally become less important over the past 15 years, and now carry one-third the weight that they did in the mid and late 1980s. This means that vehicle purchasers will logically be less sensitive to price now than was the case then, and that elasticities will therefore be lower. At the same time, safety and quality have become more important. Fuel economy has also doubled in importance since the late 1980s.

Consumer Substitutions

The results of the NERA-Sierra report depend on the assumption that consumers who do not decide to defer a new vehicle purchase will tend to shift to the LDT2-4 class. This is inconsistent with the NERA-Sierra assumption that consumers are price sensitive, because these are likely to be more expensive vehicles. More importantly, these are far less fuel efficient than PCs or LDT1s, and from Table 1 it is apparent that consumers are sensitive to fuel economy in years when fuel prices are high, rising, or expected to rise. Sensitivity to this factor almost tripled from 1998 to 2000, returning to a level last seen in 1983. Assuming wholesale switching to *less* fuel-efficient options is unreasonable.

The NERA-Sierra assumption about gasoline prices is also problematic in this context. As Table 1 indicates, in periods when fuel prices are high or rising, fuel economy becomes a more important attribute for consumer choices. In 2000, fuel economy carried as much weight as low price. The price of reformulated gasoline rose more than 20 percent from May 2000 to May 2001, reaching $1.94 a gallon (CEC 2001, EIA/DOE 2001). This price is substantially higher than the $1.26 assumed by NERA-Sierra. The U.S. Bureau of Economic Analysis (BEA, 2001) reports that sales of small cars have increased over the past year as sales of large and middle-sized cars have declined in the context of rising fuel prices. It should also be noted that gasoline prices in California tend to stay above the national average, for a variety of reasons related to supply conditions and product specifications.

It is also important to bear in mind that the major manufacturers that are subject to ZEV sales requirements compete amongst themselves, and with the intermediate manufacturers (and others) whose models consumers could well switch to. Any manufacturers that followed the cost allocation and pricing policies that are the foundation of the NERA-Sierra conclusions would lose market share. Berry et al. (1995) found large cross price elasticities across manufacturers and models. A $1,000 increase in the price of a Chevy Cavalier, for example, increases the market share of the Mazda 323 by nearly 10 percent.

In addition, many EV customers, especially in the early years, will be motivated by non-price factors such as concern for the environment, or the appeal of new cutting-edge technology. Price is not as big a factor in the decision of such factors to purchase an EV.

Finally, staff notes that the ARB has, in the past, adopted regulations that impose cost increases in the $75 or $100 per vehicle range. The fleet turnover argument has never been raised in these past rulemakings, presumably because the cost increase was not considered large enough to trigger an effect. The NERA/Sierra report asserts that the issue is germane here because the cost increases are so large relative to past regulations. As is demonstrated in Section 3 below, however, using more reasonable ARB assumptions in the NERA/Sierra model results in cost increases that are well within the range of past actions.

2.2 Fleet Population Model

Output from the New Vehicle Market Model feeds into the Fleet Population Model, which estimates the effect of changes in the new vehicle market on the entire motor vehicle fleet. The CSU Fullerton consultants raised the following issue:

> In modeling scrappage rates for older cars (January 2001 report, Appendix E) NERA-Sierra again relies on assumptions that may bias the findings toward larger impacts. … Perhaps more importantly, in the scrappage model, they use a gasoline price of $1.26 per gallon, which is clearly too low. Gasoline prices in California have recently ranged up to $1.94 per gallon, and are not expected to fall to the range of $1.26 in the foreseeable future. Higher fuel prices will lead to higher scrappage rates (NERA-Sierra also states that this is true – "rising fuel prices should increase scrappage rates for older vehicles" (January, 2001, Appendix E, p. E-7), again leading to fewer older cars on the road, with fewer resulting emissions. In fact, the NERA-Sierra results depend on an assumption of gasoline prices remaining at $1.26 over the life of the ZEV program.

Another issue related to the scrappage model involves its treatment of the interaction between vehicle prices and vehicle quality. New car prices have generally increased over time since 1970. Over the same time period, vehicle quality has improved. New car prices and new car quality are therefore correlated to some degree over 1970-1998. Better quality vehicles tend to last longer and, therefore, if some indicator of vehicle quality in each year were included in the NERA estimation, one would likely find negative coefficients.

The problem is that no attempt has been made to incorporate vehicle quality in the model. The new car price coefficient in the estimation may therefore include the effects of an increase in quality (since price and quality are correlated). In other words, given how the estimation was performed, it is impossible to tell

whether the estimated effect of new car prices on scrappage is valid or whether the price coefficients are simply picking up the effects of quality improvements.

To be more specific, suppose for argument's sake that new car prices have no effect on scrappage. As we move through time between 1970 and 1998, a car that is ten years old is less likely to be scrapped, all else being equal, because it is generally of better quality. At the same time, new car prices are rising on average. The data would then show a negative correlation between new car price and likelihood of scrappage (if quality were not taken into account), when no causal relationship actually existed.

Finally, staff notes that the August 7, 2000 Staff Report in some circumstances used a pre-tax gasoline price of $1.26 per gallon, which is equivalent to of an after-tax price of $1.75. It appears that the NERA/Sierra report relies upon the pre-tax price, which is inappropriate in this instance. Staff also notes that California has programs in place to encourage scrappage of older, higher polluting vehicles, which would increase California versus national scrappage rates.

2.3 VMT Model

The VMT Model determines the extent to which ZEVs would replace non-ZEV vehicle miles of travel. The CSU Fullerton consultants identified an issue regarding the data used to estimate ZEV vehicle miles traveled:

> Expected ZEV VMT Replacement
>
> To estimate the fraction of conventional vehicle travel that ZEVs can be expected to replace, NERA-Sierra analyzed travel data from the "Three Cities Study" conducted in Baltimore, Spokane, and Atlanta (January 2001, page 12). If Californians do not exhibit similar driving patterns and behaviors, then another bias is introduced into the analysis.

Staff also notes that future battery electric vehicles may have extended range as compared to today's battery vehicles, which would minimize the effect of any decrease in VMT. Moreover, fuel cell vehicles, because they can be rapidly refueled, will have range sufficient to remove any purported VMT reduction effect.

2.4. Emissions Model

The Emissions Model estimates the effect that changing fleet composition has on fleetwide emissions. Staff has determined that the NERA/Sierra report fails to take into account recent changes to the LEV II program that increase the emission benefit of the ZEV program.

In December 2000, the ARB amended the LEV II regulations to incorporate portions of U.S. EPA's recently promulgated Tier 2 regulations, in order to ensure that California continues to receive only the cleanest cars and light trucks available. While the California LEV II standards are generally more stringent than the comparable federal requirements, there are some features of the Tier 2 program that could result in manufacturers certifying certain vehicle models to a more stringent federal exhaust emission standard than is required in California. This could occur, for example, because LEV II program flexibilities built into the phase-in years (2004 through 2006) for heavier light-duty trucks do not require full implementation until 2007, while under Tier 2, manufacturers must certify some of these vehicles to a cleaner intermediate federal standard before 2007. The December 2000 "LEV II follow-up" amendments require that if a manufacturer certifies a cleaner federal vehicle model and offers an equivalent model in California, the California model must be certified to the same federal exhaust emission standards. These amendments were approved by the Office of Administrative Law April 30, 2001 and became operative May 30.

The LEV II follow-up amendments have a significant impact on the emissions impact of the ZEV program, because of the relationship of the ZEV requirements to the fleet average NMOG requirement that is a central feature of the overall LEV regulations. Each year, a manufacturer's overall fleet of passenger cars and light-duty trucks certified to the LEV program's various tiers of exhaust emission standards must meet an incrementally more stringent fleet average NMOG standard – based on the NMOG standards to which individual vehicle models are certified. At the same time, the manufacturer must separately meet the ZEV requirements, with a chosen mix of ZEVs and PZEVs. Since the zero or almost zero NMOG emissions of a manufacturer's ZEVs and PZEVs are included in the calculation of its overall fleet average NMOG levels, the ZEVs and PZEVs allow the manufacturer to market other models with relatively high NMOG emissions. But the LEV II follow-up amendments will in some instances preclude the manufacturer from fully offsetting the zero or almost zero emissions from the ZEVs and PZEVs with higher-emitting vehicles, because the manufacturer will instead have to market Tier 2 models certified to cleaner standards. Because of the ratcheting down of the NOx standards in LEV II and Tier 2, those cleaner Tier 2 models will also result in lower NOx emissions. To the extent this happens, the emission benefits of the ZEV program will increase.

In order to determine the effect of the LEV II follow-up amendments on the light-duty fleet, staff incorporated the fleet implementation for Tier 2 contained in the draft version of U.S. EPA's Mobile 6 into the fleet implementation for LEV II. The affected vehicles are passenger cars (PCs) and light-duty trucks (LDTs) up to 8500 lbs. gross vehicle weight. Incorporating Tier 2 into the LEV program forces PCs and trucks in the LDT1 class to phase into LEV II at a more aggressive rate than previously required. This occurs because U.S. EPA expects a significant percentage of Tier 2 vehicles will be certified to federal Bin 5 standards in the early years. Emission benefits also result from SUVs and larger trucks certifying

to the interim Tier 2 standards in model years 2004 through 2006 (beyond 2006, LEV II requirements are more stringent for these vehicles.) Furthermore, beyond 2007, U.S. EPA projects that cleaner PCs and LDT1 Tier 2 vehicles certifying to Bins 4 and 3 will be used by the manufacturers to offset higher emitting sport utility vehicles and larger trucks, providing additional NOx benefits. Beginning in 2009, the LDT2 class is impacted by a significant percentage of vehicles certifying to Bin 4 standards, also resulting in additional NOx benefits. In each of these instances, the marketing of Tier 2 models in California because of the LEV II follow-up amendments will mean that a manufacturer will not be able to fully "use up" the NMOG benefits of its ZEVs and PZEVs, and there will accordingly be reductions in overall fleet emissions of NOx and to a lesser extent HC.

The effect of these changes on estimated emissions is incorporated in the emission impact scenarios modeled in Section 5 below.

3. MODEL RESULTS USING STAFF ASSUMPTIONS

Section 2 above outlined staff concerns with a number of the assumptions used in the NERA/Sierra report, and described more reasonable ARB assumptions and their rationale. Staff has analyzed the results obtained using the more reasonable ARB assumptions rather than NERA/Sierra assumptions in the NERA/Sierra model. This section describes the effect of these changes.

3.1 OVERVIEW

Before describing the effect of using more realistic assumptions in the NERA/Sierra model, it is important to recognize that two key assumptions drive the NERA/Sierra study results. First of all, the NERA/Sierra argument assumes that manufacturers will act in concert to raise prices on California vehicles to cover the increased cost of the ZEV program. As was noted in Section 2 above, manufacturers may not be able to pass along the cost increase, due to competitive pressures from manufacturers not subject to the full ZEV requirement. Moreover, manufacturers may choose to absorb part or all of the cost in order to maintain market share. This effect is not considered further here, but it is essential to keep in mind.

Second, the NERA/Sierra study assumes that any price increase, no matter how small, results in a permanent decrease in vehicle sales. As was also discussed in Section 2 above, this assumption fails to take into account the many strategies manufacturers and dealers can employ in order to close the sale on a new vehicle despite a price increase. Therefore this assumption again results in an overstatement of the effect of any price increases that may result.

In addition, staff has identified and outlined in Section 2 above a number of other issues that are relevant to the discussion but are not readily addressed within the model as developed by NERA/Sierra. Such issues include the decreasing importance of price as a vehicle attribute considered by consumers, the horizontal marginal cost curve employed, the effect of consumer substitutions, and the effect of gasoline prices on scrappage rates.

All of these factors definitely or plausibly work to reduce the magnitude of the impact projected by NERA/Sierra. Therefore the model results using more reasonable ARB assumptions, as outlined below, should be viewed as an upper limit on the purported effect.

3.2 NEW VEHICLE MARKET MODEL

As noted above, ARB staff believes that there are a number of factors that will serve to reduce the impact of the ZEV program on vehicle sales below the levels estimated by the NERA/Sierra model. In this section, however, we ignore such factors and review the effect of substituting ARB staff assumptions (which we

believe are more realistic) for those employed by NERA/Sierra, otherwise using the NERA/Sierra model without modification. We conclude that the use of more realistic assumptions significantly reduces the projected reduction in new vehicle sales.

GM's January 23, 2001 submittal included a CD ROM containing a copy of the Logit model employed in the NERA/Sierra study. ARB staff performed a number of model runs with more reasonable assumptions, all using the Logit model on the CD ROM submitted by GM. Staff first describes the impact of each change in isolation, then discusses the combined impact of substituting the more realistic ARB assumptions for those used by NERA/Sierra throughout the model.

3.2.1 Effect of Modifications to Individual Assumptions

This section describes the specific changes made by ARB staff, and their effect on the model results. The revised assumptions are introduced in the same order as they were discussed in Section 2 above.

Staff reports the model results for three parameters. For each, staff shows the value as calculated by the model, and the percent change in the value of the parameter as compared to the NERA/Sierra base case. The parameters reported are:

- "ZEV Tax": The average price increase per covered vehicle, excluding ZEVs. This is the primary measure discussed by NERA/Sierra in its report.
- Overall Price Increase: The average price increase per covered vehicle, including ZEVs. This is related to, but separate from, the "ZEV tax".
- Vehicle Shortfall: The reduction in passenger car sales for each model run as compared to the sales assumed in the ARB December 8, 2000 Staff Report emission analysis. For this parameter, the reported percent change means the percent by which the sales "shortfall" is increased or decreased by the use of the revised assumption. (The model does not directly calculate the percent reduction in this shortfall. ARB staff have calculated it by taking the difference in sales for the ARB model run as compared to the NERA/Sierra base case, and then comparing that difference to the total sales decrease reported by the model for the NERA/Sierra base case.) Staff notes that the "passenger car" sales change is only a portion of the total effect modeled by NERA/Sierra. It does, however, provide a useful indicator of the effect of the revised assumption.

For comparison purposes staff first provides the results for each parameter as reported for the NERA/Sierra base case analysis. This is followed by a discussion of each more reasonable assumption introduced by staff, and its effect on the model results. Results are reported for the 2007, 2012, and 2020 model years.

NERA/Sierra Base Case

Table 3 below shows the values reported for each parameter in the NERA/Sierra base case:

Table 3
NERA/Sierra Base Case

	2007	2012	2020
"ZEV Tax"	$305	$420	$416
Overall Price Increase	$197	$270	$254
Vehicle Shortfall	18,378	25,735	26,289

PZEV Incremental Cost

In this model run staff uses an incremental PZEV cost of $200 per vehicle, rather than the NERA/Sierra assumption of $500 per vehicle. All other assumptions are as used in the NERA/Sierra base case. The results of this change are shown in Table 4 below:

Table 4
Effect of Change to PZEV Incremental Cost

	2007	2012	2020
"ZEV Tax"	$240	$355	$350
Percent Change	-21%	-15%	-16%
Overall Price Increase	$152	$225	$210
Percent Change	-23%	-17%	-17%
Vehicle Shortfall	14,101	21,314	21,587
Percent Change	-23%	-17%	-18%

Required Number of AT PZEVs

In this model run staff assumes that the average AT PZEV earns a credit score of 0.544, rather than the 0.45 assumed by the NERA/Sierra report. This corrects for the report's failure to take into account the effect of the efficiency multiplier on AT PZEV scores. All other assumptions are as used in the NERA/Sierra base case. The results of this change are shown in Table 5 below:

Table 5
Effect of Change to Required Number of AT PZEVs

	2007	2012	2020
"ZEV Tax"	$289	$393	$389
Percent Change	-5%	-6%	-6%
Overall Price Increase	$186	$252	$236
Percent Change	-6%	-7%	-7%
Vehicle Shortfall	17,406	24,066	24,509
Percent Change	-5%	-6%	-7%

AT PZEV Incremental Cost

In this model run staff decreases the model year 2006 and beyond incremental cost of AT PZEVs by $1,400 per vehicle, to account for technical improvement over time that will reduce the incremental cost for AT PZEVs. All other assumptions are as used in the NERA/Sierra base case. The results of this change are shown in Table 6 below:

Table 6
Effect of Change to AT PZEV Incremental Cost

	2007	2012	2020
"ZEV Tax"	$252	$331	$327
Percent Change	-17%	-21%	-21%
Overall Price Increase	$161	$210	$194
Percent Change	-18%	-22%	-24%
Vehicle Shortfall	15,182	20,252	20,445
Percent Change	-17%	-21%	-22%

AT PZEV Fuel Savings

In this model run staff decreases the incremental cost of AT PZEVs by $1,600 per vehicle, to account for the value of the fuel savings achieved by such vehicles. All other assumptions are as used in the NERA/Sierra base case. The results of this change are shown in Table 7 below:

Table 7
Effect of Change to AT PZEV Fuel Savings

	2007	2012	2020
"ZEV Tax"	$245	$320	$315
Percent Change	-20%	-24%	-24%
Overall Price Increase	$156	$202	$186
Percent Change	-21%	-25%	-27%
Vehicle Shortfall	14,760	19,527	19,673
Percent Change	-20%	-24%	-25%

ZEV Incremental Cost

In this model run staff assumes that the incremental cost of a ZEV is roughly $14,000 in 2003, $12,000 in 2007, $10,000 in 2012, and $8,000 in 2020, plus $750-$1,000 per vehicle for necessary infrastructure. These cost levels were chosen to correspond to the mid term cost estimates provided in the Arthur D. Little report ($9,300 for a hydrogen fuel cell in 2010-2020). Due to the nature of the NERA/Sierra model, which fits a curve to various cost/volume data points, staff was unable to precisely mirror the Arthur D. Little projections. The numbers used by staff are low in 2003, higher than Arthur D. Little in 2012, and slightly lower than Arthur D. Little in 2020. All other assumptions are as used in the NERA/Sierra base case.

The results of this change are shown in Table 8 below:

Table 8
Effect of Change to ZEV Incremental Cost

	2007	2012	2020
"ZEV Tax"	$235	$320	$318
Percent Change	-23%	-24%	-24%
Overall Price Increase	$149	$202	$188
Percent Change	-24%	-25%	-26%
Vehicle Shortfall	14,194	19,561	19,836
Percent Change	-23%	-24%	-25%

Manufacturer Decision to Raise Prices for California Vehicles Only

In this model run staff reduced the NERA/Sierra assumed incremental cost for all vehicle types by a factor of 10, to account for the effect of spreading these costs nationally rather than only over California sales. All other assumptions are as used in the NERA/Sierra base case. The results of this change are shown in Table 9 below:

Table 9
Effect of Change to California vs. National Sales Assumption

	2007	2012	2020
"ZEV Tax"	$38	$63	$60
Percent Change	-88%	-85%	-86%
Overall Price Increase	$14	$26	$11
Percent Change	-93%	-90%	-96%
Vehicle Shortfall	1,804	2,977	2,218
Percent Change	-90%	-88%	-92%

Consumer Preference for ZEVs

In this model run staff assumes ZEVs sales are 10 times the level reported by NERA/Sierra during the MOA period. This change is intended to account for the fact that the MOA period did not represent a true test of consumer demand for ZEVs. (This case corresponds to Scenario E from the NERA/Sierra report.) All other assumptions are as used in the NERA/Sierra base case. The results of this change are shown in Table 10 below:

Table 10
Effect of Change to ZEV Sales

	2007	2012	2020
"ZEV Tax"	$282	$380	$375
Percent Change	-8%	-10%	-10%
Overall Price Increase	$95	$164	$164
Percent Change	-52%	-39%	-35%
Vehicle Shortfall	18,671	24,928	25,426
Percent Change	-2%	-3%	-3%

Assumed Price Elasticity of Demand

In this model run staff uses a price elasticity of demand of –0.87, rather than the –1.0 used in the NERA/Sierra report. All other assumptions are as used in the NERA/Sierra base case. The results of this change are shown in Table 11 below:

Table 11
Effect of Change to Price Elasticity of Demand

	2007	2012	2020
"ZEV Tax"	$305	$419	$415
Percent Change	0%	0%	0%
Overall Price Increase	$197	$270	$254
Percent Change	0%	0%	0%
Vehicle Shortfall	17,274	24,187	24,706
Percent Change	-6%	-6%	-6%

3.2.2 Combined Effect, Cost Spread to California Sales

This section looks at the model results obtained when all assumptions noted above are changed to reflect the more reasonable ARB staff estimates. Staff first presents results assuming that costs are spread across California sales only, per the NERA/Sierra analysis. Section 3.1.3 below then presents a case assuming that costs are spread across national sales.

In this model run staff adopts ARB changes to all assumptions. The results of this change are shown in Table 12 below:

Table 12
Effect of ARB Changes to All Assumptions, Cost Spread to CA Sales

	2007	2012	2020
"ZEV Tax"	$36	$29	$26
Percent Change	-88%	-93%	-94%
Overall Price Increase	-$74	-$76	-$74
Percent Change	-138%	-128%	-129%
Vehicle Shortfall	3,336	2,680	1,918
Percent Change	-82%	-90%	-93%

As is illustrated by the above model results, even if one accepts the NERA/Sierra assumption that all costs are charged to California vehicles only, the combined effect of using the more realistic ARB assumptions is to reduce the estimated impact of the ZEV program on vehicle sales by some 80 to 90 percent.

3.2.3 Combined Effect, Cost Spread to National Sales

This section looks at the model results obtained when all assumptions noted above are changed to reflect more reasonable ARB staff estimates, and costs are spread across national sales. The results of this change are shown in Table 13 below:

Table 13
Effect of ARB Changes to All Assumptions, Cost Spread to National Sales

	2007	2012	2020
"ZEV Tax"	-$60	-$96	-$98
Percent Change	-120%	-123%	-124%
Overall Price Increase	-$140	-$162	-$160
Percent Change	-171%	-160%	-163%
Vehicle Shortfall	-2,289	-4,863	-6,055
Percent Change	-112%	-119%	-123%

As the table shows, if more reasonable ARB assumptions are used and the cost is spread across national sales, the NERA/Sierra model actually predicts an increase in new passenger car sales as compared to the ARB base case. This outcome perhaps seems unlikely. The point of this case is to show that reasonable assumptions can lead to a result in which vehicle prices and sales are not affected to any significant degree.

4. EFFECT OF BOARD'S JANUARY 25, 2001 ACTION

The NERA/Sierra report is based on modifications to the ZEV regulation as proposed by staff in the December 8, 2000 Staff Report. At its January 25, 2001 hearing, the Board directed that staff develop additional proposed modifications. This section discusses the effect of the Board's modifications on the NERA/Sierra findings and conclusions. Staff notes that the Board's modifications will not actually be adopted until the supplemental 15-day comment period is completed, and the Executive Officer has considered all comments and incorporated any appropriate further modifications in light of the comments.

4.1 Description of Board's Action

The Board's major directives to staff were to:

- Add LDT2 vehicles to the base against which a manufacturer's ZEV obligation is assessed, on a phased-in basis beginning in MY 2007 and concluding in MY 2012.

- Make other modifications as necessary to increase the required number of ZEVs to twice that called for under the December 8, 2000 staff proposal, again beginning in MY 2007 and concluding by MY 2012.

- Encourage the placement of ZEV program vehicles in "transportation systems" that offer shared vehicle use and linkage to transit.

Other changes directed by the Board are not discussed here because they have no effect on this analysis.

4.2 Effect of Board's Action on Model Results

From the standpoint of the NERA/Sierra model, adding LDT2 vehicles to the base used to calculate the ZEV obligation increases the number of "covered vehicles" under the ZEV program. This affects the internal structure of the model, and ARB staff are unable to directly manipulate the model to calculate the effect of this change. The impact of the other two major Board changes (further increasing the number of ZEVs required to twice the staff proposal by 2012, and providing increased incentives for placement of vehicles in transportation systems) likewise cannot be directly incorporated by staff into the model.

As an alternative, staff has assessed the impact of these changes in relative terms. Using current sales information, adding LDT2 vehicles to the base increases the size of all program categories (ZEV, AT PZEV, and PZEV) by about 70 percent in 2012 and beyond. For ZEVs, further increasing the required number of vehicles to twice the staff proposal increases the ZEV portion of the program by an additional 18 percent (the additional change needed to go from

1.7 times the staff proposal to 2 times the staff proposal). Using the NERA/Sierra incremental cost estimates, staff estimates that the combined effect of these two changes is roughly an 80 percent increase in the overall cost of the program for model years 2012 and beyond, as compared to the December 8, 2000 staff proposal.

Providing incentives for manufacturers to place cars in transportation systems, on the other hand, will reduce the number of ZEVs required. In its proposed modifications to the regulation, staff proposes that up to 9 increased credits per vehicle be provided through the 2007 model year for ZEVs placed in transportation systems. If fully used by manufacturers, staff estimates that these incentives would reduce the 2003-2007 ZEV totals by roughly 35 to 40 percent, depending on the assumed mix of vehicles. Again using the NERA/Sierra incremental cost numbers, staff estimates that this results in roughly a 10 percent reduction in the overall cost of the entire program (ZEV, AT PZEV and PZEV) in 2007. Taking into account that other costs associated with placing vehicles in transportation systems will offset some of these savings, staff estimates roughly a 5 percent savings for 2003-2007 due to this provision.

Taking all of these factors into account, staff estimates that overall, the Board's action will:

- Decrease 2003 through 2006 incremental program costs by about 5 percent (to account for the reduction in ZEVs due to the transportation system incentives).
- Increase incremental costs in 2007 by about 5 percent (due to the combined effect of the transportation systems savings and the cost increase due to the initial phase of adding LDT 2 vehicles to the base).
- Further increase incremental costs in 2008 through 2011 as LDT 2 vehicles are phased in and the number of ZEVs is increased to twice that of the staff proposal.
- Increase incremental costs for 2012 through 2020 by 80 percent (to account for adding LDT2 vehicles to the base and increasing the number of ZEVs to twice that of the staff proposal).

As noted above, the fleet turnover effect disappears if one uses the more reasonable ARB assumptions and spreads costs over national sales. Staff also has concluded that at the modest levels relevant here, any price increases that do occur will not have a significant effect on vehicle sales. Therefore from these standpoints the expansion of the ZEV program, as directed by the Board, likewise would have no fleet turnover impact. To be conservative, however, and to fully assess all aspects of the NERA/Sierra argument, staff has taken the results calculated for the "all ARB assumptions" case, with costs spread to California sales only, and modified them in accordance with the factors noted above. The results for model years 2007, 2012, and 2020 are shown in Table 14

below. For comparison purposes, Table 14 presents the results prior to the Board action, after the Board action, and the difference between the two.

Staff notes that given the operation of the NERA/Sierra model, an increase in the required number of ZEVs will be partially offset by a reduction in the per-unit incremental cost, due to increased production volume. This would increase the per vehicle cost for 2003-2007, and decrease the per vehicle ZEV cost in 2007 and beyond, as the required number of vehicles increases. Staff is unable to directly model this effect and has not included it in this analysis.

Table 14
Effect of Board's January 25 Action
Incremental Cost Spread to California Sales Only

	2007	2012	2020
Results Not Including Board Action			
"ZEV Tax"	$36	$29	$26
Percent Change from NERA/Sierra Base	-88%	-93%	-94%
Vehicle Shortfall	3,336	2,680	1,918
Percent Change from NERA/Sierra Base	-82%	-90%	-93%
Results Including Board Action			
"ZEV Tax"	$38	$52	$47
Percent Change from NERA/Sierra Base	-87%	-88%	-89%
Vehicle Shortfall	3,536	4,824	3,452
Percent Change from NERA/Sierra Base	-81%	-81%	-87%
Difference Attributable to Board Action			
"ZEV Tax"	$2	$23	$21
Percent Change	1%	79%	81%
Vehicle Shortfall	200	2,144	1,534
Percent Change	6%	80%	80%

As Table 14 shows, staff estimates that the Board's January 25 action increases the "ZEV tax" by about 80 percent in 2012 and 2020 as compared to the December 8, 2000 staff proposal. For example, the 2012 "ZEV tax" of $52 is 79 percent larger than the "no Board action" estimate of $29.

When compared to the NERA/Sierra base, however, the increases are small. For example, the "including Board action" 2012 "ZEV tax" of $52 is still about 88 percent less than the NERA/Sierra base estimate. This is due to the fact that substituting ARB assumptions significantly reduces the calculated impact of the ZEV program on vehicle prices and sales. As a result, even though the ARB estimated "ZEV tax" grows by 80 percent, it is still quite small in comparison to the original NERA/Sierra estimate.

Thus in all cases, the projected results using ARB assumptions are significantly less than the original NERA/Sierra estimate, even when taking into account the effect of the Board's January 25, 2001 action. This is true even without taking into account the effect of other issues not modeled, such as the decreasing importance of price as a vehicle attribute considered by consumers, the horizontal marginal cost curve employed, the effect of consumer substitutions, and the effect of gasoline prices on scrappage rates.

5. EMISSION ANALYSIS

ARB staff has concluded that modest price increases as predicted here, if they occur at all, will have no significant effect on fleet turnover. The original ARB emission analysis, which does not take such impacts into account, thus remains valid and consistent with the ARB's emission analysis in all previous rulemakings pertaining to its motor vehicle program.

5.1 Updated ARB Emission Estimate

Staff has prepared an updated estimate of the emission benefits of the ZEV program. Revisions to the previous estimate include:

- Use of the EMFAC 2001 inventory, the most recent Board approved tool.
- Inclusion of the December 2000 LEV II follow-up amendments discussed above.
- Inclusion of the Board's January 25, 2001 expansion of the ZEV program to include LDT2 vehicles in the base, and increase the number of ZEVs to twice that required under the December 2000 staff proposal.

This updated estimate projects a ZEV program emission benefit, in the South Coast Air Basin, of 3.26 tons per day (tpd) ROG plus NOx in 2010, and 3.97 tpd in 2020. These totals do not include additional reductions that will occur due to decreases in indirect (upstream) emissions. Staff has not prepared a revised estimate of upstream emission reductions based on the Board's July action.

5.2 Purported Fleet Turnover Effect

The NERA/Sierra analysis uses a revised fleet population, as estimated in the previous steps, to project fleet emissions for the South Coast Air Basin and for the state as a whole.

For a variety of reasons discussed previously, staff does not accept the premise that the ZEV program will result in reduced vehicle sales. Section 3 above showed the individual and combined effect of substituting more reasonable ARB assumptions for the assumptions used in the NERA/Sierra report. Noteworthy findings include:

- The purported fleet turnover effect disappears, or indeed is reversed, when more reasonable ARB assumptions are used and the increased cost is spread across national sales.
- Even if costs are spread across California sales only, the "ZEV tax" and the effect on fleet turnover calculated by the NERA/Sierra model are reduced by some 90 percent.

Section 4 above discussed the expansion of the ZEV program as directed by the Board in January 2001. Again, there is no fleet turnover effect if costs are spread nationally; if costs are spread to California only, the purported impacts are still reduced by 80 percent or more.

Meanwhile, these results must be viewed in the context of other points discussed previously in this report. For example:

- Manufacturers will not necessarily be able to pass along all increased costs.
- A $50 per vehicle price increase results in a monthly payment increase of just $1.17 for a 48 month loan.
- Only 2 out of 2,068 manufacturer incentives reviewed were for amounts less than $500.
- $50 per vehicle is less than the price of carpeted floor mats for a new Chevrolet Malibu.
- The relative importance of price to vehicle consumers has decreased in recent years.
- The NERA/Sierra report itself acknowledges that manufacturers have in the past spread “relatively modest” cost increases across national rather than California sales.
- Past ARB regulations with similar cost impacts have not raised fleet turnover issues.

Taking all of these points into account, staff concludes that the effect of the ZEV program on vehicle prices, vehicle sales and fleet turnover related vehicle emissions will be insignificant. Nevertheless, in order to fully analyze the NERA/Sierra arguments, staff has undertaken an emission analysis to determine how emissions would be affected if one accepts the NERA/Sierra argument regarding fleet turnover.

5.2.1 Methodology

Staff analyzed three scenarios using the ARB’s latest approved emission inventory model, EMFAC2001, to determine the emission impact of the ZEV requirement in 2010 and 2020. In order to use our most up-to-date inventory but track as closely as possible the NERA/Sierra methodology, the scenarios use the EMFAC2001 fleet schedules, modified as necessary to reflect the fleet schedules derived from the NERA/Sierra model. The scenarios were analyzed for the South Coast Air Basin, as NERA/Sierra has done. Due to inconsistencies in the output file generated by the NERA/Sierra model, staff used the statewide results as reported by the NERA/Sierra model and modified the South Coast data to reflect the statewide results. In addition, staff notes that the output file from the NERA/Sierra model for T2 diesel vehicles had missing values. These are not expected to materially affect the results.

As discussed above, the NERA/Sierra report does not take into account the December 2000 LEV II follow-up amendments, under which any vehicle model certified to the federal Tier 2 program that is cleaner than its California LEV counterpart will be required to be sold in California as well. This correction is incorporated in all scenarios discussed below.

The NERA/Sierra methodology also does not include the effect of the Board's January 2001 action to add LDT2 vehicles to the ZEV program base and further increase the number of ZEVs. Staff is unable to manipulate the NERA/Sierra model to directly incorporate these modifications. Therefore the emission analysis was done using the NERA/Sierra model structure, which does not include these modifications. As is discussed further below, staff is confident that inclusion of the January 25 action would not change the basic direction of the conclusion—that the ZEV program results in an emission decrease compared to the no ZEV alternative.

The details of the scenarios are as follows:

> Scenario 1—EMFAC2001, No ZEV Program. The LEV program is adjusted by the LEV II follow-up amendments adopted in December 2000, but without a ZEV requirement. This scenario uses the base fleet in EMFAC2001.
>
> Scenario 2—EMFAC2001, Modified to Reflect NERA/Sierra Model Results Using NERA/Sierra Assumptions. The LEV program is adjusted by the LEV II follow-up amendments adopted in December 2000. This scenario modifies the EMFAC2001 fleet to reflect the NERA/Sierra model output, using all assumptions as submitted to ARB on the NERA/Sierra model. This scenario shows reduced new vehicle sales and an increase in the number of older vehicles. It should be noted that the ZEV requirement in this scenario, as used in the NERA/Sierra model, does not reflect either the staff's proposal at the January 2001 hearing or the modifications adopted by the Board at the hearing.
>
> Scenario 3—EMFAC2001, Modified to Reflect NERA/Sierra Model Results Using ARB Assumptions. The LEV program is adjusted by the LEV II follow-up amendments adopted in December 2000. The EMFAC 2001 base fleet is adjusted to reflect the output from the NERA model using more reasonable ARB assumptions (principally regarding vehicle cost increases) as discussed above. The ZEV requirement in this scenario is the same as that used in Scenario 2.

5.2.2 Emission Impact

This analysis assumes for the sake of argument that the fleet turnover effect posited by NERA/Sierra will occur. Staff does not believe this to be the case at

the low levels of cost increase that result from the use of ARB assumptions. Nevertheless to fully investigate the NERA/Sierra arguments staff undertook the emission analysis described above.

The scenarios follow the NERA/Sierra methodology, in that the base fleets are modified to reflect the NERA/Sierra model and they include where appropriate the purported decrease in new vehicle sales due to the incremental cost of the ZEV program.

Scenario 2, the NERA/Sierra base case, shows an increase in emissions of 2.72 tons per day ROG plus NOx in 2010 and 1.63 tons per day in 2020 as compared to the "no ZEV program" Scenario 1. This is consistent with the NERA/Sierra argument that the purported decrease in new vehicle sales results in an emission increase, if one accepts the NERA/Sierra methodology and assumptions.

As discussed throughout this report, however, staff has identified problems and concerns with the NERA/Sierra analysis. Staff has noted, for example, that manufacturers may not be able to pass along cost increases, and that small price increases do not necessarily result in decreased sales.

Assuming for the sake of argument that the methodology is sound, the results are driven by the assumptions employed. Scenario 3 uses the more reasonable ARB assumptions rather than the NERA/Sierra base case assumptions. The result is an emission benefit of 0.32 tons per day ROG plus NOx in 2010, and 1.57 tons per day in 2020, as compared to the NERA/Sierra "no ZEV" alternative. Thus, even if one accepts the NERA/Sierra methodology, using realistic assumptions the model still shows an emission benefit rather than the emission increase reported by NERA/Sierra in their base case analysis.

The emission results from the various scenarios are shown in Table 15 below. As was the case for the baseline ARB analysis discussed above, the ZEV program results reported below in scenarios 2 and 3 do not take into account additional reductions that will occur due to decreases in indirect (upstream) emissions.

Table 15
Emission Inventory SCAB (TPD ROG + NOx)
Exhaust and Evaporative Emissions

	2010	2020
Scenario 1—No ZEV Program	339.11	167.36
Scenario 2—NERA/Sierra Model Results Using NERA/Sierra Assumptions	341.83	168.99
Scenario 3—NERA/Sierra Model Results Using ARB Assumptions	338.79	165.79

Staff estimates that with the expansion of the ZEV program identified by the Board and reflected in the modified regulations released in late October, the ZEV program will still result in an emission decrease. The EMFAC 2001 inventory results reported above confirm that this is the case using the ARB methodology. With respect to the NERA/Sierra methodology and any purported fleet turnover effect, staff has also shown above that using more reasonable ARB assumptions in the NERA/Sierra model results in a much smaller "ZEV tax" and decline in new vehicle sales than occurs in the NERA/Sierra base case. These results, when reflected in the EMFAC 2001 emission inventory, result in an emission decrease for the ZEV program relative to the "no ZEV" alternative. Thus the decrease in emissions from the ZEV program in that instance is more than sufficient to offset the purported fleet turnover effect. The modifications approved by the Board in January will further reduce emissions due to the increased number of ZEVs and PZEVs. There is no reason to expect that any additional reduction in fleet turnover will be sufficient to offset the increased emission benefit.

6. SUMMARY AND CONCLUSIONS

ARB staff concludes that the NERA/Sierra report significantly overstates the impact of the CA ZEV program on vehicle prices, vehicle sales, and fleet turnover-related changes to vehicle emissions.

Using reasonable ARB staff assumptions, rather than the assumptions used by NERA/Sierra, the NERA/Sierra model predicts a "ZEV tax" of only $36 in 2007 and $26 in 2020, even if the entire increased cost is spread only to vehicles sold in California. When the Board's January expansion of the ZEV program is taken into account, the estimated "ZEV tax" is about $50. Staff concludes that at these modest levels, such cost increases, if they occur at all, will have an insignificant effect on vehicle sales.

Although staff does not accept the purported effect on vehicle sales, in order to fully investigate the NERA/Sierra arguments staff conducted additional analyses, using to the extent possible the NERA/Sierra methodology. Staff has determined that the significant reductions in the "ZEV tax" noted above lead to equally significant reductions in the effect on vehicle sales. Looking at passenger car sales, the NERA/Sierra base case predicts a reduction in new vehicle sales in 2012 of 25,735 vehicles as compared to the sales level used in the ARB Staff Report emission analysis. Using more realistic ARB assumptions, the sales decrease in 2012 is 4,824 vehicles, a reduction of 81 percent from the NERA/Sierra base case.

Finally, the reduced impact on vehicle sales results in a reduced impact on vehicle emissions. Rather than the emission increase reported in the NERA/Sierra base case, staff estimates that the ZEV program results in an emission decrease of 0.32 tons per day in 2010 and 1.57 tons per day in 2020 using the NERA/Sierra methodology with more reasonable ARB assumptions.

Thus the basic conclusion of the NERAS/Sierra report—that the ZEV program results in an emission increase due to reduced fleet turnover—does not hold.

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