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Commentary on the California Air Resources Board's Report, "Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Public Hearing to Consider Adoption of Regulations to Control Greenhouse Gas Emissions from Motor Vehicles", August 6, 2004

Summary of Commentary

The August 6 notice announcing the Air Resources Board's September public hearing to consider adoption of proposed regulations pursuant to AB 1493 states: "Before taking final action on the proposed regulatory action, the Board must determine that no reasonable alternative considered by the board or that has otherwise been identified and brought to the attention of the board would be more effective in carrying out the purpose for which the action is proposed or would be as effective and less burdensome to affected private persons than the proposed action." I recommend that the Board defer final action on the proposed LEV-based regulation and instead consider adopting a simpler, weight-based emission standard (described herein), for the following reasons:

- (1) The Initial Statement of Reasons (ISOR) specifies a maximum feasible and cost-effective emissions reduction level, and yet the proposed emission standard does not conform to this specification as required by AB 1493, paragraph 3(a).
- (2) The methodology by which the standard was determined is overly complex and error-prone. In particular, the standard was apparently erroneously calculated on the basis of an incorrect LEV weight cutoff; it is based on a regression model of dubious validity; and an incorrect optimality criterion was applied in establishing the emission limits.
- (3) The proposed emission standard is specifically based on year-2002 market data, and could hence violate either the maximality or cost-effectiveness requirements of AB 1493, paragraph 3(a), as market conditions change in future years.
- (4) The proposed emission standard is specifically based on California market data, and could hence deter adoption of the standard by other states, or could violate maximality or cost-effectiveness if adopted by others.
- (5) Although the regulation may be cost-effective on a sales-averaged basis, the LEV-type structure of the emission standard may motivate inequitable price increases, with some vehicle weights incurring price increases significantly in excess of cost-effective limits.

(6) The LEV-type standard would tend to destabilize the existing competitive balance between manufacturers and between different vehicle weights.

(7) The standard would create perverse incentives to increase vehicle weight in order to take advantage of the much less-stringent LDT2 standard relative to the PC/LDT1 standard.

An alternative that would circumvent the above limitations is a simple weight-based standard of approximately 140 g/mi/ton near-term (2012) and 132 g/mi/ton mid-term (2016), based on vehicle test weight. This alternative would represent a radical departure from the proposed LEV-type standard; but it is radical in the direction of simplification and would therefore not require significant rework by ARB staff. The alternative serves industry interests (by better preserving the existing competitive balance between manufacturers and between different vehicle weights), and also serves environmental interests (by improving environmental effectiveness); so it should be more acceptable to all stakeholders. And most importantly, the alternative would bring the regulation into conformity with the requirements of AB 1493.

Introduction

Paragraph 3(a) of AB 1493 mandates the Air Resources Board to “develop and adopt regulations that achieve the maximum feasible and cost-effective reduction of greenhouse gas emissions from motor vehicles”. The mandate comprises three essential requirements: (1) maximality, (2) feasibility, and (3) cost-effectiveness. As indicated by paragraph 3(i), “feasible” means “capable of being successfully accomplished within the time provided by this section, taking into account environmental, economic, social, and technological factors”; and “cost-effective” means “economical to an owner or operator of a vehicle, taking into account the full life-cycle costs of a vehicle”. These definitions are necessary requirements of the regulations, but they clearly are not intended to represent sufficient requirements, since these defining conditions alone would not necessitate emissions reduction of any significance. The maximality condition of paragraph 3(a) is clearly intended to mean that the regulations should achieve the maximum emissions reduction that is reasonably attainable within the constraints of feasibility, cost-effectiveness, and other stipulated limitations (paragraph 3(d)).

The requirements of AB 1493 represent a tightly constrained compromise between economic and environmental interests. The flat, bilevel form of the emission standard proposed in the ISOR imposes an additional constraint, which has been adopted as a matter of convenience, does not serve either environmental or economic interests, and is inconsistent with the requirements of AB 1493. The standard was chosen to conform to the current LEV program, although the bill imposes no such conformity requirement. This commentary outlines a variety of ways that the proposed standard fails to comply with AB 1493, and suggests a simple alternative (a weight-based standard) that would remedy these deficiencies.

Non-conformity to maximum feasible, cost-effective emissions reduction standard

Figures 6-1 and 6-2 in the ISOR illustrate regression lines that are described as representing the “maximum feasible reduction levels” of CO₂ as a function of vehicle test weight (ISOR, page 112), and the regression model is also constructed to satisfy the cost-effectiveness criterion (ISOR, Section 6.1.A and Tables 6.1-2, 6.1-3 and 5.3-8). According to this characterization, a weight-indexed emission standard based on the regression model would achieve “maximum feasible and cost-effective” emissions reduction, as required by AB 1493. (For brevity, “maximum feasible and cost-effective” will be abbreviated as “MFCE” hereafter.) But the proposed LEV-based, bilevel standard differs substantially from the regression model and does not comply with the requirements of paragraph 3(a).

The bilevel standard comprises two emission limits, one for each LEV weight category. As stated in the ISOR, page 105, “The proposed emission standards for each category were ... based on the manufacturer with the highest average weight vehicles to ensure all manufacturers can comply with the standards (i.e. not simply according to the average of all the manufacturers).” This prescription is intended to ensure cost-effectiveness for all manufacturers, but at the cost of increasing the aggregate emissions allowed by the standard in relation to the MFCE standard. This loss of environmental effectiveness is incurred by the restrictive bilevel form of the standard, and not by any requirement or limitation of AB 1493, and hence represents a violation of the maximality requirement of paragraph 3(a).

The bilevel standard’s environmental effectiveness can be quantified in terms of its “excess emissions allowance”, which is defined for each manufacturer (and for the aggregation of all manufacturers) as the difference between the sales-averaged emissions allowed by the standard and that of the MFCE standard. Table 1 lists these values for the proposed mid-term standard under the column heading “Proposed standard”. (The values in Table 1 represent sales averages over both weight categories, and hence take into account any allowance trading between categories.) The 12 g/mi value in the bottom row (“All”) is a measure of the degree by which the maximality requirement is violated.

Table 1
Excess mid-term emissions allowance (CO₂e g/mi) relative to MFCE standard (regression model).

	Proposed standard	GM-based bilevel	Optimal bilevel	Perverse bilevel	Weight-based
DaimlerChrysler	15	11	11	25	10
Ford	11	7	7	14	9
General Motors	4	0	0	9	10
Honda	12	9	0	9	12
Nissan	19	15	11	11	10
Toyota	18	14	11	30	10
All	12	8	6	17	10

Errors in standard determination

The proposed standard is intended to achieve zero excess emissions allowance for General Motors within each weight category; hence the excess allowance over both categories should also be zero, and not 4 g/mi as indicated in Table 1. This discrepancy is due to an error that was apparently made in computing the emission standard. The CARB analysis apparently used a 4000 lb weight ceiling for the PC/LDT1 category, rather than 3750 lb LEV weight cutoff.

The following analysis is based on emissions and test-weight data provided by CARB, which is a distillation of 2002 California sales data from the California Department of Motor Vehicles and other sources¹. The following Tables 2-7 summarize Tables 6.1-4 and 6.1-5 from the ISOR, along with recomputed values based on the CARB-supplied data. ISOR Table 6.1-4 is replicated in Table 2, and Table 3 shows the corresponding values that were recomputed from CARB data, based on an erroneous 4000-lb weight cutoff. The Table 2 sales percentage split between the two weight categories is reproduced in Table 3, although there are some small discrepancies in the weight and emissions data. (It isn't clear why there are such discrepancies, but the differences are comparatively insignificant.) Table 4 shows the corresponding data, recomputed with the correct 3750-lb weight cutoff. Table 5 replicates data from ISOR Table 6.1-5; Table 6 shows the corresponding data that was recomputed with a 4000-lb weight cutoff; and Table 7 shows recomputed data with the 3750-lb weight cutoff.

The "GM-based bilevel" column in Table 1 shows excess emissions allowance data, based on the mid-term emission standard specified in Table 7. The excess is zero for General Motors, positive for the other companies, and 8 g/mi for aggregate emissions.

The GM-based bilevel standard for the PC/LDT1 category was determined by matching it to the MFCE standard (as defined by the regression model) for a vehicle weight equal to General Motors' sales-averaged test weight within PC/LDT1 (i.e., 3384 lb, see Table 4); and the LDT2 standard was similarly matched to the MFCE standard for General Motors' sales-averaged test weight in LDT2 (5021 lb). The rationale for this methodology is discussed in Section 6.1.C of the ISOR; however this is not the correct methodology for determining the standard.

Cost-effectiveness (with trading) requires that the emission limits be constrained so that each manufacturer's excess emissions allowance is non-negative. There are six such constraints, and subject to these constraints, the maximality condition of AB 1493 requires that aggregate emissions be minimized. This objective translates into a linear programming problem, which can be solved graphically by the method outlined in the Appendix following this Commentary. Table 8 shows the resulting emission limits (identified as "Optimal bilevel") in comparison to the GM-based emission limits (from Table 7). As indicated in Table 1, the aggregate mid-term emissions allowance with the

¹ The data is in an Excel spreadsheet, "for CostEffect, Inventory,etc 052804_nl.xls", provided to me by Paul Hughes on July 27, 2004.

optimal bilevel standard is 6 g/mi, which is marginally better than the 8 g/mi of the GM-based bilevel standard and a factor of two better than the proposed standard.

Table 2

From ISOR, Table 6.1-4. Equivalent Emissions and Test Weight by Manufacturer

Company	Percent of vehicles for each auto (2002)		Sales-averaged test weight (lb)		Sales-averaged CO ₂ (g/mi)	
	PC/LDT1	LDT2	PC/LDT1	LDT2	PC/LDT1	LDT2
DaimlerChrysler	45%	55%	3644	4729	346	451
Ford	44%	56%	3569	4909	334	445
General Motors	41%	59%	3470	5113	318	459
Honda	82%	18%	3248	4544	282	379
Nissan	61%	39%	3369	4393	305	447
Toyota	59%	41%	3462	4555	301	422
Average	53%	47%	3457	4833	312	443

Table 3

Equivalent Emissions and Test Weight by Manufacturer, recomputed from CARB data with erroneous weight cutoff (4000 lb)

Company, market share by vehicle count	Percent of vehicles for each auto (2002)		Sales-averaged test weight (lb)		Sales-averaged CO ₂ (g/mi)	
	PC/LDT1	LDT2	PC/LDT1	LDT2	PC/LDT1	LDT2
DaimlerChrysler 15%	45%	55%	3652	4751	348	449
Ford 21%	44%	56%	3522	4945	328	446
General Motors 24%	41%	59%	3465	5131	319	456
Honda 13%	82%	18%	3241	4548	280	375
Nissan 5%	61%	39%	3351	4397	302	444
Toyota 23%	59%	41%	3446	4587	299	422
All 100%	53%	47%	3443	4857	310	441

Table 4

Equivalent Emissions and Test Weight by Manufacturer, recomputed from CARB data with correct weight cutoff (3750 lb)

Company, market share by vehicle count	Percent of vehicles for each auto (2002)		Sales-averaged test weight (lb)		Sales-averaged CO ₂ (g/mi)	
	PC/LDT1	LDT2	PC/LDT1	LDT2	PC/LDT1	LDT2
DaimlerChrysler 15%	36%	64%	3594	4642	341	440
Ford 21%	36%	64%	3424	4810	319	435
General Motors 24%	35%	65%	3384	5021	311	448
Honda 13%	82%	18%	3237	4530	279	377
Nissan 5%	60%	40%	3337	4385	300	442
Toyota 23%	52%	48%	3375	4485	289	413
All 100%	46%	54%	3377	4749	302	433

Table 5
From ISOR, Table 6.1-5. CO2 Equivalent Emission Standards

	Emission standard (g/mi)	
	PC/LDT1	LDT2
Near-term	233	361
Mid-term	205	332

Table 6
CO2 Equivalent Emission Standards, recomputed from CARB data with erroneous weight cutoff (4000 lb)

	Emission standard (g/mi)	
	PC/LDT1	LDT2
Near-term	233	362
Mid-term	205	333

Table 7
CO2 Equivalent Emission Standards, recomputed from CARB data with correct weight cutoff (3750 lb)

	Emission standard (g/mi)	
	PC/LDT1	LDT2
Near-term	229	355
Mid-term	202	327

Table 8
CO2 Equivalent Emission Standards

	Emission standard (g/mi)			
	GM-based bilevel		Optimal bilevel	
	PC/LDT1	LDT2	PC/LDT1	LDT2
Near-term	229	355	212	364
Mid-term	202	327	190	334

Figure 1 at the end of this Commentary provides a graphical illustration of the regression model (blue lines), GM-based bilevel standard (green lines) and optimal bilevel standard (red lines).

Dependence on year 2002 market conditions

Table 1 indicates that with allowance trading, the bilevel standard would be cost-effective for all six manufacturers. However, this is only true under the assumed year-2002 market conditions. In particular, cost-effectiveness might not be maintained for General Motors and Honda, who have zero emissions allowances under the optimal bilevel standard. If these manufacturers were to design their vehicles to the MFCE standard, they would have exactly the right amount of emission credits from over-compliant vehicles to cover under-compliant vehicles. But if they lose market share in the over-compliant category in future years, they would have to also restrict sales in the under-compliant category due to loss of emission credits. On the other hand, if sales were

to increase in the over-compliant category while diminishing in the under-compliant category, they would be incurring excess costs associated with unnecessary over-compliance.

Unless the emissions reduction required of a manufacturer is significantly less than the MFCE reduction level, the manufacturer would only be able to use trading to optimize compliance costs if the weight distribution of its fleet remains close to the 2002 distribution that was assumed in setting the emission standard. Due to uncertainty in future market conditions, the manufacturer may be compelled to make each vehicle fully compliant with the bilevel standard without trading. However, compliance with the bilevel standard may be considerably more expensive than complying with the MFCE standard. As noted in the ISOR (Section 12.7), even if the assumed fuel price were increased from \$1.74/gal to \$2.30/gal, further emissions reduction beyond the MFCE level would not be cost-effective; hence making the under-compliant vehicles fully compliant with the bilevel standard could be very expensive and in some cases may not even be feasible.

Dependence on California market conditions

The standard is not only premised on the year 2002 sales mix; it also assumes sales data specific to California. A standard that is cost-effective in the California market may not be so in other states or in a national or global context. (Conversely, even if it is cost-effective in other contexts it may not have maximal environmental effectiveness.) The environmental benefits of AB 1493 will be insignificant unless the regulations are adopted by other states and other countries; yet a standard that is custom-fit for the California market might deter adoption by others.

Weight-stratified profitability and pricing disparities

Although a manufacturer might be able to optimize its aggregate compliance costs by trading between over-compliant and under-compliant vehicles, the bilevel standard could nevertheless induce large disparities in vehicle prices or profitability between different vehicle weights, with some weights greatly exceeding the cost-effectiveness threshold. Trading would not necessarily even out these disparities.

For example, a manufacturer who puts a 5500-lb vehicle on the market in California would have a degree of flexibility in how the compliance costs for that vehicle are distributed. The vehicle could fully comply with the standard; or it could comply partially, with the balance being made up for by other over-compliant vehicles. But irrespective of how the costs are distributed, the *full* compliance costs represent costs that would be incurred by putting a 5500-lb vehicle on the market in California, and would not be incurred if the vehicle is not put on the market. Hence the full compliance costs will be accounted for in that vehicle's profit margin, and in order to maintain profitability the manufacturer will likely pass the full compliance costs to the consumer.

Destabilized competitive balance between manufacturers and between vehicle weights

As noted above, trading could help a manufacturer minimize its aggregate compliance costs (at least under year-2002 California market conditions), but it would probably *not* be effective at eliminating the weight-stratified profitability loss or price increase induced by the bilevel emission standard. Even with trading, the bilevel standard would destabilize the existing competitive balance between different vehicle weights, and could have substantial market impact. Furthermore, there would be no compensating environmental advantage because weight disparities would motivate manufacturers to concentrate their fleet weight distributions at weights where the bilevel standard is less stringent than the MFCE standard.

The weight disparities would also disrupt the existing competitive balance between manufacturers, due to their varying degrees of specialization in different weight categories. As indicated in Table 1, the optimal bilevel standard would put General Motors and Honda at a disadvantage relative to other manufacturers who have excess emissions allowances over the MFCE level.

Perverse incentives

One effect of weight disparity is that it would perversely incentivize manufacturers to increase some vehicle weights in order to avoid the more stringent PC/LDT1 standard.

Figure 1 shows the weight and emissions distribution of new vehicle models sold in California in 2002. Individual models are represented by x's, and there are a number of models with test weights right at the 3750-lb cutoff between PC/LDT1 and LDT2. These vehicles are in the PC/LDT1 category, but manufacturers would be motivated to increase vehicle weights to move them into the LDT2 category to take advantage of the less stringent LDT2 emission standard. Conversely, a manufacturer who might want to decrease an LDT2 vehicle's weight (e.g. to achieve cost savings) would be deterred from doing so if this would result in it being reclassified as a PC/LDT1 vehicle.

The effect of the discontinuity-induced perverse incentive can be approximated by computing the excess emissions allowance with the weight discontinuity changed from 3750 to 3749 lb, so that the 3750-lb vehicles are now in the LDT2 category. (Except for this change, the optimal bilevel standard is assumed.) This result is shown in the "Perverse bilevel" column of Table 1. The aggregate excess emissions allowance increases from 6 to 17 g/mi. If manufacturers similarly increase the weights of lighter (e.g. 3625 lb) vehicles, the increase could be much greater.

Unreliable regression model

The weaknesses of the bilevel standard outlined above undermine the standard's practicality and could make it vulnerable to legal challenges. In principle, these deficiencies could be overcome by using an emission standard based on the regression

model. The above analysis assumes that the regression model represents the MFCE emissions reduction level, as characterized by the ISOR; but there are a couple of discrepancies in the model that raise questions about its reliability. Unless these discrepancies can be resolved or rationalized, the regression model should not be relied on as an MFCE standard.

The regression model uses two-point linear regression within each weight category, under the premise that the MFCE emission level is an approximately linear function of sales weight. But the regression data is not consistent with this premise, as evidenced by the model's discontinuity at the 3750 lb transition point and by the misfit of the model to the representative minivan data point (see Figure 1).

Since the regression model is an explicit function of weight, it is not clear why separate functions are needed for the two weight classes. There may be a natural division of vehicles into two categories with different MFCE emission limits, but if so, the 3750-lb weight cutoff apparently does not adequately characterize the distinction between these categories. As noted in the ISOR, page 105, minivans are better aligned with passenger cars, although the weight criterion puts them in the LDT2 category. Furthermore, trucks in the LDT1 category would probably have MFCE emission characteristics more similar to LDT2 trucks than to passenger cars.

There is also a discrepancy in how the regression data points were selected. The points are based on the five representative vehicles characterized in the NESCCAF study. For each representative vehicle, two or three best-option technology packages were chosen based on emissions performance and cost-effectiveness. Quoting from the ISOR, page 110, "The average CO₂ gram-per-mile values of the selected technology packages were then used to determine the maximum feasible CO₂ equivalent reduction for each of the two LEV II vehicle classes". The policy rationale for choosing the average is unclear. If the objective is "maximum feasible CO₂ reduction", then the standard should be based on the lowest gram-per-mile value. If cost-effectiveness considerations require that manufacturers be given multiple technology options, then the highest value should be used. In any case, the "average" is not among the options available to manufacturers.

Weight-based standard

A practical and robust emission standard should reasonably satisfy the requirements of AB 1493, paragraph 3(a) – and not just on a sales-averaged basis. The requirements should, insofar as possible and practicable, be satisfied for each separate vehicle test weight. A consumer typically needs or wants a vehicle in a specific weight range, and does not have the option of purchasing a "sales-averaged" vehicle; so the standard should be reasonably well optimized for each weight.

Vehicle emissions are generally approximately proportional to vehicle weight, so the emission standard should similarly be weight-proportionate. The flat, bilevel standard proposed in the ISOR represents only the crudest approximation to weight proportionality. A much simpler and more effective way to achieve weight

proportionality would be to specify the standard in terms of an emissions limit (g/mi) per unit of vehicle weight (ton)². Such a standard is specified in Table 9 and illustrated in Figure 1 (violet lines). The near- and mid-term standards are 140 and 132 g/mi/ton (based on vehicle test weight), compared to the 2002 aggregate emissions of 181 g/mi/ton.

Table 9

Alternative emission standard, based on vehicle test weight

	Emission standard (g/mi/ton)
Near-term	140
Mid-term	132

The definition criterion for the above weight-based standard is that for every one of the five NESCCAF representative vehicles, at least one the associated best-option technology packages should be capable of reducing emissions to the compliance level. In actuality, many of the representative vehicles would have two or three options well within the compliance limit, and with trading, it is possible that all would (see Figure 1).

The above definition makes no reference to vehicle market data; hence the standard should perform equally well under a broad range of market conditions (not just year-2002 California market conditions). Also, the definition does not rely on a questionable regression model.

The last column in Table 1 (“Weight-based”) indicates that the sales-average emissions allowed by the mid-term, weight-based standard is 10 g/mi higher than the MFCE limit defined by the regression model. (Although it is uncertain whether the regression model is actually an accurate representation of the MFCE standard, it nevertheless provides a useful basis for comparing the various policy options.) The 10 g/mi excess is higher than that of the optimal bilevel standard (6 g/mi), but lower when the effects of perverse incentives are taken into account. To the extent that this 10 g/mi excess compromises environmental effectiveness, it is a compromise that is necessitated by cost conservatism. A cost-conservative standard is required because of the sparsity of data represented by the five NESCCAF base vehicles and the lack of a regression model that reliably fits the five data points.

The weight-based standard is substantially “weight-neutral”, in the sense that it facilitates commercialization of emissions-reduction technology without significantly incentivizing manufacturers to either increase or decrease vehicle weights, or inducing consumers to choose heavier or lighter vehicles. Thus, the standard would have comparatively little effect on the existing competitive balance between different vehicle weights. Also, the 10 g/mi excess shown in Table 1 is approximately the same for all manufacturers, indicating that the standard would not significantly affect the existing competitive balance between manufacturers.

² 1 ton = 2000 lb

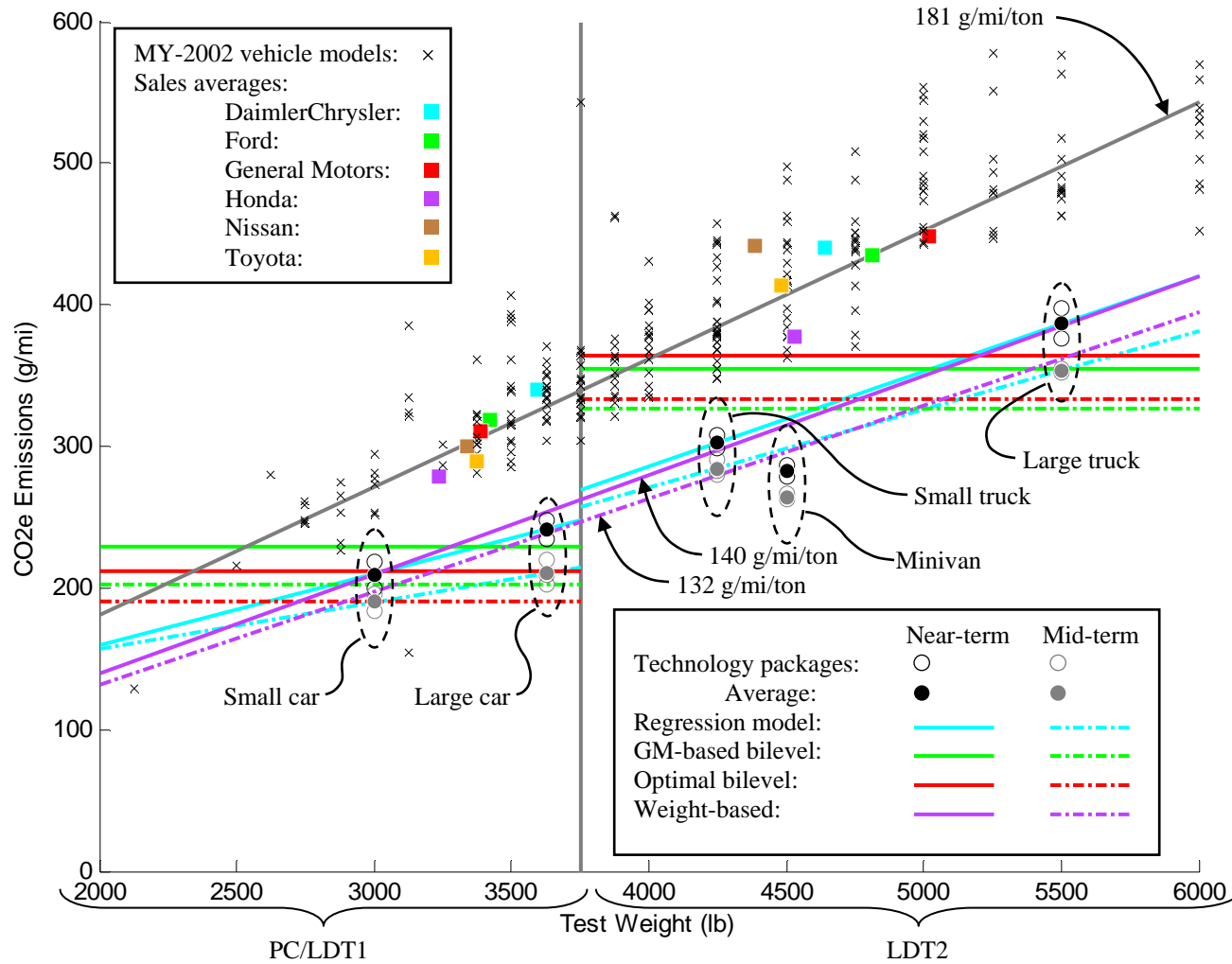


Figure 1. Alternative emission standards

Appendix

The determination of the bilevel emission caps is based on two premises: First, it is assumed that the regression model (blue lines in Figure 1) represents the minimum emissions level that can be achieved cost-effectively for each test weight. Second, a manufacturer is not actually required to comply with the mandated emission standard (red lines) for each specific test weight; all that is required (with trading) is that the manufacturer's sales-averaged emissions not exceed the sales-averaged emissions allowed by the standard. Thus, cost-effectiveness is ensured if the sales-averaged emissions level allowed by the bilevel standard is not less than that of the regression model.

In this context "cost-effective" means that it would be *possible* for the manufacturer to pass compliance costs to the consumer in a manner that is "economical to an owner or operator of a vehicle" (AB 1493, paragraph 3(i)), although this does not mean that the manufacturer will necessarily be motivated to do so. As indicated previously, the weight-stratified compliance costs induced by the bilevel standard could create an incentive to distribute price increases inequitably, so that prices would not be economical for some vehicle weights. But the following analysis is only concerned with defining conditions under which economical pricing is at least possible.

The bilevel standard is specified by the emission caps for the two weight classes, and each manufacturer's sales-averaged excess emissions (for year-2002 California sales data) relative to the MFCE level (as defined by the regression model) is a linear function of the caps. For example, the blue line in Figure 2 below represents the locus of emission caps for which DaimlerChrysler's sales-averaged emissions would match the sales-averaged emissions allowed by the near-term regression model. The half-plane to the right of this line represents caps that would be cost-effective, while points to the left represent caps that may not be cost-effective. Similar lines are shown for the other five manufacturers, and Figure 3 shows the same kind of data for the mid-term regression model. The intersection of all six half-planes to the right of the colored lines represents cap levels that would be cost-effective for all manufacturers.

Each black, dashed line in Figures 2 and 3 represents the locus of caps for which the industry-wide, sales-average emissions are at a particular constant value. Lines closer to the origin correspond to lower aggregate emissions, and the cap specification objective is to minimize aggregate emissions within the constraints of the six cost-effectiveness conditions. It is clear from both Figure 2 and Figure 3 that the red and violet lines (General Motors and Honda) are the limiting constraints, so the optimal caps are defined by the intersection between these two lines (see Table 8, under "Optimal bilevel").

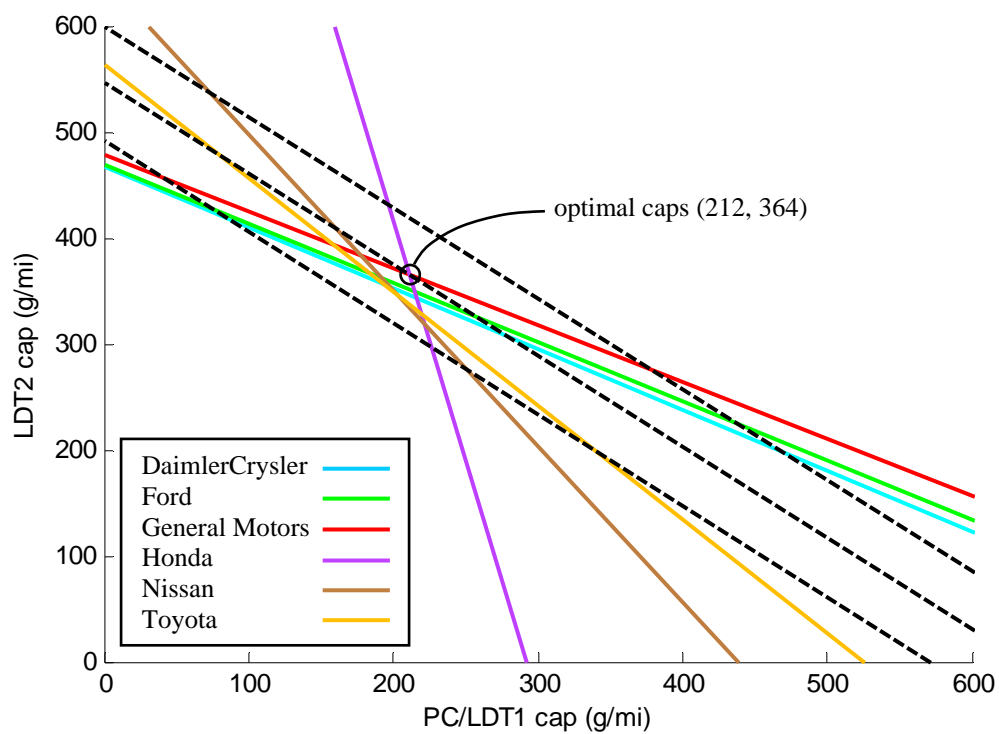


Figure 2. Bilevel emission cap determination for near-term standard.

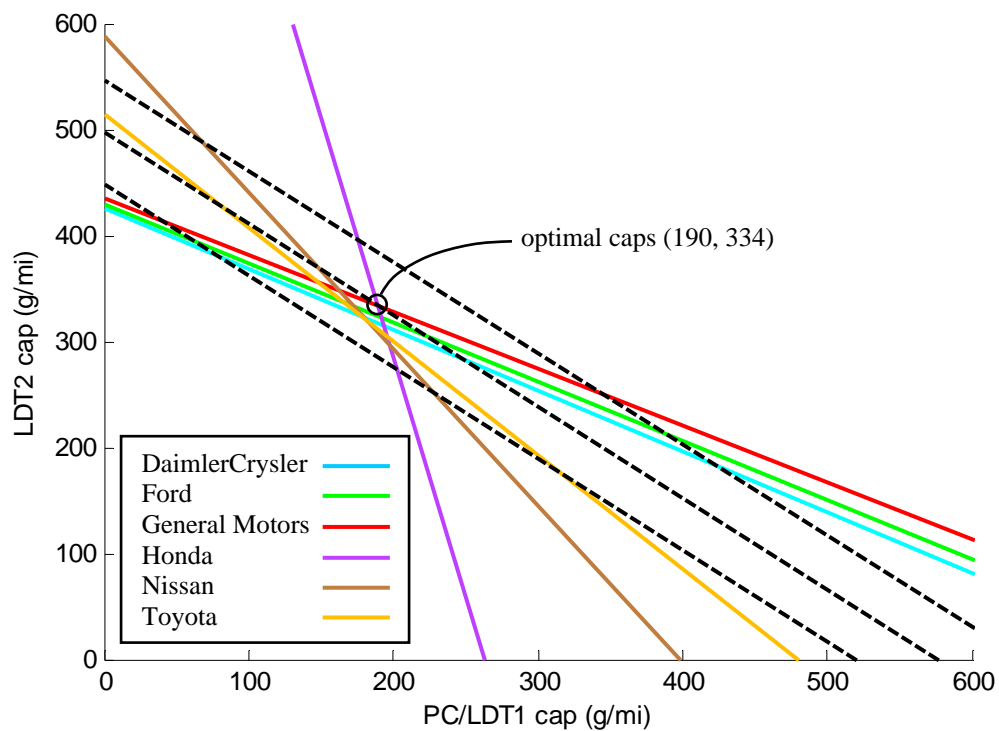


Figure 3. Bilevel emission cap determination for mid-term standard.