Title

California’s greenhouse gas law, Assembly Bill 1493: Deficiencies, alternatives, and implications for regulatory climate policy

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Abstract

California’s Air Resources Board has finalized regulations implementing Assembly Bill (AB) 1493, which requires “maximum feasible and cost-effective

reduction of greenhouse gas emissions from motor vehicles". By 2030, when California's light-duty vehicle stock has been substantially replaced by regulation-compliant vehicles, total emissions from regulated vehicles are projected to be reduced by 27% relative to "business-as-usual", but are nevertheless expected to be 8.7% higher than 2004 emissions. If an 8.7% increase truly represents the "maximum feasible and cost-effective" emissions reduction from transportation vehicles, then global climate stabilization clearly will not be attained within limits of "feasibility" and "cost-effectiveness", and climate sustainability will only be achievable through severely draconian measures. On the other hand, if significantly greater emissions reduction would be feasible and cost-effective, then the AB 1493 regulations fail to satisfy the legislative policy mandate and the task is to find a regulatory mechanism that will. The thesis of this paper is that the regulations do not satisfy the mandate for several reasons, the most important being the conflicting policy objectives of the "cost-constrained" legislative mandate and the "quantity-constrained," standard-based regulatory instrument. An alternative policy instrument that would better fit legislative policy and environmental objectives would be a feebate-type system (although not necessarily a conventional vehicle feebate).

1. Introduction

In July 2002 California enacted Assembly Bill (AB) 1493, which directed 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" (California Legislature, 2002). In August 2004 the Board staff issued its Initial Statement of Reasons supporting its proposed regulations pursuant to AB 1493 (CARB, 2004a), which were subsequently adopted by the Board at a public hearing in September 2004 and reviewed by the Assembly Transportation Committee in a legislative hearing in February 2005. In August 2005 staff issued its Final Statement of Reasons (CARB, 2005), which responded to numerous comments and criticisms that were raised in the September 2004 hearing and in two subsequent, supplemental comment periods. (The auto industry filed a federal lawsuit against CARB in December 2004, challenging the regulations on the grounds that they effectively constitute a fuel economy standard[1] in violation of federal preemption under the Energy Policy and Conservation Act, so it is not yet certain that the regulations' legality will be upheld.)

The bill stipulated a number of limitations, which constrained CARB's options in implementing the mandate. In particular, the regulations were prohibited from requiring any of the following:

- fees or taxes on any vehicle, fuel, or vehicle miles traveled
- a ban on the sale of any vehicle category
- reduction in vehicle weight
- limitation on or reduction of speed limit
- limitation on or reduction of vehicle miles traveled

Furthermore, the bill instructed the Board to "provide flexibility, to the maximum extent feasible, in the means by which a person may comply with [the] regulations". In response to these requirements, CARB implemented the regulations as a tradable performance standard, which employs an emissions trading system similar to that pioneered by the US Acid Rain program.

The new greenhouse gas (GHG) regulations were incorporated into California's preexisting Low Emission Vehicle (LEV) standards, which have since 1994 regulated criteria pollutants (non-methane organic gas, nitrogen oxides, and carbon monoxide) that relate to air quality and public health. (The Federal Clean Air Act allows California to establish vehicular pollution regulations more stringent than federal standards, and other states have the option of adopting California's standards.) In essence, GHGs were added to the list of regulated pollutants, and the LEV vehicle classification scheme was adopted and used as a basis for the GHG regulations. Separate GHG emission limits are defined for each of two LEV vehicle categories; however, a manufacturer is only required to meet the standard on a fleet-average basis so that overcompliance in one category can counterbalance undercompliance in the other. In addition, emissions trading can be used to optimally balance compliance costs between manufacturers.

The stated legislative intent of AB 1493 is to "adopt regulations that ensure reductions in emissions of greenhouse gases". Nevertheless, the regulation-induced emissions reduction is expected to be overcome by demand growth so that even with the new regulations, aggregate emissions from the regulated vehicle sector are expected to increase by 8.7% between 2004 and 2030.[2] This performance level falls short of the "maximum feasible and cost-effective" emissions reduction mandated by AB 1493, for several reasons. One reason is that the standard's emission limits were determined using an erroneous computational methodology that did not properly take into account emissions trading between the two LEV vehicle classes. A more fundamental problem is that in order to achieve LEV compatibility, the form of the emission standard was modified in a manner that deviated from CARB's best estimate of the maximum feasible and cost-effective emissions reduction level. The LEV modification was constructed to preserve feasibility and cost-effectiveness, but it significantly increased the allowed emissions level; hence, the LEV constraint represents an explicit contravention of the legislative mandate. But the most significant problem is that the “quantity-constrained” regulatory instrument represented by the tradable performance standard is fundamentally incompatible with AB 1493’s explicitly mandated “cost-constrained” legislative policy objective. (The bill was clearly structured to steer CARB toward a tradable performance standard, so the policy conflict represents an inconsistency in the bill itself, rather than a defect in its regulatory implementation.)

The policy conflict is not unique to AB 1493; it is symptomatic of a general policy incoherence that is endemic to regulatory climate policy. Legislative policy is generally “cost-constrained” in the sense that cost acceptability takes precedence over environmental objectives. This is reflected in AB 1493’s explicit policy mandate, which does not specify emissions reduction according to environmental sustainability requirements, but rather requires that the emissions reduction be “feasible and cost-effective” and that emissions be minimized subject to that constraint. Quantity-constrained policy instruments such as tradable performance standards and cap-and-trade, by contrast, have the converse policy objective of constraining emissions and minimizing costs within that constraint. This policy incompatibility forces regulators to rely on long-term and highly uncertain projections of future economic and technology conditions in order to match the regulations’ emissions constraint to the legislated cost constraint; and since the legislative policy gives priority to cost acceptability, such projections are highly biased in favor of cost conservatism and against environmental goals. Consequently, the regulations are only constructed to satisfy the legislative mandate under the most pessimistic predictive assumptions.

An alternative regulatory instrument that would better suit AB 1493's cost-constrained policy objective would be a revenue-neutral feebate system, which controls regulatory costs directly and is therefore not susceptible to the predictive uncertainty of quantity-constrained policy instruments (Greene et al., 2005; Johnson, 2005; Langer, 2005; NRTEE, 2005).[3] A feebate is similar to an emissions tax except that all of the tax revenue is refunded to the tax payers in such a way that those with worse-than-average emissions performance incur a net loss ("fee") from the feebate, while those with better-than-average performance accrue a net profit ("rebate"). A similar policy has been employed with success in Sweden's power sector to reduce nitrogen oxide emissions from large combustion plants (Ågren, 2000; Barg et al., 2000; Isaksson and Sterner, 2005; Millock and Sterner, 2004; Wolff, 2000). In contrast to the Swedish NOx program, automotive vehicle feebates have not gained political acceptance and have not yet proved to be an effective policy instrument, primarily because they are conventionally constructed to impose fees mainly on large vehicles and distribute rebates mainly to small vehicles. However, feebates can alternatively be constructed so that the revenue flow is concentrated more within, rather than between, weight classes, so that the regulatory incentive is focused more exclusively on technology rather than on downweighting. This would help overcome barriers of political acceptability and improve policy effectiveness, perhaps making it possible to achieve the kind of performance exhibited by the Swedish NOx program in the automotive sector.

The remainder of this paper is organized as follows: Section 2 reviews the methodology used by CARB to determine the AB 1493 GHG emission standard; Section 3 discusses regulatory alternatives that CARB could have considered; Section 4 outlines the deficiencies of the standard; Section 5 discusses feebates; and the conclusions are summarized in Section 6. The Appendix discusses the accompanying Electronic Annexes, which provide additional background information and technical data relating to AB 1493.

2. CARB's methodology

The methodology employed by CARB in setting the GHG emission standard is described in Section 6.1 of CARB (2004a) and is briefly summarized here.

The standard is based on an engineering study of five representative vehicles selected from the model-year 2002 new vehicle fleet. These vehicles' feasible emission levels (corresponding to "maximum feasible and cost-effective" emissions reduction) were determined by engineering simulation and cost analysis, and were extrapolated to construct a parametric model representing the feasible emission level for all light-duty vehicles. The most significant emissions-related vehicle characteristic is weight (and AB 1493 specifically prohibits regulations imposing a reduction in vehicle weight), so the feasible emission level was parameterized as a function of "test weight" (i.e., the loaded vehicle weight at which emissions performance is tested). The emission standard was intended to be incorporated into the LEV program, so separate functions were defined for the two LEV vehicle classes. The first class ("PC/LDT1") comprises passenger cars up to 6000 lbs and light-duty trucks up to 3750 lbs, and the second class ("LDT2") comprises light-duty trucks exceeding 3750 lbs. (The “truck” categories include SUVs and minivans. For California, model-year 2002, the LDT2 category comprised 46% of the major manufacturers’ vehicle fleets and accounted for 54% of their emissions.)

The five representative vehicles’ feasible emission levels are plotted against test weight in Fig. 1 (cf. Figs. 6-1 and 6-2 in CARB, 2004b). The vertical scale in the figure represents CO2-equivalent GHG emissions in gram-per-mile (g/mi) units. The plotted emission levels are actually slightly below the calculated feasibility limit because of the way the regulations handle air conditioning emissions. Vehicle emissions performance is tested without air conditioning, but manufacturers are encouraged to comply with recommended practices for controlling air conditioning emissions. Those who demonstrate compliance will be granted a compensating allowance of emission credits. The emission levels represented in Fig. 1, when incremented by the air conditioning credit, equate to the actual estimated feasible emission level. (The credit varies somewhat between small and large vehicles, but is approximately 18 g/mi – see Table 6.1-1 in CARB, 2004a.)

The feasible emission level, as a function of arbitrary vehicle weight, was defined by linearly extrapolating from the “small car” and “large car” data points for the PC/LDT1 category, and by linearly extrapolating from the “small truck” and “large truck” points for the LDT2 category. These extrapolations, termed “regression lines”, are illustrated in Fig. 1. The “minivan” data point was neglected in defining the regression lines because even though the LEV classification places minivans in the LDT2 category, “these vehicles are generally based on a passenger car chassis and … their CO2 emissions are more properly aligned with passenger cars than trucks" (CARB, 2004a, p. 105).

The regression lines represent CARB's best estimate of "the maximum feasible reduction levels" (CARB, 2004a, p. 112), and cost-effectiveness is implicit in this characterization (as indicated by the data in Table 5.3-8 of CARB, 2004b). According to this characterization, the regression lines represent the "maximum feasible and cost-effective" reduction level specified by the AB 1493 mandate; hence the regression lines define an emission standard (the "regression standard") that would satisfy the mandate. However, this is not the standard that was adopted. Instead, each regression line was converted to a flat, weight-independent emission limit defined by a sales average of the regression line for each LEV class, and the standard defined by these two emission limits (termed the "bilevel standard" herein) is what was adopted. The sales average was computed based on General Motors' model-year 2002 California sales fleet. The choice of GM as the standard-setting manufacturer was intended to ensure that the standard would be feasible and cost-effective for all six major manufacturers (Daimler Chrysler, Ford, General Motors, Honda, Nissan, and Toyota) without relying on emissions trading between manufacturers.

The standard is to be phased in over an 8-year period between 2009 and 2016. Fig. 1 illustrates the final (2016) standard, which has the following emission limits:

PC/LDT1: 205 g/mi

LDT2: 332 g/mi

(See Electronic Annex 3, Std_Effect tab, cells S12:S13, and Annex 6, cells W16:W17.[4])

3. Regulatory alternatives

Several alternatives to the adopted standard could have been considered (and to some extent were, although this is not fully documented in CARB's staff reports). One option would have been to base the regulations on the regression standard. If the regression lines do, in fact, represent the "maximum feasible and cost-effective" reduction level, then such a standard would, by definition, satisfy the legislative mandate.

The rationale for adopting the bilevel standard in lieu of the regression standard is that the two are equivalent on a sales-average basis, but by the same rationale there would be no need for the two LEV vehicle categories – the regression standard could be sales average matched to a flat emission standard that applies uniformly to all vehicles. (Based on CARB's methodology, such a standard would be 281 g/mi; see Electronic Annex 6, cell V42.)

Another option would have been to maintain the standard's functional weight dependence, but to use a single regression line for all vehicles rather than two. The rationale for using the two LEV vehicle categories is that large and small vehicles cannot reasonably be expected to conform to the same emission standard; but a single regression line's weight dependence would accommodate larger vehicles' higher emissions, thus obviating the need for separate vehicle categories. Vehicle emissions tend to be roughly weight-proportionate (this is evident in Fig. 1), so the standard could perhaps be specified in terms of a simple proportionality factor relating the emission limit to vehicle weight. (The National Research Council (NRC, 2002) has proposed such a weight-based standard to replace federal CAFE standards.)

One additional policy option that might have been considered would have been an incentive-based system, such as vehicle feebates, which are discussed in Section 5. The AB 1493 prohibition against fees and taxes precluded this alternative, but it could have been considered at the legislative level.

4. Deficiencies of the adopted standard

4.1 Incorrect calculation methodology

The implicit rationale for applying sales averaging in defining and applying the emission standard is that the environmental effect of GHG emissions depends only on total emissions, and not on how emissions are distributed between vehicles. The total emissions defined by the standard is unaffected by sales averaging, so the bilevel standard is equivalent to the regression standard, in terms of total allowed emissions, for the assumed vehicle fleet. This is also the rationale underlying emission trading: Trading has no effect on total allowed emissions; it only functions to minimize compliance costs. (Averaging is equivalent to trading within a manufacturer's fleet.)

The regulations naturally allow trading between, as well as within, the two LEV vehicle classes. As explained in CARB (2004a, p. 113), "Trading offers flexibility for each manufacturer to overcomply with one category's standard and trade those credits to compensate for a debit, or under-compliance, within the other category." However, CARB's calculation methodology requires that the bilevel standard be sales-average matched to the regression standard within each separate LEV class. This methodology would be appropriate if trading were allowed within but not between classes. But with unrestricted trading it is only necessary that the bilevel and regression standards be sales-average matched over the entire vehicle fleet.

Applying sales averaging over all vehicles in a manufacturer's fleet (including both LEV classes), the matching condition only defines one condition in two unknowns (the PC/LTD1 and LDT2 emission limits). Hence the matching condition can be simultaneously imposed on two manufacturers. Choosing General Motors and Honda as the two standard-setting manufacturers, the resulting bilevel standard would be feasible and cost-effective for all six manufacturers (assuming their 2002, California fleets), and the emission limits would be

PC/LDT1: 189 g/mi

LDT2: 343 g/mi

(See Electronic Annex 6, cells X27:X28.)

The above analysis does not imply that a standard based on the above limits would necessarily comply with the legislative mandate, because the analysis only relates to the correctness of the sales averaging calculations and does not consider whether the use of sales averaging, the LEV-compatibility constraint, and CARB's criteria for "feasibility" and "cost-effectiveness" are consistent with the mandate. However, none of these issues need be addressed to establish that the adopted standard does not, according to CARB's criteria, comply with the mandate. The following two conditions are sufficient to establish non-compliance: First, a standard based on the 189 and 343 g/mi limits would satisfy CARB's criteria for feasibility and cost-effectiveness; and second, the emissions reduction required by such a standard would be greater than that of the adopted standard, based on the California, model-year 2002 market data upon which the adopted standard is premised.

Electronic Annex 6 demonstrates that the first condition is satisfied (this is indicated by the non-negative values in cells AO20:AO25), and that the adopted standard would, on average, allow vehicle emissions greater by 3.2 g/mi than the alternative standard (see cells AN26 and AO26). The 3.2 g/mi excess is not, in itself, a large difference, but it represents a performance compromise that results only from miscalculation and not from a consideration of tradeoffs or of any identified advantage of the adopted standard.

4.2 LEV-compatibility constraint

The bilevel standard can only be constructed to be equivalent to the regression standard, on a sales-average basis, for a particular assumed vehicle fleet (or actually for two assumed fleets, with the above correction). CARB selected General Motors' 2002, California fleet as the standard-setting fleet to ensure that the standard would be feasible and cost-effective for all six major manufacturers. However, none of the manufacturers other than GM would be required to achieve *maximum* feasible and cost-effective emissions reduction under the adopted standard, as stipulated by AB 1493. Consequently, the allowed sales-average emissions level for the 2002 California fleet is 7.6 g/mi higher than that of the regression standard (see Electronic Annex 6, cell AN26). (The 7.6 g/mi excess includes 3.2 g/mi due to the calculation error indicated in Section 4.1; hence only 4.4 g/mi of the total excess is actually attributable to the LEV constraint.) This loss of environmental effectiveness results from the restrictive LEV-style, bilevel form of the standard, and does not result from any requirement or limitation of AB 1493; hence the LEV compatibility constraint contravenes the legislative mandate. (If the bilevel standard is admissible under the mandate, then a flat, one-class emission standard that applies uniformly to all vehicles would also be admissible, even though a uniform standard would have much worse environmental effectiveness.)

The bilevel standard is explicitly dependent on assumed market conditions because its calculation is premised on a particular standard-setting vehicle fleet. This dependence unnecessarily raises the level of predictive uncertainty inherent in the standard. The standard is premised on California market conditions, so it is not clear how relevant the standard would be if adopted by other states or countries. It is also premised on the model-year 2002, so the standard may become less relevant as the market changes in the future. (Although the regression standard is premised on assumed vehicle technologies and cost parameters, it is not based on an assumed vehicle fleet; so it would tend to be applicable over a broader range of market conditions.)

The unnatural form of the bilevel standard, and the discrepancy between the standard and the feasible emissions level, could result in economic distortions and perverse incentives. For example, the emission allowance for a typical SUV or minivan in the LDT2 class is 62% higher than that of a car with the same weight and seating capacity. (With the correction indicated in Section 4.1, the difference would be even greater – 81% – due to the standard's reliance on trading between the two LEV vehicle categories.) This disparity could induce a market shift from cars to LDT2 vehicles, further undermining the standard's environmental effectiveness. The bilevel standard seems to be based on the notion that sales averaging would, in effect, neutralize such disparities. But if it did there would be no need for two vehicle classes, because a uniform standard's greater stringency at high weights would be balanced by its lesser stringency at low weights.

There is no clear policy rationale for adopting a standard that will perpetuate – for decades – an overly simplistic LEV classification scheme that has already been subverted by market changes and by the introduction of "crossover" vehicles. For example, in constructing the regression lines (Fig. 1) the "minivan" representative vehicle was excluded from the regression because of its classification ambiguity, and the number of vehicle models with ambiguous LEV classifications will probably increase in the future.

The regression standard would, according to CARB's characterization, be consistent with the legislative mandate; but there is no demonstrated need for separate LEV vehicle categories with this standard because the regression lines' weight dependence automatically accommodates the intrinsically higher emissions of larger vehicles. A simple weight-proportionate standard based on a five-point regression would be simpler and probably equally effective.

CARB gave consideration to such a weight-based standard, but rejected it on the grounds that the weight proportionality would make the standard less stringent for heavier vehicles, and could therefore incentivize upweighting (CARB, 2005; see comment #322). However, baseline emissions are also roughly weight-proportionate, so the required emissions reduction from the baseline level would similarly tend to be weight-proportionate. Thus, even with a weight-proportionate standard, compliance costs would tend to increase with vehicle weight[5]. On the other hand, the fuel-savings benefit would also increase with weight and would tend to counterbalance the greater compliance costs at higher weights. (If the balance of costs and benefits actually would motivate upweighting, then an intermediate policy option between a simple weight-proportionate standard and a weight-independent standard could substantially neutralize the weight-changing incentives.)

CARB's rationale for rejecting weight-based standards would be equally applicable to the regression standard, which is constructed to satisfy the AB 1493 mandate, so this implies that the legislative mandate is inconsistent with the objective of avoiding upweighting incentives. However, a standard that is constructed to require maximal cost-effective emissions reduction for each individual vehicle weight (without relying on sales averaging) would, according to CARB's interpretation of "cost-effective", be substantially cost-neutral for all weights (i.e., the fuel-savings benefits would balance compliance costs); and it would hence provide no significant economic incentive to either increase or decrease weight.

The preceding analysis in Sections 4.1 and 4.2 establishes that the adopted standard does not conform to the legislative mandate according to CARB's criteria for "feasibility" and "cost-effectiveness" (upon which the five data points in Fig. 1 are based). The more significant issue of whether those basic criteria are themselves reasonable and appropriate is considered in Section 4.3.

4.3 Conflicting policy objectives

The succinctly stated legislative policy objective of AB 1493 is to "achieve the maximum feasible and cost-effective reduction of greenhouse gas emissions from motor vehicles". In formulating the AB 1493 regulations, CARB interpreted "cost-effective" to mean the regulation-induced cost of emission controls should not exceed the value of associated fuel savings. In terms of net costs to the consumer (taking no account of environmental benefits), the cost acceptability threshold is zero.

Although the zero-cost limit might seem to be prohibitively constraining, CARB has identified a variety of commercially available emission control technologies, such as advanced gas-electric hybrid engines, that can achieve up to 50% reduction in per-vehicle emissions at zero or negative net cost (see Table 5.3-8 in CARB, 2004b). But the adopted standard does not require emission reductions of quite this scale because CARB based the standard on highly conservative economic and technology assumptions. CARB's quantification of "cost effectiveness" values fuel savings on the basis of a $1.74/gal fuel price (in 2004 dollars). This price is assumed to apply over the 16-year (typical) life of a vehicle purchased after 2009. Although higher fuel prices might raise the cost-effectiveness limit, CARB's analysis indicates that no feasible technologies are available that would justify a more stringent emission standard, even at significantly higher fuel prices[6]. However, CARB's "feasibility" criterion is also highly conservative, in that it only admits commercially available, incremental technologies. For example, hybrid vehicles, which represent one of the fastest growing automotive product segments, were considered to be "infeasible" for the purpose of determining the standard[7].

CARB's extreme cost conservatism was necessitated by the combination of two factors: predictive uncertainty, and a legislative mandate that favors cost effectiveness over environmental effectiveness. The standard is biased by predictive uncertainty because of the inconsistency between the cost-constrained legislative policy and the quantity-constrained regulatory instrument. A tradable performance standard controls emissions, and does not directly control compliance costs; so regulators have to rely on long-range predictions of future technologies and economic conditions to estimate what emission level will achieve the mandated cost target. Such predictions are necessarily biased in favor of cost conservatism due to the cost-constrained legislative policy, and this bias constrains the environmental effectiveness of standard-based regulatory instruments.

The US Acid Rain program typifies the kind of inefficiencies that result from mismatched or incoherent policy objectives such as those of AB 1493. The program has succeeded in reducing SO2 emissions by about 50%, but emissions would have to be reduced by another 80% beyond current mandated limits before sensitive ecosystems would begin to recover from the effects of acid rain (Baum, 2001). Power plants in the US with over 2 million MWh generating capacity emit SO2 at a rate of 8.3 lb/MWh, on average, whereas plants with state-of-the art scrubbers have emission levels of about 1 lb/MWh (Levin and Schaeffer, 2005); so a five-fold emissions reduction would be technically feasible. The SO2 abatement cost with scrubbers is less than $300/ton, but the associated public health benefits have been estimated by OMB to be $7,300/ton (Levin and Schaeffer, 2005); so even neglecting environmental benefits, the human health benefits alone would far outweigh the cost of greater emission reductions. Moreover, the Acid Rain program's compliance costs are far below original expectations (Burtraw and Palmer, 2003), so substantial further reductions should be well within the limits of political viability. Yet even though such reductions are necessary and would be technically feasible, exceedingly cost-effective, and politically viable, the program's cap-and-trade system continues to focus regulatory incentives on cost reduction rather than emissions reduction.

AB 1493's tradable performance standard can be viewed as a kind of cap-and-trade system that caps average emissions per vehicle, rather than total emissions. Such policies favor cost reduction over emissions reduction because they are based on the implicit premise that emission caps (or standards) are set at environmentally sustainable levels, so that further emissions reduction is unnecessary. But when caps are determined not by environmental requirements, but rather by cost-acceptability criteria based on over-inflated or overly-conservative cost projections, such policies have the perverse effect of locking in emissions at environmentally unsustainable levels. Tradable (and bankable) emission allowances effectively become long-term contracts entitling allowance holders to generate emissions far in excess of environmentally sustainable levels for years to come, and any regulatory action to achieve significant further reduction of emissions would, in effect, have to abrogate or nullify those contracts.

The Acid Rain program has succeeded in at least achieving 50% emissions reduction. The same cannot be said of cap-and-trade-type systems for GHG reduction, such as the AB 1493 regulations, which have much more modest reduction targets even though their fundamental policy objective – global climate stabilization – is much more ambitious and far-reaching. Considering the Acid Rain program's inability to achieve environmentally sustainable levels of SO_2 emissions, it is questionable whether similar policies would be able to achieve environmentally adequate greenhouse gas reduction targets such as Governor Schwarzenegger's recent Climate Action Initiative, which calls for a reduction of California's GHG emissions, by 2050, to 80% below 1990 levels (California Executive Department, 2005).

Regulatory policies that merely cap emissions at environmentally unsustainable levels, and provide no incentive for further emissions reduction, are clearly not sufficient to the task of climate stabilization. What is required is a policy approach that focuses regulatory incentives on minimizing emissions, rather than minimizing costs, but which minimizes emissions within defined (and directly controlled) limits of cost acceptability to ensure the economic and political viability of the regulatory policy. This approach is essentially what the AB 1493 legislative policy calls for, but the AB 1493 regulations fail to deliver.

5. Feebates

A cost-constrained alternative to cap-and-trade-type policies would be an emissions tax. But a tax, unlike cap-and-trade (with freely distributed emission permits), is not revenue-neutral. A quantity-constrained analogue of an emissions tax would be cap-and-trade with auctioned permits, but neither regulatory approach would be consistent with policy objectives because greater emissions reduction could typically be achieved if the money spent on taxes or auctioned permits were instead invested in emission controls. An effective regulatory policy should operate to motivate such investment.

In the context of cap-and-trade, revenue neutrality makes it possible to achieve emission targets at lower cost (if the policy objective is cost minimization) or to set more stringent targets (if the objective is emissions minimization). The cost-constrained counterpart of a revenue-neutral cap-and-trade system would be a feebate-type system, which is essentially a refunded emissions tax. The tax is levied on emissions and is refunded in proportion to some measure of emissions-related economic utility, so that tax-paying entities that generate greater-than-average emissions per unit of economic utility incur a net loss ("fee") from the feebate, while those that generate less-than-average emissions per economic unit accrue a net profit ("rebate"). In comparison to an unrefunded tax, the feebate's revenue neutrality makes it possible to increase the "emissions price" (i.e., the emissions tax rate) within limits of economic and political viability, which greatly increases the regulatory incentive to invest in emission controls.

A good example of successful a feebate-type policy is represented by Sweden's nitrogen oxide program (Ågren, 2000; Barg et al., 2000; Isaksson and Sterner, 2005; Millock and Sterner, 2004; Wolff, 2000), which was enacted in 1990 with the intention of achieving a 35% reduction in NOx emissions from large combustion plants by 1995. The industry responded by rapidly reducing emissions so that the 35% target was already achieved in 1993; and by 1995 average emission intensity of regulated plants was 60% below 1990 levels. (Even with demand growth, total emissions in 1995 were reduced by 50% from 1990.) Had the program employed a cap-and-trade approach, regulators would have set the reduction target at 35% and the regulations would not have incentivized any further reduction.

The method of tax refunding in a feebate system represents a policy design issue analogous to that of initial allowance allocation in a cap-and-trade system, and it can be just as critical to the policy's success. In either case, an economically-valuable asset (the tax refund, or emission allowances) is distributed in proportion to some measure of emissions-related economic utility. The Swedish NOx program refunds the tax in proportion to a power plant's "useful energy output", so that the plant's feebate depends on how its energy "emissions intensity" (i.e., GHG emissions per unit energy) compares to the industry average (Isaksson and Sterner, 2005; Millock and Sterner, 2004). A conventional vehicle feebate (such as the "single-pivot-point" feebate in Greene et al., 2005) distributes the refund on a per-vehicle basis so that all vehicles receive the same refund irrespective of their relative economic value or transportation utility (e.g. a subcompact two-seater would receive the same refund as an eight-seater minivan). This would be analogous to a power-sector feebate that distributed the refund on a per-power-plant basis, irrespective of power generating capacity.

Generally, vehicle GHG emissions are approximately proportional to vehicle weight; so the tax portion of a conventional vehicle feebate would be roughly weight-proportionate whereas the refund would be weight-independent. Consequently, large vehicles would all pay high fees, even if they have the best available emissions-control technology, while even the highest-emission small cars would receive substantial rebates. The large feebate disparity between large and small vehicles would create a strong downweighting incentive, but economic studies indicate that even with this incentive the primary market response to the feebate incentive would be to improve emissions technology, and only a small fraction (e.g. 5 to 10%) of the emissions reduction would result from downweighting (Greene et al., 2005, p. 769). Thus, the downweighting incentive provides little environmental benefit, but it significantly limits the feebate's political viability.

A conventional vehicle feebate is inconsistent with policy objectives because the economic incentive required to achieve a particular quantity of GHG reduction through downweighting could typically induce much greater emissions reduction if the incentive were instead focused on emissions technology improvement. However, feebates can be constructed to focus the regulatory incentive more exclusively on technology. Such feebates have some commonality with standard-based regulations. Both must, to some extent, accommodate different vehicle classes' emission characteristics. For example, AB 1493 discriminates between the two LEV vehicle classes, and an analogous two-class feebate system could be constructed to apply separate, revenue-neutral feebates in the two LEV classes. (This system corresponds to the "two-pivot-point" feebate in Greene et al., 2005.) A two-class feebate structure would exhibit some of the same kinds of problems as the bilevel standard discussed in Section 2 (e.g., there would be a large feebate difference between comparable vehicles in the two classes), but these problems could be overcome by using many vehicle weight classes with overlapping weight ranges. Alternatively, the weight disparity of a conventional feebate could be neutralized by distributing the tax refund in proportion to vehicle weight, in a manner analogous to the weight-proportionate emission standard discussed in Section 3. Feebate structures of these types are discussed in Johnson, 2005.

Feebates represent a versatile policy instrument that can be applied to a wide variety of emissions-intense products and processes, and which can be combined in a complementary manner to optimize policy objectives. For example, a feebate on hydrocarbon fuel could complement a vehicle feebate in such a way that the two, in combination, approximate a single vehicle feebate that better reflects a vehicle's actual lifecycle GHG emissions. (The same approach would be applicable to hydrogen production for fuel cell vehicles or electric power for plug-in hybrids.) The vehicle feebate would be based on estimated lifecycle GHG emissions, assuming an industry-average value for the GHG content of fuel, and the fuel feebate would represent a kind of "correction factor" that compensates for the difference between the fuel's actual emissions intensity and the assumed industry-average value.

To illustrate the operational principles of feebates, consider a feebate on hydrocarbon-based vehicle fuels, and suppose that renewable fuels (i.e. those with zero fossil fuel content) have 1% market penetration. (Biofuels are renewable but typically entail upstream fossil fuel emissions in their production, so only a portion of each biofuel gallon would generally be counted as "100% renewable". The method of accounting for upstream emissions would depend on whether those emissions are subject to GHG regulations.) Also suppose that the feebate is based on a GHG emissions price, stated in fossil-fuel-equivalent units, of $1.00/gal. (A gallon of gasoline equates to about 20 lbs of CO2, so this price corresponds to $0.05/lb-CO2, or $100/ton-CO2.) At the assumed 1% market penetration, renewable fuels would accrue a $0.99/gal rebate, which would be financed by a $0.01/gal fee on conventional fuel. As the market penetration increases the fee/rebate balance would automatically shift to maintain the $1.00/gal difference and to maintain revenue neutrality. For example, at 10% penetration the rebate would decrease to $0.90/gal, while the fee would increase to $0.10/gal. If renewable fuel were to completely displace fossil fuels, the rebate would eventually approach zero and the fee would approach $1.00/gal as the market penetration approaches 100%.

In the above example, the $1.00/gal price differential between fossil fuel and renewable fuel would create a market incentive to reduce GHG emissions. This contrasts with a cap-and-trade system's market incentives, which function only to reduce costs. (In any emissions trading transaction, the seller's reduced emissions are neutralized by the buyer's increased emissions, so the trade provides no net environmental benefit.)

The feebate incentive in the above example would not be sufficient to induce commercialization of alternative fuels whose intrinsic costs are more than $1.00/gal greater than conventional fuels. Thus, the mandated $1.00/gal emissions price provides direct regulatory control over costs. This contrasts with cap-and-trade, which provides no direct cost control and is susceptible to price volatility. [An example of such volatility is illustrated by southern California's "RECLAIM" program, which uses a cap-and-trade system to regulate NOx emissions from power plants. Over a one-year period between 2000 and 2001 emission prices jumped from about $1 to over $60 per pound of NOx (Moore, 2004; Unger, 2004). This compares to the Swedish NOx program's regulated price of SEK 40/kg, or approximately $2.50/lb (Isaksson and Sterner, 2005; Millock and Sterner, 2004).] Cost certainty and price stability would create a stable investment climate that can support sustained, long-term investments in low-emission technologies.

The above example also illustrates how the feebate incentives vary over time in a sensible manner. Rebates on renewable fuels are high when the renewable fuel market is in its nascent stage and is most dependent on the rebate subsidy. As renewable fuels gain market share and achieve economies of scale, they become less dependent on the rebate and the rebate automatically diminishes, eventually phasing itself out as renewables gain complete market dominance. At the same time, the fee on fossil fuels is initially minuscule and only begins to be significant when commercially viable alternatives become available in quantity. If renewable fuels become dominant, fossil fuels would eventually be relegated to niche markets where their economic value justifies the $1.00/gal premium.

6. Conclusions

Quantity-constrained regulatory instruments such as AB 1493's tradable performance standard, which merely limit emissions to environmentally unsustainable levels, are clearly inadequate to the task of climate stabilization. A more constructive policy approach would seek to minimize emissions within defined limits of cost acceptability. This is essentially the legislative policy approach mandated by AB 1493, but its tradable performance standard operates to minimize costs – not emissions. Moreover, the standard prioritizes LEV compatibility over "maximum feasibility", and it is not correctly constructed to achieve maximum emissions reduction even within the constraint of LEV compatibility. Hence the standard falls short of the legislative policy mandate. By contrast, a feebate-type system would better fit the AB 1493 legislative policy and environmental objectives. Feebates could provide both the economic incentives and the stable investment climate that are necessary to support and sustain the transition to a low-carbon economy.

Appendix. Background information and data

The electronic annexes accompanying this paper include the author's correspondence with CARB and the California legislature regarding AB 1493, and include both CARB's and the author's data and calculations supporting the emissions standard. Following is a listing of the annexes:

Electronic Annex 1: AB1493_Commentary.pdf (August 11, 2004).

Author's commentary on the ISOR (CARB, 2004a).

Electronic Annex 2: AB1493_Commentary2.pdf (September 5, 2004)

Additional commentary on the ISOR (CARB, 2004a).

Electronic Annex 3: for_costeffect,_inventory,etc_082404.xls

CARB's calculations underlying the adopted emission standard

Electronic Annex 4: Corporate Fleet Average Weights (2002).xls

LEV classification data upon which CARB's calculations were based

Electronic Annex 5: CARB_notes.html

Explanatory notes from CARB relating to Electronic Annexes 3 and 4

Electronic Annex 6: AB1493.xls

Author's calculations

Electronic Annex 7: AB1493.pdf (March 28, 2005)

A Policy Critique of California's Assembly Bill 1493 to Regulate Vehicular Greenhouse Gas Emissions. (Author's analysis, conveyed to the California Assembly Transportation Committee on April 8, 2005.)

Electronic Annex 8: AB1493_Commentary3.pdf

Author's commentary in response to CARB's "Second Notice of Public Availability of Supporting Documents and Information," posted on May 11, 2005.

Electronic Annex 9: FSOR_notes.pdf

Author's supplementary notes and rebuttals to the FSOR (CARB, 2005).

Annexes 1 and 2 contain some errors, as indicated below. The errors have been corrected in Annexes 6, 7, and 8, but Annexes 1 and 2 are included here because the Agency Responses in the FSOR (CARB, 2005) are directed toward these commentaries.

The Annex 1 commentary is partly in error because the author misinterpreted the LEV vehicle class distinctions. The ISOR (CARB, 2004a) defines the PC/LDT1 class as "passenger cars and light duty trucks under 3751 lbs loaded vehicle weight", but the 3751-lb limit does not apply to cars. A more concise definition is "passenger cars up to 6000 lbs loaded vehicle weight and light duty trucks up to 3750 lbs loaded vehicle weight" (see Annex 5). The LEV classifications of all vehicle models in the DMV database for California model-year 2002 are tabulated in Annex 4, and these data are incorporated into Annex 6.

The data in Annex 1 were based on an earlier version of the Annex 3 spreadsheet, which CARB provided the author in July, 2004. The market data in two spreadsheets are identical. (Neither spreadsheet contains LEV classification data.)

The Annex 2 commentary is based on an erroneous interpretation of the proposed section 1961.1 regulatory language. The commentary interpreted the regulation as imposing a noncompliance penalty of $24.39 per g/mi debit for PC/LDT1 and $15.06 per g/mi debit for LDT2, whereas the penalty actually appears to be $24.39 + $15.06 = $39.45 per g/mi debit for both weight classes. Thus, contrary to points (2) and (3) in the commentary, there is no disparity between weight classes and the penalty may be sufficient to deter noncompliance. But points (1) and (4) are valid. (The correct interpretation of section 1961.1 is reflected in Annex 7, Section 2.4.)

A couple points in Annex 7 need clarification. It states on p. 7 that cap-and-trade and feebates "can be applied conjunctively, with the emission caps establishing a minimal expectation level for emissions performance while the feebate also motivates the maximum practically achievable emissions reduction". However, as long as emissions remain well below the cap level "there would be no incentive to trade at a price differing from the mandated emissions price" (p. 27), and trading would only function as a bookkeeping device to shift allowances from over-compliant to under-compliant emitters. The feebate would "perform the same function as trading" (p. 27) in the sense that the feebate revenue transfers would shift resources to more cost-effective emission controls, but this would have the effect of minimizing emissions – not minimizing costs. As emissions approach the cap level, the trading price would begin to exceed the feebate's emissions price, and the market would then start functioning to minimize compliance costs.

An alternative approach, which is used by the Swedish NOx program, is to simply impose a non-tradable emissions standard in conjunction with the feebate system. This guarantees a basic level of emissions performance without incurring the administrative complications and transaction costs of a trading system. (As a practical matter the Swedish NOx standard has become largely irrelevant because power plants generally outperform the standard by a wide margin.)

Endnotes

Page 3:

[1] There is some merit to the industry's argument. AB 1493 mandates emissions reduction based on a "cost-effectiveness" requirement, rather than environmental or health-and-safety requirements; and under CARB's interpretation "cost-effectiveness" is quantified solely in terms of fuel economy benefits, taking no account of environmental externalities.

Page 4:

[2] CARB staff estimates baseline emissions for California light-duty vehicles in 2004 at 386,600 tons CO2-equivalent per day (CARB, 2004a, p. 143), and emissions in 2030

(with the AB 1493 regulations) are estimated at 420,300 tons per day (CARB, 2004b, p. 17).

Page 6:

[3] State-mandated feebates would also be more consistent with federal preemption rules under EPCA (Langer, 2005, p. 14). Since a feebate does not impose a mandated performance standard, the policy rationale for federal preemption does not apply.

Page 9:

[4] The very slight numerical differences between the emission limits calculated in Annexes 3 and 6 are due to round-off of the representative vehicles' feasible emissions. (Compare Annex 3, std_regressions tab, cells AA26:AA27 and AA37:AA38 to Annex 6, cells X5:X6 and X8:X9.)

Page 15:

[5] CARB's cost analysis illustrates the tendency of compliance costs to increase with vehicle weight: The estimated technology cost to achieve "maximum feasible emissions reduction" for the 5500-lb "large truck" is 54% higher than that of the 3000-lb "small car" ($1672 versus $1087), even though the large truck's emission limit (including the air conditioning credit) is 81% higher than that of the small car (354+18.5 g/mi versus 190+15.6 g/mi). (These values are from CARB, 2004b, Table 6.2-7, and CARB, 2004a, Tables 6.1-1 and 6.1-3.)

Page 17:

[6] CARB (2004a) states (in the Executive Summary, p. xi) that "… although using a fuel price of $2.30 per gallon reduces the payback period and increases the net present value for all technology packages, this change by itself would not allow staff to set a more stringent standard. Rather, the limiting factor on the standard is the availability of technology packages for widespread deployment". However, it is not clear whether CARB warrants that a more stringent standard would not be cost-effective at fuel prices higher than $2.30/gal. The Final Statement of Reasons (CARB, 2005) addresses a request made by one commenter (at the September, 2004 hearing) to run staff's analysis at $5.00/gal (comment #280 in the FSOR). Staff's response affirmed that the regulations would still be cost-effective at the higher fuel price (as would be expected), but it did not indicate whether a significantly more stringent standard might be justified at $5.00/gal. (As of August 15, 2005, the average retail price for regular gasoline in California was $2.716/gal (California Energy Commission, 2005).)

Page 17:

[7] CARB (2004a) notes (on p. 62) that Califonia's Zero Emission Vehicle (ZEV) program will yield about 10% hybrids in the timeframe of the AB 1493 regulations, but it nevertheless relegates hybrids to the "long-term" technology category (i.e., beyond the timeframe of the regulations). AB 1493 will, in a sense, undermine the ZEV program because the extra emission credits generated from ZEV-compliant credits will result in higher emission allowances for other vehicles, neutralizing the ZEV vehicle's superior emissions performance. The ZEV program does not affect the aggregate emissions limit

defined by the AB 1493 regulations; it only constrains the means of compliance, and hence undermines AB 1493's mandate to "provide flexibility, to the maximum extent feasible, in the means by which a person may comply with [the] regulations".

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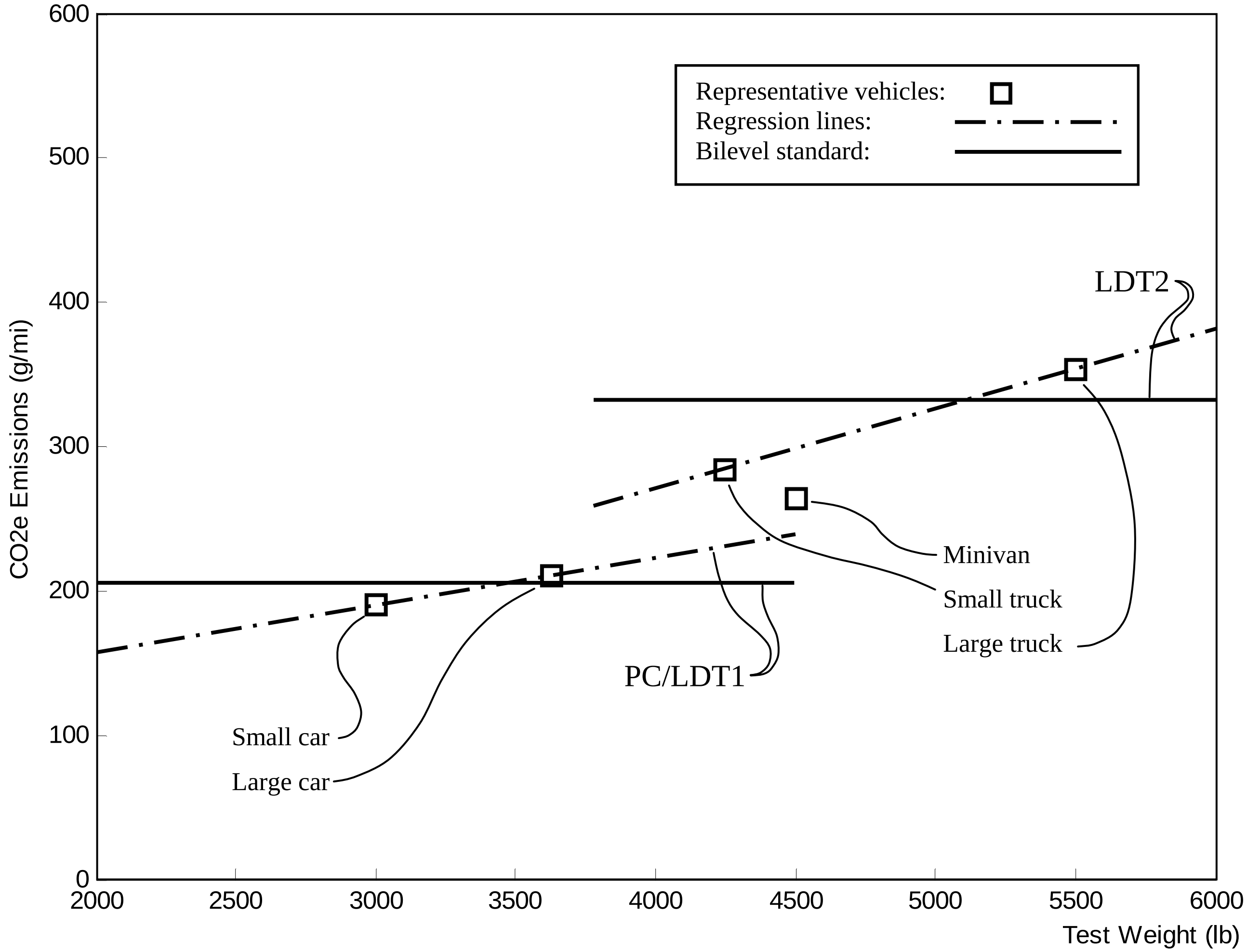

Fig. 1. Methodology of standard determination.